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SIGNALS TRANSMISSION BY INVARIANT METHOD WITH FURTHER NON-LINEAR PROCESSING UNDER WEAK CORRELATION

The invariant system of information processing based on square-law characterized non-linear processing has been synthesized. In calculating of the parameters of such system it is assumed that the readings of the sub-carrier are interfered with additive noise and weakly correlated with each other. The quantitative estimation of the operation of such system is compared with the quantitative indications of the classical system with amplitude modulation and with the characteristics of the invariant system on the basis of extended synchronous detection.

Keywords: noise immunity; invariant; probability of pairwise transition; signal/noise relation.

The analysis of the qualitative parameters of the invariant system with non-linear processing of the readings of the sub-carrier under weak correlativity of the noise readings is carried out. The analytical expression of calculation of the probability density of the invariant estimation is found. All this allows to use the given structure for qualitative transmission of information.

In papers [1–5] the invariant systems of transmission of information having different probabilities of pairwise transition were investigated.

It should be pointed out that the mentioned above invariant systems have appreciably better characteristics in comparison with the classical systems of amplitude modulation under complex influence of noise.

The advantage in noise immunity of the invariant systems is explained by the fact that the modulating parameter is included in the relation of energies of informative and training signals.

However, it should be pointed out that the search for construction of such invariant systems is not stopped. The given paper is devoted to the further investigation of characteristics of the invariant system using square-law characterized detection, that is non-linear processing of signals.

Statement of Purpose. There is a channel of communication, limited by the frequencies f_h and f_l. Temporal dynamics of the channels with variable parameters can be conventionally divided into the intervals of stationarity. Consider the reception of the informative and training signals within the extracted intervals of stationarity. Within the above-mentioned intervals the influence of multiplicative noise is described by the constancy of the coefficient of transmission $k(t)$ on a certain frequency. The algorithm of reception is determined by the carrying frequency, given as an average frequency of the channel, whose amplitude is modulated by the sub-carrier.

Each transmitting block will contain an informative part and a sequence of training signals S_{tr}. The quantity of the elements of the information sequence related to the quantity of the elements of the training sequence is equal to:

$$N_{\text{inf}} : N_{\text{tr}} = \frac{2}{3} : \frac{1}{3}.$$

Due to the changing of parameters of the communication channel to informative and training signals, the additive noise is interfering.

The Solution of the Stated Problem. On the receiving side the training signals are averaged and used for demodulation of the informative part of the block and for reduction of additive noise influence of the communication channel.

In figure 1 the structure of the receiving part of the invariant relative amplitude modulation is represented. Such kind of structure contains a synchronous detector (multiplier, PLL and LPF) and a special calculator.

Due to the equal influence of multiplicative noise on both parts of each transmitted block, the algorithm of demodulation of the reception signals with the chosen way of signals processing will consist in calculation of the invariant estimation.

Since non-linear square-law characterized algorithm is used in calculation of the estimation of the invariant, the following relationship is true:

$$\text{INV}^{*2} = \frac{\sum_{i=1}^{N} \left(k \cdot \text{INV}_l \cdot S(i) + \xi(i) \right)^2}{\frac{1}{L} \sum_{m=1}^{L} \sum_{j=1}^{N} \left(k \cdot S_{tr} \cdot S(j) + \eta(m, j) \right)^2} S_{\text{tr}}^2. \quad (1)$$

In the numerator of the expression (1) there is a sum of N squares of instantaneous readings of the signal of information impulse. The information signal is formed by the sub-carrier of the kind

$$S(i) = A \sin\left(2\pi f_s \cdot \Delta t \cdot i \right),$$

where A is amplitude; f_s is frequency of oscillations of the sub-carrier; Δt is digitization interval and is equal to the following expression:

$$C(i) = k \cdot \text{INV}_l \cdot S(i) + \xi(i),$$

where $k \cdot \text{INV}_l \cdot S(i)$ is instantaneous reading of the signal of the information part of the block, coming from the channel; $x(i)$ – additive noise readings, distributed according to the normal law; k is the coefficient of transmission of the communication channel on the interval of stationarity.

In the denominator of the expression (1) there is a sum of N squares of instantaneous readings of the signal of training impulse, formed by the sub-carrier

$$G(m) = k \cdot S_{\text{tr}} \cdot S(i) + \eta(m, j),$$

where $\eta(m, j)$ is noise in m-realization of the training signal, distributed according to the normal law; L is the quantity of accumulation $G(m)$.

Without loss of generality it is supposed that $S_{tr} = 1$. If $S_{tr} \neq 1$ then all the initial parameters, namely INV_l and σ_ξ (root-mean-square deviation of the noise $\xi(i)$, $\eta(m, j)$) can be scaled by the quantity S_{tr}.

In accordance with the restrictions introduced, formula (1) will be as follows:

$$\mathrm{INV}^{*2} = \frac{\sum_{i=1}^{N} \left(k \cdot \mathrm{INV}_l \cdot S(i) + \xi(i)\right)^2}{\frac{1}{L}\sum_{m=1}^{L}\sum_{j=1}^{N} \left(k \cdot S(j) + \eta(m, j)\right)^2} = \frac{A}{B}, \qquad (2)$$

where variables are described above.

Let us assume that the occasional quantities $\xi(i)$ and $\eta(m, j)$ are equally distributed according to the normal law with the zero mathematic expectation and dispersion σ_ξ^2. Besides, it is supposed that in each block only the next occasional quantities are dependent. Then

$$\mathrm{corr}\left(\xi(i), \xi(i-1)\right) = \\ = \mathrm{corr}\left(\eta(m, j), \eta(m, j-1)\right) = R,$$

where R is the coefficient of correlation.

All the other occasional quantities entering each receiving block will be independent. To realize this model, it is necessary to have

$$|R| \leq 1/\sqrt{2}\,.$$

Let us use the known approach of estimation of pairwise transition probability, described by the formula of average probability [6]

$$P_{tr} = P_1 \int_0^{z_{thr}^2} W_i(z)\,dz + P_i \int_{z_{thr}^2}^{\infty} W_1(z)\,dz\,, \qquad (3)$$

where P_{tr} is the probability of transition of $\underline{\mathrm{INV}}_1{}^2$ to $\underline{\mathrm{INV}}_i{}^2$ and vice versa; P_1 is the probability of appearing $\underline{\mathrm{INV}}_1{}^2$; P_i is the probability of appearing $\underline{\mathrm{INV}}_i{}^2$.

The first integral is probability of appearing $\underline{\mathrm{INV}}_i{}^2$ when $\underline{\mathrm{INV}}_1{}^2$ is sent.

The second integral is probability of appearing $\underline{\mathrm{INV}}_1{}^2$ when $\underline{\mathrm{INV}}_i{}^2$ is sent.

z^2_{thr} is the threshold value, necessary to calculate P_{tr}; with the known P_1 and P_i.

It is calculated by the best bias estimation using minimization P_{tr} on z^2_{thr}.

Having unknown P_1 and P_i we choose $P_1 = P_i = 0{,}5$.

From analysis (3) it is evident that to calculate P_{tr} it is necessary to know the analytical expression $W_1(z)$ and $W_i(z)$ of the density of probability of invariant estimation.

At non-linear processing and calculation of quantities of the invariants the shift appears. This shift is stipulated by the fact that in the formula (3) the quantities $W_1(z)$ and $W_i(z)$ are calculated for the squares of invariants. The threshold value z_{thr} in the expression (3) is also squared. The shifted squares of the invariants in the formula (3) are marked as $\underline{\mathrm{INV}}_1{}^2$ и $\underline{\mathrm{INV}}_i{}^2$.

On the basis of the expression (2) mathematic expectation and dispersion of instantaneous values A and B are calculated. Mathematic expectation of the numerator is equal to [7]:

$$m_A = \sum_{i=1}^{N} \left(k^2\,\mathrm{INV}_l^2\,S(i)^2 + \sigma^2\right). \qquad (4)$$

Mathematic expectation of the denominator is [7]:

$$m_B = \sum_{i=1}^{N} \left(k^2 S(i)^2 + \sigma^2\right). \qquad (5)$$

Dispersion of the numerator is equal to [7]:

$$D_A = 4k^2\,\mathrm{INV}_l^2\,\sigma^2 \sum_{i=1}^{N} S^2(i) + 2N\sigma^4 + \\ + 8\sum_{i=1}^{N-1} k^2\,\mathrm{INV}_l^2\,S(i)S(i+1)\sigma^2 R + 4(N-1)R^2\sigma^2. \qquad (6)$$

Dispersion of the denominator is equal to [7]:

$$D_B = \frac{1}{L}\left(\begin{array}{l} 4k^2\sigma^2 \sum_{i=1}^{N} S^2(i) + \\ +8k^2\sigma^2 R \sum_{i=1}^{N-1} S(i)S(i+1) + \\ +2N\sigma^4 + 4(N-1)R^2\sigma^4 \end{array}\right). \qquad (7)$$

The calculation of the quotient of two accidental values is made on the basis of the formula given below [7]:

$$W(z) = \int_{-\infty}^{\infty} \frac{1}{2\pi\sigma_A\sigma_B} \times \\ \times\, e^{-\frac{(zx - m_A)^2}{2\sigma_A^2}}\, e^{-\frac{(x - m_B)^2}{2\sigma_B^2}}\, |x|\,dx, \qquad (8)$$

where σ_A and σ_B are calculated using expressions (6) and (7), m_A and m_B are calculated using expression (4) and (5).

It should be noted that in the formula (3) INV_1 is used calculating $W_1(z)$, and INV_i is used calculating $W_i(z)$. The value of the pairwise probability P_{tr} was calculated using the method of numerical integration. The number of accumulations with averaging is equal to 40.

The data obtained are restricted by the first six pairs of compared invariants, when $\mathrm{INV}_1 = 1$, $\mathrm{INV}_i = 2; 3; 4; 5; 6; 7$.

The probability of the pairwise transition was calculated by the values h-relations of signal/noise with the help of the formula defined by the relation of the signal intensity to the noise intensity

$$h^2 = \frac{k^2\,\mathrm{INV}_l^2\,a}{N\sigma_\xi^2}\,.$$

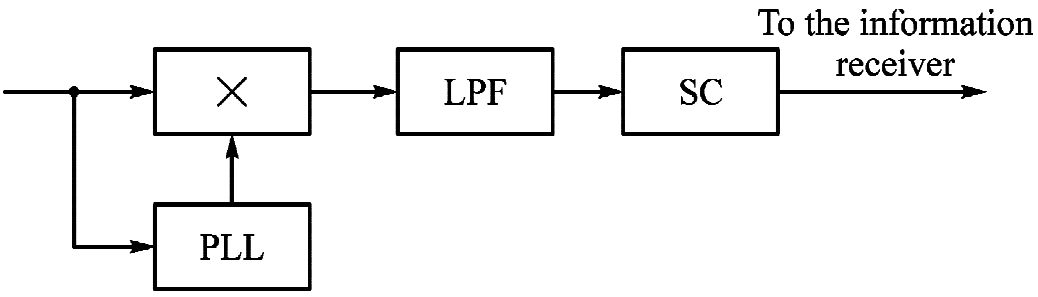

Fig. 1. Structural circuit of invariant system of information transmission: PLL is a phase-lock loop; LPF is a low-pass filter

Threshold values z^2_{thr} were calculated by minimization P_{tr} in formula (3). For $k = 1$, $R = 0{,}7$ and $INV_1 = 1$; $INV_i = 2; 3; 4; 5; 6; 7$ the calculations are $z^2_{thr} = 1{,}521; 2{,}047; 2{,}513; 3{,}406; 4{,}117; 4{,}595$. For $k = 0{,}7$, $R = 0{,}7$ and $INV_1 = 1$; $INV_i = 2; 3; 4; 5; 6; 7$ the calculations are $z^2_{thr} = 1{,}341; 1{,}689; 2{,}117; 2{,}617; 2{,}970; 3{,}401$.

The peculiarity of any invariant system based on the principle of the invariant relative amplitude modulation is amplitude modulating signals formed by INV_l and S_{tr} transmitted through the channel.

The transmission of these signals is provided on the basis of classical algorithms of information processing and has low noise immunity. Only after processing of these signals in accordance with the algorithm of the quotient of the expression (2) we obtain the estimation of the invariant which is really a number, not a signal.

Curve 2 in figures 2 and 3 corresponds to the probability of error P_{er} in classical systems, being an analogue of the probability of pairwise transition, and is calculated by the known formulas [6].

As we can see from figures 2 and 3 the probability of pairwise transition in invariant system is determined by the quantity ($10^{-1}...10^{-18}$). At the same values signal/noise probability of inaccurate reception of a single symbol in the classical systems is in the limits ($10^{-1}...10^{-5}$).

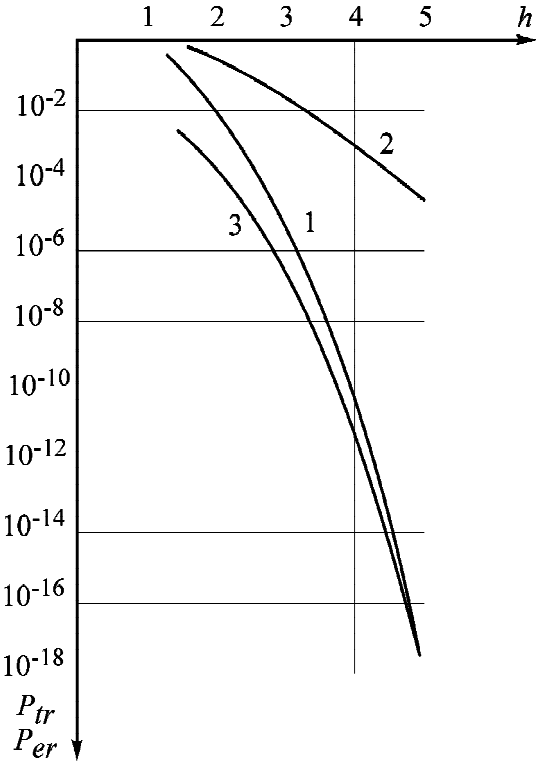

Fig. 2. Noise immunity of invariant system under the absence of multiplicative noise and $INV_1 = 1$; $INV_i = 2; 3; 4; 5; 6; 7$ Curve 1 is the probability of pairwise transition under weak correlation of readings of the noise and non-linear processing of signal readings Curve 2 is the probability of error of classical AM Curve 3 is the probability of pairwise transition under non-correlativity of noise readings and using extended synchronous detector

The carried out analysis shows that the invariant system of information transmission under additive noise with non-correlated readings has high noise immunity. The probability of error of the classical algorithm with amplitude modulation is at least by two orders greater than the probability of pairwise transition in invariant system.

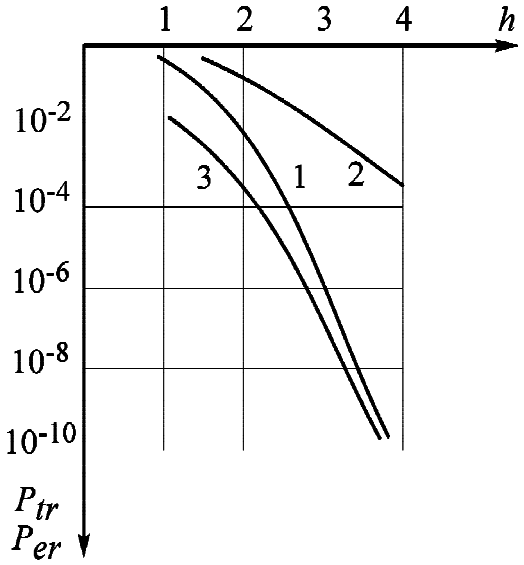

Fig. 3. The noise immunity of the invariant system under multiplicative noise and $k = 0{,}7$; $INV_1 = 1$; $INV_i = 2; 3; 4; 5; 6; 7$ Curve 1 is the probability of pairwise transition under weak correlativity of the readings of noise and non-linear processing of signal readings Curve 2 is the probability of error of the classical AM Curve 3 is the probability of pairwise transition under non-correlativity of the readings of the noise and application of the extended synchronous detector

We should like to emphasize that the system with the square-law characterized non-linear processing is much simpler in realization in comparison with the invariant systems, developed by the authors earlier [1–5]. Simplification presupposes that in the developed above algorithm the extended synchronous detection is not required. Therefore, the system can be used in telecommunication systems, telecontrol systems and other systems requiring high level of immunity to noise.

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IMPLEMENTATION ERROR OF RELATIVE MEASUREMENTS

The RNE time scale parameters impact the NSC signal-tracking system operation and the forming of radio navigation signal parameter evaluations had been studied.

Keywords: error, measurement, frequency, reference generator, navigation spacecraft, phase.

Pseudorange measurement errors are affected by the instability of an automatic voltage control reference-frequency generator. The purpose of the analysis is to measure the impact parameters on the automatic voltage control provisional scale for low critical range of signal tracking system operation; and the formation of radio-navigation signal parameter evaluations.

An automatic voltage control provisional scale is formed on the base of reference generator frequency. The reference generators used, are not ideal and the reference generator frequency is unstable. These disadvantages affect the automatic voltage control provisional scale. There are two kinds of reference-frequency generator instabilities: the short-term instability and the long-term instability.

During fulfillment of the task, concerning relative coordinates' position measurement, the short-term instability of frequency can be of some interest. Short-term instability of frequency means that relatively quick changes of reference generator signal frequency that took place for example, during an interval of one second. Long-term instability of frequency does not impact tracking system operation; therefore it is possible to not consider it.

The frequency variation Δf_k that takes place during the time of a constant interval Δt_k is a random quantity within the Gaussian law and zero-centered. It is suggested that a value of frequency instability δ at a correct time interval, determined in the reference generator ratings (for example, $1 \cdot 10^{-11}$ per 1 second), is the limit (3σ) value of a frequency chance variation Δf_k for this time interval.

If a value of the reference generator instability during any time interval Δt is equal to δ, it means that by means of the completion moment in every following time interval Δt_k a current frequency value of the reference generator Δf_k can change, relatively to the frequency value $f(k-1)$, affecting the random value at the beginning of interval Δt_k. The limit value of a random quantity is calculated by using the following formula:

$$\Delta f_{\max} = \delta \cdot f_k. \quad (1)$$

Considering the fact that frequency deviation of a reference generator is much lower than the nominal value of the reference generator frequency, we can replace in formula (1) the frequency value $f(k-1)$ by the nominal frequency value of a reference generator f_{H}.

Then:

$$\Delta f_{\max} = \delta \cdot f_{\text{H}}. \quad (2)$$

It is recommended to study two variants of the frequency variation model during the time interval resulting from its instability (linear and steplike).

Under the linear frequency variation, a frequency variation of the reference generator takes place during the whole time interval Δt_k linearly, beginning from the value null; by the end of the interval it reaches the value Δf_k, which accidentally occurred in the given interval [1]. This variant is probably the closest to the actual processes of a reference generator. A frequency variation in the first model will occur if a frequency derivative change discontinuously at the beginning of interval Δf_k and remains unchanged during all of its extent. In this case a frequency derivative value can be the following:

$$f_k^{`} = \frac{\Delta f_k}{\Delta t}. \quad (3)$$

According to the linear model a phase variation of a reference generator signals $\Delta\varphi_k$ in interval Δt_k the value will be the following:

$$\Delta\varphi_k = 2\pi f_k^{`} \frac{\Delta t^2}{2} = 2\pi \frac{\Delta f_k \Delta t}{2}. \quad (4)$$

A phase variation limit value of a reference generator signal $\Delta\varphi \max$ is:

$$\Delta\varphi_{\max} = 2\pi \frac{\Delta f_{\max} \Delta t}{2} = 2\pi \frac{\delta \cdot f_H \Delta t}{2}. \quad (5)$$

In the case of a steplike frequency variation; a frequency variation Δf_k taking place discontinuously at the beginning

of every interval Δt_k immediately on a whole magnitude of a frequency variation that occurred in the given interval and during the whole interval Δt_k remains unchanged. It seems to be an imperfect variant and it could be used for achieving the limit evaluations.

The change of the reference generator signal phase $\Delta\varphi_k$ is determined as:

$$\Delta\varphi_k = 2\pi\Delta f_k \Delta t \,. \qquad (6)$$

In accordance to (6), a limit value of a RG phase variation $\Delta\varphi_{max}$ will be:

$$\Delta\varphi_{max} = 2\pi\delta f_H \Delta t. \qquad (7)$$

Comparing formulas (6) and (7), it is easy to notice that a phase variation of a RG signal in a steplike frequency variation is twice as high as the changes in a linear model. A linear frequency variation would be enough to analyse the calculation results and a steplike frequency variation would be corrected.

Analyzing the impact of short-time instability of a RG on Servo Systems filter operation that measures a signal phase (and its derivations), there has been a consideration. When an interval of a filter discretization is 1 second, 100 milliseconds, and 10 milliseconds – the analysis should be performed.

The nominal value of a RG frequency is equal to 10 megahertz.

During the 1 second interval the value is $\delta = 1\cdot10^{-11}$. According to the formula (7), the maximum phase shift of the RG output signal for one second for the linear variant equals 0.018°. For the period of 100 msec the RG signal phase shift will be 0.00018°, for 10 msec – 0.00018°. The given changes of the RG phase are equal to the shift of the radio navigation equipment timeline, thus $5\cdot10^{-12}$ sec, $5\cdot10^{-13}$ sec и $5\cdot10^{-14}$ sec.

Resulting from the multiplication of the RG frequency and the Phase-Locked Loop, and forming conversion signals of radio navigation equipment (the overall multiplication coefficient ≈ 160) on NSV carrier frequency phase shift will be $\approx 3°$ for 1 sec, $\approx 3°$ for 100 msec, $\approx 0.03°$ for 10 msec.

The received values of signal phase variation caused by RG frequency instability are considered to be valid in terms of a phase estimation dynamic error for all analyzed interval values of a filter discretization. A limited value of this error $\approx 9°$ (when a discriminator curve aperture of phase discriminator is $\pm 90°$).

It is possible to compare the given values of additional fluctuations for an input signal phase determined by the RG instability, and the value of a random error component (noise error). Under the selected interval values of a filter discretization, the maximum values for a coherent integration interval in a phase filter discriminator (PD) comprises 1 sec, 100 msec and 10 msec. Noise values in these conditions are 1 Hz, 10 Hz and 100 Hz, consequently.

It is obvious that the values for a discretization interval and a coherent integration interval in PD could be different. For example, by using a discretization interval of 100 msec it is possible to apply an acquisition interval of 10 msec; however this case is limited.

With the bottom value of an energy potential in GLONASS/GPS radio navigation equipment ($\approx$ 35dBHz), a noise error of a phase estimation ($\sigma\varphi$) has the following values (for 1 Hz $\sigma_\varphi \approx 1°$, for 10 Hz $\sigma_\varphi \approx 2.5°$, for 100 Hz $\sigma_\varphi \approx 8°$).

For the intervals of 10 msec and 100 msec additional phase fluctuations caused by RG instability are lower than a value of a noise error. At the same time for the accumulation interval of one second an error resulted from RG instability is dominant.

It can be concluded that for the long-duration coherent integration intervals (≥ 1 sec) in a PD it is recommended to use RG with improved characteristics of short-time instability).

A limit value of a short-time instability of the RG frequency is determined as a value that includes a chance variation of a phase difference between input signal and reference signal caused by the change of reference signals (including heterodyne signals) during the filter discretization interval providing a phase evaluation of an input signal.

The threshold value of phase fluctuation is possible to be equal to 9°; at various discretization critical change intervals, the reference signal phase will be caused by the different levels of the RG instability. The changing of the reference signal phase by 9° will take place in phase change of the RG of $\approx 0.06°$. It is necessary to determine that the allowable instability of the RG frequency for the discretization interval during one second equals $3.5\cdot10\cdot11^{-11}$ ($1.6\cdot10^{-11}$). For the intervals of 100 msec and 10 msec the possible values of instability will be $3.3\cdot10^{-10}$ ($1.6\cdot10^{-10}$), $3.3\cdot10^{-9}$ ($1.6\cdot10^{-9}$).

Using this way it is possible to estimate the instability value that would not just be admissible, but be "working". As a criterion it is advisable to take the value of the heterodyne oscillator phase noises 1°.

The heterodyne oscillator phase will become 1° in condition that the reference generator phase will be changed to $\approx$ 0.006°. On this basis a required instability of the RG frequency for the discretization interval of 1 second equals $3.5\cdot10^{-12}$. For the intervals of 100 msec and 10 msec the desired values of instability will be $3.5\cdot10\cdot11^{-11}$ and $3.5\cdot10^{-10}$. The shift of the RNE time scale in the specified target values of instability will not exceed $1.6\cdot10^{-12}$ sec.

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THE INFLUENCE OF MOBILE POSITIVE CHARGE ON ELECTRONIC CONDUCTIVITY OF DIELECTRIC WITH HETEROGENEOUS BLOCKING BORDER

The correlation between the size of a positive mobile charge and electronic conductivity of oxide on polycrystalline silicon is established with the help of experimental method of thermally stimulated polarization and depolarization of MIS-structures. The boundary conditions of a problem for the working model of behavior of a mobile charge in isolating layers generated on a rough semiconductor film are formulated.

Keywords: mobile charge of a dielectric, heterogeneous blocking border between a dielectric and a semiconductor, oxide on polycrystalline silicon.

Multilayer components consisting of semiconductor, dielectric, conductor layers are the basis of modern microelectronic structures. The technology of formation of these layers develops permanently in the direction of improvement of reproducibility of electric parameters and physicochemical properties. One of the basic technological problems is conductivity control in the dielectric films which are built into active electronic blocks both on a plane surface of a single-crystal substrate and on a surface of granular layers, for example, of polycrystalline silicon.

Conductivity of various dielectric layers including layers formed on rough surfaces is well studied. The influence of separate components of a charge on conductivity of isolating films is the goal of permanent researches. For example, the influence of a negative charge of electrons trapped in the film of oxide over polycrystalline silicon (OPs) on its conductivity is considered in details in [1; 2]. The influence of a surface charge consists in shielding of external electric field by this charge and is accompanied with decreasing of conductivity of an oxide layer. However, until recently there are no data about the influence of a positive ionic charge, mobile under thermo-field loadings on electric conductance of dielectric films with heterogeneous blocking border. The results of researches of this problem are presented in this paper.

For this investigation the complex of techniques including measurements of volt-ampere characteristic (VAC) of samples at a room temperature, currents TSP/TSD of test structures within temperature range of 30...300 °C was used. The conductivity of a dielectric layer was estimated by the size of electric field of breakdown E_{dis}, corresponding to the density of current through structure 10^{-6} A/cm^2. The general density of mobile ions N_{mc} in oxide was defined by the area of curves of TSP/TSD currents.

Measurements were taken on a series of the samples prepared by thermal oxidation of polycrystalline silicon (OPs).

Presence of ions in OPs causes movement of VAC of dielectric in the region of smaller electric fields in a wide range of density of currents from 10^{-6} A/cm^2 till 10^{-10} A/cm^2 and changes the slope of VAC (fig. 1). This movement of VAC decreases from maximum level in a low-voltage part of a curve to a minimum level in a low-voltage part. So, for a pair of samples with density of a mobile charge $4\cdot10^{11}$ cm^{-2} and $4\cdot10^{12}$ cm^{-2} the movement of VAC is 1 MV/cm and 0,2 MV/cm under current density of 10^{-10} A/cm^2 (E < 2 MV/cm) and 10^{-6} A/cm^2 (> 4 MV/cm) respectively.

Under the increasing of ions concentration Nmc in OPs, the dielectric strength E_{dis} of oxide films on Ps monotonously decreases, whereas the conductivity of structure increases (fig. 2). So, if the concentration of ions in a dielectric increases by a factor of a hundred, the electric field of disruption OPs decreases by a factor of 1.5 .

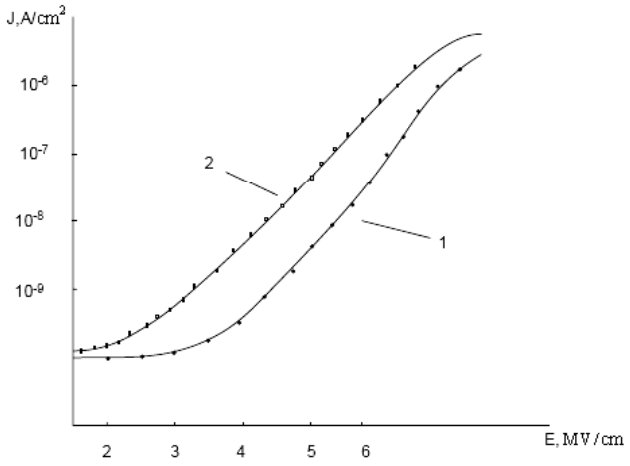

Fig. 1. VAC of OPs with various density of mobile charge N_{mc} in a dielectric: *1* – $N_{mc} = 1\cdot10^{11}$ cm^{-2}; *2* – $N_{mc} = 1\cdot10^{12}$ cm^{-2}

Changing of the form and position of VAC of the oxide on the surface of polysilicon is caused by the appearance of an additional internal electric field E^+ directed along an external field and promoting the growth of currents of conductivity and reduction of dielectric strength of OPs [3] in a dielectric. It is caused by a positive charge of ions (fig. 3).

According to the received data, this component arises under weak electric loadings $E < 2$ MV/cm (fig. 1).

Now we should estimate the density of mobile charge N_{mc} responsible for occurrence E^+ by the data of VAC (fig. 1). Like the calculation of density of mobile ions on the basis of VAC movement the definition of N_{mc} should be performed on the basis of the shift of VAC (ΔV_{mc}) with respect to the theoretical curve corresponding to $N_{mc} = 0$, for the chosen level of an electrical current density:

$$\overline{N}_{mc} = \frac{\overline{Q}_{mc}}{q} = \frac{C_{spec}\Delta V_{mc}}{q} = \frac{\varepsilon\cdot\varepsilon_0\cdot\Delta E}{q}. \qquad (1)$$

Then we should calculate the density of mobile ions in OPs (1) for the film Ps with the thickness of 50 nm and the degree of heterogeneity of the border $\zeta = 1.1$. In this case the shift $\Delta E = E^+$ on the level 10^{-10} A/ cm^2 is approximately

1 MV/cm. The density N_{mc} corresponding to this shift is equal to:

$$\overline{N}_{mc} = \frac{\varepsilon \cdot \varepsilon_0}{q} \cdot E^+ = \frac{3.8 \cdot 8.85 \cdot 10^{-14}}{1.6 \cdot 10^{-19}} \cdot 10^6 \approx 2 \cdot 10^{12}\,\text{cm}^{-2}. \quad (2)$$

At the same time the density of ions in this film, measured by the method of TSP current is $4 \cdot 10^{12}$ cm^{-2}.

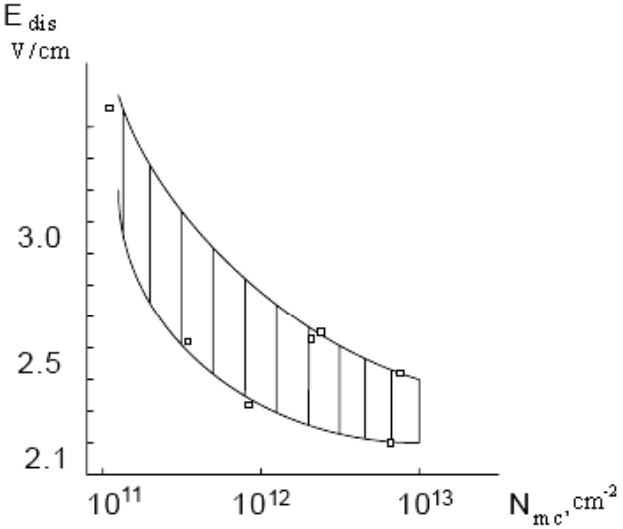

Fig. 2. The dielectric strength E_{dis} vs. average density of mobile charge N_{mc} in OPs

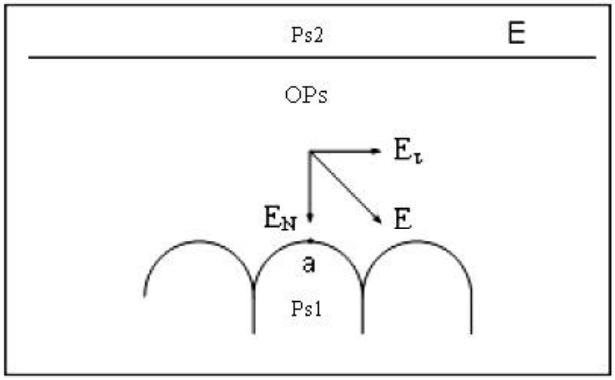

Fig. 3. Distribution of electric field in OPs near the edges of Ps

Hence, only half of ions in layer OPs makes the contribution to the change of internal electric field on a blocking surface. This result is in accordance with calculation data of the centroid of mobile charge in the oxide on the surface of polysilicon, which shows this charge located in the center. Thus, it confirms the conclusion about approximately equal distribution of ions on the internal and external interfaces. It means that the increasing of currents of conductivity in a low-voltage part of VAC of OPs is caused by the ionic charge placed near the oxidized surface of Ps.

At measurement of VAC the appearance of additional electronic currents caused by a positive ions field takes place at a room temperature under the redistribution of ionic charge along the heterogeneous blocking border. Redistribution of ions at measurement of VAC occurs permanently in accordance with a map of internal electric fields in time τ_{rel}.

Effective time of relaxation for silicon oxide $\tau_{rel} = 10^{-5}...10^{-3}$ sec [4], therefore in a range of weak electric fields Ep 2 MV/cm the time of relaxation of a mobile ionic charge is:

$$\tau_{rel} = \tau_{eff.0} \cdot \exp\frac{\varepsilon_a}{K \cdot T} = (10^{-5}...10^{-3}) \times \times \exp\frac{1.34 - 4.82 \cdot 10^{-4}\sqrt{2 \cdot 10^6}}{0.025} = 1...600\ \text{sec}. \quad (3)$$

Time of VAC registration τ_{reg} for the oxide of 50 nm thickness at the speed of scanning V_{reg} = 0,25 V/s in the specified limits of electric fields 2 MV/cm is:

$$\tau_{reg} = \frac{\chi SiO_2}{v_{reg}} \cdot E_n = \frac{2 \cdot 10^{-6} \cdot 2 \cdot 10^6}{0.25} = 4\text{s}. \quad (4)$$

The comparison of τ_{rel} and τ_{reg}, estimations N_{mc} using VAC and curves of TSP currents shows that only a part of charge of ions for which $\tau_{rel} < \tau_{reg}$, is shown as a change of conductivity of OPs.

The change of the relief of the geometrical border leads to redistribution of the internal electric field of mobile charge of ions. It is possible to predict, that at increasing the degree of heterogeneity of interface OPs – Ps there appears accumulation of ions on the edges of Ps and increasing of the local electric field. It is accompanied by displacement of VAC in the area of weak electric fields and reduction of steepness of VAC.

The presence of mobile positive charge in OPs and accumulation of this charge near the edges of polysilicon leads to the increasing of the local electric fields at the blocking border of Ps and growth of conductivity of an isolating layer. The electric field caused by ionic charge, accumulated on the edges of polysilicon, stimulates the injection of electrons from polysilicon. The influence of charge of mobile ions on conductivity of the oxide with heterogeneous geometrical interface become stronger or weaker at increasing or decreasing the degree of roughness of a blocking surface.

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ASYMMETRIC INVARIANT ECHO-JACK OF THE SECOND ORDER WITHOUT A PROTECTIVE TIME INTERVAL AND ITS CHARACTERISTICS

The structure of the invariant echo-jack of the second order without a protective time interval is synthesized. Control elements of such echo-jack are given. The calculation of the basic technical characteristics is presented.

Keywords: invariant, an echo-jack, asymmetric, echo-compensator, asymmetric, power of self-noise.

The main telecommunication network uses, in overwhelming majority of cases, fiber-optical transmission systems. However the standard streams often don't reach the consumer because of the «last mile», presented by a copper cable.

Existing modern high-speed technologies of access use xDSL adaptive echo-jacks in the equipment. The principle of work of adaptive echo-jacks is based on modelling of parameters of an unknown system. The main defect in the work of such systems is the big criticality of work to correlation communications of signals of two directions. In some cases it can lead to work failure.

Another approach in construction of adaptive echo-jacks is the use of invariants. So in works [1; 2] the structures of invariant echo-jacks with protective and without protective time intervals are presented. The basic difference between invariant echo-jacks and classical ones is that the former are controlled by transmission signals while the latter are controlled by an error signal.

The given article is devoted to the further research in the above-mentioned direction where the results of synthesis of the invariant echo-jack of the second order are presented.

We have a communication channel (echo-path) meeting the requirement of stationarity. The communication channel is limited by a pass-band with bottom f_e and top f_t frequencies. It is necessary to synthesize the algorithm of functioning of the invariant echo-jack of the second order.

If the communication channel (echo-path) meets the requirement of stationarity we can write the following equality:

$$H_{i-1}(z) = H_i(z) = H_{i+1}(z) = H_{i+2}(z), \qquad (1)$$

where $H_i(z)$ $-z-$ is the image of the transmission characteristics of an echo-path on i-block of processing.

In [3] it is proved that if the identical signal $V(Z)$ arrives at an input of two parallel working linear digital filters then the correlation of relations of Z-images on the next blocks of processing on the exits of these digital filters is equal to

$$\frac{S_i(z)}{S_{i-1}(z)} : \frac{S_{i-1}(z)}{S_{i-2}(z)} = \frac{\Pi_i(z)}{\Pi_{i-1}(z)} : \frac{\Pi_{i-1}(z)}{\Pi_{i-1}(z)}, \qquad (2)$$

where $S_i(z), S_{i-1}(z), S_{i-2}(z)$ $-z-$ is the signal image on the exit of the additional digital filter on i, $(i-1)$ and $(i-2)$ processing blocks respectively under the entrance influence equal to $V_i(Z)$; $V_{i-1}(Z)$; $V_{i-2}(Z)$; $\Pi_i(z), \Pi_{i-1}(z), \Pi_{i-2}(z)$ $-z-$ is the echo-signal image on i, $(i-1)$ and $(i-2)$ processing blocks respectively under the entrance influence equal to $V_i(Z)$; $V_{i-1}(Z)$; $V_{i-2}(Z)$.

Let's consider the cascade connection of a sending device and an echo-path to be the digital filter forming $\Pi(Z)$.

The additional digital filter included in parallel to a sending device forms signals $S(Z)$.

Equality (2) does not impose restrictions on a signal of transmission $V(Z)$ and allows to transmit it without a protective time interval.

In its turn equality (2) falls apart into the following equalities [3]:

$$\left.\begin{aligned} \hat{\Pi}_i(z) &= \Pi_{i-1}(z) \cdot \frac{S_i(z)}{S_{i-1}(z)} \\ \hat{\hat{\Pi}}_i(z) &= \Pi_{i-2}(z) \cdot \frac{S_i(z)}{S_{i-1}(z)} \cdot \frac{S_{i-1}(z)}{S_{i-2}(z)} \\ \Pi_i(z) &= \frac{1}{2}\hat{\Pi}_i(z) + \frac{1}{2}\hat{\hat{\Pi}}_i(z) \end{aligned}\right\}. \qquad (3)$$

Equality (3) is a basis for the synthesis of the invariant echo-jack of the second order. The estimations of echo-signals on the previous blocks of processing can be used for calculation of the size of an echo-signal on the current block of processing. In fig. 1 the structure of the invariant echo-jack of the second order with control elements is presented.

In figure 1 it is clearly seen, that unlike the classical echo-jack, the invariant one is included before the intake. The invariant echo-jack is controlled by the transmission signals $S(z)$. It results in the fact that its technical characteristics do not depend on correlations of signals of two directions. For echo-signals an invariant echo-jack is an original rejector, and for reception signals it is a two-port network bringing minimum AHI and FHI. The characteristic of the invariant echo-jack is defined on the basis of laws of digital filtration [4].

$$H(z) = \frac{1 - \frac{1}{2}M_1(z)\cdot z^{-1} - \frac{1}{2}M_2(z)\cdot z^{-2}}{1 - \frac{1}{2}M_1(z)\cdot z^{-1} - \frac{1}{2}M_2(z)\cdot z^{-2}C}, \qquad (4)$$

where $M_1(z) = \frac{S_i(z)}{S_{i-1}(z)}$ is the 1st operating factor; $M_2(z) = \frac{S_i(z)}{S_{i-1}(z)} \cdot \frac{S_{i-1}(z)}{S_{i-2}(z)}$ is the 2nd operating factor; $S_i(z)$ – z is the image of a transmission signal on i-block of processing; $C < 1$ – is an additional attenuator, included in a recursive chain.

For stable work of the offered structure it is necessary for the poles of the transmission characteristic to be inside the individual circle, then

$$\left.\begin{aligned} M_1(z) &\le 1, \\ M_2(z) &\le 1. \end{aligned}\right\} \qquad (5)$$

When the chosen word length is equal to m, the maximum values $M_1(z)$ и $M_2(z)$ are 2^m. If the operating factors have such values then the work of the invariant echo-jack will be unstable.

One of possible ways to solve the problem of stable work of the invariant echo-jack is the rationing of operating signals and echo-signals, together with reception signals.

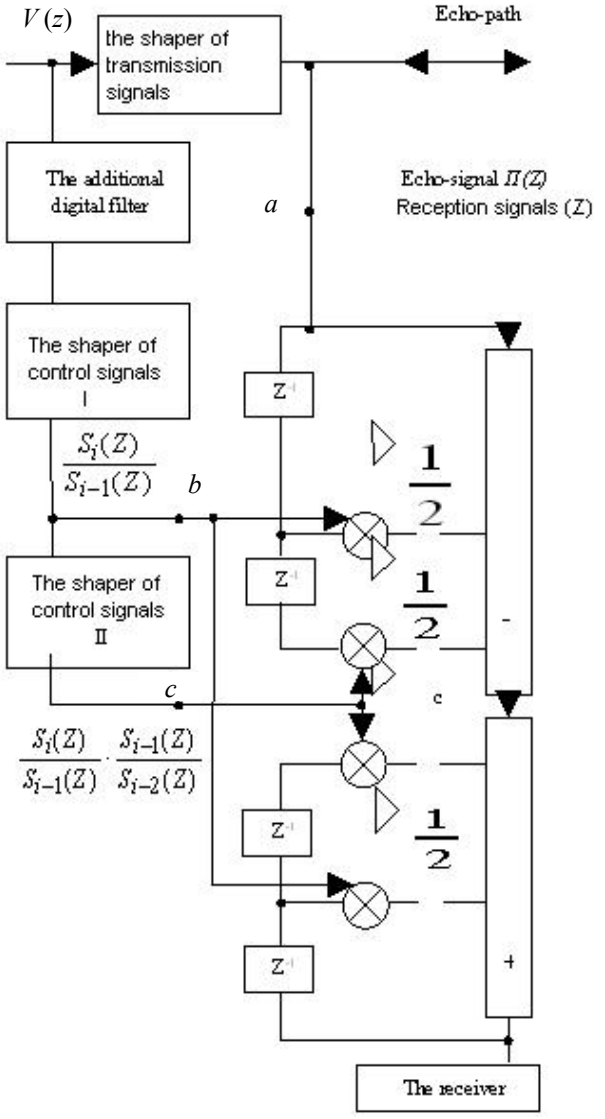

Fig. 1. The structure of the invariant echo-jack of the second order

It will lead to the use of additional scaling two-port networks which should be included not only before an input of the invariant echo-jack itself (point a), but also on the inputs of the shapers of operating signals (points *b* and *c)*.

The other way to provide the stability of the invariant echo-jack of the second order is the transformation of a recursive part into a non recursive digital filter. From the theory of digital filtration it is known, that any recursive digital filter (CF) can be transformed into a non recursive digital filter [4].

Then

$$\frac{1}{1-\frac{1}{2}M_1(Z)\cdot Z^{-1}-\frac{1}{2}M_2(Z)\cdot C\cdot Z^{-2}}=1+\sum_{i=1}^{k}Q_i(Z)\cdot Z^{-i}, \quad (6)$$

where k is the quantity of taps.

For the first five taps of the transformed structure the values $Q_i(Z)$ are accordingly equal to

$$Q_1(Z)=\frac{1}{2}M_1(Z);$$

$$Q_2(Z)=\frac{1}{4}M_1^2(Z)+\frac{1}{2}M_2(Z)\cdot C;$$

$$Q_3(Z)=\frac{1}{2}M_1(Z)\cdot M_2(Z)\cdot C+\frac{1}{8}M_1(Z);$$

$$Q_4(Z)=\frac{1}{4}M_2^2(Z)\cdot C^2+\frac{3}{8}M_1^2(Z)\cdot M_2(Z)\cdot C+\frac{3}{16}M_1^3(Z);$$

$$Q_5(Z)=\frac{3}{8}M_1(Z)\cdot M_2^2(Z)\cdot C^2+\frac{1}{16}M_2(Z)\cdot M_1^2(Z)\cdot C+$$
$$+\frac{3}{16}M_1^3(Z)\cdot M_2(Z)\cdot C+\frac{1}{32}M_1^4(Z).$$

In figure 2 the structure of the invariant echo-jack consisting of two in cascade joined digital filters is presented. In the first digital filter the indemnification of echo-signals is made. In the second digital filter the restoration of reception signals is made. It should be noted that the phase-frequency characteristic of two in cascade joined digital filters will be linear [4].

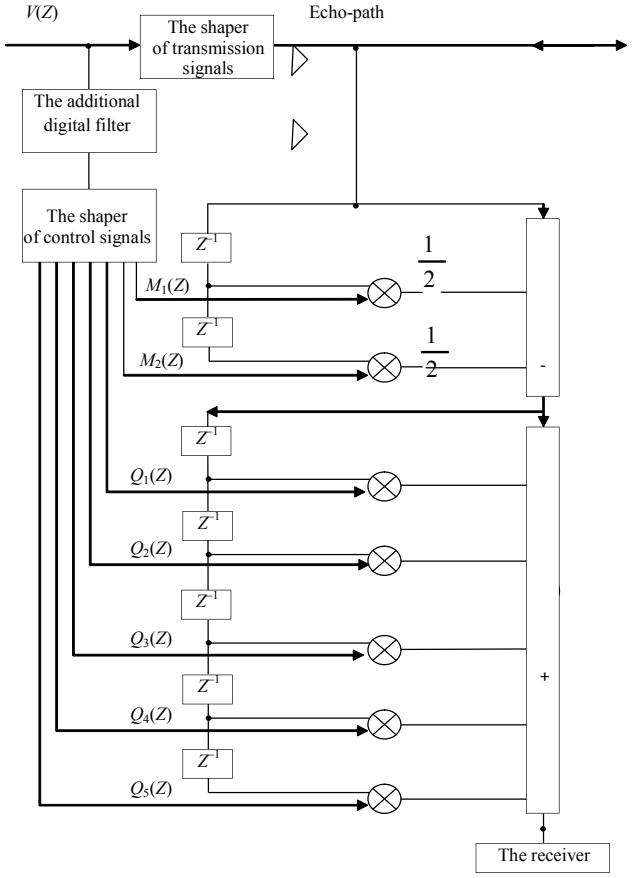

Fig. 2. The transformed structure of the invariant echo-jack of the second order

For the definition of technical characteristics of the developed invariant echo-jack we assume $M_1(z)=M_2(z)=1$. Then the transmission characteristic will be equal to

$$H(z)=\frac{1-\frac{1}{2}z^{-1}-\frac{1}{2}z^{-2}}{1-\frac{1}{2}z^{-1}-\frac{1}{2}z^{-2}C}. \quad (7)$$

Let's decompose $H(z)$ into two transmission functions of the first order

$$H(z) = H_0(z)\cdot H_1(z)=\frac{1+\frac{1}{2}z^{-1}}{1-B_0z^{-1}}\cdot\frac{1-z^{-1}}{1-B_1z^{-1}}, \quad (8)$$

$$B_0=\frac{1}{4}-\frac{1}{4}\sqrt{1+8C},$$

$$B_1=\frac{1}{4}+\frac{1}{4}\sqrt{1+8C},$$

where B_0 and B_1 are the poles of transmission function.

Pulse reaction CFVH-2 is defined by convolution $h_0(nT)$ и $h_1(nT)$.

The general level of self-noise CFVH-2 is defined by a known parity [4]:

$$\sigma^2=\frac{\Delta_{0^2}}{12}\sum_{n=0}^{N-1}h^2(nT)+\frac{\Delta^2}{12}\sum_{j=1}^{M}\sum_{n=0}^{N-1}h_j^2(nT), \quad (9)$$

where Δ – is a step of a quantum entrance word; Δ_0 is a step of quantum in CFVH-2; $h(nT)$ – is pulse reaction CFVH-2; $h_j(nT)$ – is pulse reaction from j-th source of noise in CFVH-2 to an exit.

Let's find the value of separate components included in equality (9), using Cauchy–Bunyakowsky inequality

$$\sum_{n=0}^{N-1}h^2(nT)=\sum_{n=0}^{N-1}\left[h_0(nT)*h_1(nT)\right]^2\le$$

$$\le\sum_{n=0}^{N-1}\left[\sum_{n=0}^{N-1}h_0(nT)\right]^2\cdot\left[\sum_{n=0}^{N-1}h_1(nT)\right]^2, \quad (10)$$

where symbol $*$ designates the convolution operation.

If we omit intermediate calculations, the definitive result will be the following:

$$\sum_{n=0}^{N-1}h^2(nT)=\left[\frac{(B_0+\frac{1}{2})(B_0^{N-2}-1)}{(B_0^2-1)}\right]^2\times$$

$$\times\left[\frac{(B_1-1)(B_1^{N-2}-1)}{(B_1^2-1)}\right]^2. \quad (11)$$

For the simplicity of computations in the process of calculation of the second composed expression (9) we will suppose that all pulse reactions from j-th source of noise to an exit are equal among themselves and are defined by value $h(nT)$. Then the second composed expression (9) will be equal to (taking into account Cauchy–Bunyakowsky inequality)

$$\sum_{j=1}^{M}\sum_{n=0}^{N-1}\left[h_j(nT)\right]^2=5\sum_{n=0}^{N-1}h^2(nT).$$

If $\Delta=\Delta_0$ then expression (9) becomes simpler and it will be equal to

$$\sigma^2_{own}\le\frac{\Delta^2}{2}\left[\frac{(B_0+\frac{1}{2})(B_0^{N-2}-1)}{(B_0^2-1)}\right]\times$$

$$\times\left[\frac{(B_1-1)(B_1^{N-2}-1)}{(B_1^2-1)}\right]^2. \quad (12)$$

Substituting the values of poles B_0 and B_1 into equation (12) we will definitively receive (at $N\ge1000$)

$$\sigma^2_{own}\le\frac{\Delta^2}{2}\cdot\frac{(5+4C+\sqrt{1+8C})^2}{(6+5C)^2}. \quad (13)$$

The noise level of undercompensation in the invariant echo-jack will be equal to

$$\sigma^2_{inv.und}=\sigma^2_{cc}\cdot\sum_{n=0}^{\infty}h^2(nT), \quad (14)$$

where $h(nT)$ – is pulse reaction of the invariant echo-jack of the second order; σ^2_{cc} – capacity of noise of a communication channel. At

$$M_1(Z)=M_2(Z)=1 \text{ size } \sum_{n=0}^{\infty}h^2(nT)\approx1.003.$$

The overall performance of any method of signal processing can be compared with an overall performance of known methods. As an analogue we will use the characteristics of Widrow classical algorithm which is realized in the equipment of xDSL. Comparison will be made taking into account the level of self-noise and the value of undercompensation of an echo-signal.

In Widrow algorithm the adaptive filter joins in parallel with a sending device and models the parameters of an unknown system, i. e. of an echo-path. Pulse reaction of the adaptive filter depends on the connected channel (line) and can be arbitrary. For the simplicity of computations we will suppose that the pulse reaction of the adaptive filter is described by the readings of the homogeneous digital filter and is equal

$$h_{AF}(nT)=\left\{1;c;c^2;K\ldots c^n\right\}, \quad (15)$$

where c is the factor of transmission of the second tap of the adaptive filter (AF); $c<1$.

For the calculation of self-noise level of the adaptive filter we will use expression (9). We will consider, that the word length of an entrance word Δ_0 and the word length of processing Δ in the adaptive filter are equal. Besides we will suppose, that pulse reactions $h_j(nT)$ from j-th source of noise in the adaptive filter are equal among themselves and are defined by pulse reaction of all adaptive filter $h_{AF}(nT)$. Omitting intermediate transformations, we definitively receive analytical expression of the calculation of self-noise level in Widrow classical algorithm:

$$\sigma^2_{AF\ own}=(N+1)\cdot\frac{\Delta^2}{12}\cdot\frac{1-c^{2n}}{1-c^2}, \quad (16)$$

where N – is the quantity of taps of the adaptive filter; $n=\{0;\ 1;\ \ldots\infty\}$ – is a supervision step; c – is a factor of transmission of the second tap of the adaptive filter; Δ – is a quantization step; $\Delta=\frac{1}{2^m}$, m – is the word length of processing.

Let's estimate the noise level of undercompensation in Widrow classical algorithm which is caused by the influence of noise of a communication channel. The noise level of undercompensation at an exit of the adaptive filter in classical algorithm is equal to [5]

$$\sigma^2_{AF\ undercomp}=\frac{\gamma\cdot N\cdot R}{\left|2-\gamma\cdot N\right|}, \quad (17)$$

where γ – is a fine tuning step (in relative sizes), $\gamma\in\{0;\ 1\}$; N – is the quantity of taps in the adaptive filter; $R=\sum_{n=N+1}^{\infty}h^2_{AF}(nT)+\sigma^2_{cc}$; $\sum_{n=N+1}^{\infty}h^2_{AF}(nT)$ – considers noise of

work of the adaptive filter because of truncation of its pulse reaction to size N; σ^2_{cc} – is the capacity of noise of a communication channel.

At an intake input (a subtracter exit) in classical algorithm the level of noise of a communication channel doubles. It is caused by the fact that undercompensation noise $\sigma^2_{AF\ undercomp}$ and communication channel noise σ^2_{cc} are not correlated.

The gain value in relative sizes will be equal to

$$\Delta A = 10 \lg \cdot \frac{\sigma^2_{A\Phi}}{\sigma^2}, \quad (18)$$

where σ^2 – defines either the self-noise level or noise level of undercompensation in the invariant echo-jack; $\sigma^2_{A\Phi}$ – defines either the self-noise level or noise level of undercompensation in Widrow algorithm.

For $c = 0.9$; $N = 100$; $n = 1{,}000$; $m = 12$ the size of ΔA_{own} will be equal to 21.79db.

Similarly, for $c = 0.9$; $N = 100$; $\gamma = 0.05$; $P_{ш.сс} = 40$db; the size $\Delta A_{undercomp}$ will be equal to 5.3 db.

The received gain can be explained by several reasons:

Firstly, the invariant echo-jack is controlled by a transmission signal. The classical echo-jack is controlled by a signal of an error from a subtracter exit.

Secondly, the invariant echo-jack uses the readings of hindrance taken directly from a communication channel. The classical echo-jack calculates the echo-signal estimation artificially.

Thirdly, the work of the invariant echo-jack does not depend on correlation communications of signals of two directions.

The structure of the invariant echo-jack of the second order is synthesized. The overall performance of the invariant echo-jack is proved. The invariant echo-jack of the second order can find application in systems of telecommunications and objects control.

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THE NOISE IMMUNITY OF THE INVARIANT SYSTEM OF INFORMATION TRANSMISSION BASED ON COHERENT RECEPTION UNDER WEAK CORRELATION COMMUNICATIONS

The invariant system of information processing based on obtaining of the rectangular envelope by using a synchronous detector is considered. The indexes of the noise immunity of such system are calculated. It is supposed that the closest readings of the rectangular envelope are interfered with the additive noise whose readings are weakly correlated with each other. The quantitative estimation of the operation of such system is compared with the quantitative indexes of the known invariant system under non-correlativity of the noise readings.

Keywords: noise immunity, invariant, invariant relative amplitude modulation, probability of pairwise transition, signal/noise relation, coefficient of correlation.

The method of analysis of the qualitative parameters of the invariant system using synchronous detector under the weak correlativity of the noise readings is developed. The analytical expression of calculation of the probability density of invariants transition is worked out on the basis of the expression of invariant estimation.

The results obtained under non-correlativity of the noise readings are presented. All this helps to use the offered structure for qualitative transmission of information.

The invariant systems of information transmission can be based on different methods of information processing. The aim is to reduce the influence of the multiplicative noise using the algorithm of the particular information parameter to the training one [1].

The authors considered the four ways of signals processing with the help of invariant relative amplitude modulation and noise readings of different correlativity.

In the paper [1] the invariant relative amplitude modulation (IRAM) under ideal conditions is considered.

In the paper [2] the invariant non-coherent system of information processing is considered.

In the paper [3] the qualitative characteristics of the invariant relative amplitude modulation with the noise in generator are considered.

In the paper [4] the qualitative characteristics of the invariant relative amplitude modulation of the near readings of the information and training signals are obtained. The given paper completes the investigation of the invariant relative amplitude modulation behavior in case of weak correlativity of the readings of information and training signals.

We have a communication channel limited by the frequencies f_l and f_h. The condition of the communication channel is determined by the interval of stationarity inside which the influence of multiplicative noise is described by the channel transmission $k(t)$ on a certain frequency.

Multiplicative noise equally corrupts informational and training parts of the block of transmitted signals. However the ratio of the energy of the information signal to the energy of the training signal is constant on the interval of stationarity.

Besides, each transmitting block is influenced by the additive noise.

It is supposed that the nearest readings of the additive noise are weakly correlated with each other.

It is necessary to calculate the probability of the pairwise transition of invariants in the system under consideration. For this purpose the analytical expression of the density of probability of invariant estimation is to be found.

In figure 1 the structure of the receiving part of the invariant relative amplitude modulation is presented. Such structure contains synchronous detector (multiplier, AFCc, LPF) and special calculator.

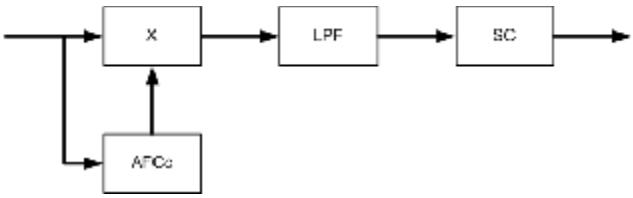

Fig. 1. Block diagram of invariant system of information transmission: AFCc is an automatic – frequency control circuit, LPF is a low – pass filter, SC is a special calculator

On the transmitting side, the modulating parameter is put into the ratio of the energy of the information signal to the energy of the training signal.

Owing to the fact that multiplicative noise equally influences both parts of each transmitted block, the algorithm of demodulation of reception signals taking into consideration the chosen method of signals processing will consist in the expression of invariant estimation:

$$\mathrm{INV}_L^* = \frac{\sum_{i=1}^{N}(k\cdot \mathrm{INV}_l + \xi(i))}{\frac{1}{L}\sum_{j=1}^{N}\sum_{m=1}^{L}(k\cdot S_{tr} + \eta(m,j))}\cdot S_{\mathrm{tr}}. \qquad (1)$$

In the numerator (1) the N sum of instantaneous readings of the signal of the information impulse is presented. The information signal is formed by the rectangular envelope with the amplitude $k\cdot \mathrm{INV}_l + \xi(i)$, where $\xi(i)$ is additive noise readings distributed according to the normal law [5].

In the denominator (1) the sum N of instantaneous readings of the signal of the training impulse formed by the rectangular envelope is represented: $k{\cdot}S_{\mathrm{tr}} + \eta(m, j)$, where $\eta(m, j)$ is the noise the m-realization of the training signal, distributed according to the normal law [5].

Without loss of generality we suppose that $S_{\mathrm{tr}} = 1$. If $S_{\mathrm{tr}} \neq 1$, then all outcome parameters, namely INV_l and σ_ξ (root-mean-square deviation of the noise $\xi(i)$, $\eta(m, j)$) can be scaled by the quality S_{tr}. In this case the formula (1) will be changed due to the introduced restrictions as follows:

$$\mathrm{INV}_L^* = \frac{\sum_{i=1}^{N}(k\cdot \mathrm{INV}_l + \xi(i))}{\frac{1}{L}\sum_{j=1}^{N}\sum_{m=1}^{L}(k\cdot S_{\mathrm{tr}} + \eta(m,j))} = \frac{A}{B}. \qquad (2)$$

In the formula (2) $k{\cdot}\mathrm{INV}_l$ is the instantaneous reading of the signal of the information part of the impulse, coming from the channel; $\xi(i) - i$ – is instantaneous value of the noise in the information signal; k is coefficient of transmission of the channel; $\eta(m, j) - j$ – is instantaneous value of the noise in m-realization of the training signal.

Let us suppose that the occasional values $\xi(i)$ and $\eta(m,j)$ are equally distributed according to the normal law with the zero mathematic expectation and the dispersion σ_ξ^2. Besides, it is supposed that in each block only the next occasional values are dependent. Then

$$\mathrm{CORR}(\xi(i), \xi(i-1)) = \mathrm{CORR}(\eta(m,j), \eta(m,j-1)) = R,$$

where R is coefficient of correlation.

All the other occasional values entering each receiving block will be independent. For the realization of this model it is necessary that [6]

$$|R| \le 1/\sqrt{2}.$$

Let us use the known way of estimation of the probability of the pairwise transition described by the formula of the full probability.

$$P_{\mathrm{tr}} = P_1\int_0^{Zp} w_i(z)dz + P_i\int_{Zp}^{\infty} w_1(z)dz, \qquad (3)$$

where P_{tr} is the probability of transition of INV_l into INV_i and vice versa; P_1 is the probability of appearing of INV_l. P_i is the probability of appearing of INV_i, where INV_l is sent. The second integral the probability of appearing of INV_l when INV_i is sent; Z_{thr} is threshold value, necessary for calculating P_{tr}; when P_1 and P_i are known it is calculated with the help of the best bias estimation by minimization of P_{tr} on Z_{thr}. When P_1 and P_i are unknown we choose $P_1 = P_i = 0.5$.

From the analysis (3) we can see that for calculation of P_{tr} it is necessary to know the analytical expression $W_1(z)$ and $W_i(z)$ of the probability density of the estimation of the invariant. On the basis of (2) let us calculate the mathematic expectation and dispersions of the instantaneous values A and B.

Mathematic expectation of the numerator is equal to [7]

$$m_A = N{\cdot}k{\cdot}\mathrm{INV}_l. \qquad (4)$$

But mathematic expectation of the denominator is equal to [7]

$$m_B = N \cdot k. \quad (5)$$

The dispersion of the numerator is [7]

$$\sigma_A^2 = D(\sum_{i=1}^{N} \xi(i)) = N \cdot \sigma_\xi^2 + 2(N-1)\mathrm{cov}(\xi(i), \xi(i+1)) =$$

$$= N \cdot \sigma_\xi^2 + 2(N-1)R \cdot \sigma_\xi^2 = \sigma_\xi^2 (N + 2(N-1)R). \quad (6)$$

The dispersion of the denominator is equal to [7]

$$\sigma_B^2 = \frac{1}{L}\sigma_\xi^2 (N + 2(N-1)R). \quad (7)$$

The quotient of the two occasional values is calculated by the formula [7]

$$W(z) = \int_{-\infty}^{\infty} \frac{1}{2\pi\sigma_A\sigma_B} e^{-\frac{(zx-m_A)^2}{2\sigma_A^2}} \cdot e^{-\frac{(x-m_B)^2}{2\sigma_B^2}} |x| dx, \quad (8)$$

where σ_A and σ_B are calculated by the expressions (6) and (7); m_A и m_B – by the expression (4, 5).

It should be pointed out that in the process of calculation in the formula (3) $W_i(z)$ – INV_i, is used where $i = 2, 3, 4, 5, 6, 7$. The value of the probability of the pairwise transition P_{tr} was calculated using the method of numerical integration. The number of accumulations with averaging is 40 [1].

The received data are limited by the first 6 pairs of the compared invariants, when $\mathrm{INV}_1 = 1$, $\mathrm{INV}_i = 2, 3, 4, 5, 6, 7$.

The probability of the pairwise transition is calculated at the value h – signal/noise relations which was calculated by the formula expressed by the relation of the power of signal to the power of noise [5]

$$h^2 = \frac{k^2 \mathrm{INV}_l^2}{N\sigma_\xi^2}.$$

The threshold values Z_{thr} were calculated by minimization P_{tr} in the formula (3). The results of the calculation for different values of the coefficient of the channel transmission k, the coefficient of correlation R and the quantity $\mathrm{INV}_l = 1$, $\mathrm{INV}_i = 2, 3, 4, 5, 6, 7$ are placed in tables 1, 2.

If in the formulas (6) and (7) $R = 0$ (the readings of the noise are non-correlated) the general expression of probability density of the invariant estimation obtained in the paper turns into the relation of the calculation of the analogous parameter received under the operation of the non-correlated readings of the white noise [1].

However, the received expression of the density of the probability in the given paper is redetermining and most fully reflects the real situation.

The peculiarity of any invariant system based on the principle of the invariant relative amplitude modulation is the fact that the amplitude modulated signals formed by INV_l and S_{tr} are transmitted along the channel.

The transmission of these signals is carried out on the basis of classical algorithms of information processing and has no high noise immunity.

The curve 3 in figure 2 and figure 3 corresponds to the error probability P_{er}, which is the analogue of the probability of the pairwise transition P_{tr} and is calculated by the known formulas (5) and only after processing of these signals in accordance with the algorithm of the quotient by the expression (1), we obtain the invariant estimation which is in reality a number but not a signal. As we can see from figures 2 and 3, the probability of the pairwise transition in the invariant system is defined by the quantities (10^{-1}...10^{-33}). At the same values the signal/noise probability of the inaccurate reception of the single symbol in classical systems is within the limits (10^{-1}...10^{-7}).

The given analysis of the invariant system shows that the invariant system of information transmission under the weak correlation of the readings of the additive noise has a high noise immunity. The error probability of the classical algorithm with the amplitude modulation is at least twice as large as the probability of the pairwise transition in invariant system.

Therefore, the given system should be used in telecommunication systems, telecontrol systems and other systems, placing exacting demands upon the noise immunity.

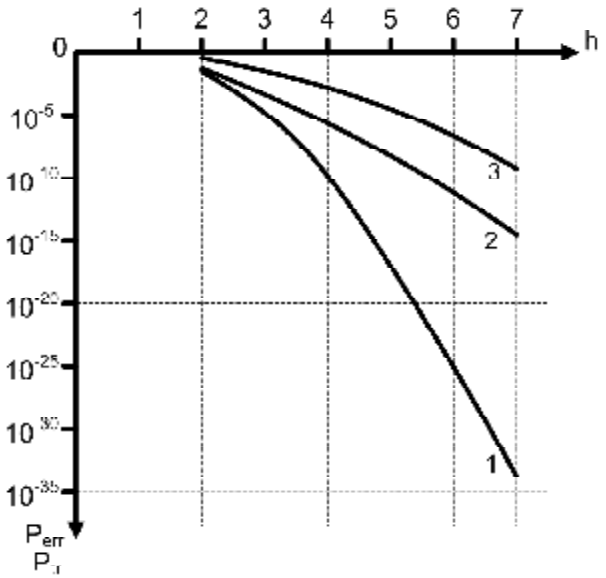

Fig. 2. The noise immunity of IRAM at $k = 1$ and $\mathrm{INV}_l = 1$; $\mathrm{INV}_i = 2; 3; 4; 5; 6; 7$.
Curve 1 is the probability of the pairwise transition into IRAM under non-correlativity of the noise readings (theoretical limit); Curve 2 is the probability of the pairwise transition of IRAM at $R = 0{,}7$; Curve 3 is the error probability of the classical AM

Table 1

The value Z_{thr} at the given K, R

	$K = 1$			$R = 0.7$		
Z_{thr}	1.627	2.057	2.488	3.062	3.516	4.162

Table 2

The value Z_{thr} at the given K, R

	$K = 0.7$			$R = 0.7$		
Z_{thr}	1.820	2.226	2.632	3.038	3.646	4.078

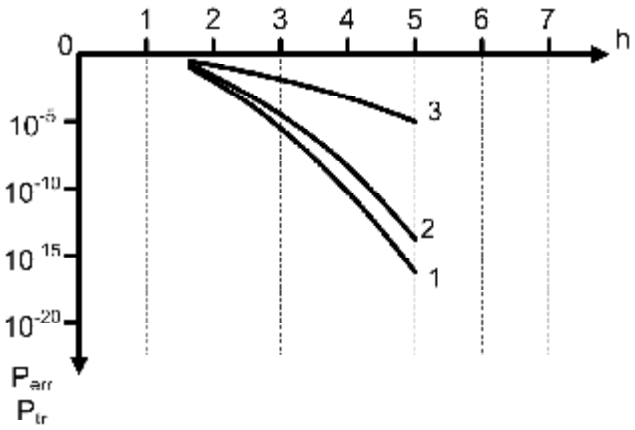

Fig. 3. The noise immunity of IRAM at k = 0,7 and INV_i = 1; INV_i = 2; 3; 4; 5; 6; 7.
Curve 1is the probability of the pairwise transition into IRAM under non-correlativity of the noise readings (theoretical limit; Curve 2 is the probability of the pairwise transition of IRAM at R = 0,7; Curve 3 is the error probability of the classical AM

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THE NUMERICAL MODELING OF A CESIUM CYCLE IN THE UPPER ATMOSPHERE BY AN L-STABLE METHOD OF SECOND-ORDER ACCURACY*

An algorithm of right-hand side and Jacobian formation of differential equations of chemical kinetics is described. Numerical simulation of the cesium cycle in the upper atmosphere is conducted by means of the L-stable method of the second order of accuracy with the control accuracy. The results of the computation are presented.

Keywords: chemical kinetics, cesium cycle, stiff problem, L-stable method, accuracy control.

The modeling of chemical reactions kinetics' is applied in the studies of various chemical processes. The subject of this study is the time dependence on concentration of reagents being a solution for the Cauchy problem and for systems of ordinary differential equations. Difficulties in solving such problems are related to stiffness and a large scale. In modern methods for the solving stiff problems, an inversion of the Jacobi matrix of the equations' system is used. In the case of the original problem's large scale, the decomposition of the given matrix essentially defines a total of computational work. To improve calculation efficiency, in a number of algorithms the freezing of the Jacobi matrix, i. e. the application of the same matrix at several iteration steps, is used [1–2]. This approach is used in advantage to algorithms based on the multistep methods, in particular the formula for backward differentiation [3]. The situation is worse in algorithms for integrations based on known iteration-free methods among which are the Rozenbrok type methods and their modifications [1]. Here is an algorithm for the construction of the right-hand side and the Jacobi matrix of the differential chemical kinetics' equations. Results of numerical modeling of an ionization-deionization cesium cycle in the upper atmosphere with an L-stable method of second-order accuracy, in which the numerical freezing as well as analytical Jacobi matrix is allowed, are given here.

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A kinetic scheme of a chemical reaction consisting of elementary stages which are written in formula [4]

$$\sum_{i=1}^{N_r} \alpha_{ij} x_i \xrightarrow{k_j} \sum_{i=1}^{N_r} \beta_{ij} x_i, \qquad (1)$$

where x_i, $1 \le I \le N_r$ are reagents; k_j, $1 \le j \le N_s$ are constants of stages' rates; N_r and N_s are a number of reagents and a number of stages respectively; α_{ij} and β_{ij}, $1 \le I \le N_r$, $1 \le j \le N_s$ are stoichiometric coefficients. In the framework of an isothermal reactor of a constant volume lumped model, to the process (1) corresponds a system of ordinary differential equations

$$C' = A^T V \qquad (2)$$

with a given initial condition $C(0) = C_0$. Here A^T is a stoichiometric matrix, C and V are vectors of reagent concentrations and rates of stages respectively. When a reaction occurs in non-isothermal conditions, the heat balance equation is

$$T' = [Q^T V - \alpha(T - T_{01})] / C_V^T C, \qquad (3)$$

where T is the temperature of a reactor mixture, T_{01} is temperature of reactor walls, Q^T is a vector of specific heat of stages, C^T_V is a vector of the reagents' heat capacity, $\alpha = \alpha s / r$, α is a heat transfer coefficient, s and r are an area of a surface and the volume of a reactor respectively, is added to the system (2). The superscript T of the vectors Q^T and C^T_V means transposition. Heat capacity of reagents and a heat transfer coefficient may be the functions of reagent concentration α may depend on temperature as well.

When the reaction occurs in an isothermal reactor of a constant volume with an agent change (an open system, a reactor of the ideal mixing), a system of differential equations is written in the formula

$$C' = AV^T + \frac{1}{\Theta}(C_p - C), \qquad (4)$$

where C_p is a vector of reagent concentration in the inlet, Θ is time of the mixture being in the reactor, $\Theta = r/u$, u is volume velocity of the mixture flow through a reactor. When a reaction occurs in non-isothermal conditions, the heat balance equation is

$$T' = [Q^T V - \alpha(T - T_{01})] / C_V^T C - \frac{1}{\Theta}(T - T_{02}), \qquad (5)$$

where T_{02} is the temperature of a mixture at the inlet of a reactor, is added to the system (4). The temperature of a reacting mixture can be given as a function of time and concentration, i. e. $T = T(t,C)$.

If a stage is reversible, then the difference of rates W_s^+ and W_s^- (of direct and inverse processes) respectively, is conventionally taken as a rate W_s of a stage, i. e.

$$W_s = W_s^+ + W_s^-, \ 1 \le s \le N_s.$$

If the third particle is involved in the reaction, then a rate is recalculated by the formula

$$V_s = P_s W_s, \quad P_s = \sum_{i=1}^{N_r + N_{in}} \varepsilon_{si} c_i,$$

where ε_{si}, $1 \le i \le N_r$ are efficiencies of the third particles, N_{in}, ε_{si} and c_i, $N_r + 1 \le i \le N_r + N_{in}$ are quantity, efficiencies and concentrations of inert agents, respectively. The values of the components of the vector W_s are determined from scheme (1) of a chemical reaction by the relations

$$W_s^+ = k_s \prod_{i=1}^{N_r + N_{in}} c_i^{\alpha_{si}}, \ W_s^- = k_{-s} \prod_{i=1}^{N_r + N_{in}} c_i^{\beta_{si}},$$

where k_s and k_{-s}, $1 \le s \le N_s$ are constants of rates of direct and reverse stages, respectively. Constants of rates are calculated by the formula

$$k_j = A_j T^{n_j} \exp(-E_j / RT),$$

where T is temperature of the mixture in the reactor; A_j, n_j and E_j/R are the given constants. The immediate use of this formula may lead to a wrong result or arithmetic overflow because of the large constant data spread [5–6]. Therefore for calculating constants of stages' rates the following relation is used:

$$k_j = \exp(\ln A_j + n_j \ln T - E_j / RT).$$

The stoichiometric matrix A^T with entries α_{ij} is formed from the kinetic scheme (1) by the following rule: a stage number coincides with a column number and a reagent number coincides with a number of the row of the matrix A^T. If x_i is an initial reagent then $a_{ij} = -\alpha_{ij}$, if x_i is a product then $a_{ij} = \beta_{ij}$. If x_i is an initial reagent and a product simultaneously then $a_{ij} = \beta_{ij} - \alpha_{ij}$. Usually a small number of reagents take part in an elementary stage, i. e. a stoichiometric matrix is sparse. For the system (2) the j-th column b_j of the Jacobi matrix defined by the formula

$$b_j = A^T \frac{\partial V}{\partial c_j}, \quad 1 \le j \le N_r. \qquad (6)$$

In the case that the system (2), (3) is solved simultaneously, the row $b_{Nr+1,i}$, the column $b_{i,Nr+1}$ and the corner element $b_{Nr+1,Nr+1}$, which are determined the following way:

$$b_{N_r+1,i} = \{Q^T \frac{\partial V}{\partial c_i} - \frac{\partial \alpha}{\partial c_i}(T - T_{01}) + [\alpha(T - T_{01}) - Q^T V] c_{vi} / C_V^T C\} / C_V^T C,$$

$$b_{i,N_r+1} = (A \frac{\partial V}{\partial T})_i, \quad 1 \le i \le N_r,$$

$$b_{N_r+1,N_r+1} = [Q^T \frac{\partial V}{\partial T} - \frac{\partial \alpha}{\partial T}(T - T_{01}) - \alpha] / C_V^T C - [Q^T V - \alpha(T - T_{01})](\frac{\partial C_V^T}{\partial T} C) / (C_V^T C)^2,$$

are added to the matrix. For a flow reactor, the diagonal elements of the obtained matrix are adjusted considering the component $1/\Theta$. Observe that the components of the vector $\partial V / \partial c_i$ have the form

$$\partial v_s / \partial c_i = \alpha_{si} p_s k_s c_i^{\alpha_{si}-1} \prod_{k=1,k\ne i}^{N_r+N_{in}} c_i^{\alpha_{sk}} - \beta_{si} p_s k_{-s} c_i^{\beta_{si}-1} \prod_{k=1,k\ne i}^{N_r+N_{in}} c_i^{\beta_{sk}} - \varepsilon_{si}(W_s^+ - W_s^-), \qquad (7)$$

and for the components of the vector $\partial V / \partial T$ we have the following reactions:

$$\partial v_s / \partial T = p_s \frac{\partial k_s}{\partial T} \prod_{i=1}^{N_r+N_{in}} c_i^{\alpha_{si}} - p_s \frac{\partial k_{-s}}{\partial T} \prod_{i=1}^{N_R+N_{in}} c_i^{\beta_{si}}, \quad 1 \le s \le N_s.$$

If at the s-th stage there is no third particle, then in the expressions for $\partial v_s / \partial c_i$ and $\partial v_s / \partial T$ one should put $p_s = 1$ and $\varepsilon_{si} = 0$.

To determine the entries b_{ij}, $1 \le i, j \le N_r$ of the Jacobi matrix with the help of (6), we can apply the formula

$$b_{ij} = \sum_{s=1}^{N_s} a_{js} \frac{\partial v_s}{\partial c_i}, \quad 1 \le i, j \le N_r.$$

Consider the individual term (7), i. e.

$$\alpha_{js} p_s k_s \alpha_{si} c_i^{\alpha_{si}-1} \prod_{k=1,k\neq i}^{N_r+N_{in}} c_i^{\alpha_{sk}} -$$

$$-\alpha_{js} p_s k_{-s} \beta_{si} c_i^{\beta_{si}-1} \prod_{k=1,k\neq i}^{N_r+N_{in}} c_i^{\beta_{sk}} + a_{js}\varepsilon_{si}(W_s^+ - W_s^-).$$

To determine this expression, it is necessary to perform three steps. Repeating them in a loop allows the forming of the relations (8). At the first step $a_{js}p_s k_s \alpha_{si}$ and $a_{js}p_s k_{-s}\beta_{si}$, are formed with $p_s k_s$ or $p_s k_{-s}$ assumed to be calculated. At the second step we define

$$c_i^{\alpha_{si}-1} \prod_{k=1,k\neq i}^{N_r+N_{in}} c_i^{\alpha_{sk}}, \qquad c_i^{\beta_{si}-1} \prod_{k=1,k\neq i}^{N_r+N_{in}} c_i^{\beta_{sk}}.$$

In the case that the third particles are involved in the scheme of a reaction, for the third step $a_{js}\varepsilon_{si}(W_s^+ - W_s^-)$ is given.

We describe a numerical method which is applied for numerical integration of an ionization-deionization cesium cycle in the upper atmosphere. For the numerical solution of the Cauchy problem in a system of ordinary differential equations

$$y' = f(t, y), \quad y(t_0) = y_0, \quad t_0 \le t \le t_k, \tag{8}$$

where y and f are real N-dimensional vector functions, t is an independent variable, we consider the (m, k)-method of the form [7]

$$y_{n+1} = y_n + ak_1 + (1-a)k_2, \quad a = 1 - \frac{\sqrt{2}}{2},$$

$$D_n k_1 = h_n f(t_n + \beta h, y_n), \quad D_n k_2 = k_1. \tag{9}$$

Here k_1 and k_2 are stages of the method; $D_n = E - ah_n A_n$; E is the identity matrix; h_n is an integration step; A_n is a matrix which can be represented in the form $A_n = f'_n + hB_n + O(h^2)$; $f'_n = \partial f(y_n)/\partial y$ is the Jacobi matrix of the system (8); B_n is a matrix which does not depend on an integration step. We can apply the method (9) of freezing the numerical as well as the analytical Jacobi matrix. Using the Taylor expansion of the stages, a local error δ_n of the method (9) can be written in formula

$$\delta_n = (a - 1/3)h^3 f_y'^2 f + h^3[\frac{1}{24} f_{tt}'' + \frac{1}{6} f_{yy}'' f^2 +$$

$$+\frac{1}{3} f_{yt}'' f - \frac{1}{2} f_y' f_t' - \frac{1}{2} B_n f] + O(h^4).$$

Then, according to [8], for the accuracy control in (9) we can use the error estimation of the form

$$\varepsilon_n = (a - \frac{1}{3})h^2 f_y' f + O(h^3).$$

Taking into account

$$k_2 - k_1 = ah^2 f'_{y,n} f_n + O(h^3)$$

we can estimate ε_n within the order terms of $O(h^3)$ using this formula

$$\varepsilon_n = a^{-1}(a - \frac{1}{3})[k_2 - k_1].$$

As a result, in the accuracy control for the method (9) we can apply the inequality

$$\varepsilon(j_n) = \| D_n^{1-j_n}(k_2 - k_1) \| \le \frac{a\varepsilon}{1/3 - a},$$

where ε is a required accuracy of integration, $\|\cdot\|$ is some norm in R^N, and the value of the parameter j_n, $1 \le j_n \le 2$, is taken the least one for which this inequality holds. In precise calculations the norm in the inequality had been calculated with the formula

$$\| D_n^{1-j_n}(k_2 - k_1) \| = \max_{1\le i\le N} \frac{|[D_n^{1-j_n}(k_2 - k_1)]_i|}{|y_n^i| + tr},$$

where i is the number of the component of the approximate solution, tr is a positive parameter. If for the i-th component of a solution the inequality $|y_n^i| < tr$ holds then the absolute error $tr \cdot \varepsilon$ is controlled, in the opposite case the relative error e is controlled. In the calculations the parameter tr is chosen so that for all components of the solution the actual accuracy is not worse than the given one.

In the numerical calculation of the Jacobi matrix a step r_j, $1 \le j \le N$ of numerical differentiation is taken by the formula $r_j = \max(10^{-14}, 10^{-7}|y_j|)$. Usually in the solution of stiff problems double precision is used since the Jacobi matrix of the system (9) is ill-conditioned. Now the j-th column a_n^j of the matrix A_n in (9) is calculated by the formula

$$a_n^j = \frac{f(y_1, ..., y_j + r_j, ..., y_N) - f(y_1, ..., y_j, ..., y_N)}{r_j},$$

i. e., calculation of the matrix A_n requires N calculations of the right-hand side of the problem (8). An attempt to use the previous matrix D_n is performed after each successful integration step. To ensure that the stability property of a numerical scheme holds, the integration step remains constant when freezing the matrix D_n. Unfreezing of the matrix takes place in the following cases:

– the accuracy of calculations is violated;

– the number of steps with a frozen matrix achieves a given maximal value I_h;

– the predicted step is Q_h times greater than the last successful one;

– $\varepsilon(1) > \varepsilon(2)$.

The choice of I_h and Q_h can have influence on redistribution of computational work. For $I_h = 0$ and $Q_h = 0$ freezing a matrix does not take place, with increasing I_h and Q_h the number of calculations of the right-hand side of the problem (8) increases and the number of inversions of the Jacobi matrix decreases. Efficiency of the integration algorithm depends on I_h and Q_h by the choice of which the algorithm can be adjusted for a concrete type of problems. They are chosen depending on the ratio of the computational cost of the function f to that of the decomposition of the Jacobi matrix.

Now we consider a model of the ionization-deionization cesium cycle in the upper atmosphere. The presented model is obtained from a large kinetic scheme and is widely used abroad as a typical example of a stiff problem of kinetics [9]. The scheme of the reaction has the form

1) $O_2^- + C_s^+ \to C_s + O_2$,
2) $C_s^+ + e \to C_s$,
3) $C_s \to C_s^+ + e$,
4) $O_2 + C_s + M \to C_s O_2 + M$,
5) $O_2 + e + M \to O_2^- + M$,
6) $O_2^- \to O_2 + e$,

where the constants of rates are the following: $k_1 = 3{,}0 \cdot 10^{10}$,

$k_2 = 6{,}0\cdot10^5$, $k_3 = 3{,}24\cdot10^{-3}$, $k_4 = 3{,}63\cdot10^4$, $k_5 = 3{,}63\cdot10^4$, $k_6 = 4{,}0\cdot10^{-1}$. The reaction occurs with participation of the inert substance N_2, its concentration is $[N_2] = 3{,}32\cdot10^{-3}$. Efficiencies of the third substances are equal to 1 for all reagents with the exception of the efficiency of O_2 at the fifth stage which is equal to 12,4. We denote the concentrations of the reagents in the following way:

$$c_1 = [e],\ c_2 = [O_2^-],\ c_3 = [C_s],$$
$$c_4 = [C_sO_2],\ c_5 = [C_s^+],\ c_6 = [O_2].$$

The corresponding system involves 6 differential equations of the form

$$\begin{aligned}
c_1' &= -k_2c_1c_5 + k_3c_3 - k_5p_2c_1c_6 + k_6c_2,\\
c_2' &= -k_1c_2c_5 + k_5p_2c_1c_6 - k_6c_2,\\
c_3' &= k_1c_2c_5 + k_2c_1c_5 - k_3c_3 - k_4p_1c_3c_6,\\
c_4' &= k_4p_1c_3c_6,\\
c_5' &= -k_1c_2c_5 - k_2c_1c_5 + k_3c_3,\\
c_6' &= k_1c_2c_5 - k_4p_1c_3c_6 - k_5p_2c_1c_6 + k_6c_2,
\end{aligned} \qquad (10)$$

where

$$p_1 = c_1 + c_2 + c_3 + c_4 + c_5 + c_6 + [N_2],$$
$$p_2 = c_1 + c_2 + c_3 + c_4 + c_5 + 12.4c_6 + [N_2].$$

Integration is performed over the segment [0.1000] with initial step 10^{-5} for the following initial concentrations of the reagents:

$$c_1 = [e] = 1.66\cdot10^{-16},$$
$$c_2 = [O_2^-] = 8.63\cdot10^{-16},$$
$$c_3 = [C_s] = 1.66\cdot10^{-6},$$
$$c_4 = [C_sO_2] = 0.0,$$
$$c_5 = [C_s^+] = 1.03\cdot10^{-15},$$
$$c_6 = [O_2] = 5.98\cdot10^{-4}.$$

The presented algorithm was compared in efficiency with the known *dlsode* method of Gear in the implementation of A. Hindmarsh [10] for accuracy $\varepsilon = 10^{-2}$ of calculations. Poor accuracy of calculations is related to the fact that the method (9) is of second-order accuracy and there is no sense in using it in high-accuracy calculations. The number *if* of calculations of the right-hand side and the number *ij* of decompositions of the Jacobi matrix of the problem (10) on the integration interval are taken as an efficiency criterion. To solve the problem (10), the constructed algorithm requires 101 calculations of the right-hand side and 14 decompositions of the Jacobi matrix. In the *dlsode* method the required accuracy of 10^{-2} is achieved for $\varepsilon = 10^{-3}$ with computational costs *if* = 192 and *ij* = 22.

The numerical results show that the proposed algorithm has the advantage for the number of calculations of the right-hand side almost by a factor of two, whereas the advantage for the number of decompositions of the Jacobi matrix is about by a factor of 1.5. This integration algorithm is assumed to have the most efficient application for stiff problems for accuracy $\varepsilon=10^{-2}$ of calculations (of order of one percent) and lower.

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BUCKLING OF ORTHOTROPIC PLATES WITH THE TWO FREE EDGES LOADED FOR THE PURE IN-PLANE BENDING MOMENT

In this paper we have solved the buckling problem of orthotropic plates with two free and two simply-supported edges loaded for the pure in-plane bending moment. We have used the finite difference method to solve the problem.

Keywords: orthotropic plates, finite difference method.

The buckling problem of rectangular plates involving two opposite edges loaded with distributed stress has been studied for a long time. Bubnov [1] and Timoshenko [2] were the first who solved this problem for isotropic plates. The same buckling problem of orthotropic plates was solved by Lekhnitskii [3]. These classical solutions in the form of trigonometric series are obtained for plates with simply-supported edges. The Ritz energy method is used to define critical loads because the partial differential equation of stability involving the floating factor makes integration difficult. Reddy [4] and Whitney [5] used the Ritz method for solving this buckling problem of composite plates with simply-supported edges loaded even with compressed stress.

Therefore, the buckling of plates was studied mostly in widespread boundary conditions i.e. simply-supported edges. There is only one reference to Nolke's paper [6] in Bloom and Coffin's manual [7], in which the same problem is solved for the plate with two clamped edges.

So we have decided to solve the buckling problem of the orthotropic plate with two free and two simply-supported edges loaded for the pure in-plane bending moment. We have not been solving the buckling problem of orthotropic plate loaded for line-distributed forces due to the limits. The solutions for buckling of orthotropic plate loaded for even compressed forces are given in Leissa's manual [8].

In our research the solution of an original equation for stability analysis is based on the Levy-type solution procedure. It allows the reduction of partial differential equation to ordinary differential equation. The latter is solved by the finite difference method. Linear homogeneous algebraic combined equations had been used. The determination of the critical load is reduced to the calculation of buckling coefficient corresponding to minimal eigenvalue of combined equations. The solutions for isotropic plate buckling and symmetrically reinforced orthotropic plate had been obtained as well.

The buckling solution. We have considered an orthotropic plate the middle plane of which is corresponds to the Cartesian coordinates xy. The dimensions of the plate are a and b as shown in the figure below. Edges along the $y = 0$ and $y = b$ are free, and edges loaded with the line-distributed stress along the $x = 0$ and $x = a$ are simply-supported. The load distribution corresponds to two bending in-plane moments.

The equation for the stability analysis of orthotropic plate is given as follows

$$D_{11}\frac{\partial^4 w}{\partial x^4} + 2\left(D_{12} + 2D_{33}\right)\frac{\partial^4 w}{\partial x^2 \partial y^2} + D_{22}\frac{\partial^4 w}{\partial y^4} - $$

$$-N_x^\circ \frac{\partial^2 w}{\partial x^2} - 2N_{xy}^\circ \frac{\partial^2 w}{\partial x \partial y} - N_y^\circ \frac{\partial^2 w}{\partial y^2} = 0, \qquad (1)$$

where $w = w(x,y)$ is the transverse displacement, D_{11}, D_{12}, D_{22}, D_{33} are the bending stiffnesses of the plate given in [9]. N_x°, N_y°, N_{xy}° are membrane stresses corresponding to the subcritical state of the plate.

We assume that the origin stressed state corresponds to it's pure in-plane bend. Then membrane subcritical stresses could be define as

$$N_x^\circ = -N\left(1 - 2\frac{y}{b}\right),\ N_{xy}^\circ = 0\ ,\ N_y^\circ = 0\,, \qquad (2)$$

where N is the maximal stress value at edges $y = 0$, $y = b$.

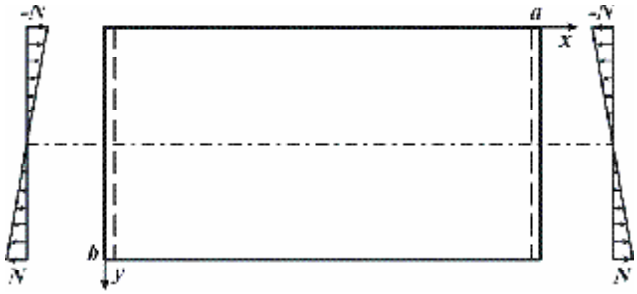

Plate stress

Equation (1) with (2) taken in account is depicted as

$$D_{11}\frac{\partial^4 w}{\partial x^4} + 2(D_{12} + 2D_{33})\frac{\partial^4 w}{\partial x^2 \partial y^2} +$$

$$+D_{22}\frac{\partial^4 w}{\partial y^4} + N\left(1 - 2\frac{y}{b}\right)\frac{\partial^2 w}{\partial x^2} = 0. \qquad (3)$$

Let us consider the boundary conditions. Displacements and bending moments are equal to null when the edges are simply-supported ($x = 0$ и $x = a$). Generalized forces and bending moments are equal to null when the edges are free ($y = 0$ и $y = b$) [9]. These boundary conditions could be derived from plate displacement w can be presented as

$$w = 0\ ,\ D_{11}\frac{\partial^2 w}{\partial x^2} + D_{12}\frac{\partial^2 w}{\partial y^2} = 0 \ \text{ at } x = 0 \text{ and } x = a, \qquad (4)$$

and

$$D_{12}\frac{\partial^2 w}{\partial x^2} + D_{22}\frac{\partial^2 w}{\partial y^2} = 0\ ,$$

$$D_{22}\frac{\partial^3 w}{\partial y^3} + (D_{12} + 4D_{33})\frac{\partial^3 w}{\partial x^2 \partial y} = 0$$

$$\text{at } y = 0 \text{ and } y = b. \qquad (5)$$

Thereby, the buckling problem of plate is reduced to the definition of parameter N corresponding to nonzero solution of the boundary-value problem (3, 4) and (5).

The fact that there are edges simply supported makes the representation of solution possible (3) in Levy-type form

$$w(x,y)=\sum_{m=1}^{\infty} w_m(y)\sin\lambda_m x. \quad (6)$$

Here m is the amount of half-waves along side a, $w_m(y)$ is an unknown function, $\lambda_m = m\pi/a$. However, there no necessity to approximate the solution with series (6) in the problem we overlook. It's enough to keep one term of the series corresponding to $m = 1$. Indeed, the buckling of the plate doesn't experience resistance along side a. Therefore, the plate's bend takes place with formation of only one half-wave along side a. This half-wave has a maximal amplitude at the edge $y = 0$, which decrease along y to the edge $y = b$.

Now the solution of the equation (3) can be presented as

$$w(x,y)=w(y)\sin\lambda x. \quad (7)$$

Here $w(y) = w_1(y), 1 = \pi/a$.

Substituting of (7) into equation (3) gives the ordinary differential equation

$$D_{11}\lambda^2 w - 2(D_{12}+2D_{33})\frac{d^2w}{dy^2} + \frac{D_{22}}{\lambda^2}\frac{d^4w}{dy^4} - N\left(1-2\frac{y}{b}\right)w = 0. \quad (8)$$

Here $w = w(y)$.

Substituting of (7) into boundary conditions (5) gives

$$D_{12}\lambda^2 w - D_{22}\frac{d^2w}{dy^2} = 0, \quad (9)$$

$$-D_{22}\frac{d^3w}{dy^3} + (D_{12}+4D_{33})\lambda^2\frac{dw}{dy} = 0, \quad (10)$$

where $y = 0, y = b$.

The difference method is used to solve equation (8). Let's divide side b into numerous equal parts. The points of division have the following coordinates

$$y_i = s(i-1), \qquad i = 1,2,\ldots,k. \quad (11)$$

Here $s = b/n$ and is subinterval, $k = n + 1$.

The approximation of derivatives corresponding arbitrary point y_i gives

$$\left(\frac{dw}{dy}\right)_i = \frac{1}{2s}(-w_{i-1}+w_{i+1}),$$

$$\left(\frac{d^2w}{dy^2}\right)_i = \frac{1}{s^2}(w_{i-1}-2w_i+w_{i+1}), \quad (12)$$

$$\left(\frac{d^3w}{dy^3}\right)_i = \frac{1}{2s^3}(-w_{i-2}+2w_{i-1}-2w_{i+1}+w_{i+2}),$$

$$\left(\frac{d^4w}{dy^4}\right)_i = \frac{1}{s^4}(w_{i-2}-4w_{i-1}+6w_i-4w_{i+1}+w_{i+2}).$$

Here $w_i = w(y_i)$.

Substituting of (12) into (8) gives the following finite difference approximation of equation (8):

$$D_{11}\lambda^2 w_i - 2\frac{D_{12}+2D_{33}}{s^2}A_i + \frac{D_{22}}{\lambda^2 s^4}B_i - N\left(1-2\frac{y_i}{b}\right)w_i = 0. \quad (13)$$

Here A_i and B_i are defined as

$$A_i = w_{i-1}-2w_i+w_{i+1},$$

$$B_i = w_{i-2}-4w_{i-1}+6w_i-4w_{i+1}+w_{i+2}. \quad (14)$$

The transformation of equation (8) into dimensionless form gives

$$\alpha\pi^2 w_i - 2\beta n^2 A_i + \frac{n^4}{\alpha\pi^2}B_i - \eta t_i w_i = 0, \quad (15)$$

where $t_i = 1 - 2(i-1)/n$,

$$\alpha = \sqrt{\frac{D_{11}}{D_{22}}}\frac{b^2}{a^2}, \ \beta = \frac{D_{12}+2D_{33}}{\sqrt{D_{11}D_{22}}}, \quad (16)$$

$$\eta = \frac{Nb^2}{\sqrt{D_{11}D_{22}}}. \quad (17)$$

Here η is a non dimensional buckling coefficient.

Equation (15) writing for all points (i = 1, 2, …, k) represents linear algebraic combined equations, however, including outside edge points. The substituting of $i = 1$ and $i = k$ to equalities (14) gives

$$A_1 = w_0 - 2w_1 + w_2,$$

$$B_1 = w_{-1} - 4w_0 + 6w_1 - 4w_2 + w_3 \quad (18)$$

and

$$A_k = w_{k-1} - 2w_k + w_{k+1},$$

$$B_k = w_{k-2} - 4w_{k-1} + 6w_k - 4w_{k+1} + w_{k+2}. \quad (19)$$

Therefore, w_{-1}, w_0, w_{k+1}, w_{k+2} are outside edge points. It should be noted that unknown w_0 and w_{k+1} are also including in B_2 и B_{k-1}, giving

$$B_2 = w_0 - 4w_1 + 6w_2 - 4w_3 + w_4,$$

$$B_{k-1} = w_{k-3} - 4w_{k-2} + 6w_{k-1} - 4w_k + w_{k+1}. \quad (20)$$

Four equations need to define four outside edge unknowns. These equations can be obtained by finite-difference approximation of boundary conditions (9, 10). By substituting of (12) into (9), and of (10) with $i = 1$ и $i = k$, we obtain

$$\beta_1\pi^2 w_1 - \frac{n^2}{\alpha}(w_0 - 2w_1 + w_2) = 0,$$

$$\beta_1\pi^2 w_k - \frac{n^2}{\alpha}(w_{k-1} - 2w_k + w_{k+1}) = 0, \quad (21)$$

where

$$\beta_1 = \frac{D_{12}}{\sqrt{D_{11}D_{22}}}. \quad (22)$$

Equations (21) give

$$w_0 = (r_1+2)w_1 - w_2, \ w_{k+1} = (r_1+2)w_k - w_{k-1}, \quad (23)$$

where $r_1 = \alpha\beta_1\pi^2/n^2$.

Substituting of (12) into (10) with $i = 1$ and $i = k$ gives

$$-\frac{n^2}{\alpha}(-w_{-1}+2w_0-2w_2+w_3) + (\beta_1+4\beta_2)\pi^2(-w_0+w_2) = 0, \quad (24)$$

$$-\frac{n^2}{\alpha}(-w_{k-2}+2w_{k-1}-2w_{k+1}+w_{k+2}) + (\beta_1+4\beta_2)\pi^2(-w_{k-1}+w_{k+1}) = 0,$$

where

$$\beta_2 = \frac{D_{33}}{\sqrt{D_{11}D_{22}}}. \quad (25)$$

Equations (24) in accordance with (23) give

$$w_{-1} = (2+r_1+4r_2)(r_1+2)w_1 - 2(2+r_1+4r_2)w_2 + w_3, \quad (26)$$

$$w_{k+2} = w_{k-2} - 2(2+r_1+4r_2)w_{k-1} + (2+r_1+4r_2)(r_1+2)w_k,$$

where $r_2 = \alpha\beta_2\pi^2/n^2$.

So, equalities (23) and (26) define four outside edge unknowns. Substituting of (23) and (26) into (18, 19) and (20) gives

$$A_1 = r_1\, w_1,\ A_k = r_1\, w_k \tag{27}$$

and

$$\begin{aligned} B_1 &= g w_1 - 2 f w_2 + 2 w_3, \\ B_2 &= v w_1 + 5 w_2 - 4 w_3 + w_4, \\ B_{k-1} &= w_{k-3} - 4 w_{k-2} + 5 w_{k-1} + v w_k, \\ B_k &= 2 w_{k-2} - 2 f w_{k-1} + g w_k. \end{aligned} \tag{28}$$

Here $g = 6 - 4u + uf, f = 2 + r_1 + 4r_2, u = r_1 + 2, \mathrm{n} = r_2 - 2$. It should be noted that A_i (i = 2, …, k – 1) and B_i (i = 3, …, k – 2) are still defined by equations (14).

Thereby, homogeneous algebraic linear combined equations

$$\begin{gathered} \alpha\pi^2 w_i - 2\beta n^2 A_i + \frac{n^4}{\alpha\pi^2} B_i - \eta t_i w_i = 0, \\ (i = 1, 2, \ldots, k) \end{gathered} \tag{29}$$

the approximated differential equation (8) contains unknown $w_1, w_2, \ldots, w_k$ only.

Combined equation (29) could be presented as the following matrix equation

$$(\mathbf{D} - \eta \mathbf{T})\,\mathbf{W} = 0, \tag{30}$$

where

$$\mathbf{D} = \alpha\pi^2 \mathbf{E} - 2\beta n^2 \mathbf{A} + \frac{n^4}{\alpha\pi^2} \mathbf{B}. \tag{31}$$

Here

$$\mathbf{W} = \begin{Bmatrix} w_1 \\ w_2 \\ \mathrm{M} \\ w_k \end{Bmatrix},\ \mathbf{T} = \begin{Bmatrix} t_1 & 0 & \Lambda & 0 \\ 0 & t_2 & \Lambda & 0 \\ \Lambda & \Lambda & \Lambda & \Lambda \\ 0 & 0 & \Lambda & t_k \end{Bmatrix},$$

$$\mathbf{A} = \left\{\begin{array}{cccccc|cccccc} r_1 & & & & & \mathrm{M} & & & & & & \\ \hline 1 & -2 & 1 & & & \mathrm{M} & & & & & & \\ \hline & 1 & -2 & 1 & & \mathrm{M} & & & & & & \\ \hline & & 1 & -2 & 1 & \mathrm{M} & & & & & & \\ \hline \Lambda & \Lambda & \Lambda & \Lambda & \Lambda & \cdot\mathrm{M} & \Lambda & \Lambda & \Lambda & \Lambda & \Lambda \\ \hline & & & & & \mathrm{M} & 1 & -2 & 1 & & & \\ \hline & & & & & \mathrm{M} & & 1 & -2 & 1 & & \\ \hline & & & & & \mathrm{M} & & & 1 & -2 & 1 & \\ \hline & & & & & \mathrm{M} & & & & & & r_1 \end{array}\right\},$$

$$\mathbf{B} = \left\{\begin{array}{cccccc|cccccc} g & -2f & 2 & & & & \mathrm{M} & & & & & & \\ \hline v & 5 & -4 & 1 & & & \mathrm{M} & & & & & & \\ \hline 1 & -4 & 6 & -4 & 1 & & \mathrm{M} & & & & & & \\ \hline & 1 & -4 & 6 & -4 & 1 & \mathrm{M} & & & & & & \\ \hline \Lambda & \Lambda & \Lambda & \Lambda & \Lambda & \Lambda & \cdot\mathrm{M} & \Lambda & \Lambda & \Lambda & \Lambda & \Lambda & \Lambda \\ \hline & & & & & & \mathrm{M} & 1 & -4 & 6 & -4 & 1 & \\ \hline & & & & & & \mathrm{M} & & 1 & -4 & 6 & -4 & 1 \\ \hline & & & & & & \mathrm{M} & & & 1 & -4 & 5 & v \\ \hline & & & & & & \mathrm{M} & & & & 2 & -2f & g \end{array}\right\}.$$

The unspecified array of the matrix's cells A and B are equal to null. E is the identity matrix.

So, the problem we have considered has been reduced to an eigenvalue problem (30). Minimal eigenvalue of linear combined equations determine the value of the non dimensional buckling coefficient h_{cr}. The accuracy of calculations is estimated by the comparison of results obtaining different values k. Critical stress N_{cr} is defined by the following equation

$$N_{\mathrm{cr}} = \eta_{cr} \frac{\sqrt{D_{11} D_{22}}}{b^2}. \tag{32}$$

The value of η_{cr} depends on parameters α, β_1, β_2 which contain all the information about the size of the plate and its bending stiffnesses.

Examples. The first example we overlook is that of an isotropic plate. Bending stiffnesses at this case are defined by the following expressions.

$$\begin{gathered} D_{11} = D_{22} = \overline{E} \frac{h^3}{12}, \\ D_{12} = \mu \overline{E} \frac{h^3}{12},\ D_{33} = \frac{1-\mu}{2} \overline{E} \frac{h^3}{12}, \end{gathered} \tag{33}$$

where h – is the thickness of plate, $\overline{E} = \mathrm{E}/(1 - \mu^2)$. Here E is the modulus of elasticity, m is Poisson's coefficient.

Expressions (16), (22) and (25) give us

$$\alpha = 1/c^2,\ \beta = 1,$$

$$\beta_1 = \mu,\ \beta_2 = (1-\mu)/2.$$

Here $c = a/b$ is the ratio of the plate's sides. In fact, the buckling coefficient depends on parameter c only. Dependence of η_{cr} on c has been studied for m = 0,3, n = 50. Parameter c has varied within 1…5. The data is shown in table 1.

The buckling coefficient could also be represented by an expression obtained by the least-squares method, from which we get

$$\eta_{\mathrm{cr}} = \frac{18.9695}{(c - 0.2726)^{0.9559}}. \tag{34}$$

In the second example we have overlooked the plate formed from unidirectional or orthogonal reinforced layers which reinforce axes form angles $\pm\varphi$ with axis x.

If there is a large amount of layers, the plate's structure could be considered as homogeneous and orthotropic. Then the bending stiffnesses are defined as

$$\begin{gathered} D_{11} = A_{11} \frac{h^3}{12},\ D_{22} = A_{22} \frac{h^3}{12}, \\ D_{12} = A_{12} \frac{h^3}{12},\ D_{33} = A_{33} \frac{h^3}{12}, \end{gathered} \tag{35}$$

where

$$\begin{aligned} A_{11} &= \overline{E}_1 c_\varphi^{\,4} + \overline{E}_2 s_\varphi^{\,4} + 2\overline{E}_{12} c_\varphi^{\,2} s_\varphi^{\,2}, \\ A_{12} &= \overline{E}_1 \mu_{12} + (\overline{E}_1 + \overline{E}_2 - 2\overline{E}_{12}) c_\varphi^{\,2} s_\varphi^{\,2}, \\ A_{22} &= \overline{E}_1 s_\varphi^{\,4} + \overline{E}_2 c_\varphi^{\,4} + 2\overline{E}_{12} c_\varphi^{\,2} s_\varphi^{\,2}, \\ A_{33} &= (\overline{E}_1 + \overline{E}_2 - 2\overline{E}_1 \mu_{12}) c_\varphi^{\,2} s_\varphi^{\,2} + G_{12} (c_\varphi^{\,2} - s_\varphi^{\,2})^2, \\ \overline{E}_{12} &= \overline{E}_1 \mu_{12} + 2G_{12},\ \overline{E}_1 = \frac{E_1}{1 - \mu_{12}\mu_{21}},\ \overline{E}_2 = \frac{E_2}{1 - \mu_{12}\mu_{21}}, \\ c_\varphi &= \cos\varphi,\ s_\varphi = \sin\varphi. \end{aligned} \tag{36}$$

Here E_1, E_2 are modulus of elasticity along the reinforce-direction and along the transverse direction respectively, G_{12} is the rigidity modulus, μ_{12}, μ_{21} are Poison's coefficients.

The substituting of (35) into (16), (22) and (25) gives

$$\alpha = \frac{1}{c^2}\sqrt{\frac{A_{11}}{A_{22}}},\ \beta = \frac{A_{12}+2A_{33}}{\sqrt{A_{11}A_{22}}},$$

$$\beta_1 = \frac{A_{12}}{\sqrt{A_{11}A_{22}}},\ \beta_2 = \frac{A_{33}}{\sqrt{A_{11}A_{22}}}. \qquad (37)$$

Thereby, the buckling coefficient depends on the parameter c and the angle φ for the orthotropic plate. A transformation of the expression

$$\eta_{cr} = \frac{N_{cr}b^2}{\sqrt{D_{11}D_{22}}} \qquad (38)$$

to

$$\overline{\eta}_{cr} = \frac{N_{cr}b^2}{D_1} \qquad (39)$$

makes the parametrical analysis more convenient. Here

$$\overline{\eta}_{cr} = \eta_{cr}\sqrt{f_{11}f_{22}},\ f_{11} = A_{11}/E_1,\ f_{22} = A_{22}/E_1,$$

$$D_1 = E_1\frac{h^3}{12}. \qquad (40)$$

We have finished studying the dependence of η_{cr} on c and φ. The calculation has been done for carbon-filled plastic with elastic characteristics $E_1 = 142.8\ GPa$, $E_2 = 9.13\ GPa$, $G_{12} = 5.49\ GPa$, $E_1 = 142.8\ GPa$, $\mu_{12} = 0.02$, $\mu_{21} = 0.32$. The data is shown in table 2.

The maximal buckling coefficient for the square plate realizes with angle $\varphi = 14E$. The optimal angle tends to 22E with an elongation increase.

The buckling problem of orthotropic plates with two free unloaded edges and two simply-supported edges loaded for in-plane line-distributed stress had been solved. The definition of the critical load has been reduced to the calculation of a non dimensional buckling coefficient. The value of the coefficient depends on plate's geometric and elastic parameters. The finite difference method had been used to solve the aforementioned problem. The buckling coefficient had been defined as a minimal eigenvalue of homogeneous linear combined equations approximating the boundary-value problem; it has been solved for the isotropic plate and the orthotropic symmetrically reinforced plate. Different elongation angles of optimal reinforcement for the plates had been defined. We have completed studying the influence of the side ratio and reinforcement angles on wave generation.

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Table 1

The buckling coefficient $\eta_{cr}(c)$

c	1	2	3	4	5
η_{cr}	25.71	11.25	7.27	5.39	4.29

Table 2

The dependence of parameters c, φ, $\overline{\eta}_{cr}$

c	1.0	2.0	3.0	4.0	5.0
φ	14.0	22.0	22.0	22.0	22.0
$\overline{\eta}_{cr}$	16.17	6.29	3.94	2.88	2.27

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AN AUTOMATIC DEVICE FOR MEASURING RESISTIVITY OF THE SILICON FOUR-POINT PROBE METHOD*

An automatic device for measuring the resistivity of single-crystalline silicon by means of the four-point probe method has been developed.

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Keywords: automatic device, single-crystalline silicon, resistivity, four-point probe method.

Modern silicon production and quality control require novel generation of a resistivity measuring device which can provide measurements of resistivity in an automatic high speed precision mode. The four-point probe method is a declared arbitration to compare with other methods by SEMI (Semiconductor Equipment & Materials International) organization [1–3]. This method is recommended by the Russian State Standard (GOST 19658 [4]).

The Rometer device has been developed based on standards, methods, and requirements of equipment and techniques for developing measuring devices and methods. It is designed for automatic measurement of single crystalline silicon resistivity by the four-point probe method.

The device. In figure 1 – a photo of the device is shown, in figure 2 – its block diagram.

The device consists out of following functional elements: a four-point probe with in-line placed probes; two power supplies (the first – supplies the measuring unit, and the second – supplies the stepper motor); electrical current source for probe head outside probes; two microcontrollers (the first – for work management of the measuring unit, the second – for the management of the displacement test desk and probe head); an Analog-to-Digital Converter (ADC); an analogue resistive equivalents; a measuring amplifier; a temperature sensor; the Motors Management Unit (MMU); a test desk angle position sensor; a probe head work position censor.

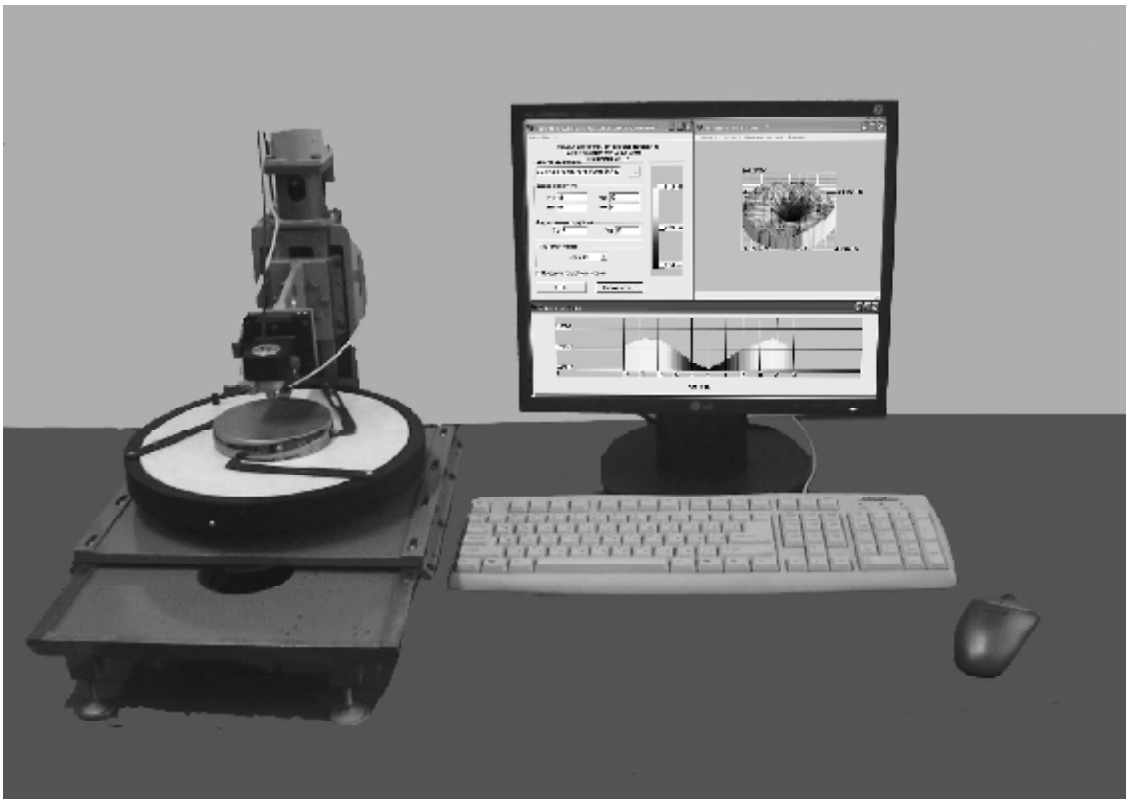

Fig. 1. Structure of the Rometer device

* This work was supported by the Siberian Branch of the Russian Academy of Sciences; program "Importozamechenie".

The probe head (in the Rometer device a Jandel Engineering ltd probe head is used; the distance between the probes is 1.59 mm) it provides direct current of the specify value on sample through outer probes, and measuring voltage on inner probes, which are connected to a measuring amplifier. The analog signal comes from the amplifier exit to an 18-digit ADC MAX132 input, and transforming into a digital code, then – to ATMEGA8 microcontroller input, and then – into the personal computer. The power supply for measuring the unit gives stable voltage of +15 V and –15 V for measuring amplifier work, ADC and also its gives +5 V for first microcontroller and the temperature sensor. The second power supply gives voltage of +10 V for the stepper motors and +5 V for the second microcontroller ATMEGA8 and MMU. Power supplies are screened to decrease sound influence on the measuring amplifier. The current source for probe head is adapted for generating currents with discrete selection current strength of 0.25 μA, 2.5 μA, 25 μA, 250 μA, 2.5mA, 25 mA, and 100 mA with a possibility of polarity change. The current value is set for a measuring value range in accordance with SEMI MF84 [1]. In the measuring mode the current flows through samples between outer probes of four-point probe head; in the calibration mode the current flows to the analogue resistor equivalents. Theses are 7 10,000 Ohm, 1,000 Ohm, 100 Ohm, 10 Ohm, 1 Ohm, 0.1 Ohm, 0.01 Ohm precision resistors. These resistors are connected to current source by transition resistors, which simulate transition resistance between probe pins and silicon sample.

Silicon wafers and single crystalline silicon ingots temperature control is provided by the DS1820 temperature sensor. Its output signal comes to the first microcontroller. The second command microcontroller MMU gives necessary impulse sequences to the stepper motors for forward and reverse rotation. In the ДШИ-200-1 stepper motor is used in the device. The angle position sensor ЛИР458А monitors the angle of the moving part test desk from the probe head. The sensor output digital code signal comes to the second microcontroller. Limit switches of horizontal and vertical displacement provide control signals to the second microcontroller if the four-point probe or the test desk position reaches the agreed value. The Optron sensor working position of the probe head AOT 147-A produces a control signal in the second microcontroller, if the probes pressure at sample makes a value recommended in [1].

The manager program. The working control program of the device consists from four subprograms, which allow the following: the measurement of silicon resistivity in one point with user times defined; the measurement of resistivity in 6 points with accordance to [2] (variant B); creating a measurement resistivity map with accordance to [3]; measurement resistivity non-standard volumetric samples. The manager program in an automatic mode allows the following: calibrating with analogue equivalents; measuring silicon wafer or ingot thickness; setting a necessary current value in outer probes of the four-point probe head; measuring potentials between inner probes; calculating resistivity with accordance to [1] and considering correctional factors (geometrical, thermal). In the program window the measuring protocol, which provides control resistivity value during measurements can be seen.

Operating the device. After the manager program has been started, the memory management unit (MMU) panel gives a signal to the horizontal, vertical and rotation stepper motors for setting the test desk in a default position. A sample of single crystalline silicon is fixed so that its center coincides with the probe head center. Then, the automatic calibration is performed. To do this, the probe head is disconnected from the power supply and measuring

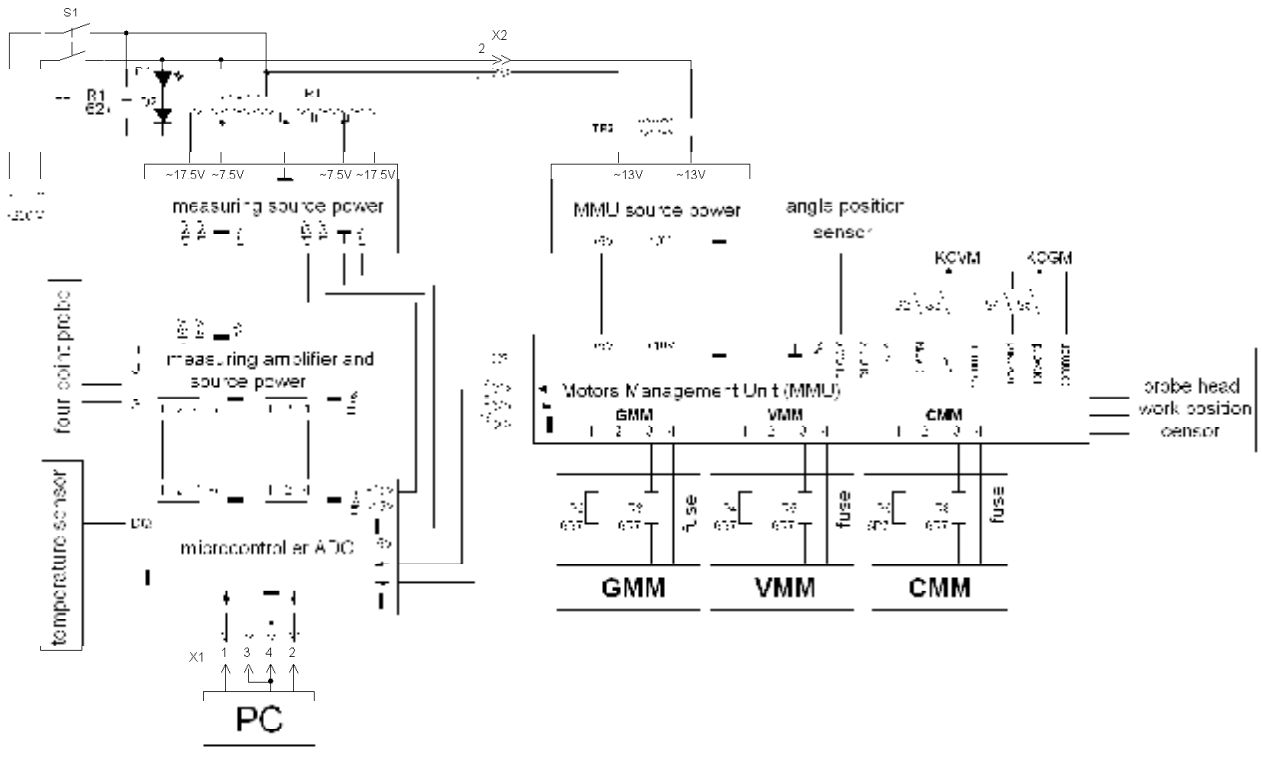

Fig. 2. The block diagram of the device

amplifier by a command from the manager program and an analogue equivalent is connected instead. The electrical current with a set value is launched through the analogue equivalent and the microcontroller indicates voltage decrease with a change in the polarity. After that, the calibration power supply, measuring amplifier and probe head is automatically connected. Then, the vertical manipulator moves the probe head down on the sample until the probes touch its surface. The resistivity is measured automatically, in compliance with the selected subprogram and temperature corrections [1].

In figure 3 the measurement result is shown. A sample single-crystalline silicon wafer had been synthesized by the Czochralski method. The manager program makes it possible to show resistivity in any point of the 3D figure and shows the sectional distribution of resistivity.

General technical specification. The range of electrical resistivity measurements is from 0.001 to 10,000 Ohm · cm. The range of the allowed relative error in resistivity measurement is within 0.001 – 0,01 Ohm · cm = ±3 %; 0,011 – 10,000 Ohm · cm = ±2 %. The diameter of the silicon wafer (slices) varies from 10 to 200 mm, with the thickness being from 0.1 to 30 mm. The overall dimensions of the device are 560 × 320 × 410 mm. The weight is 25 kg.

Thus, the automatic measuring device for single crystalline, slices, and wafer silicon resistivity is similar to the best foreign constructions according to the technical characteristics. Tests of major relative errors, defined in the certification, do not exceed the value [1–4].

The device was certified in 2007. According to its certificate the ROMETR device for silicon resistivity measuring was registered in the State Catalog of Measuring Devices under the index № 35567-07 and can be exploited in the Russian Federation.

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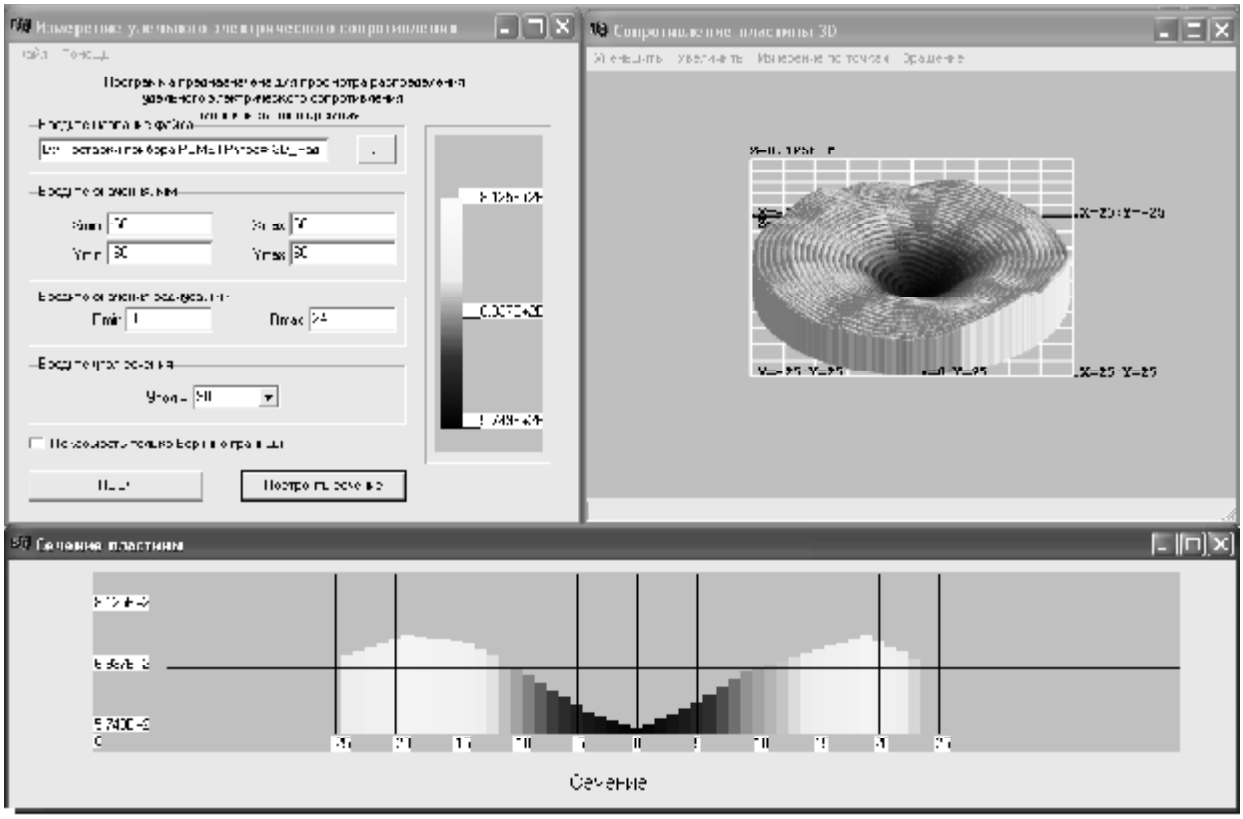

Fig. 3. Results of the single-crystalline silicon measuring resistivity map

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THE METHODS OF MODELLING AND THE EFFICIENCY FACTORS IN INVESTMENT PROJECTS*

In this research we have classified the methods of investment project modeling, made a comparative analysis of the given methods, and studied their advantages, disadvantages, and the directions of application. The efficiency factors of the investment project are displayed, based on the developed of enterprise net profit algorithm calculation.

Keywords: investment project, estimation and the analysis of efficiency, modeling of the project.

Viewing the development of investment resources activities (which are necessary for any enterprise) we see a constant struggle increase in conditions of a growing competition. Naturally, the need for an exact substantiation of development projects and the most effective utilization of the involved investments increases. It is impossible to achieve the goals without use of the toolkit, which allows the modeling of the investment process and detailed representation of the influence mechanism for various factors rendering direct or indirect influence on the investment project efficiency.

The classifications of parameters, methods, the used approaches are the important elements when selecting a toolkit, by the consideration and negotiation of the investment project at an enterprise.

The most widespread toolkits are decision-making support systems in the field of investment financing. Any software product used by the consideration of investment projects, is based on a mathematical model. Now we shall investigate the expedient to allocate three methods of the investment modeling process (investment projects):

– simulation;
– optimization;
– optimization-simulation.

The software products based on simulation mathematical models correspond to the simulation method; the applied programs constructed on the basis of models of the optimization correspond to optimization; the applied programs which are based in combined mathematical models, combining elements of the optimization and simulation methods. A more detailed comparison of the given methods is shown in table 1.

The most widespread method of investment projects modeling is the simulation method. Within the limits of this method such software products, as *Project Expert*, *Alt-Invest*, *Comfar*, and others are widely used for the estimation and the analysis of investment projects [1]. The specified software products are convenient in means of project efficiency substantiation to the potential investor as they enable to plan the investment project in detail and to forecast financial reporting.

Solving the problem of enterprise monetary streams and parameters of IE calculation efficiency in the optimization mode is a more complicated task; it is directed on the formation of optimal monetary streams formation, which leads to the maximal value of the investment project efficiency parameter.

It is necessary to say that when using the optimization method, the mathematical complexity of the modeling imposes essential restrictions on a refinement level of elaborating calculations and their conformity to legislative techniques. In this case it is advised to use the optimization-simulating method which combines features of optimization and simulating methods, thus the priority is given to the optimization method.

The expediency of the optimization-simulation method application to consider the investment projects is shown as following:

1. The System of decision-making support, constructed on the basis of the optimization-simulation method sustains an optimization wholeness character. Hence, it allows to compute the optimal parameters of the investment project efficiency at a preliminary analysis stage and to define the best script of project development.

2. A combination of the two methods makes it possible to calculate the techniques, reducing the conformity of enterprise activity financial parameters and legislative techniques. Therefore the calculation of project efficiency parameters becomes more exact and adequate to the validity.

3. The optimization-simulation method allows reducing dimension of the optimization models that makes the wider horizon of planning and a higher level of detailed elaboration of initial data possible.

In use of the optimization-simulation method the concept of the aggregated basic production asset (ABPA) as it is a link between two methods. Under ABPA the minimal set of objects of the basic production assets (BPA), including quantity of the different kinds of BPA necessary for the beginning of production is meant. Thus, at least one unit of ABPA is necessary to start the project.

For the definition of by means of what factors the management of investment project efficiency is possible at the stage of its planning and during realization, is necessary to define the criteria of the project efficiency and the algorithm of enterprise monetary streams formation.

As the main criterion of efficiency it is expedient to use a parameter of net present value NPV which can be presented in the following equation:

$$\mathrm{NPV} = \frac{W_r + Am}{1+r} - I,$$

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where W_r – net profit on results of realization of the investment project; Am – the amortization calculated for whole period; r – the rate of discounting considering risks of the project for whole period; I – volume of investment investments for whole term of realization of the project.

The expediency of use of parameter NPV accounts for by the following, that it:

1. An additive parameter that allows considering the cost of investment projects set as the costs is the sum of each of them.

2. Through the rate of profitableness the risks of activity connected with the project are considered.

3. It is an unequivocal parameter (in difference, for example, from internal rate of return).

4. The absolute parameter expressed in the monetary uniform influences all the monetary stream elements from the given investment project on its efficiency (unlike dimensional time of a payback period or such relative parameters as internal rate of return, return of investment index, etc.) and answers to the basic purposes of enterprise activity – the increase of additional cost.

5. Defines the majority of other parameters, rather then vice versa.

To find a pure current cost it is necessary to settle an invoice net profit *W*r and amortization *Am*, considering thus the features of accounting and tax accounts. In this case the following calculation of net profit algorithm which is a basic element of the offered decision-making support system is offered.

1. Proceeds from the realization, equal to total cost of all kinds of realized production:

$$R = \sum_{k=1}^{K} M_k \cdot V_k \cdot P_k ,$$

where M_k – quantity of ABPA of k-th kind, necessary for realization of the project; V_k – productivity of unit ABPA of k-th kind; P_k – cost of the unit of production made on ABPA of k-th kind.

Each kind of ABPA corresponds to a kind of production made within the limits of investment project realization.

2. Amortization is calculated on the basis of data of the previous stage:

$$Am = \sum_{k=1}^{K} Am_k \cdot M_k ,$$

where Am_k – the sum of amortization for the period of project realization of the on unit ABPA of k-th kind, calculated at a preliminary stage.

3. Expenses for turnaround actives will be calculated under the following formula:

$$z = \sum_{k=1}^{K} z_k \cdot V_k \cdot M_k ,$$

where z – total expenses for turnaround actives for whole period of realization of the project; z_k – expenses for current assets for a unit of production, made at ABPA of k-th kind.

4. Calculation of the VAT is made as follows:

$$N_1 = \alpha_1 \cdot (R - \sum_{k=1}^{K} C_k \cdot M_k - z_k) ,$$

where N_1 – the sum of the VAT; C_k – cost of unit ABPA of k-th kind; α_1 – the rate of the VAT.

5. The tax to property is calculated under the formula:

$$N_2 = \sum_{k=1}^{K} N_{2_k} \cdot M_k ,$$

where N_2 – the total wealth tax for whole period of project realization; N_{2_k} – the wealth tax to unit of ABPA of k-th kind for the period, calculated at a preliminary stage.

6. Fund of a payment (FP). As the estimation of the project is carried out "by an incremental method", we shall consider only FP for the personnel, employed in addition in connection with realization of the project:

$$F = \sum_{k=1}^{K} F_k \cdot M_k ,$$

where F – the general FP for whole period of realization of

The comparative characteristic of investment projects modeling methods

Method	Advantages	Disadvantages	Way of use
Simulation	– the high level of detailed elaboration at calculation of enterprise activity parameters ; – opportunity to estimate projects both in structure of the enterprise, and by the «increment method» [2]	– absence of an opportunity to reception of project optimum efficiency parameters; – absence of an opportunity to find an optimal way of project development	– estimation and the analysis of investment projects; – tactical planning of enterprise activity
Optimization	– allows to consider a mode formation of monetary streams of the enterprise during the project realization in an optimization procedure; – allows to see the optimal script of project development	– a low level of detailed enterprise elaboration in activity parameters calculation; – the difficulty of modeling leads to the simplification of calculating techniques and their deviation from accounting and tax accounts	– estimation and the analysis of investment projects; – strategic planning of enterprise activity
Optimization-simulation	– allows to consider a mode formation of monetary streams of the enterprise during the project realization in the optimization procedure; – allows to see the optimal script of project development. – techniques of the enterprise activity financial parameters calculations correspond to accounting and tax accounts	– the level of detailed elaboration is higher, than when using the optimization method, but nevertheless it concedes to simulating	– estimation and the analysis of investment projects; – strategic planning of enterprise activity (when using the dynamic model, the application for tactical planning is also possible)

the project; F_k – FP on unit of *k*-th ABPA, calculated at the preliminary stage.

7. Consolidated social tax, calculated in view of a descending scale:

$$N_4 = \sum_{k=1}^{K} N_{4_k} \cdot M_k,$$

where N_4 – total consolidated social tax for whole period of realization of the project; N_{4_k} – consolidated social tax on unit ABPA of *k*-th kind for the period counted at a preliminary stage.

8. The general expenses are all expenses, including taxes (except for PT), i. e. the sum of amortization, FP, material and investment expenses, the VAT, the wealth tax and consolidated social tax:

$$Z = Am + F + N_1 + N_2 + N_4 + z \ .$$

9. The balance profit is a difference between proceeds from realization and the general expenses:

$$W_b = R - Z \ ,$$

where W_b – balance profit on results of the project.

10. PT, equal to product of PT rate on balance profit:

$$N_3 = \alpha_3 W_b \ ,$$

where α_3 – the rate of the profit tax.

11. The pure profit is a part of proceeds from the realization, remaining at the disposal of the enterprise after the account of all expenses and payment of all taxes, equal to a difference between balance profit and PT:

$$W_r = W_b - N_3 \ ,$$

where W_r – net profit by results of the project.

It is necessary to note, that in the calculation of net profit the taxes, making the basic tax load of any enterprise independent on a field of activity: the value-added tax, the wealth tax, the consolidated social tax and the profit tax, are considered in the algorithm. Also, it is necessary to pay attention on the fact that when using the optimization-simulation method of investment process modeling the received model will have a two-level structure and will consist of simulation and optimization stages. Calculation of parameters which are problematic to calculate at the optimization, a stage is prepared on simulation stage. Cost ABPA, the wealth tax, consolidated social tax, amortization concern to such parameters.

On the basis of the described algorithm the decision-making support system in the field of investment projects financing [3] is constructed.

Based on the offered criterion of efficiency and algorithm it is possible to allocate the major factors having impact on efficiency of the investment project:

– norms of an expenditure of the surplus earnings, received during realization of the project, on project development;

– the price of ready product;

– a way of amortization.

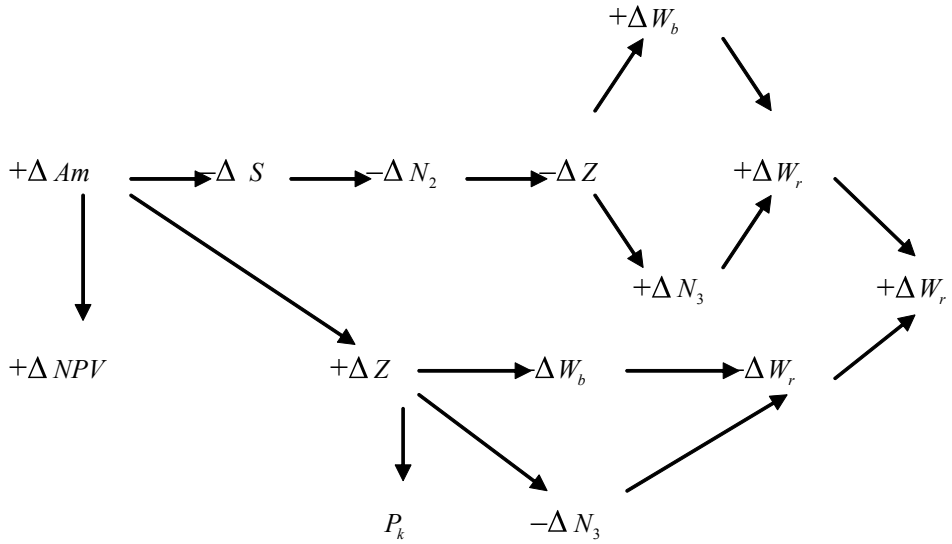
It is necessary to note, that not only the listed factors are capable to influence the investment project efficiency. It will vary also in case of tax rates, the discount rates, turnaround expenses, production demand changes. Features of the given factors show that the enterprise realizing the project has an opportunity to influence them prior to the beginning of the project or operatively during its realization.

The enterprise realizing the project has an opportunity to change the norm of expenditure of surplus earnings on project development, i. e. to define, what percent of surplus earnings will be invested in the project during its realization. The increase in norm of an expenditure of surplus earnings will increase the project efficiency, in case of if it allows to make a demand restraint for made production.

The influence of such factor as the price for made production on the project efficiency is ambiguously, as the production price change influences demand, therefore the influence of the production price on efficiency will depend on elasticity of demand for an exact production, competitive enterprise position in the market.

The use of the nonlinear method of amortization for those objects of the basic means, for which it is possible, also raises the efficiency of the project. In the figure it is shown in detail, how the given effect is reached.

Apparently from the figure, the use of the nonlinear method will entail not only change of the tax to property N_2 that has been described above, but also increase in amortization Am which doubly influences on NPV. On one



Influence of amortization on the investment project efficiency

hand, the increase in the savings amortization leads to increase of cumulative expenses Z, that reduces balance profit W_b, cumulative profit tax N_3 and, finally, net profit W_r and reducing efficiency of the project.

On the other hand, the amortization directly influences the parameter NPV aside its increase. Thus, the size change of amortization Am influences the NPV in three directions at the same time. Therefore during the use of the nonlinear method the efficiency of the project will increase, as negative influence of amortization on expenses will be compensated, first, by the positive influence of reduction of the wealth tax, and, secondly, direct influence of amortization on NPV.

Due to the fact that the size increase of amortization Am will lead to increase in general expenses *Z*, it will be reflected in the price of production P_k aside its increase, that, in turn, will influence the demand again. Therefore the problem of how much the parameter NPV will finally change after a change in the amortization charge method will depend on elasticity of demand for an exact production, a competitive position of the enterprise in the market.

An account of considered factors during the preparation of this project and during its realization makes the management of its efficiency possible. Thus it is necessary to consider interaction of factors and change of production demand.

In conclusion we can say that the offered classification of investment projects modeling methods and the lead comparative analysis allows the choosing of toolkit which will correspond to purposes of the user. The investment project efficiency factors, allocated on the basis of the net profit calculation algorithm enable to operate the project efficiency at the stage of planning and during its realization.

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A MODIFIED PROBABILISTIC GENETIC ALGORITHM FOR THE SOLUTION OF COMPLEX CONSTRAINED OPTIMIZATION PROBLEMS*

A new algorithm for the solution of complex constrained optimization problems based on the probabilistic genetic algorithm with optimal solution prediction is proposed. The efficiency investigation results in comparison with standard genetic algorithm are presented.

Keywords: probabilistic genetic algorithm, constrained optimization.

The necessity to develop complex system models appears in different fields of science and technology such as mathematics, economics, medicine, spacecraft control and so on. In the process of modeling there emerge many optimization problems which are multiextremal, multiobjective and have implicit formalized functions, complex feasible area structure, many types of variables etc. There is no possibility to solve such problems using classical optimization procedures thus we have to design and implement more effective and universal methods such as genetic algorithms (GAs). GAs proved their efficiency in the process of solving of many complex optimization problems [1; 2].

The GAs efficiency depends on fine tuning and control of their parameters. If an untrained user sets arbitrary parameters values, the GA efficiency may vary from very low to very high. The recent trends in a field of GAs are adaptive GAs based on complex hybrid structures and efficient GAs with reduced parameters set.

A known approach to GA parameters set reduction is probabilistic genetic algorithms (pGAs) [3; 4]. The essential difference between pGA and standard GA is that pGA has no crossover operator and new solutions are generated according to statistical information about search space. Thus, collecting and processing such kind of information, pGAs can adapt to the problems they solve.

PGAs demonstrated their efficiency with many complex optimization problems and their further investigation and improvement are promising. There are actual problems of the pGA's features analysis for wide-range optimization problems

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and parameters set reduction without efficiency loss. This article is devoted to pGAs efficiency for complex constrained optimization problems investigation.

Probabilistic genetic algorithm for non-constrained optimization problems. During its run the GA collects and processes some statistical information about search space, but the statistics is absent in an explicit form. PGA uses the following form of statistics representation – the probabilities vector of the current population:

$$P^k = (p_1^k, ..., p_n^k),\ p_i^k = P(x_i^k = 1),\ i = \overline{1,n},$$

here p_i^k is the probability of unit value for *i*-th bit in solution X^k, *k* is iteration number.

The general scheme of pGA is:

1. Random generation of the initial population.

2. Selection of *r* individuals (called parents) on the basis of their fitness. Evaluate the probabilities vector as:

$$\overline{P} = (p_1, \ldots, p_n),$$

$$p_j = P\{x_j = 1\} = \frac{1}{r}\sum_{i=1}^{r} x_j^i,\ j = \overline{1,n},$$

here *n* is chromosome length, x_j^i is *j*-th gene of *i* th individual.

3. Form a new population (called offspring) according to the distribution $\overline{P}$.

4. Apply mutation operator to the offspring.

5. Form a new population from parents and offspring.

6. Repeat 2–5 steps.

As it was previously mentioned, during pGA run the algorithm collects the statistics about null and unit values distribution in the population. The experimental results show that the probability vector components converge to the corresponding values of the optimal solution vector as shown in figure 1.

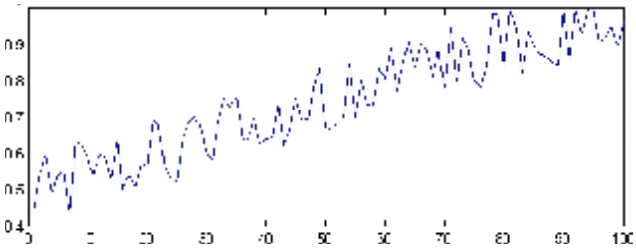

Fig. 1. The values change for *j*-th component of the probability vector

As it is shown in figure 1, the given *j*-th component value of $\overline{P}$ converges to unit. It means that the value of *j*-th gene of optimal solution most probably is equal to unit (for binary representation). One can use this feature to predict the optimal solution.

The following prediction algorithm was proposed in [3; 4]:

1. Choose the certain scheme of pGA for the given problem, set the iteration number $i = 1, ..., I$ and the number of independent algorithm runs $k = 1, ..., K$.

2. Collect the statistic $(p_j)_i^k, j = 1, ..., n$. Average $(p_j)_i$ over *k*. Determine the tendency for p_j change.

3. Set $x_j^{\text{opt}} = 1$, if $\sum_{i=1}^{I}\left((p_j)_i - 0.5\right) > 0$, else $x_j^{\text{opt}} = 0$.

The main idea is that the more often probability value is greater than 0.5, the higher the probability of optimal solution unit value.

In practical problems there may be such situations when pGA collects not enough information at the beginning and *j*-th gene value is equal to unit (or zero) for almost every solution. At the final stage pGA can find a much better solution with inverted values of *j*-th gene and it means that the probability vector values will change their convergence direction (fig. 2). But the above mentioned prediction algorithm will give us the primary value, because the *j*-th value of probability vector was greater than 0.5 (or less than 0.5 for zero values) for a long time.

Thus one can use the following prediction algorithm modification:

1. Set the prediction step *K*.

2. Every *K* iteration use the given statistics $\overline{P}_i$, $i = \overline{1, N_K}$, $N_K = t \cdot K$, $t \in \{1, 2, K\}$ to evaluate the probability vector change: $\Delta\overline{P}_i = \overline{P}_i - \overline{P}_{i-1}$.

3. Set the weights for every iteration according to its number: $\sigma_i = 2i / N_K (N_K + 1)$, $i = 1,\ K, N_K$.

4. Evaluate the probability vector weighted change as:

$$\Delta\tilde{P} = \left(\Delta\tilde{p}_j\right) = \sum_{i=1}^{N_K} \sigma_i \cdot \Delta\overline{P}_i .$$

5. Set the optimal solution: $\overline{X}^{\text{opt}} = \left(x_j^{\text{opt}}\right)$, where $x_j^{\text{opt}} = 1$ if $\Delta\tilde{p}_j \geq 0$, and $x_j^{\text{opt}} = 0$ otherwise.

6. Add the optimal solution in the current population and continue pGA run.

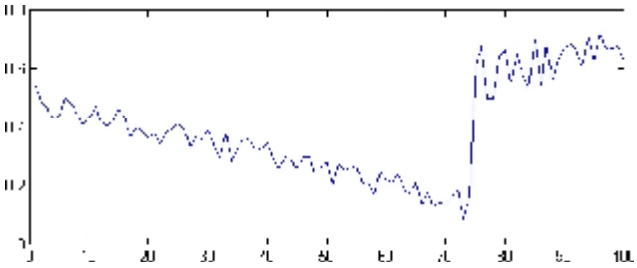

Fig. 2. The situation when prediction can be wrong

The main idea of the given algorithm is that the probability values on the later iterations have the greater weights as the algorithm collects more information about search space. The weights have values such that $\sigma_{i+1} > \sigma_i$ и $\sum_{i=1}^{N_K} \sigma_i = 1$.

Genetic algorithms for constrained optimization problems. In general GAs and pGAs select an individual in accordance with its fitness value, but there is no optimization constrains control. There are many possible methods to solve this problem.

Let the following constrained optimization problem be solved:

$$f(x) \to \text{extr},$$

$$\begin{cases} g_j(x) \leq 0,\ j = \overline{1,r}, \\ h_j(x) = 0,\ j = \overline{r+1,m}. \end{cases}$$

In general, the individual *x* fitness is evaluated as:

$$\text{fitness}(x) = f(x) + \delta \cdot \lambda(t) \cdot \sum_{j=1}^{m} f_j^{\beta}(x),$$

where *t* is iteration number; $\delta = 1$ for the minimization problem; $\delta = -1$ for the maximization problem; $f_j(x)$ is the penalty value for *j*-th constrain break; β is the real number.

The penalty functions $f_j(x)$ are evaluated as:

$$f_j(x) = \begin{cases} \max\{0, g_j(x)\}, j = \overline{1,r} \\ |h_j(x)|, j = \overline{r+1,m} \end{cases}.$$

The following penalty methods are known: the "death" penalty, the static penalty, the dynamic penalty, the adaptive penalty and hybrid methods of the individuals "cure".

As the authors analyzed every penalty method, the further investigation was limited by the dynamic and adaptive penalty methods as other methods have a number of disadvantages.

In particular, the "death" penalty eliminates every unfeasible solution even if it can have the important information for new feasible solutions. The static penalty contains a large set of parameters that should be well tuned – a non-optimal set of parameters can lead to unfeasible solutions. The "cure" method involves local optimization procedures on every iteration of GA, thus such methods use much more computational recourses.

The dynamic penalty. The method uses the previously mentioned penalty functions and defines $\lambda(t)$ in a following way:

$$\lambda(t) = (C \cdot t)^{\alpha}.$$

The fitness of x individual on the t-th iteration is evaluated as:

$$\text{fitness}(x) = f(x) + \delta \cdot (C \cdot t)^{\alpha} \cdot \sum_{i=1}^{m} f_i^{\beta}(x).$$

The values C, α, β are set according to a certain problem. The recommended values are $C = 0.5, \alpha = \beta = 2$ (obtained experimentally).

The adaptive penalty uses the same penalty functions, but $\lambda(t)$ is evaluated as:

$$\lambda(t+1) = \begin{cases} \beta_1 \cdot \lambda(t), \text{ if } \bar{b}^i \in D, \\ \text{for } t-k+1 \le i \le t \\ \beta_2 \cdot \lambda(t), \text{ if } \bar{b}^i \notin D, \\ \text{for } t-k+1 \le i \le t, \\ \lambda(t), \text{ otherwise}, \end{cases}$$

where $\bar{b}^i$ is the best solution in the i-th population, $\beta_1 \in (0,1)$, $\beta_2 > 1$ and $\beta_1\beta_2 \neq 1$. The penalty decreases on the $(t+1)$ step, if the best individual was feasible during the last k iterations. Otherwise, if it was unfeasible, the penalty increases.

The method uses three parameters: β_1, β_2, k. The adaptive penalty method uses both kinds of information: if the solution is unfeasible and if the previous solutions was unfeasible [5].

Probabilistic genetic algorithms for constrained optimization problems. The general scheme of pGA is the same as for the penalty method. The main difference is in the fitness function definition. Thus, one can extend the optimal solution prediction method for the constrained optimization problems. It is appropriate to use the modified prediction procedure as the objective function surface with penalty can have a lot of local optima and the general prediction algorithms can lead to a local solution instead of a global one.

GA and pGA computational efficiency investigation for constrained optimization problems. We compare the algorithms efficiency on a set of test problems of single objective constrained optimization. The objective functions and constrains are linear and non-linear functions of several variables. A part of test problems set is presented in table 1 [6].

We investigate "the best-efficiency" and "the worst-efficiency" parameters set for both algorithms to determine how parameters influence the efficiency in a wide range. The better results for "the worst-efficiency" parameters set give us better effectiveness for arbitrary parameters chosen by an untrained user.

As GA and pGA are stochastic procedures, we average characteristics of algorithms with every unique parameter set over 100 independent runs.

To estimate algorithms efficiency we will use the following criteria:

– the rate of runs (%), where the exact optimal solution was computed;

– the average iteration number (*N*), on which the exact optimal solution was computed for the first time.

At the first stage we define the constrains control method that gives the best efficiency with the given test problems set. We have resumed that the standard GA with "the best-efficiency" parameters shows the best results with the dynamic penalty for the whole test problems set. The standard GA with "he worst-efficiency" parameters shows the best results with the dynamic penalty only for 60 % cases (problems). On the average, the dynamic penalty is more effective than the adaptive penalty in 60 % cases.

PGA both with "the worst-efficiency" and "the best-efficiency" parameters shows the best results with the dynamic penalty for the whole test problems set.

Thus, we have determined that the dynamic penalty is more effective than the adaptive penalty for both GA and pGA algorithms.

At the second stage we compare the efficiency of standard GA and pGA with dynamic penalty. For "the best-efficiency" parameters set the standard GA is more effective than pGA in 67 % cases. But in cases when pGA yelds to GA, their efficiency differs insignificantly. For "the worst-efficiency" and "average-efficiency" pGA is more effective than GA in 100 % and 67 % cases respectively. The computational results of comparison are given in table 2.

At the third stage we compare the efficiency of standard GA and pGA with dynamic penalty. For "the best-efficiency" parameters set the standard GA is more effective than pGA in 67 % cases. But in cases pGA yelds to GA, their efficiency differs insignificantly. For "the worst-efficiency" and "average-efficiency" pGA is more effective than GA in 100 % and 67 % cases respectively. The computational results of comparison are given in table 2.

At the forth stage we compare the efficiency of standard GA and pGA with optimal solution prediction. For «the best-efficiency» parameters set the pGA with optimal solution prediction is more effective than the standard GA in 60 % cases, "the worst-efficiency" pGA is more effective in 67 % cases. Moreover, the pGA with optimal solution prediction finds the optimal solution at much earlier iteration. The comparison of computational results are in table 3.

The results of the investigation shows that the pGA algorithm is more preferable than the standard GA, because it is more effective on the average and it has smaller number of parameters. The pGA with optimal solution prediction allows to compute optimal solution at much earlier iterations.

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Table 1

The test problems for constrained optimization

The problem statement	The exact solution
$z = x^2 + y^2 \to \max$ $\begin{cases} y \le 7 + \sin(2 \cdot x) \\ y \ge 1 - \sin(2 \cdot x) \\ x \in [0, 4] \end{cases}$	$x = 4$ $y = 7.989358247$ $z^* = 79.82984520$
$z = 5 \cdot x + 0.5 \cdot y \to \max$ $\begin{cases} y \le -2 \cdot x + 5 \\ y \ge x - 1.5 \\ y \le 2 \cdot x + 1 \\ x \ge 0 \\ y \ge 0 \end{cases}$	$x = \frac{13}{6} = 2.16666$ $y = \frac{2}{3} = 0.66666$ $z^* = \frac{67}{6} = 11.16666667$
$z(x, y) = 2000x + 2400y \to \max$ $\begin{cases} x \ge 0 \\ y \ge 0 \\ \frac{x}{120} + \frac{y}{110} \le 1 \\ 4x + y \le 320 \\ x + y \le 110 \\ \frac{x}{340} + \frac{y}{120} \le 1 \\ x + 2y \le 160 \\ x + 4y \le 280 \end{cases}$	$x = 50$ $y = 55$ $z_{\text{opt}} = 232,000$
$z = 20 + e - 20\exp\left(-0.2\sqrt{\sum_{i=1}^{N} \frac{x_i^2}{N}}\right) - \exp\left(\sum_{i=1}^{N} \frac{\cos(2\pi \cdot x_i)}{N}\right) \to \min$ $N = 4$ $\begin{cases} 2x_1 - 3x_2 + 4x_3 \le 10 \\ 4x_2 - 5x_3 + x_4 \le 1 \\ 10x_1 + 7.5x_3 - 8.4x_4 \le 3.5 \\ -3.1x_1 + 21.7x_2 - 36.4x_4 \le 16.2 \end{cases}$	$x_i = 0, i = \overline{1, N}$ $z_{\text{opt}} = 0$
$z = \sum_{i=1}^{N} \left(0.1 \cdot x_i^2 - 4\cos(0.8x_i) + 4\right) \to \min$ $N = 2$ $\begin{cases} x_1^2 + 9x_2^2 \le 36 \\ 9x_1^2 + x_2^2 \le 36 \end{cases}$	$x_i = 0, i = \overline{1, N}$ $z_{\text{opt}} = 0$

Table 2

The GA and pGA with the dynamic penalty efficiency comparison for constrained optimization problem

The problem	The best-efficiency parameters				The best-efficiency parameters				The average-efficiency parameters			
	GA		pGA		GA		pGA		GA		pGA	
	%	N	%	N	%	N	%	N	%	N	%	N
Linear problem 1	76	31.05	64	32.81	12	16.83	14	14.14	41.78	27.67	40.22	26.2
Linear problem 2	100	472.04	100	446.9	0	0	0	0	61.19	357.38	61.56	375.58
Non-linear problem 1	58	32.28	66	32.39	8	25	24	18.25	34.22	28.95	41.33	26.49
Non-linear problem 2	100	21.22	98	15.02	44	9.93	68	9.12	76.07	14.49	83.56	12.24
Non-linear problem 3	20	18.8	68	29.94	0	0	22	13.64	7.41	19.45	40.89	24.68
Non-linear problem 4	94	35.77	92	36.09	52	43.42	48	42.96	72.81	33.07	72.44	31.86
Rastrigin function	100	54.4	100	33.4	5	10	100	76.92	56.85	58.32	100	48.22
Ackley (and)	100	2.76	100	4.51	95	61.21	100	69.71	99.63	23.02	100	32.92
Ackley (or)	100	1.94	100	3.79	100	63.04	100	42.24	100	12.57	100	13.41
The number of wins	7	6	6	3	2	2	7	6	3	4	7	5
The rate of wins	53.85	66.67					77.78	75			70	55.56
The number of double wins	4		2		0		5		1		3	
The rate of double wins	66.67						100				75	

Table 3

The GA and pGA with optimal solution prediction efficiency comparison for constrained optimization problem

The problem	The best-efficiency parameters				The best-efficiency parameters				The average-efficiency parameters			
	GA		pGA (prediction)		GA		pGA (prediction)		GA		pGA (prediction)	
	%	N	%	N	%	N	%	N	%	N	%	N
Linear problem 1	76	31.05	48	34.29	12	16.83	22	24.64	41.78	27.67	39.33	32.8
Linear problem 2	100	472.04	100	438.4	0	0	2	8	61.19	357.38	60	350.82
Non-linear problem 1	58	32.28	46	23.96	8	25	0	0	34.22	28.95	21.78	19.49
Non-linear problem 2	100	21.22	66	18.12	44	9.93	28	14.21	76.07	14.49	45.11	16.91
Non-linear problem 3	20	18.8	34	29.47	0	0	0	0	7.41	19.45	17.33	21.45
Non-linear problem 4	94	35.77	100	38.92	52	43.42	60	41.77	72.81	33.07	84.22	30.84
Rastrigin function	100	54.4	100	32.36	5	10	98	55.22	56.85	58.32	99.78	47.82
Ackley (and)	100	2.76	100	3.06	95	61.21	100	50.57	99.63	23.02	100	29.74
Ackley (or)	100	1.94	100	3.47	100	63.04	100	56.65	100	12.57	100	15.58
The number of wins	7	4	5	6	3	4	6	4	5	5	5	4
The rate of wins	58.33			60		50	66.67	50	50	55.56	50	
The number of double wins	2		3		2		4		1		2	
The rate of double wins			60				66.67				66.67	

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NUMERICAL INVESTIGATION OF THE PROBLEM OF COHESIVE RUNNING SOILS PUNCHING SHEAR*

A special mathematical model generalizing the classical model of the elasticity theory is used for the analysis of directions of the deformations localization in samples of soils with different strengths. Numerical solution of the problems is carried out by means of iterative process, the equations of the elasticity theory with initial stresses being solved on each step thereof on the basis of the finite-element method.

Keywords: finite element method, initial stress method, strains localization, materials with different strengths.

Let us consider a sample of material (soil) with different strengths occupying a plane domain W with the boundary Γ, consisting of three non-intersecting parts Γ_u, Γ_p and Γ_{up}, with displacement vector $u=(u_1,u_2)$ being set on the first part, a vector of distributed external force $p=(p_1,p_2)$ being set on the second one, and mixed-boundary conditions being set on the third part: in the absence of the displacement of the bound points in the direction of the normal the tangential stresses have been fixed

$$u_n = u\cdot n = 0, \qquad (1)$$

where $n=(n_1,n_2)$ and $\tau=(\tau_1,\tau_2)$ are normal and tangential vectors to the boundary, P_{fr} is the given function modeling friction.

The problem is to define vector displacement field *u* and tensor stresses field σ, satisfying boundary conditions

$$u=0 \text{ at } \Gamma_u,\ u_n=0 \text{ at } \Gamma_{up},$$

to the equilibrium equation in variation form:

$$\iint_\Omega \sigma:\varepsilon(\tilde{u})\,d\Omega = \int_{\Gamma_p} p\cdot\tilde{u}\,d\gamma + \int_{\Gamma_{up}} p_{fr}\cdot\tilde{u}_\tau\,d\gamma \qquad (2)$$

for any vector field $\tilde{u}$, satisfying homogeneous boundary conditions in displacement at Γ_u and Γ_{up}. Here $2\varepsilon(u)=\nabla u+(\nabla u)^*$ is the deformation tensor, corresponding to the vector field *u* (asterisk means transposition). Besides, determining equations must be carried out in Ω domain. With the help of them it is possible to determine stresses tensor according to the given deformation tensor in every point of domain Ω.

Mixed-boundary conditions on the section Γ_{up} appear, for example, at the modeling of the process of the materials punching through the die with rigid bounds. In this case, the value P_{fr} presents friction stress equal to zero if the die surface is perfectly smooth.

For the description of deflected mode of the materials with different strengths, having special ultimate strengths under tension and compression, we will use the model of granular material with plastic couplings [1]. Under the action of compressive or stretching stresses, which are less than engagement coefficient (ultimate strength of the couplings) such materials are not deformed. The attainment of the ultimate strength corresponds to equilibrium condition, at which deformation may be an arbitrary positive quantity. Stresses above this limit are impossible. Regulated determining deformation relations of the materials with different strengths, taking into account the particles and binder elasticity, are given in the equations system

$$\sigma = a:\varepsilon - \frac{1}{1+\lambda}a:\Pi\left(\varepsilon - a^{-1}:\sigma_0\right), \qquad (3)$$

where σ is the stress tensor, σ_0 is the engagement tensor, *a* is symmetric positively determined coefficients tensor of the particles elasticity, λ is the regularization parameter, Π is the projection operator to the *C* cone of allowable deformations according to the norm $|\varepsilon| = \sqrt{\varepsilon:a:\varepsilon}$.

In the model of granular material with absolutely rigid particles the determining relations of which are obtained from (3) in the limit of $a\to\infty$, $\lambda\to 0$, the stress potential is equal to $\sigma_0:\varepsilon+\delta_C(\varepsilon)$, where $\delta_C(\varepsilon)$ is the indicator function of *C* cone, equal to zero on the cone and equal to infinity outside this cone. The dual deformations potential $\delta_K(\sigma-\sigma_0)$ is expressed in terms of the indicator function of the conjugate *K* cone, which is composed of stress tensors, subtending obtuse angles with tensors of *C* cone in the scalar product sense, given by the contraction $\sigma:\varepsilon$ [2].

Computational algorithm. The main idea of the algorithm is the change of determining equations (3) by iterative formula ($n=1,2,3,K$)

$$\sigma^n = a:\varepsilon^n - \frac{1}{1+\lambda}a:\Pi\left(\varepsilon^{n-1}-a^{-1}:\sigma_0\right)$$

or

$$\varepsilon^n(u^n) = a:\left(\sigma^n+\Delta\sigma^{n-1}\right),$$
$$a:\Delta\sigma^{n-1} = \Pi_{c^{-1}}\left(c:\left(a^{-1}:\varepsilon^{n-1}(u^{n-1})-\sigma_0\right)\right). \qquad (4)$$

At the first stage the initial stress field $\Delta\sigma^0$ is identically zero: the elastic problem for unstressed material with the tensor of compliance modules *a* is solved. At the following stages, initial stresses are calculated through the field of deformations obtained by the previous solution. Iterations are continued until the difference norm of two approximate solutions at the adjacent stages becomes less than the preassigned calculation accuracy.

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The task at the *n* stage of the algorithm is reduced to the minimization of the integral functional

$$I^n(u)=\int_\Omega\left(\frac{|\varepsilon(u)|^2_{a^{-1}}}{2}-\Delta\sigma^{n-1}:\varepsilon(u)\right)d\Omega-$$
$$-\int_{\Gamma_p}p\cdot u d\Gamma+\int_{\Gamma_{up}}p_{fr}\cdot u_\tau d\gamma$$

or to the numerical solution of the variational equation

$$\int_\Omega\left(\left(\varepsilon(u^n):a^{-1}-\Delta\sigma^{n-1}\right):\left(\varepsilon(\tilde u)-\varepsilon(u^n)\right)\right)d\Omega=$$
$$=\int_{\Gamma_p}p\cdot\left(\tilde u-u^n\right)d\Gamma+\int_{\Gamma_{up}}p_{fr}\cdot\left(\tilde u_\tau-u^n_\tau\right)d\gamma,$$
$$\tilde u,u^n\in U, \qquad (5)$$

for which the standard technique of the finite-element method is applied [3, 4]. As it usually is, the displacement space *U* is approximated by finite dimensional subspace U_h (*h* is a typical digitization parameter), strained on the given system of base functions from *U* space. As a result, the finite-dimensional task of quadratic programming, which results in the large-scale system of linear algebraic equations, is obtained. In the specific calculations given below the standard piecewise-linear splines defined on the irregular frame were selected as an alternative to base functions, and a system of linear equations has been solved by the conjugate gradient method. The convenience of this technique lies in the fact that it sufficiently simply allows to realize the programming technology at which only non-zero coefficients of the system matrix and indexes corresponding to them, that is, lines and columns, are constantly stored in the computer memory [5].

Exact problem solution, minimizing functional $I(u)$ on *U* space, evidently, satisfies variational equation (5) with the change of stress $\Delta\sigma^{n-1}$ for the stress

$$\Delta\sigma^\infty=a^{-1}:\Pi_{c^{-1}}\left(c:\left(a^{-1}:\varepsilon(u)-\sigma_0\right)\right). \qquad (6)$$

Having substituted exact solution *u* to the equation (5), as a varied element $\tilde u$ and an approximate solution u^n to the similar equation with $\Delta\sigma^\infty$, after results summation we will obtain

$$\int_\Omega\left(\left|\varepsilon\left(u^n-u\right)\right|^2_{a^{-1}}-\left(\Delta\sigma^{n-1}-\Delta\sigma^\infty\right):\varepsilon\left(u^n-u\right)\right)d\Omega=0.$$

In terms of scalar product

$$(\tilde\varepsilon,\varepsilon)=\int_\Omega\tilde\varepsilon:a^{-1}:\varepsilon d\Omega$$

and appropriate Hilbert norm $\|\varepsilon\|_0=\sqrt{(\varepsilon,\varepsilon)}$ the last equation can be presented in the form of

$$\left\|\varepsilon(\tilde u-u)\right\|_0=\left(a:\left(\Delta\sigma^{n-1}-\Delta\sigma^\infty\right),\varepsilon\left(u^n-u\right)\right),$$

from where by Cauchy-Bunyakovsky inequality we have

$$\left\|\varepsilon\left(u^n-u\right)\right\|_0\le\left\|a:\left(\Delta\sigma^{n-1}-\Delta\sigma^\infty\right)\right\|_0. \qquad (7)$$

Let us assume for simplicity that $a=\lambda b$, $c=(1+\lambda)^{-1}$, where l is a small dimensionless parameter.

Under Corn inequality, the left part (7) determines the norm $\left\|u^n-u\right\|_1$ on *U* space, equivalent to the $H^1(\Omega)$ norm. The right part is estimated with the help of (4) and (6) formulas, taking into account that the projection operator is a non expanding map:

$$(1+\lambda)\left\|a:\left(\Delta\sigma^{n-1}-\Delta\sigma^\infty\right)\right\|_0=$$
$$=\left\|\Pi_{a^{-1}}\left(\varepsilon\left(u^{n-1}\right)-a:\sigma_0\right)-\Pi_{a^{-1}}\left(\varepsilon(u)-a:\sigma_0\right)\right\|_0\le$$
$$\le\left\|\varepsilon\left(u^{n-1}-u\right)\right\|_0=\left\|u^{n-1}-u\right\|_1.$$

Thus, the estimation is given by

$$\left\|u^n-u\right\|_1\le\frac{1}{1+\lambda}\left\|u^{n-1}-u\right\|_1\le\frac{1}{(1+\lambda)^n}\left\|u^0-u\right\|_1,$$

which guarantees the convergence of iteration sequence to the exact solution with a speed of geometric progression with denominator $1/(1+\lambda)<1$.

Numerical experiment. As an example let's consider a plane deformed state of the homogeneous sample with direct bounds, the uniformly distributed pressure $P=(0,-p_0)$, $(p_0>0)$ operating at its upper boundary (fig. 1).

The field for shear intensity

$$\gamma(\varepsilon)=\sqrt{\frac{2}{3}(\varepsilon_1-\varepsilon_2)^2+\frac{2}{3}\varepsilon_1^2+\frac{2}{3}\varepsilon_2^2+\gamma_{12}^2},$$
$$\text{where } \varepsilon=(\varepsilon_1,\varepsilon_2,\gamma_{12}),$$

is shown in figure 2, *a*. It was obtained on the basis of classical theory of elasticity. In figure 2, *b* it is shown on the basis of the model of the material with different strengths with an internal friction parameter, corresponding to the firm ground. The intensity increases from white colour to black one in linear dependence.

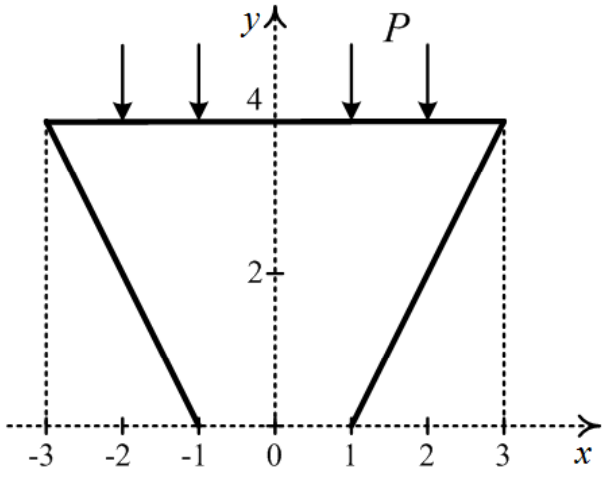


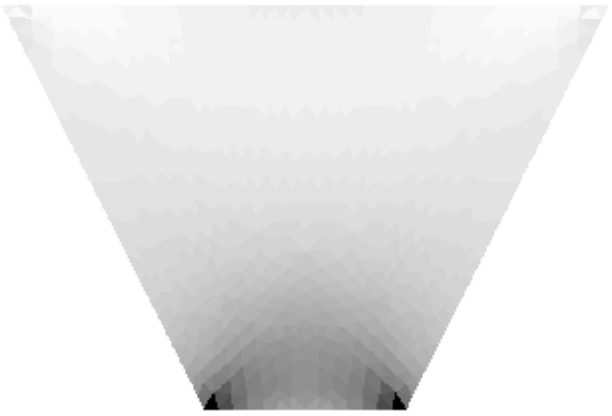
Fig. 1. The loading condition of the sample

By comparing the figures we can see that a conical inrush zone is formed in the soil with different strengths in the lower part of the sample.

The punching problem with the application of non uniformly distributed force to the upper area boundary has been considered as well: the load decrease from the centre to the lateral bounds occurs uniformly (fig. 3). The field of shear intensity obtained on the basis of the classical theory of elasticity is shown in figure 4, *a*, and the field of shear intensity obtained on the basis of the model of the soil with different strengths is shown in figure 4, *b*.

Comparing figure 4, *a* with figure 2, *b* we may draw a conclusion that the external pressure redistribution with the same integral value of the force influences the change of the deformed state in the lower part of the sample weakly.

In figure 5 we can see the loading condition in the problem concerning the sample punching through the die with concave side bounds. The P force is distributed along the upper bound of the sample uniformly.



a

b

Fig. 2. The intensity of shear deformation

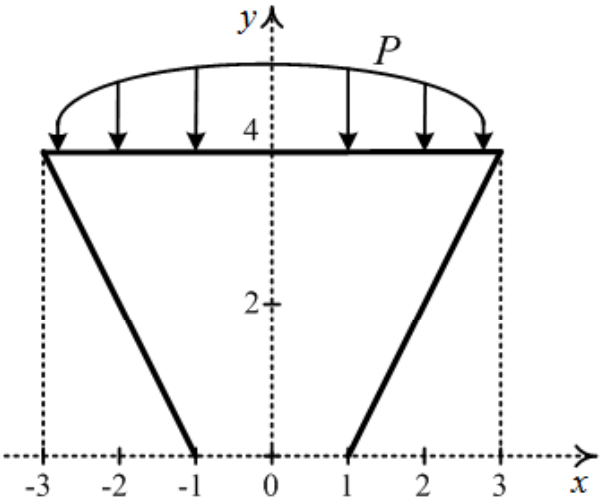
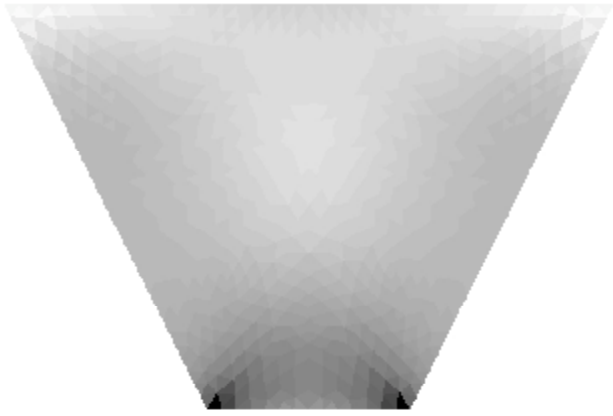


Fig. 3. The loading condition of the sample

The field of shear intensity obtained on the basis of the classical theory of elasticity is shown in figure 6, *a*, while in figure 6, *b* it is shown on the basis of the model of the materials with different strengths.

In comparison with rectilinear lateral bounds in the case of concave bounds the redistribution of strains localization zones occurs both in elastic materials and in materials with different strengths. The size of the inrush zone essentially increases.



a

b

Fig. 4. The intensity of shear deformation

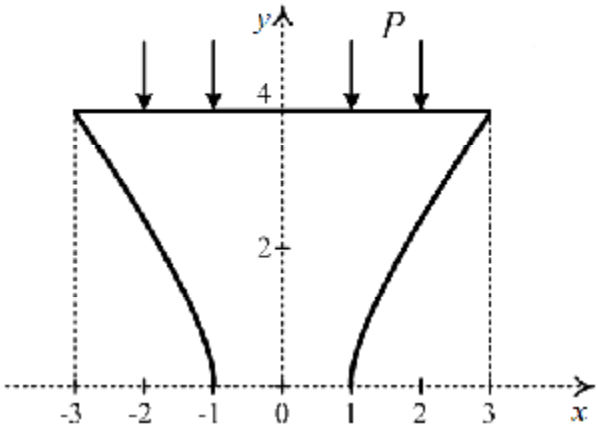


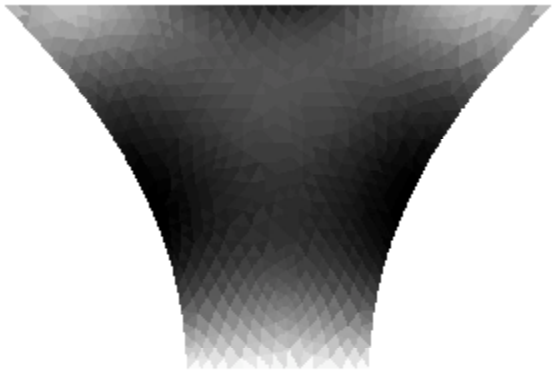
Fig. 5. The loading condition of the sample

Further the problem of punching of the sample with convex side bounds was considered. The loading condition schemes for uniformly and non uniformly distributed P force are shown in figure 7 and figure 8.

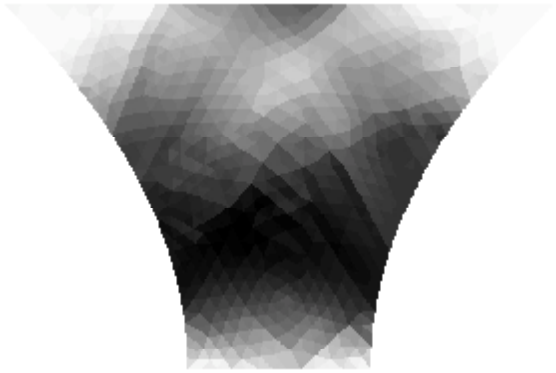
The field of shear intensity for the problem shown in figure 7 obtained on the basis of the classical theory of elasticity is presented in figure 9, *a*, but in figure 9, *b* it is shown on the basis of the model of the material with different strengths.

The field of shear intensity for the problem shown in figure 8, obtained on the basis of classical theory of elasticity

is presented in figure 10, *a*, but in figure 10, *b* it is presented on the basis of the material with different strengths.



a



b

Fig. 6. The intensity of shear deformation

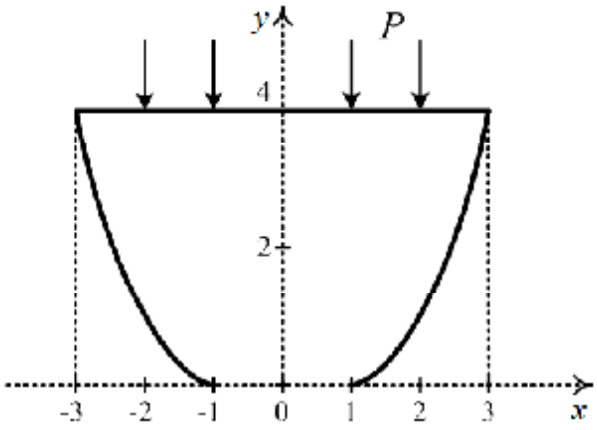


Fig. 7. The loading condition of the sample

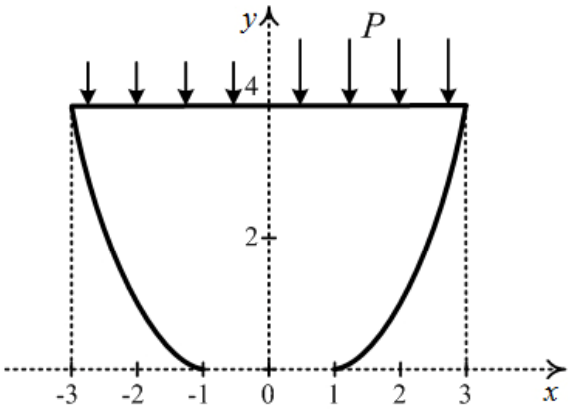
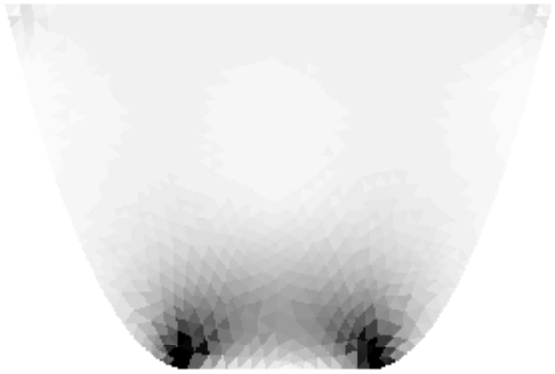


Fig. 8. The loading condition of the sample

By comparing figures we can notice that as a result of pressure redistribution there appears an additional line of strains localization corresponding to the asymmetric statements of a problem.

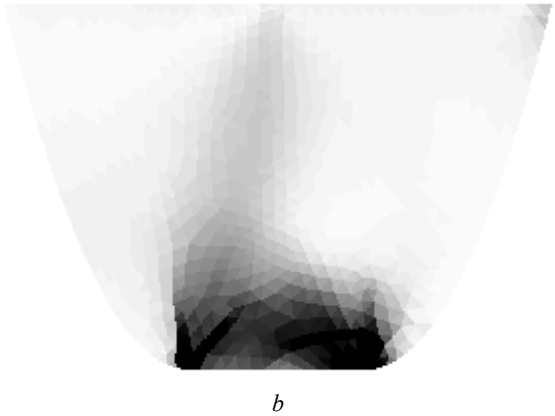


a

b

Fig. 9. The intensity of shear deformation

a



b

Fig. 10. The intensity of shear deformation

On the basis of finite-element method the computational algorithm for the solution of problems of strains localization in the materials with different strengths has been suggested in the paper. The plane deformed state of the sample of the material with different strengths at punching through the die with convex and concave lateral surfaces has been considered as an example. The advantages of the suggested algorithm in comparison with a classical approach to the elasticity theory are most pronounced during the solution of problems in asymmetric statement.

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SYSTEM FOR PROCESSING HIGHLY SPECIALIZED INFORMATION IN DISTRIBUTED NETWORKS

A new structure of a system for arranging and control of highly specialized information in corporate systems is proposed. The principle difference of the given structure is that it is capable to process multilinguistic information within one user's inquiry.

Keywords: distributed networks, multilingual information, information system, agent.

At present time network technologies are actively developed. Thus the question of gathering, processing and controlling information is the most actual for the given technologies [1; 2]. The majority of users of a Russian-language segment in the Internet uses the existing search services of a general purpose. By November, 2008 the most popular information search services are: Yandex, Google, Mail, Rambler, which share 95 % of the user inquiries. Distribution of user inquiries is shown in figure 1.

However it is necessary to notice that the services mentioned above give good results while processing generally used subjects, but if it is necessary to search the highly specialized information then there could be difficulties. Besides in these systems the problem of multilingual representation of information in the Internet is solved incorrectly [1]. Search services of a general purpose support only the languages set which the search inquiry is set for, however, while searching the highly specialized personified information it is possible to organize multilinguistic search procedure at once [1; 2].

In order to overcome the described difficulties applying existing technologies and approaches while using the processing of multilinguistic subject-focused information is offered.

It is proposed to use well-proven technology of information-operating systems realization, based on multi-agent approach.

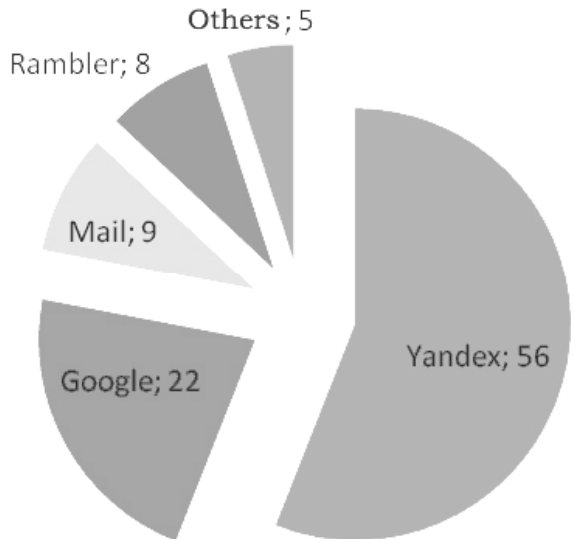

Fig. 1. Distribution of search inquiries in Russian-language segment of the Internet

The developed structure of interaction between the agents in the offered multi-agent corporate system is presented in figure 2.

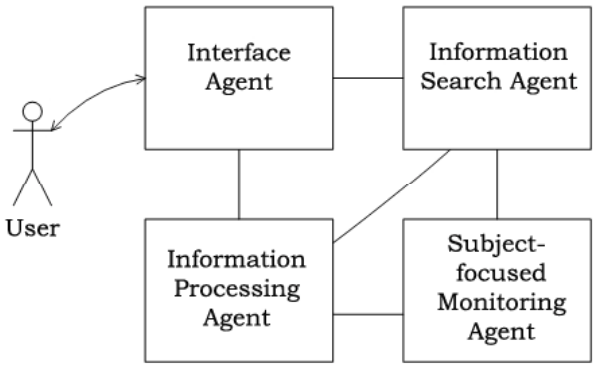

Fig. 2. Generalized diagram of the proposed multi-agent system

Apparently it is necessary to construct four logically connected program modules (agents). The function and structure of each module will be given below.

The Interface Agent is responsible for the arrangement of the user's work with an information processing system and, that is clearly shown in the figure, it is connected with two agents (the Information Search Agent and the Information Processing Agent). The given agent is simple in structure and execution.

The Information Search Agent needs more detailed description because it is offered to realize it within meta-search multilinguistic execution. The structure of the given agent is shown in figure 3.

It's evident from the structure of the given agent, that it is initial. Its basic task is to process a search line of the user which is received by the agent from the interface agent. After the line was processed, it is necessary to initialize multilinguistic meta-search procedure both in a corporate network and in the Internet network. Further the processes of documents presence check and backups removal are realized. Afterwards all received sample of the information is transferred to the Information Processing Agent. The structure of the given agent is shown in figure 4.

The given agent is responsible for control of the information in topical collection obtained during the step of search, from the point of the corporate system user.

You can see that the agent consists of following components:

– the Information-Operating Agent (functionally it is the main agent of the procedure);

– two agents which are rigidly connected to each other (the Agent for Relevance Determination of and the Agent for Correlation of the Document to Subject Domain);

– the Agent for Information Ranging;

– the agent for information processing and imaging.

Let's consider more details of Agent for Relevance Determination and Agent for Correlation of the Document to Subject Domain. The Agent for Relevance Determination makes determination for the documents from the offered sample. Applying algorithms for determination of relevance it is possible to show that some documents are "quasi more relevant to inquiry", and some are "less relevant". Thus, there is a problem of processing of conditionally relevant documents (documents from an adjacent subject domains). Although, while searching it is necessary to consider the possibility of appearance of such subject domains in a resulting sample. Taking into account the adjacency of the subject domains, it is necessary to consider preferences of the user and to solve a problem of adding or an extracting of documents from adjacent subject domains in a resulting

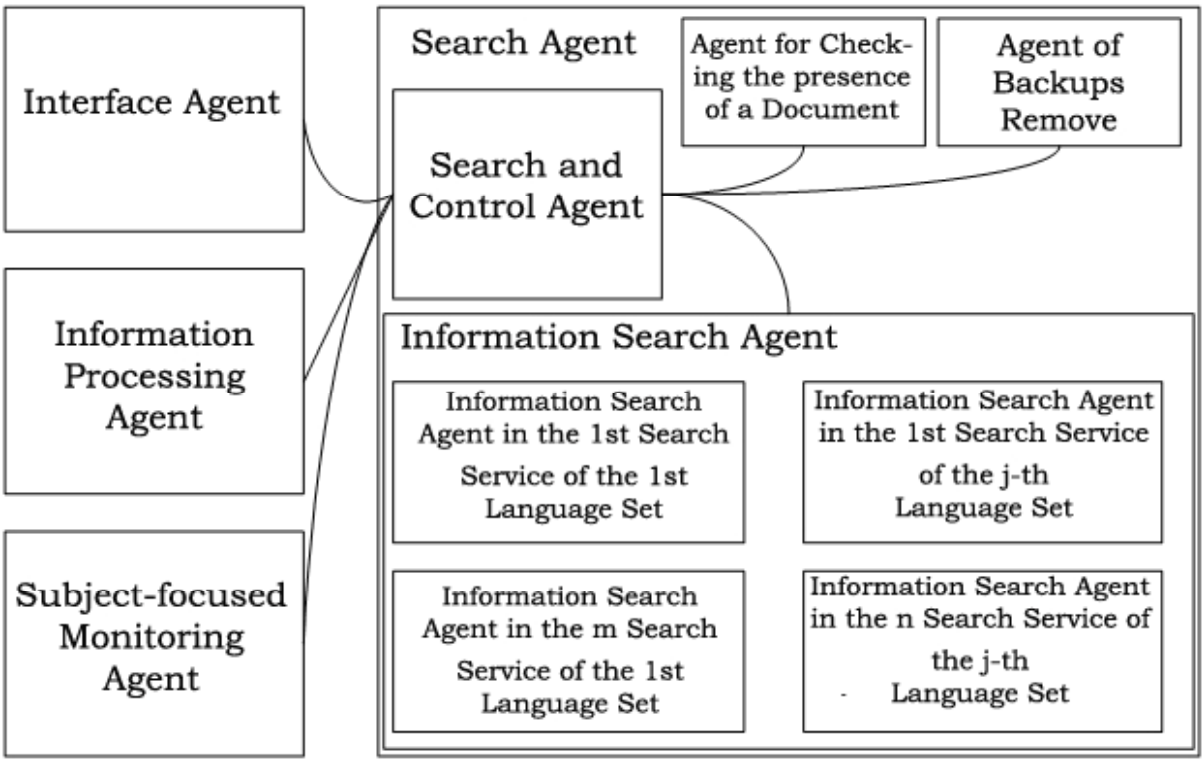

Fig. 3. Process diagram of the "search agent"

sample (the given task is solved by the agent for correlation of the document to subject domain).

Besides, in the chosen text it is possible to have not all the document relevant to a subject domain, but only its part, for example, separate units from the general purpose textbooks, separate articles from collections of articles, parts from reports of the organizations, etc. Considering the given restriction, it is necessary to make a decision of presenting to a user only a part of information necessary for him. The next agent which is offered to be considered in more details is an Agent of Ranking. It is not less important while information processing because at presentation several thousand documents to a user the first place in the display list should be taken by the most important documents.

The Subject-Focused Monitoring Agent is responsible for the analysis of information preferences of a user of corporate system in framework of topic collections and presentation of the personified support of navigation and personified data. Due to presenting to users information collections of the personified navigating menus which are references to the pages, close to their topic preferences, time necessary for searching the requested information and the user traffic is reduced – either in a corporate or external network, because of viewing only high-quality information.

In this way, the offered solution should increase the convenience of the user's work with information resources of corporate system and serve as an additional stimulus for visiting the information collections more often. Besides, the offered approach should lower a loading, both on internal corporate traffic, and on external traffic essentially.

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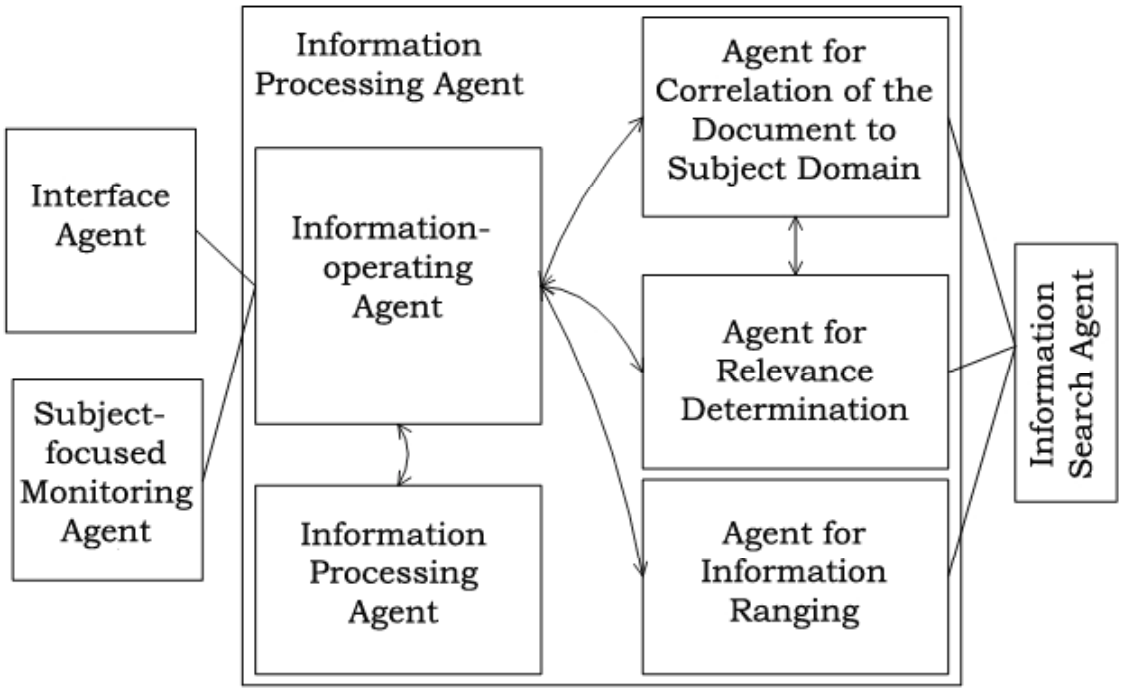

Fig. 4. Process diagram of the Information Processing Agent

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NEW EXACT SOLUTIONS WHICH DESCRIBE 2-DIMENSIONAL VELOCITY FIELD FOR PRANDTL'S SOLUTION*

New velocity fields are found for the well-known Prandtl's solution which describes pressing of a thin layer of plastic material between two parallel stiff and rough plates. The method of construction of other velocity fields is considered.

Keywords: ideal plasticity, velocity field, Prandtl's solution.

The 2-dimensional ideal plasticity equations in case of steady-state problem have the form:

$$\frac{\partial\sigma}{\partial x}-2k\left(\frac{\partial\theta}{\partial x}\cos 2\theta+\frac{\partial\theta}{\partial y}\sin 2\theta\right)=0,$$
$$\frac{\partial\sigma}{\partial y}-2k\left(\frac{\partial\theta}{\partial x}\sin 2\theta-\frac{\partial\theta}{\partial y}\cos 2\theta\right)=0, \quad (1)$$
$$\left(\frac{\partial v_x}{\partial y}+\frac{\partial v_y}{\partial x}\right)\operatorname{tg}2\theta+\left(\frac{\partial v_x}{\partial x}-\frac{\partial v_y}{\partial y}\right)=0,$$
$$\frac{\partial v_x}{\partial x}+\frac{\partial v_y}{\partial y}=0, \quad (2)$$

here σ is hydrostatic pressure, θ is the angle between the first principal direction of stress tensor and axis Ox, k is plasticity constant, $v_x v_y$ are components of velocity vector of strain field.

Prandtl's solution is one of the practically applied and frequently used in different computations. This solution describes in particular the pressing of a thin layer of plastic material between two parallel stiff and rough plates, and it has the following form:

$$\sigma_x=-p-k\left(x-2\sqrt{1-y^2}\right),$$
$$\sigma_y=-p-kx,\ \tau=ky, \quad (3)$$

p is an arbitrary constant.

It is well known that to describe the plasticity state of material completely one should know velocity field.

Let's substitute the equations (2) into the system (1). We get:

$$y\left(\frac{\partial v_x}{\partial x}-\frac{\partial v_y}{\partial y}\right)=\sqrt{1-y^2}\left(\frac{\partial v_x}{\partial y}+\frac{\partial v_y}{\partial x}\right),$$
$$\frac{\partial v_x}{\partial x}+\frac{\partial v_y}{\partial y}=0. \quad (4)$$

One can see that because of its linearity the system (4) has an infinite set of solutions which can be used for the analysis of the stress-strained state of a plastic medium.

At the present moment two classes of solutions of this system are known, Nadai's solution [1] and Ivlev–Senashov's solution [2], which are the following:

$$v_x=-\alpha xy+\beta x-\alpha\arcsin y-$$
$$-\alpha y\sqrt{1-y^2}-2\beta\sqrt{1-y^2}+C_1,$$
$$v_y=\alpha\left(\frac{x^2}{2}+\frac{y^2}{2}\right)-\beta y+C_2,$$

here α, β, C_1, C_2 are arbitrary constants (if $\alpha=0$ Nadai's solution comes out).

Let's point out others solutions of the system (4). Notice that in variables ξ, η, where $\sigma=k(\xi+\eta)$, $2\theta=\xi-\eta$, the equations (2) are written as follows (5):

$$\frac{\partial v_x}{\partial\xi}-\operatorname{tg}\theta\frac{\partial v_y}{\partial\xi}=0,\ \frac{\partial v_y}{\partial\eta}+\operatorname{ctg}\theta\frac{\partial v_x}{\partial\eta}=0. \quad (5)$$

If we put new variables into (5) using the formulas:

$$v_x=u\cos\theta-v\sin\theta,$$
$$v_y=u\sin\theta+v\cos\theta, \quad (6)$$

we'll get a system (7):

$$\frac{\partial v}{\partial\xi}-\frac{1}{2}u=0,\ \frac{\partial u}{\partial\eta}-\frac{1}{2}v=0. \quad (7)$$

Further we use the following procedure: we solve the system (7), put expressions from Prandtl's solution for ξ and η into this system, make substitution (6) and find a velocity field which corresponds to the solution (3).

Let's do it, for example, using the simplest solution of the system (7). It is obvious that

$$v=u=\exp\frac{1}{2}(\xi+\eta)$$

is a solution of the equations (7). Put it into the (6). We get:

$$v_x=(\cos\theta-\sin\theta)\exp\frac{1}{2}(\xi+\eta),$$
$$v_y=(\cos\theta+\sin\theta)\exp\frac{1}{2}(\xi+\eta).$$

From Prantl's solution (3) one can get easily

$$\xi+\eta=-\frac{p}{k}-x-\sin 2\theta,\ \cos 2\theta=y. \quad (8)$$

And finally we find a new velocity field:

$$v_x=\exp\left(\frac{1}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)(\cos\theta-\sin\theta),$$
$$v_y=\exp\left(\frac{1}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)(\cos\theta+\sin\theta).$$

By using this scheme some other velocity fields are found.

For the equations (7) solutions are given in [3]. Further with respect to these indicated solutions, 5 more classes of new solutions of the equations (5) are built.

1) $u=\cos\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\cos\left(\mu\frac{\xi-\eta}{2}\right)+B\sin\left(\mu\frac{\xi-\eta}{2}\right)\right].$

* The work was carried out with support from FOP "Scientific and Scientific-Pedagogical Personnel of Innovative Russia" for 2009–2013 years.

Here A, B, μ, λ are arbitrary constants; $\mu^2-\lambda^2=1$.
In this case

$$\frac{\partial u}{\partial \eta}=-\frac{\lambda}{2}\sin\left(\lambda\frac{\xi+\eta}{2}\right)\times$$
$$\times\left[A\cos\left(\mu\frac{\xi-\eta}{2}\right)+B\sin\left(\mu\frac{\xi-\eta}{2}\right)\right]+$$
$$+\frac{\mu}{2}\cos\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\sin\left(\mu\frac{\xi-\eta}{2}\right)-B\cos\left(\mu\frac{\xi-\eta}{2}\right)\right].$$

From the equations (7) we get

$$v=-\lambda\sin\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\cos\left(\mu\frac{\xi-\eta}{2}\right)+B\sin\left(\mu\frac{\xi-\eta}{2}\right)\right]+$$
$$+\mu\cos\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\sin\left(\mu\frac{\xi-\eta}{2}\right)-B\cos\left(\mu\frac{\xi-\eta}{2}\right)\right].$$

Making substitution for u, v into the equations (6) and taking into account the equalities (8) and $\theta=\frac{\xi-\eta}{2}$ we get

$$v_x=\cos\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]\cos\theta-$$
$$-\left(-\lambda\sin\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]+\right.$$
$$\left.+\mu\cos\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\sin(\mu\theta)-B\cos(\mu\theta)\right]\right)\sin\theta,$$
$$v_y=\cos\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]\sin\theta+$$
$$+\left(-\lambda\sin\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]+\right.$$
$$\left.+\mu\cos\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\sin(\mu\theta)-B\cos(\mu\theta)\right]\right)\cos\theta.$$

2) $u=\sin\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\cos\left(\mu\frac{\xi-\eta}{2}\right)+B\sin\left(\frac{\xi-\eta}{2}\right)\right]$.

Here A, B, μ, λ are arbitrary constants; $\mu^2-\lambda^2=1$.
In this case

$$v=-\lambda\cos\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\cos\left(\mu\frac{\xi-\eta}{2}\right)+B\sin\left(\mu\frac{\xi-\eta}{2}\right)\right]+$$
$$+\mu\sin\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\sin\left(\mu\frac{\xi-\eta}{2}\right)-B\cos\left(\mu\frac{\xi-\eta}{2}\right)\right].$$

And

$$v_x=\sin\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]\cos\theta-,$$
$$-\left(-\lambda\cos\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]+\right.$$
$$\left.+\mu\sin\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\sin(\mu\theta)-B\cos(\mu\theta)\right]\right)\sin\theta,$$
$$v_y=\sin\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]\sin\theta+$$
$$+\left(\lambda\cos\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]+\right.$$
$$\left.+\mu\sin\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\sin(\mu\theta)-B\cos(\mu\theta)\right]\right)\cos\theta.$$

3) $u=\exp\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\cos\left(\mu\frac{\xi-\eta}{2}\right)+B\sin\left(\frac{\xi-\eta}{2}\right)\right]$.

Here A, B, μ, λ are arbitrary constants; $\mu^2+\lambda^2=1$.
In this case

$$v=\lambda\exp\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\cos\left(\mu\frac{\xi-\eta}{2}\right)+B\sin\left(\mu\frac{\xi-\eta}{2}\right)\right]+$$
$$+\mu\exp\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\sin\left(\mu\frac{\xi-\eta}{2}\right)-B\cos\left(\mu\frac{\xi-\eta}{2}\right)\right].$$
$$v_x=\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\times$$
$$\times\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]\cos\theta-$$
$$-\left(-\lambda\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\times\right.$$
$$\left.\times\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]+\right.$$
$$\left.+\mu\exp\left(\lambda\left(-\frac{p}{2k}-\frac{x}{2}+\frac{\sqrt{1-y^2}}{2}\right)\right)\left[-A\sin(\mu\theta)-B\cos(\mu\theta)\right]\right)\sin\theta,$$
$$v_y=\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\times$$
$$\times\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]\sin\theta+$$
$$+\left(\lambda\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\times\right.$$
$$\left.\times\left[A\cos(\mu\theta)-B\sin(\mu\theta)\right]+\right.$$
$$\left.+\mu\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\sin(\mu\theta)-B\cos(\mu\theta)\right]\right)\cos\theta.$$

4) $u=\exp\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\exp\left(\mu\frac{\xi-\eta}{2}\right)+B\exp\left(\frac{\xi-\eta}{2}\right)\right]$.

Here A, B, μ, λ are arbitrary constants; $\lambda^2-\mu^2=1$.
In this case

$$v=\lambda\exp\left(\lambda\frac{\xi+\eta}{2}\right)\times$$
$$\times\left[A\exp\left(\mu\frac{\xi-\eta}{2}\right)+B\exp\left(\mu\frac{\xi-\eta}{2}\right)\right]+$$
$$+\mu\exp\left(\lambda\frac{\xi+\eta}{2}\right)\times$$
$$\times\left[-A\exp\left(\mu\frac{\xi-\eta}{2}\right)+B\exp\left(\mu\frac{\xi-\eta}{2}\right)\right].$$
$$v_x=\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\times$$
$$\times\left[A\exp(-\mu\theta)+B\exp(-\mu\theta)\right]\cos\theta-$$
$$-\left(-\lambda\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\times\right.$$
$$\left.\times\left[A\exp(-\mu\theta)+B\exp(-\mu\theta)\right]+\right.$$
$$\left.+\mu\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\exp(-\mu\theta)+B\exp(-\mu\theta)\right]\right)\sin\theta,$$
$$v_y=\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\times$$
$$\times\left[A\exp(-\mu\theta)+B\exp(-\mu\theta)\right]\sin\theta+$$

$$+\left(\lambda\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\times\right.$$
$$\times\left[A\exp(-\mu\theta)+B\exp(-\mu\theta)\right]+$$
$$\left.+\mu\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\exp(-\mu\theta)+B\exp(-\mu\theta)\right]\right)\cos\theta.$$

5) $u=\exp\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\frac{\xi-\eta}{2}+B\right]$.

Here A, B, λ are arbitrary constants; $\lambda^2=1$.

In this case

$$v=\lambda\exp\left(\lambda\frac{\xi+\eta}{2}\right)\left[A\frac{\xi-\eta}{2}+B\right]-A\exp\left(\lambda\frac{\xi+\eta}{2}\right).$$

$$v_x=\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\theta+B\right]\cos\theta-$$
$$-\left(\lambda\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\theta+B\right]-\right.$$
$$\left.-A\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\right)\sin\theta,$$

$$v_y=\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\theta+B\right]\sin\theta+$$
$$+\left(\lambda\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\left[-A\theta+B\right]-\right.$$
$$\left.-A\exp\left(\frac{\lambda}{2}\left(-\frac{p}{k}-x-\sin 2\theta\right)\right)\right)\cos\theta.$$

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THE ASYMPTOTIC PROBABILISTIC GENETIC ALGORITHM*

This paper proposes the modification of probabilistic genetic algorithm, which uses genetic operators, not affecting the particular solutions, but the probabilities distribution of solution vector's components. This paper also compares the reliability and efficiency of the base algorithm and proposed modification using the set of test optimization problems and bank loan portfolio problem.

Keywords: probabilistic genetic algorithm, mutation, selection.

The probabilistic genetic algorithm (PGA) is an attempt to create an algorithm with a scheme similar to that of the traditional genetic algorithm (GA), preserving the basic properties of the genetic operators, but defined in terms of the pseudo-Boolean optimization theory [1].

The probabilistic genetic algorithm explicitly (as opposed to the traditional GA) computes the components of the probability vector and has no crossover operator (it is replaced a by random solution generation operator) but retains the genetic operators of mutation and selection.

The purpose of this study is to develop a probabilistic genetic algorithm modification with mutation and selection operators, effecting not particular individuals, but genes' values distribution as a whole; and to compare efficiency and reliability of basic algorithm and modification.

Asymptotic mutation. PGA uses a standard GA mutation operator, which inverts genes with a given probability (as a rule, this probability is very low). Since genes mutate independently, we can study one particular gene. All following formulas will stand for every gene in the chromosome. Let us suppose that p – denoting the probability of that fact was equal to 1 before mutation. We will determine the probability as equal to 1 for same gene after mutation (p' denotes this probability). The mutation probability is p_m.

The gene can be equal to 1 after mutation in two cases: it was equal to 1 before mutation and has not mutated or it was equal to 0 before mutation and has mutated. If x denotes the gene value before mutation and y – after mutation – the following equality is:

$$P\{y=1\}=P\{x=1\}(1-p_m)+P\{x=0\}p_m=$$
$$=p(1-p_m)+(1-p)p_m=p_m+p(1-2p_m).$$

Using the aforementioned designations for genes probabilities before and after mutation we can write down:

$$p'=p_m+p(1-2p_m).$$

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This equation can be used to implement the mutation operator, not affecting the solution genes, but the distribution of genes in whole.

The difference of this scheme from the classical one is that mutation (in the traditional GA sense) is absent, but after estimating intermediate population genes distribution each component of the probabilities vector must be transformed by the formula aforementioned. Such a transformation can be called "the mutation operator effecting the distribution" or "asymptotic mutation operator".

The traditional implement of mutation in the PGA can be seen as an estimation of gene distribution using the Monte-Carlo technique. In the end we have a stochastic approximation of computation formula results. The term asymptotic mutation states that this procedure is a limited case of traditional mutation operators if the population size tends to increase.

Let us examine some properties of the proposed procedure. The transformation definition is linear, mapping intervals from [0; 1] to interval $[p_m; 1 - p_m]$. The linearity is obvious and the boundaries can be calculated if we replace p by 0 and 1. Since the linear function is also monotonous, the values from interval [0; 1] will be mapped into interval $[p_m; 1 - p_m]$. Thus asymptotic mutation doesn't let probability p reach values 0 and 1 exceed p_m; this excludes premature convergence.

It is easy to see that value $p = 0.5$ is the fixed point of this mapping, meaning that if the gene values have had equal probabilities before mutation, this property will remain after mutation. Thus, the proposed distributing transformation procedure makes the distribution formal.

Another feature of the proposed procedure is that its time consumption does not depend on population size because it performs only simple linear transformations of gene probability vector components. In the traditional PGA, random real numbers from intervals [0; 1] are generated for each gene iteration for every solution, if this number is in the interval $[0; p_m]$ (where p_m is the mutation probability), then the gene will be inverted (flipped). The complexity of the traditional mutation procedure (for one iteration) is $O(N; M)$, where N is the population size, and M is the genes' number. Most of the genes will not be flipped since mutation probability is usually small.

Let us compute the probability of a situation where some solution will stay unchanged after mutation. Let us denote this probability Q. The solution will not change if all of the genes remain unchanged. Genes mutate independently, they will stay unchanged within the probability $1–p_m = q_m$. Using this rule for calculating the joint probability of independent events, we get the needed probability, which is equal to $Q = (1 - p_m)^M$. Mutation probability is often set to $p_m = 1 / M$; in this case $Q \approx e^{-1}$. This approximate equality is precise enough even when M is equal to 10. This means that more than one third of all solutions will not change during the mutation procedure; in other words all computations connected with the implementation of the mutation operator, affecting the solutions, in more than one third of cases were performed only to find out that no action must be performed.

The proposed mutation implementation approach has no such drawbacks. Its algorithmic complexity is $O(M)$ meaning that the time for this procedure does not depend on the population size, in practice meaning that the time consumption of the mutation procedure is relatively small compared to other procedures, the complexity of which depends on the population size (in the proposed algorithm such a procedure is selectional).

The proposed mutation implementation does not require a generation of random numbers (which can be expensive operations). The probabilities of genes values are computed independently; therefore the proposed procedures may be implemented on parallel or vector hardware.

This approach does not contain conditional logic (branching statements), and therefore is more suitable for modern processors with instruction pipeline [2].

It is necessary to notice that in spite of the fact that the proposed PGA modification has no traditional mutation procedure; the parameter of this procedure – mutation probability – retains, it means that user has to specify the parameter. This can be seen as both an advantage and a disadvantage. On the one hand, it is handily for user to not specify and tune parameters. On the other, the proposed modification makes no assumption about the mutation probability, and therefore it can be used with any mutation probability setup method, including self-adjusting (the tuning of mutation probability during an optimization process).

The proposed distribution transformation procedure can be seen not only as a mutation implementation procedure, but as an additional step of the estimation of distribution, the purpose of which is the avoiding of premature convergence. The connection between the distributions before and after mutation is analogous to the connection between the classical and Bayesian statistical estimations of probability based on sample rates. This connection is expressed by the following formula:

$$p_{\mathrm{B}} = \frac{np+C}{n+2C},$$

where p_{B} is the Bayesian estimation of probability, p is the classical estimation of probability, n is the total experiment number (sample size), C is the parameter, (usually equal to 1). After simple transformations we can find out, that the Bayesian estimation of probability is equivalent to the "mutating" classical estimation, if the mutation probability is equal to $C/(n + 2C)$.

Asymptotic selection. Let us now consider the selection procedure. During this the PGA (and traditional GA) intermediate population is generated – the probability is to be selected in the intermediate population is higher for individuals with better health. After the intermediate population estimation has been completed, the mutation and estimation of the genes' values probabilities are performed. This procedure is known as the Monte-Carlo estimation (as it was done for the mutation procedures in the previous section. Since the distribution is known exactly, we can simply compute the distribution.

Let the population contain individuals $x_1, \ldots, x_n$, the probabilities to be selected (in one experiment) are $g_1, \ldots, g_n$. The expected value of the probability of this case is that the i-th gene will be equal to 1.

$$p^{(i)} = \sum_{k=1}^{n} x_k^{(i)} g_k.$$

It is possible to calculate the distribution of genes in the intermediate population without explicit selection procedure using the given formula. This approach can be called "asymptotic", since it distributes the genes in the limit for distributions, generated by the traditional approach in situations when the population size tends to infinity.

Proportional and ranking selection methods calculate selection probabilities explicitly; therefore the asymptotic approach can be applied directly to these methods. During the tournament selection the explicit selection probabilities are not used and the asymptotic approach can not be applied without modifications. However, tournament selection is often more efficient and reliable than other selection methods, and therefore distributing the asymptotic approach on tournament selection is important problem.

It can be shown, that tournament selection is a kind of ranking with implicit selection probabilities. Let us consider selection procedure of this method: tournament groups are generated randomly (not considering an individuals' health), and the winner of the tournament is an individual with the best health (in tournament groups). The issue is to find a solution with a maximal fitness value; values themselves have no importance – we can consider only the ranks of these values.

To build an asymptotic selection method, equivalent to tournament selection it is necessary to find out the dependence between selection probabilities and fitness ranks.

Let the tournament group size be denoted as S. Let us assume (for simplicity), that the population does not contain individuals with equal fitness values. Our objective is to find the probability of selecting an individual with a k-th fitness value. Tournament groups are random – distribution is uniform. A tournament winner is an individual with highest rank, meaning that the winner's rank has same distribution as maximal S uniformly distributed random values [3]:

$$g_k = \frac{k^S - (k-1)^S}{n^S}.$$

Let us now assume that the population consists of individuals with equal physical values. Let the population consist of K different fitness values; k-th value appears in the population n_k times. It is clear that following equality is:

$$\sum_{k=1}^{K} n_k = n\,.$$

In this case it is simple to find out the expression for cumulative probabilities G_k, defined by the following formulas:

$$G_1 = g_1,$$
$$G_k = G_{k-1} + g_k, \quad k = 2,..., K.$$

Since solutions are selected for tournament groups without considering their physical abilities, then all possible tournament groups have the same probability, and the k-th cumulative probability is equal to the number of tournament groups containing solutions where the fitness is less or equal to k-th fitness value, divided by the total number of tournament groups:

$$G_k = \frac{1}{n^S}\left(\sum_{j=1}^{n} n_j\right)^S.$$

Asymptotic selection does not generate intermediate population; therefore this approach consumes less memory (if as usual the genes' number is high consuming half of the memory necessary for traditional PGA).

Using proposed selection and mutation techniques we get the following modification of the PGA procedure:

– create and estimate initial population within uniform genes distribution;

– if the termination condition is met – stop;

– compute genes distribution using asymptotic selection;

– transform genes distribution using asymptotic mutation;

– generate new population using computed distribution, estimate it;

– return to step 2.

Algorithm comparison using test problems. Quality characteristics of stochastic optimization methods are reliability (number of experiments in which the algorithm found global optimum divided by total number of experiments) and the average number of objective value computations required for reaching the optimum (average over successful experiments). The primary characteristic is reliability: if two algorithms have equal reliability, the algorithm which performs a lower number of objective computations is better.

The number of objective computations is a secondary characteristic, since this criterion can be inadequate if the reliability of the optimization algorithm is low; in such case the algorithm can be used to find global optimum only if the initial population is extremely promising (many solutions belong to the attraction region of the global optimum), therefore the algorithm will converge very quickly. Furthermore, low reliability means that the average is calculated over a sample small in size, therefore the variation is high.

PGA is a stochastic optimization algorithm; its quality cannot be determined by one experiment, it's necessary to perform many experiments and average the results.

We have used the following settings: the population size is equal to 100, the maximum iterations number is 50, the number of experiments for qualified estimation of the characteristics is 1,000, the mutation is weak, and the coding method is Code Grey. We have used same test problems as set in the paper [1].

To define if the difference between the two methods is statistically significant – the Wilcoxon–Mann–Whitney nonparametric test [4] (with samples sizes 5) was used. The results of experiments are summed up in table 1.

The result column contains a number of testing problems where the differences between algorithms are statistically significant. Values for base algorithm and modification are divided by a slash (the total problems number is 16).

The results show that in all cases the difference between algorithms is not statistically significant and that the modification's performance is better than the one of base algorithm. The proposed modification's reliability is not worse than that of base algorithm (and in some cases surpasses it), but in most of experiments the modification performs more calculations of the objective value. Since PGA is a global optimization algorithm, such a trade-off can be acceptable.

The observed increase of reliability and computational cost can be explained by the fact that selection probabilities

for solutions with small fitness values are also small. Therefore such solutions, selected in the intermediate population affect genes distribution rarely in traditional selection. In the case for asymptotic selection all solution can contribute into distribution (the contribution of "bad" solution is low). It is clear that accounting of "bad" solutions decreases the speed of local convergence and the probability of finding a local minimum; in turn this increases the probability of global convergence.

Algorithm comparison within the problem of the bank loan portfolio. Let us compare standard PGA and the proposed modifications within the bank loan portfolio problem [5]. This problem is a constrained pseudo-Boolean optimization problem (constrained optimization of the function with Boolean domain and real values). The dimension of the search space is equal to 50. The constraints dynamic penalty method was used [6]. The population size was equal to 1,000, the number of iterations was 100, and the number of averaging experiments was 100.

For each selection method we test the equality of the expected values of profitability best loan portfolios, defined by the base algorithm and modifications. To test the statistical significance of the difference we've used the Student two sample test [4]. Since the sizes of the samples are quite high we can use the asymptotic value. For the significance level 0,95 it is approximately equal to 1.97.

For the bank loan portfolio problem we've performed a full comparison of all the four possible variants of PGA: base probabilistic genetic algorithm (PGA), PGA-M – probabilistic genetic algorithm with asymptotic mutation (and traditional selection), PGA-S – probabilistic genetic algorithm with asymptotic selection (and traditional mutation), PGA-MS – probabilistic genetic algorithm with both asymptotic mutation and selection.

The results of the experiments were placed in the following table. Table 2 contains the averages of the best objective values found by optimization algorithms, the standard deviation of these quantities, and time consumption (in seconds).

The Students' test of equality means shows that the efficiency of algorithms with asymptotic mutation or asymptotic selection (PGA-M and PGA-S) doesn't significantly differ in statistics from the base algorithm (with the significance level 0.95). Furthermore, the difference between these two algorithms is also not statistically significant. The difference significance between PGA with asymptotic mutation, selection (PGA-MS), and other algorithms depends on the selection methods: it is significantly higher when using the proportional and ranking selection efficiency of PGA-MS, than the efficiency of the other three algorithms. However in tournament selection there are no statistically significant differences.

Let us now consider the time consumption of the PGA variants. It can be seen that in all cases the base algorithm consumes more time than its asymptotic modifications. Furthermore, PGA-MS surpasses both PGA-M and PGA-S, if we use proportional or ranking selection. Only in the case of tournament selection, the algorithm PGA-M is the most rapid. This can be explained by the fact, that the asymptotic variant of the tournament selection performs a relatively expensive operation: the sorting of population, which traditional tournament selection does not (ranking without sorting – is one of the most important features of tournament selection). However the usage of asymptotic mutation and/or selection does not slow down the algorithm when comparing to the PGA.

We can conclude that asymptotic variants of probabilistic genetic algorithm perform according to their designed goals, i. e. to give statistically equivalents of probabilistic genetic algorithm consuming fewer amounts of computational resources.

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Table 1

Test results

Selection method	Base algorithm		Modification		Result
	Reliability	Costs	Reliability	Costs	
Proportional	0.44	2,100	0.52	2,100	0/7
Ranking	0.46	2,200	0.62	2,300	0/7
Tournament	0.48	2,100	0.65	2,300	0/8

Table 2

Bank portfolio problem

Selection method	Algorithm	Average	Standard deviation	Time
Proportional	PGA	199,581	62.74	1.32
	PGA-M	199,579	57.41	1.28
	PGA-S	199,585	75.34	1.09
	PGA-MS	199,605	59.98	0.94
Ranking	PGA	199,631	38.35	1.71
	PGA-M	199,631	37.84	1.59
	PGA-S	199,633	40.45	1.48
	PGA-MS	199,646	38.39	1.27
Tournament	PGA	199,634	48.91	1.37
	PGA-M	199,634	48.79	1.11
	PGA-S	199,635	38.43	1.34
	PGA-MS	199,639	46.09	1.24

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THE MODELING OF THE WORLD SOCIO-ECONOMIC STRATEGY AS AN OPTIMAL CONTROL PROBLEM*

An approach to the modeling strategy of global social-economical development on the basis of the economic-mathematical optimum control model, considering interaction of the basic economic agents of the world social-economic system (WSES) – industrial, consumer, financial sectors, as well as the operating center (the world government) is described in this article. The task of optimizing the global social-economic development is formulated; the main principles of the analysis, restrictions and target criteria are analyzed.

Keywords: global economical crisis, sustainable development, mathematical models of optimal control.

Interest to the problems of human survival and the balanced development of the world socio-economic system is aroused under the conditions of the world socio-economic crisis. It is clear that such a kind of development requires the coordination of interests between business, consumer, and financial sectors. It also requires participation of a united control center (the world government). In this context the elaboration of the mathematical model of the global economy that will consider the balance of interests of required sectors is still relevant. Some mathematical models which describe the global development had been elaborated in the 1950s by scientists from The Club of Rome ([1] etc.). At the heart of these models is the system of usual first order differential equations. The analysis of such models showed the reality of crisis occurrences in world development. To these occurrences belong the greenhouse effect, over-population, the depletion of natural resources, etc. A necessity to fight them is confirmed by ratifying the Kyoto Protocol, which reduces emissions of greenhouse gases. It is important to note that the specified models don't solve the problem of optimal process control in global development and need a large amount of numeral experiments. These experiments do not always lead to optimal or quasi optimal development scenarios. Currently, the interest in investigating global development problems is aroused. This is connected with the series of world financial crises, which happened during the last years; which were caused by the imperfection of the world financial system, oriented on the dollar as the only world currency; and the domination through this, the geopolicy of one country. Let's mark works [2–4] as representative modern publications on this issue. An approach to solving the problem of global social-economic development management is based on solving the multicriterial, multistage linear optimal control problem.

It is necessary to note that for the management of global social-economic development, the operating agency of the WSES needs to accomplish several complicated and interconnected tasks: 1) socially-industrial (the maintenance of high production volumes with a solvent demand, employment, and high standards of living); 2) financial-industrial (first of all, the elimination of the financial system imbalance and production sector); 3) ecological (preserving a suitable living environment).

Let's consider the main elements of the prospective approach below. Let's formulate the following task, which will be called the main task of global social-economic development. We shall consider the available number of branches in the world's production sectors: food, clothes, housing, the articles of prime necessity etc. It is required to determine the amount of main production funds and the production volumes of the mentioned branches in set time moments, during which the total net present value of cash flows for industrial, social and financial sectors of world economy will be the greatest at a set planning horizon. The formulated task in our opinion can be considered as a global investment project (IP) of optimum WSES development management in a view of statutes to be mentioned. Let's suppose that in the global development model (GDM), the simultaneous economic agents aforementioned are the decision makers (DM), interested in a balanced development

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of global economy. The operating center (OC) defines the common "game rules" in the WSES in view of vital functioning conditions and the interests of all DM, directed to the observance of economic, ecological, social norms promoting the main goal of OC, and all the WSES in the whole to possibly survive for a long period, including extreme variants, when the time of IP is not limited.

Let's consider the possible goals of each DM. The goal of the production sector naturally, is to consider the maximization of discount sum for its own means (in monetary or material equivalent). The consumer sector is interested in having the certain minimal sum of means to provide itself with a minimal basket of goods: dwelling, clothes, food, medical and social service minimums. With a living wage exceeding these basics, provided by the OC or industrial sector in the form of grants or wages, the cumulative consumer – a worker of the industrial and financial institutions can provide himself with an individual share (nationalization, privatization) in real and financial actives of the WSES. The goal of the OC or the management quality criterion for the considered the WSES can consist of minimizing penalty sums for ecological and social-economic quotas (rules). Thus, without significant errors in the substantial sense, let's assume the performance of the following preconditions.

1. Each branch of the world industrial sector produces goods of one kind.

2. The labor compensation fund (LCF) for the world industrial sector labor force is some share of totals, proceeding from the realization of all the produced goods.

3. The manufacturing volume for each kind of production does not surpass forecast demand for this production at any moment on the time set interval, and the demand for a resource is defined as a product of norm for personal consumption of this resource in a population.

4. Monetary resources for every DM in a current time are nonnegative (i. e. this economical agent is solvent during the whole validity of IP).

5. The financial sector provides the industrial sector with credits during a current, for the period of functioning after finishing – the last one of them on a regular basis returns the sum of the credit and the percents.

Assumptions 1, 2, 5 are noted for the simplification of modeling; so they do not considerably influence the accuracy of the problem being solved. Assumption 3 limits from above the volume of produced goods by a potential demand, excepting the situation of overproduction entailing losses for the industrial sector the WSES and obviously, capable of driving the world into a crisis similar to that of overproduction, which occurred during the economic depression of the 1930s. Precondition 4 is an obligatory condition for the realizability of any IP as in the situation when the sum of means for any DM is close to null; in fact the crisis does not only refer to the DM, but to all the WSES. Emphasis on precondition 3 is essential as they are the coordinate interests of basic the WSES participants, allowing achieving the comprehensible compromise in their realization purposes during the first approximation, to basics of the following concern:

– satisfaction of a consumer sector demand;

– maintenance of industrial and financial sectors' profit (caused by a high level of production in a combination with solvent demand and promptly given and returned credits);

– timely and in due volume tax revenues in budget of the WSES (due to increase of profit and incomes of not only its industrial and financial, but also the consumer sectors);

– stability of WSES functioning (exception in the conditions of a crisis) within the limits of the selected "game rules".

It is necessary to note, that now the issue of financial crises' prevention, which can be looked upon as a problem of optimum control, in volumes of industrial and financial sector funds and their coordination with volumes of funds (material benefits) of the whole world system, obtains special urgency. Taking into account all preconditions resulted above, it is possible to consider the WSES as a self-adjusted operated system, automatically reacting to the externals of its influence, such as changes in the conjuncture of a supply and demand, investment activity in various fields, volumes of monetary weight, population, the level of pollution, or other parameters of the WSES. Then the corresponding acts by adjusting tax rates, the sums and key directions of grants, parity of the basic industrial and financial funds, quotas on the polluting substances' levels, and other parameters of system are possible to see as the control of the WSES.

Complex research of the specified problems demand the application of the system approach based on the solution for a multicriterial task of economical dynamics and the reception of values and interval ranges for model parameters in which WSES borders can balanced for as long as possible. To realize this approach we have offered to use a number of analysis principles – formulated below in the following component form for an economic-mathematical kernel.

Economic kernel.

1. As an efficiency criterion for every DM functioning, the use of net present value parameter NPV is selected.

2. Current money resources of each participant IP develop the balance of receipts and payments for the previous moment of time.

3. The general principle of risks consideration (management of risks) according to formula $r_i = r + i$ is used, where r_i, r are accordingly rates of discounting with and without taking risk into consideration, i is the inflation rate.

4. Criterion functions of DM have a general structure (the discounted balance of strategic incomes and charges in monetary streams).

Mathematical kernel.

1. Dependence on time from model variables (corresponds to realization of a substantial principle of monetary streams' time cost).

2. Linearity of model (substantially corresponds to the presence of strategic income linear calculation algorithm and charges of economic agents at abstraction from some insignificance; for the preliminary analysis of accounting and financial details).

3. Multicriterial models (substantially considers interrelation of all DM interests).

On the basis of the resulted economic-mathematical kernel components, we come to a conclusion, that for the task solution in view of optimum global social-economic development control it is expedient to use a class of

multicriterial, multistage tasks of linear programming that attracts an application opportunity of the effective analysis methods for the offered models based on the Bellman's principles: maximum, operational calculations (z-transformation).

The general balance equation of current money resources *of l*-th EA $Ds_l(t)$ $(l = 1, ..., N)$ during the moment t, participating in any global IP, formally looks like:

$$Ds_l(t+1) = Ds_l(t) + Ps_l(t+1) - \\ -Pl_l(t+1)\ (t = 0, ..., T-1), \quad (1)$$

where $Ps_l(t+1)$, $Pl_l(t+1)$ $(t = 0, ..., T-1)$ are accordingly receipts and payments *of l*-th DM, generated during realization of the given project. T is validity (horizon of planning) of IP, N is quantity of DM. It is necessary to state, that the dynamic equations of DM's own means contain monetary streams of receipts and the payments, providing their current functioning. As streams of receipts and payments, depending on DM, the profit, depreciation charges, investments into the basic and turnaround means, sale of actives, release of securities, a payment, taxes, payment of dividends, grants, social payments, the sums of basic duty, the percent for credits, etc. can be considered. For example, for world industrial sector realization of production, amortization, internal and external investments can be related to strategic receipts, and to payments – percent under credits, taxes (with the added cost on property, profit, womb using etc.), and penalties for infringement of ecological and social restrictions. The currency margin and receipts as a result of the market reference in secondary securities can be considered as receipts for the world financial sector (the currency market and the market of derivative securities), and as payments, – for example, some world tax increasing monetary weight. It is necessary to note, that during the initial moment of time $t = 0$ WSES has a fixed initial condition: $Ds_l(0) = Ds_l^0$ $(l = 1, ..., N)$, where Ds_l^0 is the initial sum of money *of l*-th DM.

For the performance of the solvency condition, according to the precondition 4, current money resources of any DM are considered non-negative during all IP action periods:

$$Ds_l(t) \geq 0 \left(t = 1, ..., T; l = 1, ..., N\right). \quad (2)$$

Infringement of a condition (2) can be treated so, that in the WSES *l*-th DM, during some moment t will not have enough financial resources for IP realization. The specified condition as it has been noted above is obligatory for IP realizability for any economic agent. Thus, if for any DM during some moment of time the specified inequality is not executed, i. e. $\exists l \in \{1,...,N\}, t \in \{1,...,T\}: Ds_l(t) < 0$, process of realization IP will be named a crisis.

Let's consider, what proceeds from the production realization of $R_k(t)$ *k*-th industrial branch MSES satisfy the following restrictions:

$$R_k(t) \leq \min\left(q_k(t), E_k(t)\right)\left(k = 1, ..., n\right), \quad (3)$$

where $q_k(t)$ is the demand for production of k-th kind in cost expression during the moment t, $E_k(t)$ is the maximal, defined by technical opportunities of industrial branches (a level of scientific and technical progress), volume production of *k*-th kind in cost expression during the moment t.

As target criterion DM it is expedient to choose the net present value (NPV) for the monetary streams representing a difference in its strategic incomes and expenses in the form of:

$$\mathrm{NPV}_l = \sum_{t=0}^{T} \frac{\text{ДП}_l(t)}{(1+r)^t} \ \left(l = 1, ..., N\right),$$

where $\text{ДП}_l(t)$ are monetary streams *of l*-th DM during the moment t; r are the rates of IP profitableness.

It is necessary to note, that in a constant, the reference to a micro- or meso-level in world WSES stocks for the majority of resources is essentially exhausting (hence limited). Therefore, for *k*-th industrial branch the conditions should be satisfied:

$$\sum_{t=0}^{T-1} \sum_{j=1}^{n} \bar{a}_{kj} y_j(t) \leq \overline{A_k} \left(k = 1, ..., m\right), \quad (4)$$

where $y_j(t)$ is volume of output *of j-th* kind during the moment t, $\overline{A_k}$ are known world reserves *of k*-th resource, $\bar{a}_{kj}$ is the charge norm *of k*-th product (resource) for product (resource) manufacturing *of j*-th kind (factors of Leontiev's matrix), m is the quantity of cores kinds considered in the model: economic (natural) resources (land, water, minerals, etc.). Conditions (3) and (4) are one of basic restrictions in WSES functioning and their neglect can considerably lower, than the value of any global model.

Taking to the account precondition 3 and condition (4) the forecast of such a social sector characteristic as population $N(t)$ becomes of basically important. Assuming, that it is described as a linear difference equation of the 1st order $N(t+1) = (1+\nu)N(t)$, $(t = 0 ..., T-1)$, it is easy to obtain the obvious formula $N(t) = N_0(1+\nu)^t$ $(t = 0, ..., T-1)$, where N_0 is the initial number during the moment $t = 0$, n is the population increase factor for one period. From the last formula it is visible, that at $\nu > 0$ $N(t)$ increases exponentially. It is obvious that for the social sector, the inequality similar to (4) takes place:

$$\bar{b}_k \sum_{t=0}^{T-1} N(t) \leq \overline{A_k} \left(k = 1, ..., n\right), \quad (5)$$

where $\bar{b}_k$ is the middleperson *of k*-th product charge norm. To consider a problem of optimum performance (survival) of the world social-economic system for as long as possible, term $T \to \max$; in conditions of stock and world resources limitation, and a growing population, the optimum value T^* can fall short. After term $T \leq T^*$, during the accomplishment of the aforementioned positions – the exhaustion of one resource can lead to world crisis. It makes us think seriously of how rationally are the resources spent, and what actions are necessary for a steady development of the world economic system for delaying the crisis. It is possible to offer the following variants of global development management: 1) population regulation (management in parameter ν); 2) rationalization of resources per capita (management in parameters $\bar{b}_k$ in conditions (5)); 3) rational wildlife management (management in parameters $\bar{a}_{kj}$ in conditions (4)); 4) regulation of the subsystem manufacturing balance – population (for example, according to conditions (3)), manufacturing – financial sector, the population – financial sector, etc.

The described approach based on the concept resulted above, and an economic-mathematical kernel is approved for the solution of following problems of large economic

system analysis: 1) management of regional social-economic system development in application to the analysis of regional industrial policy; 2) the coordination of the manufacturer, the investor and the supplier of the equipment contract (a problem of firm development); 3) the restructuralization of large enterprises in the machine-building branch; 4) development of investment analyst workplaces in the construction industry, and hypothecary crediting.

Now the package of applied programs [5], facilitating the multicriterial dynamic analysis and static linear problems of economic dynamics is developed. The use of a specified package increases the validity of decision-making in the global social-economic development management; including the interests of many persons for the reception of WSES parameter ranges and the optimum values of the operating variables. This provides stable development for as long as possible.

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ELABORATION OF A VECTOR BASED SEMANTIC CLASSIFICATION OVER THE WORDS AND NOTIONS OF THE NATURAL LANGUAGE

The problem of vector-based semantic classification over the words and notions of the natural language is discussed. A set of generative grammar rules is offered for generating the semantic classification vector. Examples of the classification application and a theorem of optional formal classification incompleteness are presented. The principles of assigning the meaningful phrases functions over the classification word groups are analyzed.

Keywords: natural language generation, natural language semantics.

One of the most important problems of the formal languages theory, a subdivision of theoretical computer science, is the problem of syntactic and semantic analysis of a given language sentences. Respecting the study of the natural and machine language structure, the foreground is the problem of generating the natural language i. e. grammatically and semantically meaningful phrases and texts of such languages, which satisfying definite meaningfulness criteria. For example, the Turing test. The importance of the matter is determined by the significance of such applied tasks as building natural-language interfaces, developing expert systems, electronic translators, electronic summarizing systems, e-learning systems, advertisement of user dialogue software provision, etc.

The principle purpose of this research is to offer a classification of natural language words and notions, allowing the generation performance for the meaningful speech and definition of meaningful speech criteria. The basic task is to determine the classification vector for natural speech words and notions, creating a dictionary for the classification of a set of the commonest English words. This make possible the algorithms of meaningful speech generation based on the given classification, proving the theorem of the optional formal classification incompleteness for the description of the differences in natural language word meanings.

The novelty of the work is reduced to the distinguishing particularities and the application efficiency of the generative grammar, described above, for the generation of the vector coordinates for the natural language word and notion classification and the particularities of using the classification for natural language generation.

A great number of researchers currently work on the problem of generating the meaningful subset of the language:

philologists, programmers, mathematicians, semantics experts, philosophers, etc. [1; 2; 3; 4]. Especially surprising for today are results in generating natural language grammatically meaningful phrases. Text editors, electronic translators and other systems effectively carry out the generation of grammatically meaningful language structure. However, the generating process of semantically meaningful speech is a less studied topic. Although many systems based on semantic nets, speech graffiti, ontology and other methods, they still show good results in a dialogue with the natural language user. The most popular method of sustaining the dialogue with the user is reduced to the application of databases in natural language dialogues between people, participators of forums, etc. Insufficient developments are provided for the natural language phrases and texts presentation in the form of functions and functional clusters over a multidimensional semantic classification, in spite of the fact that the method shows its efficiency for the generation of meaningful speech [5; 6; 7].

Classification of Natural Language Words and Notions. Let's look at a semantic classification of natural language words and notions, reduced to 16 classes of language semes (semantic, meaning "atoms") and further to four gene-semes (elementary particles of meaning). Then to a notion of link (a meaning "quantum"), that can be shown based on the notional semantic nets' apparatus. The definition based on the meaning quantum is a semantic net with arcs baring the notion semantics of some elements' equivalence, which means a link between objects.

Using four elementary particles – gene-semes such as {system, classification, localization and perception} it is possible to determine the natural language. Localization is determined as an object, in which there is a similarity between all levels of the subsystems; for example, a triangle formed by the stars of a galaxy is similar to any proportional triangle created by the planet houses of the star system. Perception is defined as an object, where all the subsystems (perceived) are similar to the super-systems (perceiving). For example, a real image of a vase in the light specter will form an information similarity pyramid, at first in the pupil of the eye, and then in the brain. The structure is defined as an object with heterogeneous and super-systems. For example, the structure of the automobile body and wheels are heterogeneous. Classification is defined as an object with the similarity of all subsystems to the super-systems. For example, crab apples posses all the properties of apples, while apples posses all the properties of fruit.

Using four gene-semes it is possible to determine 16 classes of semes. We shall give some examples of such a definition for the semes class: "Basic semes":

– creature – perceiving and localized in space;

– thing – not perceiving and localized in space;

– mind – perceiving and not localized in space;

– abstraction – not perceiving and not localized in space;

– idea – perceived and not localizing in space;

– place – not obligatory perceived and localized in space;

– information – perceived and localizing;

– abstraction – not obligatorily perceived and not localizing.

The following basic classes of meaning atoms are determined as semes of the natural language:

1. Basic semes: creature, place, information and others.

2. Semes of probability: existing, non-existing, necessary, possible and the derived ones.

3. Semes-predicates: relation-x, relation-x-x, relation-creature-x and others.

4. Semes-arguments: subject, object, recipient, instrument and others.

5. Semes of localization: of, in, on, at and others.

6. Semes-relations: includes, is included in, includes and is included in, partially includes, is more than, is less than and others.

7. Semes-numbers: digits from 0 to 15.

8. Semes of indefinite number: all, many, some, few, no and others.

9–12. Semes of the language stylistics: positive – negative, low – high and others.

13–16. Semes, characterizing the description of images and forms: wide – narrow, stable – unstable and others.

Based on the natural language semes classification a natural language notions classification vector of five coordinates is offered. The values of the G vector coordinates are assigned by means of a generative grammar of the following form:

1. The first level of the notions classification corresponds to the coordinate G_1 of the vector G. Let G_1 = {something, relation, mind, idea, information, place, thing, creature}.

2. The second level of the notions classification is presented by the coordinate G_2. A set G_2 of the coordinates value for the classification is assigned by a set of generative grammar rules: {$S \to Fd$, $S \to Fx$, $d \to$ alive, $d \to$ not alive, $x \to$ which alive, $x \to$ which not alive, $f \to$ of, $f \to$ in, $f \to$ on, $f \to$ at}, where notion *At* means any not zero distance between objects.

3. The third level of the notions classification is determined by the coordinate G_3, G_3 = {*X–y* (essence), *X–X–y* (essence of essence), *отношение–X–y* (property), *отношение–X–X–y* (connection), *отношение-существо–X–y* (action), *отношение-существо–X–X–y* (joining), *отношение-существо-существо–X–y* (presenting), *отношение-существо-существо–X–X–y* (exchange)}, where *X* is any of the basic semes, determined on the first level of the classification, while *y* is any sequence of such semes. *X* is determined as the seme, main by its meaning. Sign "–" is used in the given case for concatenation notation. Essential explanations are shown in the round brackets.

4. A set of G_4 values of the coordinate G is assigned by a set of generative grammar rules: {$S \to P_1 \cdot P_2 \cdot P_3 \cdot P_4 \cdot P_5 \cdot P_6 \cdot P_7 \cdot P_8$, $P_1 \to g$·quantity, $P_1 \to \lambda$, $P_2 \to g$·stability, $P_2 \to \lambda$, $P_3 \to g$·positivity, $P_3 \to \lambda$, $P_4 \to g$·spectrum, $P_4 \to \lambda$, $P_5 \to g$·information content, $P_5 \to \lambda$, $P_6 \to g$·location, $P_6 \to \lambda$, $P_7 \to g$·size, $P_7 \to \lambda$, $P_8 \to g$·being artificial, $P_8 \to \lambda$}, where g is a linguistic scale value like: {minimal, … ,little, …, medium, …, big,…, maximal, λ}. Here λ is an empty symbol.

5. A set G_5 of the coordinate values G is assigned by a set of generative grammar rules: {$S \to x$, $x \to (xFx)$, $x \to xFx$, $x \to 1$ (existing), $x \to 0$ (non-existing), $x \to \Diamond$ (possible), $x \to \Box$ (necessary), $F \to$ includes, $F \to$is included in, $F \to$ includes and is included in, $F \to$ partially includes, $F \to$ more than, $F \to$ less than, $F \to$ equal to, $F \to$ similar to, $F \to$ becomes, $F \to$ derives from, $F \to$ is simultaneous to,

$F \rightarrow$ is not simultaneous to, $F \rightarrow$ implies, $F \rightarrow$ is determined by, $F \rightarrow$ corresponds to, $F \rightarrow$ is connected to}.

All further levels of the classification are formed by means of the recursive repeating the offered five levels of classification. The level index can be calculated by the formula $Gi = G\mathrm{mod}(i,5)$, where i belongs to the set of natural numbers. Any notion or class of notions for the natural language corresponds to a definite classification vector.

For example, the group of words {take, give, buy, sell, accept, present, etc.} correspond to the such a vector as [thing\\relation-creature-creature-*X*].

The group of words {shop, kiosk, supermarket, etc.} correspond to such a vector as [thing\in which alive*X*]+[thing\\relation-creature-creature-*X*].

The word "transport" corresponds to a vector: [thing\in which alive*X*] + [place\\relation-creature-*X*].

Each word corresponds to a set of semantic notions – points of the notions' space. However, using the five coordinates of the multidimensional classification vector is definite simplification. In the most complete form the classification can be based on 16 coordinates of a recursively repeating vector of values.

The principle of meaningful speech generation based on the offered classification has been tested by such software as: "Electronic Dictionary".

The Incompleteness of a Formal Classification Theorem is the basis for the given classification; let's introduce a definition of a conditionally complete classification and prove the theorem of semantic classification incompleteness.

Definition 1. Let's consider a system of words semantics representation as points of a vector space to be a conditionally complete, as for an optional element $a \in \{a', a'', a''' \ldots\}$, $b \in \{b', b'', b''', \ldots\}$, …, $c \in \{c', c'', c''' \ldots\}$ and vector $v\,[a, b, \ldots, c]$ it is true, as that for any notion A, $A \sim a' \vee a'' \vee a'''$ Ъ …, for any notion B, $B \sim b' \vee b''$ Ъ $b''' \vee \ldots, \ldots$ for any notion C, $C \sim c' \vee c'' \vee c''' \vee \ldots$, where "~" is a sign of correspondence.

Theorem. Any system of words semantics representation as points of a vector space is characterized by incompleteness. In other words, for any classification there exist words, with meaning elements being classified by the classification not completely. For any classification A of the words set $\{a_i\}$, where any $a_k \sim v[a^x, b^y, \ldots, c^z]$, the meaning of the word $S(a_k)$ includes the meaning shade $S(a_k)L_n$, such that $\neg (S(a_k).L_n \sim S(v[a^x, b^y, \ldots, c^z]))$, that is $\neg (S(a_k) \in S(v[a^x, b^y, \ldots, c^z]))$, where $a = \{a^1, a^2, a^3, \ldots\}$, $b = \{b^1, b^2, b^3, \ldots\}$, …, $c = \{c^1, c^2, c^3, \ldots\}$.

Let's show an example of transfer of the meaning out of the meaning, determined by a classification. In this way, the word light ~ *v*[action, …, from the surface, …, intensive, …], while $\neg$ (*S*(light).shining ~ *S*(*v*[action,…, from the surface,…, intensive, …])), so, the emotional and associative rows, determined by a person cannot be completely manifested by a formal classification. Consequently, a row of the meaning elements cannot be manifested by any formalism, for example it is impossible to explain a blind person what is the feeling of a color such as red, and therefore it is impossible for him to imagine it. This way the words correspond to positions in a classification according to the law of the excluded third, but meanwhile their meanings are not reduced to the division.

Lemma 1. A word meaning can have optionally large power. Proof. Let's understand the power of a word meaning as the power of set $\{S(a_k).L_j\}$ for a definite word a_k. Let the word a_k meaning is assigned by definition in the form of a semantic net $\{L_j(L_{j'},L_{j''})\}$. The word a_k is correlated with an object of reality, being in a system of relations with outer objects, parts of the system and the perception of the system; because of the fact that relations with outer objects of reality (distance, concatenation, simultaneousness) determine the meaning $\{L_j(L_{j'},L_{j''})\}$, where $L_{j''}$ is an outer object, and the reality (for example, space points set, a quantity of literary worlds, time, subsets of sets of objects and points) is principally endless, so the set of word meaning is principally limited by nothing. $\{L_{j''}\} = \infty \vdash \{L_j(L_{j'},L_{j''})\} = \infty$.

For example, the meaning of any word can be always increased: a reading student, a student reading a book, a student sitting and reading a book, etc. – without limitation.

Lemma 2. The quantity of possible words with different semantics is endless. Proof. $\{L_j(L_{j'},L_{j''})\} = \infty \vdash \{L_j\} = \infty \vdash \{S(a_k).L_j\} = \infty$, because of the fact that word a_k can be optional.

Proof. Let classification A be assigned by a vector of coordinates $v[a, b, \ldots, c]$, where $a_k \sim v[a^x, b^y, \ldots, c^z]$ and $S(a_k).L_j$ is an element of a_k word meaning and where $a = \{a^1, a^2, a^3, \ldots\}$, $b = \{b^1, b^2, b^3, \ldots\}$, …, $c = \{c^1, c^2, c^3, \ldots\}$. For any a_k, let it be true that $v[a^x, b^y, \ldots, c^z] \sim S(a_k)$. For any coordinate d of vector $v[a, b, \ldots, c]$: $d = \{d' \vee \neg d'\} \cup \{d'' \vee \neg d''\} \cup \ldots$. Let's assign value $g = \{g' \vee \neg g'\} \cup \{g'' \vee \neg g''\} \cup \ldots$, where $g \neq a$, $g \neq b$, …, $g \neq c$. As a result of the union of the classification vectors $v[a, b, \ldots, c]$ and $v'[g]$, vector $v''[a, b, \ldots, c, g]$ is obtained. It is evident, that according to lemma 2, such a $S(a_r).L_h$ can be found that $S(a_r) \in v''[a, b, \ldots, c, g]$. Let's consider a set of such meaning elements $E = \{S(a_r).L_h\}$, $I = \{S(a_k).L_j\}$. $I \in E$. The sets are different, if g is not empty, because $g \neq a$, $g \neq b$, …, $g \neq c$. Let $Y = E - I$.

If such a classification $v[a, b, \ldots, c]$, can exist, that set Y is always empty, than it will be always that either $S(g) = 0$, or $S(g) \in S(a) \cup S(b) \cup \ldots S(c)$. Let's assign a word a_t such that $S(a_t) = S(v[a, b, c])$. Let's show that it is always possible to select such g, that Y will be not empty; because of lemma 2, a word a_f, can be found, such that $S(a_f) = S(v[a, b, \ldots, c, g])$ and such that its semantics will be always different from the a_t word semantics. In other case $\{S(a_{t'})\} \neq \infty$, where $S(a_{t'})$ is any meaning of the word-classification. Correspondingly, in this respect the set Y will not be empty and the complete classification $v[a, b, \ldots, c]$ cannot exist, the theorem has been proved.

In this way, a meta-notion always exists that adds an extra meaning into the classification of words. It means that, no word classification can generate all words meaning. The given theorem is correlated with the Gцdel's theorem about the incompleteness of formal systems.

The Principles of Meaningful Natural Language Generation. Let's consider the principles of meaningful speech generation based on the offered vector based classification (see the figure).

The structures of different levels are formed over the given semantic classification of words and notions of the natural language. On the first level there are word groups of the language, on the second level they are united into

word combinations – pairs of words linked semantically and grammatically, on that level the combinations of words more or less useful as word combinations are assigned. On the second level the words are united into patterns for example: "Determiner + Attribute + Subject + Modality + Predicate + Determiner + Attribute + Object + Link + Determiner + Attribute + Nominal Group (Modifier of Time) + Link + Determiner + Attribute + Nominal Group (Modifier of Place) + Link + Determiner + Attribute + Nominal Group (Modifier of Purpose) + …". Semantic chains of the type are presented in the following way: "this/that/… + hungry/full/… + vegetarian/gourmand/… + can/wants to/… + eat/cook/… + the/a/… + tasty/aromatic/… + pie/salad/… + after/before/… + five/six/… + hours + in/for/… five/six/… + minutes + … + in + a + big/beautiful/… + restaurant/canteen/… + on + a + big/beautiful/… + street/square/… named after Smith/Brown/… + in + a + big/beautiful/… + city/village/… + Ababa/Acaca/… + in order to/to/… + taste/know/… + a + pungent/spicy/… + taste/aftertaste/… + …". On the forth level words are separated into subsets of these patterns: "I/he/… + have eaten/tasted/… + on a street/square/… + named after + Smith/Brown/…". On the fifth level the fragments of the patterns are united into semantic patterns of the second rank: "the taste of a pie surprised me in the morning" (pattern type: Relation-Attribute_of_Object-Time), "The restaurant gladdened me with a crunching crust". (pattern class: Relation-Place-Part_of_Object). Generation and ordering the semantic patterns of the second rank is an important task determining the success of the system for natural speech generation by software means. Example of semantic patterns of natural speech generation are shown in the table:

the…этот...	of the…чего…	is... является...	…-а/у-йте(сь)	the...этот...	stuff предмет
taste вкус	berry ягода	sweet сладкий	enjoy наслаждаться	good хороший	thing вещь
after-taste привкус	strawberry клубника	sour кислый	feel чувствовать	great великолепный	object объект
smack привкус	raspberry малина	salty соленый	savor смаковать	excellent отличный	gem прелесть
flavor вкус	gooseberry крыжовник	bitter горький	discuss наслаждаться	wonderful чудесный	must важная вещь
	currant смородина	pungent острый	identify узнать	superior превосходный	trifle мелочь
	bilberry черника	weak слабый	notice заметить	splendid великолепный	process процесс
	blackberry черная смородина	strong сильный	learn узнавать	magnificent сказочный	time время
	cranberry клюква		experience испытать	surprising удивительный	moment момент
	sweet cherry черешня			lovely красивый	
	cherry вишня			worthy стоящий	
	grape виноград			useful полезный	
	raisin изюм			funny забавный	

In conclusion it is necessary to notice that the method semantic classification and assigning different levels structures on it is a perspective method of analysis and synthesis of a natural language and meaningful speech generation; the offered classification is new, its efficiency in the sphere of meaningful speech generation has been shown with corresponding software products.

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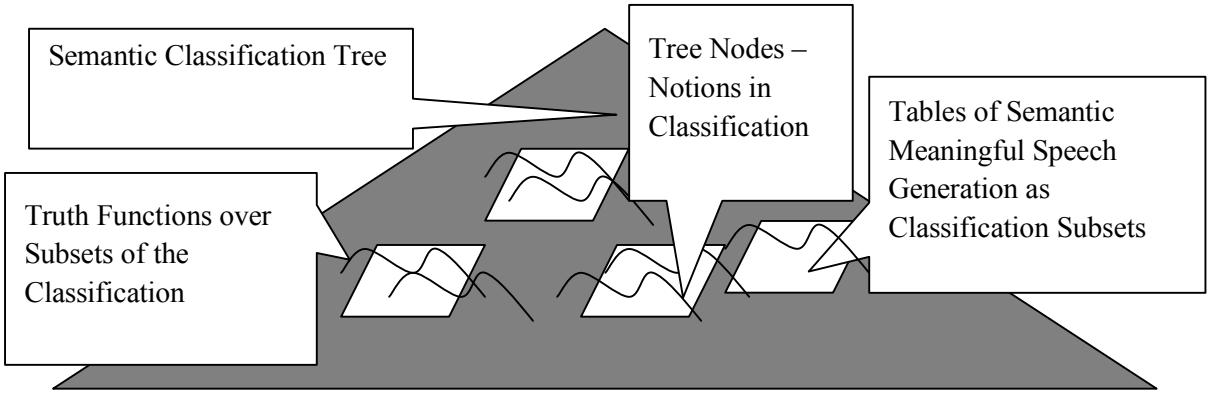

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MODELING PHASE FUNCTION OF CONTROLLED DIFFRACTION ELEMENTS ON THE BASIS OF LINEAR ELECTRO-OPTICAL EFFECT*

A design of controlled diffractive optical elements based on electro-optic effect is suggested. The influence of the electro-optical crystal orientation, the direction of light wave propagation and the electric field distribution on the characteristics of controlled diffractive optical elements is considered. The efficiency indicators of controlled diffraction elements structure and material are proposed and their values for the basic elements are calculated.

Keywords: electrostatic field, electro-optical effect, controlled diffraction element.

Elements and devices based on the electro-optical effect are widely used to control parameters of optical illumination, e. g. intensity, phase, state of polarization, spectral composition [1]. Their advantages are high speed (GHz units), great nomenclature of functional materials with various physical properties. Volume and planar modulators, switchboards, deflectors of broadband and laser illumination, tunable spectral filters etc. are developed on the basis of the electro-optical effect at present.

Development of electro-optical controlled diffraction structures (CDS) with a tunable phase function [2–4] is one of the promising directions of creating devices of this kind. In general, the design of such elements includes electro-optical material, control electrodes with individual or group addressing ensuring the required distribution of the material as will as a complex of functional coatings possessing electro insulation, protective, spectroforming or polarization-selective functions (fig. 1).

Changing the kind of phase function with the help of single or multichannel voltage source results in forming a certain diagram of orientation of such a structure and changing its spectral composition.

The aim of this study is to model the phase function of controlled diffraction structures.

Since CDSs based on diffraction gratings form periodic structures a system of conventional symbols to designate the structures has been developed for the sake of convenience. The system of designations of controlled diffraction structures is based on constructional indicators of the basic element. By the basic element the elementary part of the structure is meant, which, repeated many times, forms CDS. The system takes into account the number and type of electrodes (continuous, discrete) on each surface of the element, the distraction of potentials over the electrodes, the presence of functional coatings. The following structural formula is proposed for the designation of basic optical elements:

$$N_1 \frac{(X_1 - Y_1 - Z_1) : P_1}{(M_1 - R_1 - K_1) : T_1}$$

where N_1 is the number of times the basic structure is repeated; X_1, M_1 – the number of electrodes in the top (bottom) layer of the basic structure; $Y_1 = \{^N_D$, $R_1 = \{^N_D$ is the type of electrodes in the top (bottom) layer (continuous N or D); Z_1 indicates the potential distribution over the top (bottom) electrodes (0 for equal potentials of all electrodes, 1 for different potentials of electrodes); $P_1 = \{^0_1$, $T_1 = \{^0_1$ presence or absence of the functional top (bottom) layer of the basic structure.

Examples of the main types of basic elements with their designations and descriptions are given in table 1.

The analysis of the structure of electric fields in diffraction CDS shows that the field structure is quite complex, therefore the type of the electro-optical effect used essentially depends on the relationship between the CDS geometrical dimensions and properties of the electro-optical material. Because of this to assess the efficiency of the

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structure and of the type of electro-optical effect used local and integrated indicators of element efficiency have been stated: the indicator of the predominant type of electro-optical effect (1) and the indicator of CDS electro-optical efficiency (2). These indicators take into account both the structural design of the element and the properties of the electro-optical materials and control means chosen. They make it possible to optimize the parameters of the diffraction element controlled by a given indicator or a group of indicators:

$$g_{i,j} = \frac{\left|E^x_{i,j} \cdot n_{i,j} \cdot a^x_{i,j}\right| - \left|E^y_{i,j} \cdot n_{i,j} \cdot a^y_{i,j}\right|}{\left|E^x_{i,j} \cdot n_{i,j} \cdot a^x_{i,j}\right| + \left|E^y_{i,j} \cdot n_{i,j} \cdot a^y_{i,j}\right|}; \quad (1)$$

$$G = \sum_{i=1}^{n}\sum_{j=1}^{m} g_{i,j} =$$

$$= \frac{\sum_{i=1}^{n}\sum_{j=1}^{m}\left|E^x_{i,j} \cdot n_{i,j} \cdot a^x_{i,j}\right| - \sum_{i=1}^{n}\sum_{j=1}^{m}\left|E^y_{i,j} \cdot n_{i,j} \cdot a^y_{i,j}\right|}{\sum_{i=1}^{n}\sum_{j=1}^{m}\left|E^x_{i,j} \cdot n_{i,j} \cdot a^x_{i,j}\right| + \sum_{i=1}^{n}\sum_{j=1}^{m}\left|E^y_{i,j} \cdot n_{i,j} \cdot a^y_{i,j}\right|}, \quad (2)$$

where $|E^x_{i,j}|$, $|E^y_{i,j}|$ are absolute values of the electric field intensity vector projections along the coordinate axis x, y; i, j are discrete coordinates of the points in space where functional is calculated; n, m – number of points in the discrete space along the axes x, y respectively; $n_{i,j}$, $a^x_{i,j}$, $a^y_{i,j}$ are the refractive index of the electro-optical material and the projections of light wave propagation vectors along the x, y coordinate axis for the i, j point of discrete space.

Here the indicator $g_{i,j}$ characterizes the efficiency of electro-optical effect in the chosen point of space (local indicator), the indicator G characterizes average integrated efficiency of the basic element (integrated indicator).

A special case of (1), (2) is the case when the direction of light wave propagation coincides with one of coordinate axes x, y. Then the expressions for efficiency indicators become:

$$g_{i,j} = \frac{\left|E^x_{i,j}\right| - \left|E^y_{i,j}\right|}{\left|E^x_{i,j}\right| + \left|E^y_{i,j}\right|}; \quad (3)$$

$$G = \sum_{i=1}^{n}\sum_{j=1}^{m} g_{i,j} =$$

$$= \frac{\sum_{i=1}^{n}\sum_{j=1}^{m}\left|E^x_{i,j}\right| - \sum_{i=1}^{n}\sum_{j=1}^{m}\left|E^y_{i,j}\right|}{\sum_{i=1}^{n}\sum_{j=1}^{m}\left|E^x_{i,j}\right| + \sum_{i=1}^{n}\sum_{j=1}^{m}\left|E^y_{i,j}\right|}. \quad (4)$$

Variation of the values of local and integrated indicators $g_{i,j}$ and G ranges from minus one (–1) for the longitudinal (along the y coordinate axes) electro-optical effect to plus one (+1) for the transverse (along the x coordinate axis) electro-optical effect. Having set the threshold value of the indicator chosen (e. g. 0.1) we can obtain numerical assessment of the efficiency of the electro-optical diffraction element modeled.

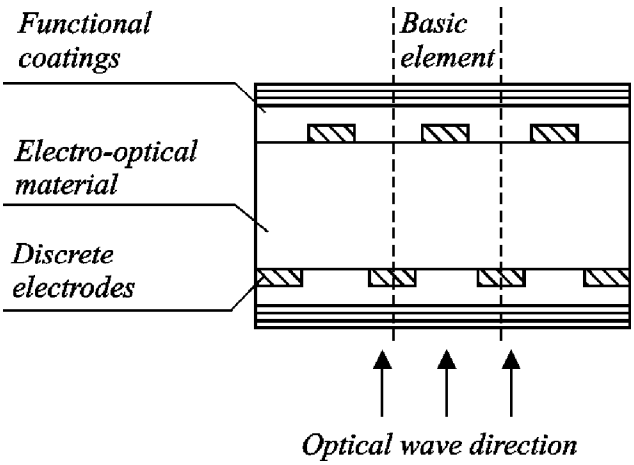

Fig. 1. General view of the controlled diffraction structure

Figures 2, 3 give examples of local efficiency indicator $g_{i,j}$ distribution for basic elements of the type (2-*D*-1) and (2-*B*-1):1/(1-*N*-*D*):

As can be seen from figure 2 the element (2-*D*-1):1 with the design and geometry parameters chosen provides

Table 1

Examples of CDS basic element structures and their designations

Symbol	Designation short description	Structure of the basic element
$\frac{1-N-0}{1-N-0}$	Series structure with one top and one bottom continuous electrodes without functional layers	
$\frac{2-D-1}{1-N-0}$	Series structure with two discrete electrodes having different potentials in the top layer and one continuous electrode in the bottom layer without functional layers	
$\frac{(2-D-1):1}{1-N-0}$	Series structure with two discrete electrodes having different potentials in the top layer and one continuous electrode in the bottom layer with one top functional layer	
$2\frac{(2-D-1):1}{1-N-0}$	Series-parallel structure consisting of two basic elements each of which comprises two discrete electrodes with different potentials in the top layer and one continuous electrode in the bottom layer as well as one top functional layer	

practically 100 percent transverse electro-optical effect in the central area and mixed effect in side areas. Therefore for the possibilities of the element in question to be used efficiently one should choose (by the value of the integrated indicator) the type and orientation of the electro-optical material which provide the transverse electro-optical effect.

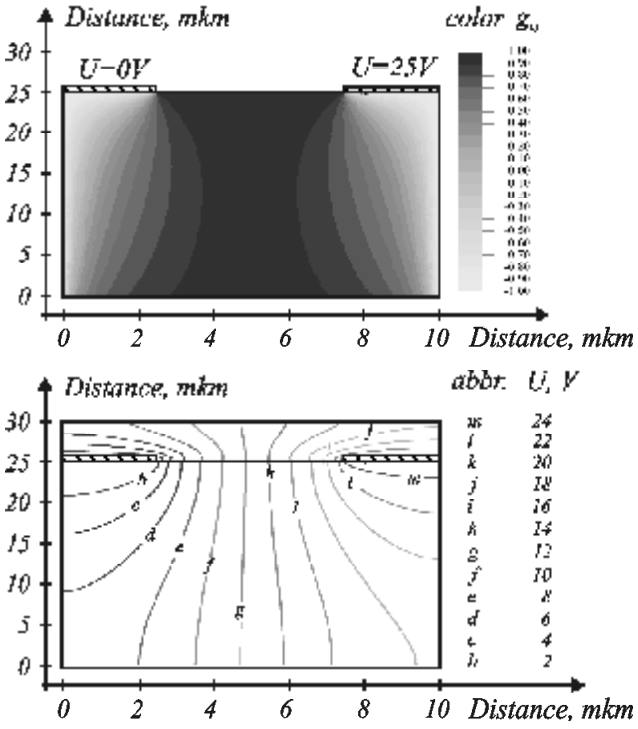

Fig. 2. Example of local efficiency indicator gi,j distribution in a basic element of the type (2-*D*-1):1

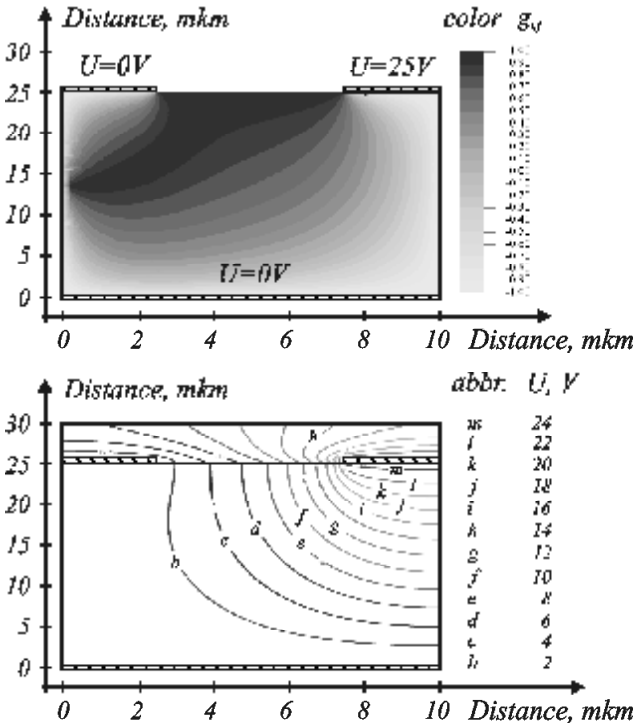

Fig. 3. Example of efficiency indicator gi,j distribution in a basic element of the type (2-*B*-1):1/(1-*N*-*D*)

The element of the type (2-*B*-1):1/(1-*N*-*D*) from figure 3 provides mixed electro-optical effect in the interelectrode area, of predominantly by transverse nature in the upper part and of longitudinal nature in the lower part. Therefore, for the possibilities of the element in question to be used efficiently one should carry out additional investigation of electro-optical efficiency for various orientations of the crystal optical axis and the direction of optical radiation propagation in the crystal.

The element of this type is fundamentally different from the one discussed above in that it makes possible to obtain inclined linear or non-linear phase profiles since the areas of predominantly transverse and longitudinal effects have approximately triangular distribution.

For more precise mathematical modeling of processes in CDS the relationship is defined between the refractive index for a light wave with arbitrary direction and state of polarization on the one hand, and the type and orientation of the electro-optical crystal, the electric field intensity, on the other. As a result, a mathematical model has been developed that takes into account the change in the optical indicatrix of the electro-optical crystal when acted upon by the components of electric field in an arbitrary oriented crystal and the final formula is derived relating the value of refractive index n_{p2} to the initial data of the problem:

$$n_{p2} = \frac{\sqrt{\left(k_{2z2}b_2 - b_3k_{2y2}\right)^2 + \left(b_3k_{2x2} - k_{2z2}b_1\right)^2 + \left(b_1k_{2y2} - k_{2x2}b_2\right)^2}}{\sqrt{B+C+D+E+F+H+J}};$$

$$B = b_1b_3k_{2x2}k_{2y2}d_3 - 2b_1b_3k_{2x2}k_{2z2}c_2 + b_3^2k_{2x2}^2c_2;$$

$$C = -b_2b_3k_1^2d_3 + b_3^2c_1k_{2y2}^2 + b_3b_2k_{2x2}k_{2z2}d_1;$$

$$D = -2b_2b_3k_{2y2}k_{2z2}c_1 + c_1k_{2z2}^2b_2^2 - b_1b_3d_2k_{2y2}^2;$$

$$E = b_1b_2k_{2y2}k_{2z2}d_2 + b_1^2k_{2y2}^2c_3 - k_{2x2}k_{2y2}b_3^2d_1;$$

$$F = -2k_{2x2}k_{2y2}b_1b_2c_3 + k_{2x2}k_{2y2}b_2b_3d_2 - k_{2x2}k_{2z2}b_2^2d_2;$$

$$H = k_{2x2}^2b_2^2c_3 - k_{2y2}k_{2z2}b_1^2d_3 + k_{2y2}k_{2z2}b_1b_3d_1;$$

$$J = -b_1b_2k_{2z2}^2d_1 + k_{2x2}k_{2z2}b_1b_2d_3 + k_{2z2}^2b_1^2c_2,$$

where k_{2x2}, k_{2y2}, k_{2z2} are coordinates of the light wave vector in the coordinate system of the crystal and coefficients b_1, b_2, b_3, c_1, c_2, c_3, d_1, d_2, d_3 are:

$$b_1 = \left(p_{2y2} + \frac{p_{2z2}\left(k_{2y2}p_{2x2} - k_{2x2}p_{2y2}\right)}{k_{2x2}p_{2z2} - k_{2z2}p_{2x2}}\right);$$

$$b_2 = -p_{2x2};\ \ b_3 = -\frac{p_{2x2}\left(k_{2y2}p_{2x2} - k_{2x2}p_{2y2}\right)}{k_{2x2}p_{2z2} - k_{2z2}p_{2x2}};$$

$$c_1 = \left(\frac{1}{n_{x2}^2} + r_{11}E_{x2} + r_{12}E_{y2} + r_{13}E_{z2}\right);$$

$$c_2 = \left(\frac{1}{n_{y2}^2} + r_{21}E_{x2} + r_{22}E_{y2} + r_{23}E_{z2}\right);$$

$$c_3 = \left(\frac{1}{n_{z2}^2} + r_{31}E_{x2} + r_{32}E_{y2} + r_{33}E_{z2}\right);$$

$$d_1 = 2\left(r_{61}E_{x2} + r_{62}E_{y2} + r_{63}E_{z2}\right);$$

$$d_2 = 2\left(r_{51}E_{x2} + r_{52}E_{y2} + r_{53}E_{z2}\right);$$

$$d_3 = 2\left(r_{41}E_{x2} + r_{42}E_{y2} + r_{43}E_{z2}\right),$$

where n_{x2}, n_{y2}, n_{z2} are refractive indices of the crystal in the absence of electric field; r_{lk} are electro-optical coefficients, m/V; E_{x2}, E_{y2}, E_{z2} are field intensity projections along the crystal axis, V/m; p_{2x2}, p_{2y2}, p_{2z2} are polarization vector coordinates.

To calculate the electrostatic field in the anisotropic medium various methods of solution were analyzed: method of mirror images, method of conformal images as well as methods based on finite difference approximation. Eventually, preference was given to numerical methods as being the most universal ones. The Flex PDE 5.0 program using an adaptive triangular grid was used to calculate the electrostatic field in CDS. Software developed by the authors made it possible to define the phase function $\varphi(x)$ at the output of CDS (taking into account the state of polarization p_{2x2}, p_{2y2}, p_{2z2} and electro-optical coefficients r_{lk}):

$$\Delta\varphi(x) = \frac{2\pi}{\lambda_0}\int_0^h \Delta n\left(E_a(x,y), E_c(x,y)\right)dy \qquad (5)$$

where λ_0 is the wavelength of radiation used, m; h is the thickness of the electro-optical material, m; Δn is variation of refractive index under the influence of electrostatic field; $E_a(x,y)$, $E_c(x,y)$ are field intensity projections on a- and c- axes of crystal, respectively, V/m.

As a result of modeling it has been found that CDS of various types can be developed on the basis of structures like (2-*B*-1):1/(1-*N*-*D*), for example, structures, dissipating illumination as well as controlled blazed diffraction structures if the electrostatic field intensity vector $E_x(x,y)$ between any two neighboring electrodes points in one direction.

Figures 4, 5 show phase functions (5) for the basic element of the (2-*B*-1):1/(1-*N*-*D*) type on the basis of *a*-cut of barium-strontium niobate, *SBN:75* grade, *c*-axis of which is perpendicular to the one-dimensional grid of control electrodes. The width of electrodes and the size of the diffraction slit was 5 mkm, electrode thickness was 0.5 mkm, the direction of light wave propagation was parallel to the *x*-axis of the crystal. The thickness of the protective coating (silicon dioxide) was 0.11 mkm.

From figures 4, 5 it follows that a change in the crystal thickness affects the electrostatic field distribution and the kind of phase function formed. As for changing the electrode potentials, it determines only the height of phase function profile, changes the diffraction efficiency of the element and restructures the CDS along the wavelength of illumination.

Figure 6 gives the phase function (5) of the element (2-*D*-1):1 with the following parameters: electro-optical material – barium-strontium niobate, *SBN:75* grade, *c*-axis of which is perpendicular to the one-dimensional grid of control electrodes, the width of electrodes and the size of the diffraction slit is 5 mkm, electrode thickness is 0.5 mkm, the direction of light wave propagation is parallel to the *a*-axis of the crystal. The thickness of the protective coating (silicon dioxide) is 0.11 mkm.

Thus, it can be seen from figure 6 that:

– the kind of phase function formed is quasirectangular with the geometry defined by the width and period of arrangement of CDS electrodes;

– changing electrode potentials defines only the height of phase function profile.

Analysis of CDS with different crystal thickness has shown that for thickness of *SBN:75* of the order of 2–3 CDS periods of electrode grid and more the kind of phase functions remains practically unchanged, i. e. approximately rectangular.

Thus model dependences obtained and calculations make it possible to announce the creation of a new class of tunable diffraction elements that realize phase functions of an arbitrary type, e. g. nearly rectangular, linear, square-law etc., which makes it possible to realize elements and devices performing the functions of switching modulation, deflection of optical radiation as well as changing (correction) of its directly diagram.

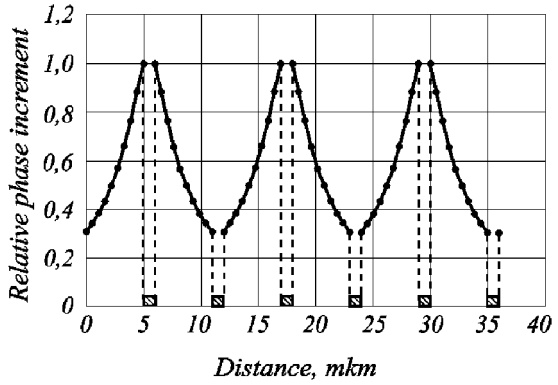

Fig. 4. Relative distribution of phase increment along the width of the diffraction slit of the element (2-*B*-1):1/(1-*N*-*D*) with crystal thickness 11 mkm

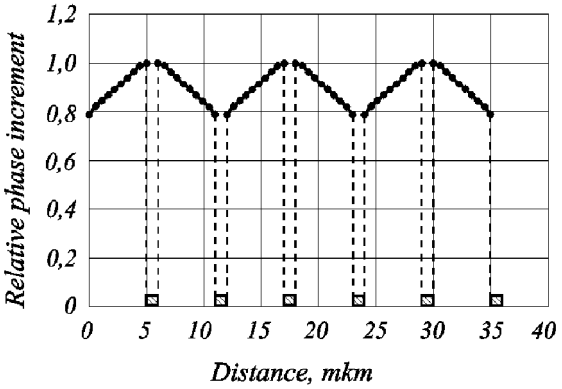

Fig. 5. Relative distribution of phase increment along the width of the diffraction slit of the element (2-*B*-1):1/(1-*N*-*D*) with crystal thickness 100 mkm

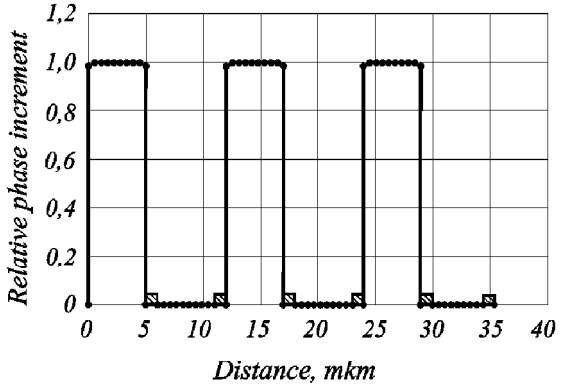

Fig. 6. Relative distribution of phase increment along the width of the diffraction slit of the element (2-*D*-1):1 with the crystal thickness 100 mkm

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ACTIVE METAMATERIAL ON THE BASE OF INTEGRAL NEMS-STRUCTURES*

The conception of integrated nanoelectromechanical systems (NEMS) formation method is considered. The method is based on original combination of self-organizing and self-aligning processes. The functionality of proposed NEMS-structures and possible applications of nanomaterial which constituted by two-dimensional array of such structures are discussed. The results of experiments directed to proposed NEMS-technology realization are led.

Keywords: nanoelectromechanical systems (NEMS), carbon nanotubes, NEMS sensors, active nanomembranes, active molecular sieves, active nanomaterial, active metamaterial.

Historically the first functional structures implemented by men for substance and information manipulation were mechanical – from stone axe to printing presses and arithmometers. Transistor invention in the second half of 20-th century became the reason of transition to systems of entirely electronic functioning principle. This has opened the path to the vast increase of information processing effectiveness. However it is interesting that on the new level of miniaturization "mechanics" is becoming relevant again and the next break-through can be made exactly on it. And it takes place both in information processing (substance and energy drawing in is forced necessity) and in substance processing (substance and energy drawing in is substantial part of process). Combination of electrical and mechanical principles in one electromechanical structure is especially perspective approach. However at the present time integral electromechanical systems adoption is restraining by limitations of photolithography witch lies in the base of common production technology. Though methods of sacrificial layer and self-organizing objects are used in some projects witch allows single sizes of functional structures elements to overcome limits of photolithography resolution, however the overall scale of integration remains hard constrained with the last. As a result the break-through products based on nanoelectromechanical systems (NEMS) have not been proposed to date.

Proposed NEMS-structures and preparation method. Main features of proposed NEMS-structures technology are following. The initial process that defines structure geometry is process of vertical carbon nanotube growth. It is the process of self-organizing that is why carbon nanotubes yield by it are characterized by high structural perfection while their diameter can reaches 0.7 nm. So small objects possessing perfect structure cannot be obtained beyond the scope of self-organizing methods ("bottom-up" methods) independently to progress perspectives of lithography methods ("top-down" methods). The current state of the arts includes approaches to adjacent vertical carbon nanotubes array formation there nanotubes stick together by Van der Waals forces. This is a classical application of, precipitation, precipitation the method of precipitation from gaseous phase for the growth of carbon nanotubes.

However, for the creation of the array of NEMS-structures, the array of separate vertical carbon nanotubes, divided by big enough gaps is necessary. To separate the nanotubes by gaps and to mechanically fix them in a vertical position, the growth of the carbon nanotubes on catalyst particles, rooted into the substrates from alumina or titanium oxide, is used in the work as particular way. The vertical sides of pores set the direction of growth of the nanotubes. It should be noted that to root the catalyst into the pores the original method of nickel sol-gel catalyst was developed.

Then on the substrate with the array of vertical carbon nanotubes 3 functional layers are formed: the metal layer (the input electrode), the layer of amorphous carbon (output electrode or- the controlling electrode) and the dielectric layer, separating them.

At the next stage physical mechanisms, providing the transmission of the geometry of each of the grown carbon nanotubes to the controlling electrode, are enacted. With

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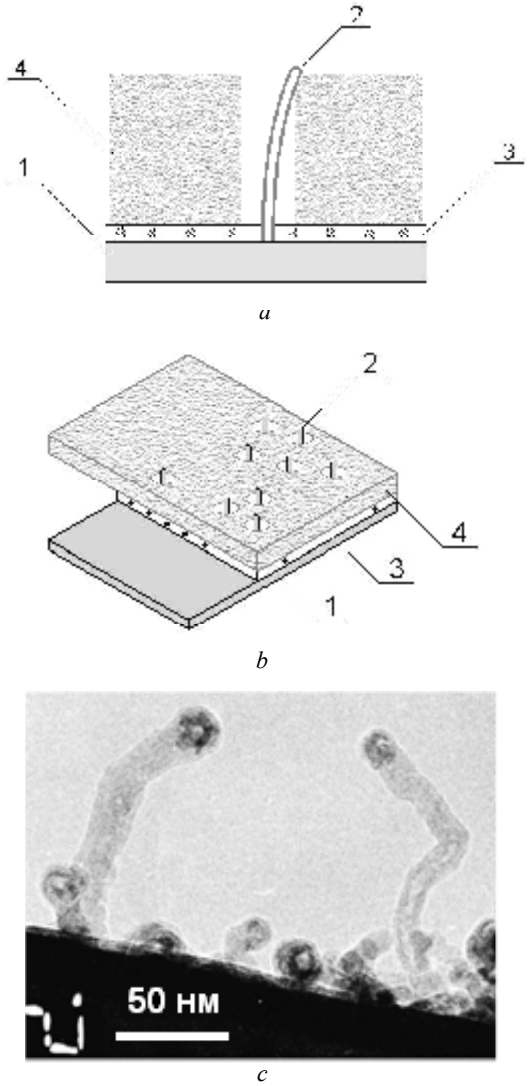
this aim the method of self-alignment was developed and applied for the fist time. This method is based on local anode oxidation (LAO) of the controlling electrode by the carbon nanotube. One of the most famous technological applications of scanning atomic-force microscopy is the modification of the properties of the conducting substrates by means of oxidation, induced by the probe of the atomic-force microscope [1]. Due to the fact that the oxidation is mediated by the probe, it has a local character. This allows to achieve high spatial resolution, which is determined by the geometry of the probe of the atomic-force microscope, namely by the effective radius of its curve. As the negative pole of the bias voltage (cathode) is applied to the probe of the atomic-force microscope and the positive pole (anode) is applied to the treated substrate, this process is the anode oxidation. Despite the fact the method of LAO demonstrates high spatial resolution, exceeding the one for photolithography, this method should be referred to as the experimental technique, rather than technology because it is based on the principle of successive treatment (it implies the increasing of time expenditure proportionally to the quantity of the elements formed). This circumstance is the main limitation of technological possibilities of the scanning probe microscopy as such.

In this work it is proposed to combine the function of the instrument of lithography (in this case – the function of the probe, inducing LAO) and the function of the operated element of the NEMS-structure. With this aim, every carbon nanotube grown on the substrate of the array should be considered as the stationary analogue of the probe of the atomic-force microscope. Having formed the layer of the certain conductive material so that it contacts with such a nanotube (in the considered case it is the layer of the controlling electrode) and having applied the bias voltage of corresponding polarity between this layer and the nanotube, one can initiate the oxidation of this layer in the area localized around the nanotube. If the products of oxidation are volatile compounds, no additional operations will be necessary to produce the gap between the nanotube and the conductive layer. Amorphous carbon can be considered as an example of the conductive layer satisfying this condition. In the process of anode oxidation the carbon nanotube plays the role of the cathode and remains stable, while the layer of amorphous carbon acts as the anode and is oxidized in the area bordering the nanotube with the production of CO_2 (carbon dioxide). The structures obtained at the end of the described process are the array of separate vertical carbon nanotubes, transpiercing the layer of the controlling electrode and separated from it by coaxial cylindrical gaps (fig. 1). It should be noted that the nanotubes shown in figure 1, *c*, were obtained with the help of the training-research plant CVDomna in the conditions close to domestic in the degree of purity that is why their structure is characterized by the considerable deficiency. Nevertheless, this examples shows that even in such extremely contaminated from the point of view of traditional microelectronics conditions integral conductors with the diameter of 15...20 nm are organized, which exceeds the possibilities of photolithography. In the less contaminated conditions carbon nanotubes with the higher degree of structural perfection can be produced.

An interesting possibility appears if chemically inert metal (e. g. gold) is used as the controlling electrode and the multilayer carbon nanotube – as the operated element. In this case the exchange of polarity of the applied bias voltage for the opposite allows to initiate the anode oxidation not of the controlling electrode but, at least, of one of the external layers of the nanotube itself. It leads to removing of the external layers of the multilayer nanotube. The minimal gap, separating the nanotube from the gold electrode, produced in this way will strictly correspond to the interlayer distance of the carbon nanotube, which is 0.33 nm. This figure can be considered as the limit of the resolution power of the suggested method of self-alignment of the controlling electrode.

The gap produced in such a way besides little breadth will be characterized by the perfect geometry. It should be noted, that in the corresponding experiments carried out by the author by means of atomic-force microscopy it became clear that the multilayer carbon nanotubes are prone to oxidize discretely, by layers, which is explained by the cardinal difference between thermodynamic stability of the whole and interfered layers.



a

b

c

Fig. 1. The schematic image of the NEMS-structure in it's one of bistable states (*a*); the intermediate step of structure formation (TEM image) (*b*); the schematic image of integral NEMS-structures array fragment (*c*); 1 – input electrode; 2 – carbon nanotubes; 3 – dielectric layer; 4 – amorphous carbon layer

In general, instead of carbon nanotubes in the described method of forming of the integral NEMS-structures some other one-dimensional objects of self organization (nanowires) can be used.

Owing to the method of production and mechanism of functioning (see the next section) of the described NEMS-structures in general, there are no demand to the order of arrangement of the carbon nanotubes, their length, chirality and the defects. This is especially important from the point of view of flexibility and applicability of the proposed NEMS-technology.

The main functionality. Let us consider the main functionality of the described structures. The carbon nanotube and the controlling electrode in every structure make up two coaxial independent electrodes, separated by a nanometer or a subnanometer gap. So, the first functionality is in creating of an electrical field in small special areas. Due to extremely small length of these areas, the voltage of the created electrical field can vary in the widest bounds and reach the quantities compared to intra-atomic (important for the described below applications of NEMS-reactors and NEMS-nanomembranes.) Further, as the carbon nanotube is separated from the controlling electrode by the gap, it is free to make mechanical movements, including oscillations on its own frequencies. The entrance electrode is electrically connected with the nanotube. The application of the bias voltage allows to affect the nanotube by means of Coulomb force. At a certain figure of the applied bias voltage, the resilient deformation of the nanotube provides transition of the nanotube into the condition of a mechanical and, consequently, electrical contact with the surface of the controlling electrode (fig. 1, *a*). In this condition the nanotube provides the electrical transport between the input and controlling electrodes. At the fairly small breadth of a separating gap the force of the resilient deformation of the nanotube, trying to return it to the initial vertical position, is less than Van der Waals force, acting in the spot of contact of the nanotube with the controlling electrode. It provides the stability of this state of the system. To return the nanotube to a free state it is necessary to apply the same potential to the input and the controlling electrodes, so that the repulsion Coulomb force together with the force of resilience exceeds Van der Waals force. So, the described NEMS-structure can exist in two stable states.

By applying alternating bias tension between the nanotube and the controlling electrode mechanical oscillations of the nanotube can be achieved. In the case of coinciding of the frequency of the applied voltage with the frequency of the nanotube, oscillations of the latter move into resonance regime and their amplitude increases sharply. This leads to the contact between the nanotube and the entrance electrode. As a result of the action of Van der Waals forces in the spot of the contact the nanotube is fixed in the state of a mechanical contact with the controlling electrode. In this state the nanotube provides the electrical transport between the input and controlling electrodes, which can be fixed by means of measuring of electrical current. To return the nanotube to the free state it is necessary to apply the same potential to the entrance and the controlling electrodes.

The described method provides a simple way of measuring the frequency of resonance oscillations of the nanotube. In contrast to the existing methods which are based for e. g. on measuring of the modulation of the electrical capacity of the system the nanotube – the distanced electrode, the modulation of the resistance or density of the charge carriers of the nanotube, this method does not demand the analysis of the high frequency electrical signal and is reduced to the detection of the events of a short circuit in the chain the input electrode – the nanotube. It simplifies technical implementation of this method and lowers the demands to parasitic capacities of the system. This method is proposed for the first time.

Final applications. The existence of a cheap group method of forming integral NEMS-structures gives opportunities for creating of devices of a brand-new type – active nanomembranes. Each pore of such a membrane is a NEMS-structure (for getting the through pores a number of additional operations is necessary, in particular a partial removal of a dielectric layer by means of etching). This, on the one hand, increases the level of control over the pore geometry (the minimum size of a pore is 0.33 nm; the dispersion of sizes, due to self organization fundamental limitations, is close to zero), but on the other hand – provides a brand-new functionality to manipulate the substance under treatment, which is connected with the possibility of sustaining of the set electrical field and the possibility of modifying in situ of the effective geometry of pores. This allows:

– the mechanism of precision tuning of the system at the target molecules (which is especially important for the task of separating of multicomponent medium, with the insignificant difference in the size of molecules, e. g. for isolation of oxygen from air);

– the new mechanisms of selectivity;

– (besides the steric mechanism of separating of molecules here adds the Coulomb mechanism, connected with differences in polarization of molecules; the alternating Coulomb forces can be used);

– the possibility of chains of chemical transformations between the molecules in the pores witch unrealizable in usual conditions (application of membrane reactors or in this case – "active nanoreactors");

– the cardinal increasing of resistance to contamination of pores (the mode of a controlled self-cleansing is possible; figuratively speaking each pore of the nanomembrane can "sneeze");

– the use of the effects of the resonance mechanical transport etc.

The above described type of devices and the method of their realization are proposed for the first time.

The proposed NEMS-structures allow to surpass the modern level of technology also in the sphere of sensors: extremely high sensitivity is provided (in the conditions of vacuum – up to registration of acts of sorption of individual molecules), a simple method of measuring of resonance frequency (is different from traditional MEMS-sensors on the base of the silicon microbeam and becomes possible owing to essential role of Van der Waals forces at the nanolevel), a whole range of universal mechanisms of selectivity (in particular electrical probing of individual molecules or their groups is possible), controlled regeneration of sensor ability, low cost, the possibility of integral

production etc. The mentioned qualities are especially important in creating of devices of the «electronic nose»-type in their most full functional variant.

Membrane and sensor functionality of the proposed NEMS-material create preconditions for reaching of a new level in the efficiency of differentiating and treating of multicomponent mediums.

In a certain perspective on the basis of the proposed element base the nonvolatile memory can be created, claiming the role of a universal type of memory and having a super high degree of integration, extremely low cost of storing of one bit of information, low density of interconnection (the additional coordinate of addressing is used in the form of frequency of resonance oscillation of the nanotube), super high radiation stability.

The described NEMS-material has applications in a number of other important spheres, in particular, it allows to produce photon crystals with the reorganizing zone structure, «smart» electromagnetic materials etc.

Experimental results. The obtained experimental results are given according to the sequence of the stages of the technological process of production of NEMS-structures. With the author's participation the experimental technology of growth of carbon nanotubes on nickel sol-gel catalyst was developed (fig. 1, *c*). The technological process of growth of vertical carbon nanotubes, fixed in the pores of alumina, is at present under development.

Also with the participation of the author the technological process of photolithography and spraying of metallic layers on the planar carbon nanotubes was realized. The samples of integral structures were obtained, which are planar carbon nanotubes distributed randomly between the conductive lines of the matrix formed by means of photolithography [2]. It is necessary to perfect these processes for the case of vertical carbon nanotubes.

The author is the first to carry out the experiments on the controlled local anodic oxidation (LAO) of amorphous carbon paths under the influence of nonhomogenious electric field, induced by the carbon nanotube. These results allow the mechanism of operated element and the controlling electrode self-alignment by the method of LAO for the first time. The example of self-alignment of a conductive path and a planar carbon nanotube band is shown in figure 2.

It can be seen that despite the complicated form of the band, an evenly spaced gap was formed between it and the conductive path. The breadth of the gap is 100...120 nm. This result corresponds to the intensive process of oxidation (some nonhomogenity of the gap in breadth is connected with it). By decreasing of the intensity of LAO the breadth of the resulting gaps can be reduced. As the removal of several layers of atoms of carbon is already enough to discontinue the electrical contact of the nanotube with the electrode (the tunnel current can be neglected), so at a sufficiently low rate of LAO the gaps with the breadth of a nanometers and less can be obtained (due to their small size it was impossible to visualize these gaps, their existence was testified by the absence of conductivity in the chain the nanotube – the controlling electrode).

Besides that, the author obtained the original results in the research of the dependence of the frequency of resonance oscillations of the silicon microbeam covered by a net of carbon nanotubes from the concentration of different gases in the atmosphere. In particular, the resolving capacity for vapor was 0.1 % (it should be noted that specific surface area and the quality of the model MEMS-beam, and correspondingly, sensitivity, is much less than those for the NEMS-resonator.) Silicon microbeam without the nanotube coating showed much less sensitivity. The described system "microbeam plus the surface monolayer of the carbon nanotubes" can be viewed as the physical model for the sensor application of the NEMS-structures under development.

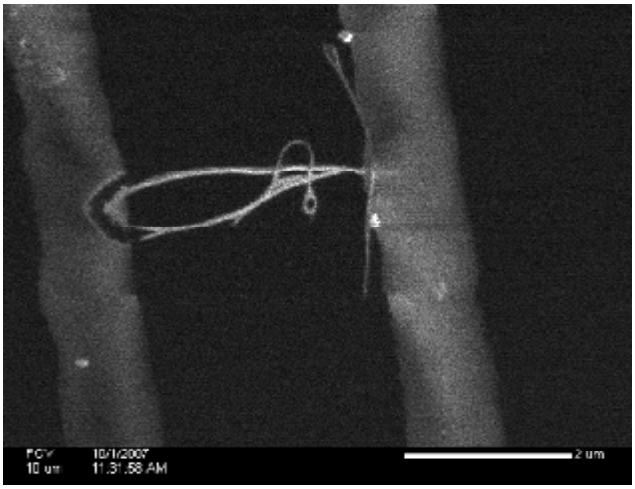


Fig. 2. The example of local anodic oxidation of the conducting path (left) by the planar carbon nanotube band; the conducting paths are made from amorphous carbon; the width of obtained gap is 100...120 nm; FIB image

So, the realizability of all the stages of the proposed technological chain of production of NEMS-structures is shown. It is necessary to unite them in a single technological process.

Generalizing, we can make the conclusion that the technology under development provides the means of industrial production of the new material, which is the whole complex of tightly packed nanostructures. This material is the representative as the active nanomaterial which is still absent on the market and plays the role of the multifunctional "NEMS-platform", on the basis of which the systems of different functionality can be created. In particular, there appears the possibility to create systems of brand new types: active nanomembranes (NEMS-membranes) and active nanoreactors (NEMS-reactors). Besides that, the described NEMS-structures are of the considerable interest as the element base for such systems as sensors, nonvolatile memory, restructuring photon crystals, "smart" electromagnetic materials etc.

In general, due to the use of the technology combining the processes of self-organisation and self-alignment, the expensive methods of lithography of high resolution are not necessary (for some of the applications, in particular the sensor one, photolithography of low resolution can be necessary). This implies the low cost of the proposed NEMS-material and also the possibility of production of this material in a prolonged shape factor.

The author thanks M. M Simunin and I. I. Bobrinetskij for cooperation in conducting of the experiments.

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THE ANALYSIS OF FILTRATION INFLUENCE AT PRIMARY PULSED-CODE CONVERSION ON DISTORTION OF INPUT SIGNALS OF CODERS WITH A COMPRESSION OF AUDIO DATA

The influence of selective circuits of digital-analogue converters at primary pulsed-code conversion on distortion of input signal of coders with audio data compression is considered.

Keywords: compression of audio data, distortion of signal, digital-analogue converters, analogue-digital converters, group delay time.

In psychoacoustic models of MPEG standards the mechanisms of time masking of signals, spatial dismasking the sources of a sound producing a stereo panorama on front, depth and feature of perception of reverberation components of the stereophonic signals are not considered. These mechanisms of spatial hearing play the most important role for stereo reproduction; they define perception of the basic features of quality of the stereophonic sounding, such as spatial perception, sounding transparency, naturalness and wealth of timbres of instruments and voices, perception of acoustic atmosphere of a primary room (a concert hall, studio), etc. Occurrence of this set of distortions leads to decrease in quality of sounding which is distinctly observing by listeners.

However it is necessary to consider, that digital audio signals arrive on an input of coder with a compression after pulsed-code (PSM) conversion. Thus quality of conversion is meant ideal. In a number of works, for example [1], an influence of the errors of quantization on sounding the audio signals written down or transferred with a compression of audio data is shown.

The selective analogue-digital and digit-analogue (ADC and DAC) PSM conversion provide an essential influence on producing the high quality indicators at using the digital methods of sound recording as well as at organizing the digital sound broadcasting.

The low-frequency filters (LPF), limiting a spectrum of input frequencies and eliminating high-frequency components of a output signal accordingly are located at the input of ADC and at the exit of DAC.

Signal suppression of LPF on the frequency equal to half of frequency of digitization, should be not less than 60 dB. In this case the steepness of slope of LPF should be very high (120 dB\octave). For achievement of such values of steepness the high order LPF should be created. Such filters have considerable disadvantages and the main essentially nonlinear phase characteristic that leads to distortions of audio signals appreciable by ear as loss of "transparency" of the sound. Besides, such filters becomes rather difficult in manufacturing and adjustment, and, hence, expensive. In audio equipment the greatest distribution was received by Butterworth and Chebyshev filters.

A dependences of an order of the filter (N_b, N_c) from demanded attenuation ($A_{\min}$) on boundary frequency of a leakless strip (f_{gtsll}) at admissible non-uniformity in pass-band $A_{\max}$ = 0.5dB for typical ADC cases are calculated for Butterworth and Chebyshev LPFs and shown in figure 1:

– for signals of a sound broadcasting (3V) for the higher class of quality (f_b = 15,000 Hz, f_{gtsll} = 16,000 Hz);

– for audio signals at a sound recording (f_b = 20,000 Hz, f_{gtsll} = 20,000 Hz).

All calculations in the given work were carried out in software MathCAD.

The figures shows, that for the reception of the required attenuation 60 dB at the boundary frequency of a leakless band the filter order of approximately 124 in the first case, and more than 42 in the second case is required. Such filters in analogue circuitry cannot been realized.

Calculations shows that, for the case of sound recording with the aid of Chebyshev or Butterworth filters, the orders of such filters of 12 and 42 are required respectively. In analogue circuitry the filters with orders 6 or 8, but not above, can be realized. As a criterion of linearity of the phase characteristic a change of group delay time (τ_{gt}) which is normalized the domestic State Standard (GOST) 11515–91 for the channels of sound broadcasting can be considered. It is obvious, that the requirements shown to the sound recording and sound reproducing equipment should be more rigid, than to the channels.

In figures 2 and 3 the received dependences of group delay time for Butterworth filters with order 42 and Chebyshev filter with order 12 are shown. The normalized frequency (w) is postponed along X axis, and w = 1 corresponds to the boundary frequency of a pass band.

Along with impossibility to realize analogue filters with considered orders, the non-uniformity of group delay time in a pass band is 40 ms for the Butterworth filter and 73 ms for the Chebyshev filter. Such non-uniformity of group delay time essentially deforms a primary audio signal (an input signal of the filter).

One of known methods for the solution of the given problem is the using of the PSM coders (decoders) in which

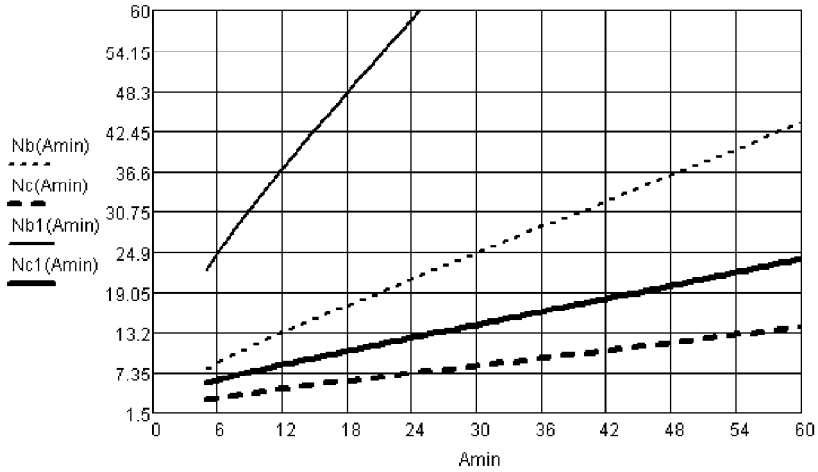

Fig. 1. Dependences of an order of Butterworth (N_b) and Chebyshev (N_c) filters from A_{min} (— — for signals 3V, ———for a sound recording case)

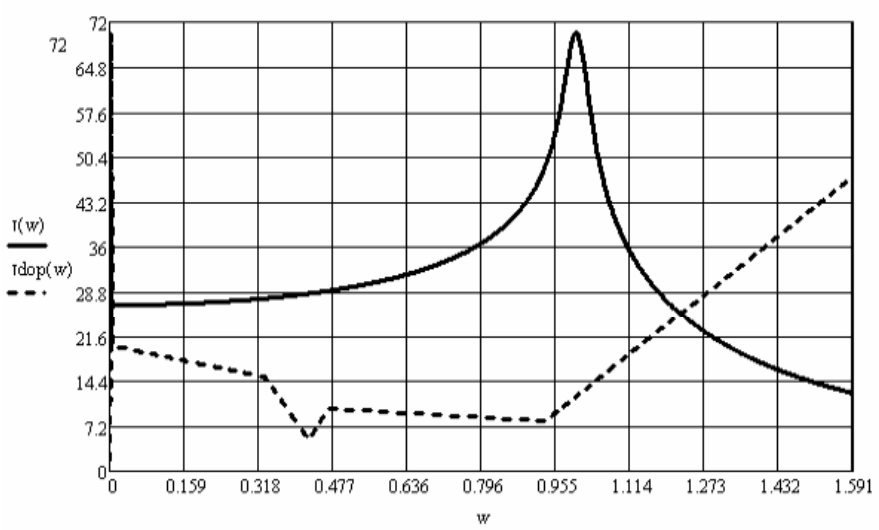

Fig. 2. The dependence of group delay time of Butterworth filter from normalized frequencies ($\tau(w)$) as well as standard ($\tau_{dop}(w)$) admissible delay time

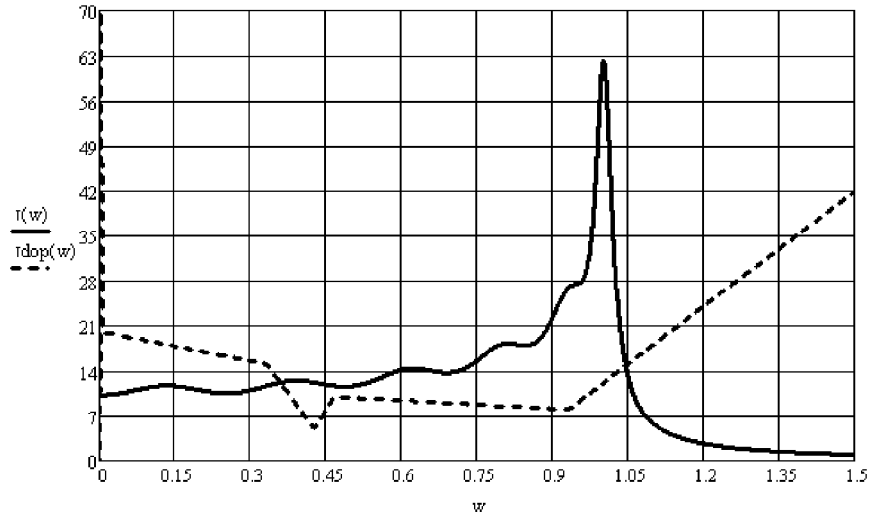

Fig. 3. The dependence of group delay time of Chebyshev filter from normalized frequencies ($\tau(w)$) as well as standard ($\tau_{dop}(w)$) admissible delay time

ADC (DAC) work at the raised frequency. It allows to make considerably lower the requirements to the slope steepness and to the order of analogue LPF, which provide a preliminary filtration of the primary signal. Then the basic attenuation at the boundary frequency of a leakless strip will be provided with a digital filter.

At the choice of structure of the digital filter the non-recursive filters have preference in this case.

The decisive advantage of such filters is possibility to receipt the linear phase-frequency characteristics. In this case, the definition of the requirements to analogue LPF and the order of such LPF should be focused on preliminary filtration and providing the demanded non-uniformity of group delay time in a filter pass band.

In figure 4 the calculated dependences of group delay time from normalized frequencies ($w_в$ a signal it is equal 1) are shown for Butterworth LPF. Such dependences for Chebyshev LPF (with 2nd, 4th, 6th and 8th orders) are shown in figure 5. For Butterworth filters with 8th order the non-uniformity in a pass band does not exceed 3.5 ms [2]. Working attenuation on the boundary frequency of leakless strip (A_{pmin}) of 5 dB for the case of digital transmission of the signals of sound broadcasting described above, and of 13 dB for the case of digital sound recording is thus provided.

The Chebyshev filter seems acceptable with an order not above than 6. In this case the non-uniformity on group delay time in a pass band does not exceed 11 ms, that seems acceptable with taking into account the properties of hearing. Besides the requirements of State Standard 11515–91 are practically satisfied. Thus LPF provides A_{pmin} of 28 dB (for the sound recording conditions given above) and 10 dB (for the case of transferring the signals of sound broadcasting).

At the using PSM coders (and decoders) with redigitization in codec's and compression of audio data for digital transmitting the signals of sound broadcasting and for digital sound recording the minimal distortion (appreciable on hearing) occur under the best linearity of phase characteristics of selective coders and decoders.

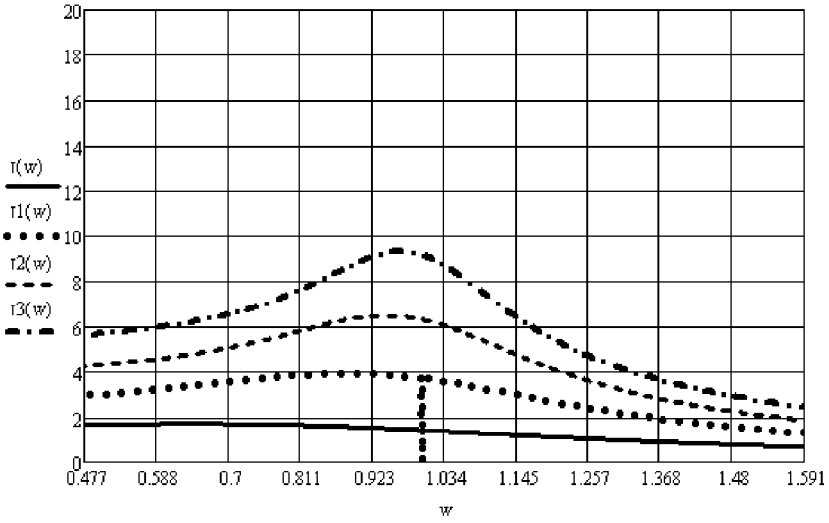

Fig. 4. The dependence of group delay time from normalized frequencies for Butterworth LPF 2nd (τ(*w*)), 4th (τ1(*w*)), 6th (τ2(*w*)) and 8th (τ3(*w*) orders

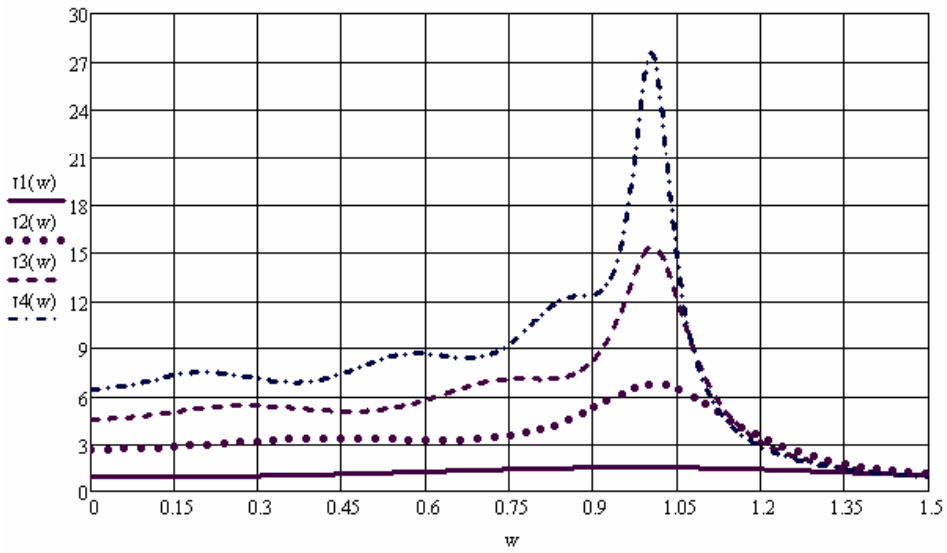

Fig. 5. The dependence of group delay time from normalized frequencies for Chebyshev LPF (τ1(*w*)), 4th (τ2(*w*)), 6th (τ3(*w*)) and 8th (τ4(*w*)) orders

For the filters realized in analogue circuitry the preliminary filtration is preferable to carry out with the help of Chebyshev filters which provide acceptable non-uniformity of group delay time from the point of view of acoustical perception of admissible distortions and provide rather big attenuation on boundary frequency of a leakless strip.

For receiving the linear phase-frequency characteristics in ADC and DAC with redigitization it is necessary to use non-recursive digital filters.

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TWO-LEVEL GENETIC ALGORITHM FOR X-RAY POWDER DIFFRACTION STRUCTURE ANALYSIS

A new evolutionary approach for crystal structure determination of powders based on X-ray diffraction full-profile analysis and genetic algorithm of global optimization is suggested. An investigation of efficiency of given algorithm is carried out on test real-world problems of structure determination.

Keywords: evolutionary algorithm, X-ray powder diffraction analysis, Rietveld method.

Crystal structure information is essential for explanation and prediction of physical and chemical properties of investigated materials. Many materials, multi-phase mixtures in particular, are available in form of powder only, thus severely impeding a research. In such cases X-ray powder diffraction methods, which are being intensively developed during last two decades, are used. They are based on analysis of a whole X-ray diffraction profile of powder pattern, which is a monochromatic X-ray radiation intensity function of polycrystalline sample diffraction angle. By now, in general, crystal cell parameters search problem (indexing methods) and structure model refinement problem (Rietveld method) have been solved. Primary mathematical means used for these problem solutions is a non-linear least-squares method (LSM). Plausible structure model determination in case of powder samples is still a problem even in case of relatively simple structures [1].

In recent years, for this problem solving so-called "direct-space" methods [1] have become of use. They are based on probabilistic generation of trial crystal structure models, their assessment through weighted difference of calculated and observed patterns (profile R-factor) and search for global minimum over corresponding parametric hypersurface in order to find an adequate structure model. An example of this approach is evolutionary algorithm, mimicking processes of natural selection in search of an optimal structure solution [2]. Several implementations of this concept have already been used for structure determination, demonstrating promising prospects [1; 3]. Here a two-level hybrid genetic algorithm is suggested for that purpose and its approval results are described on real patterns of single- and multi-phase polycrystalline samples with well-known crystal structure.

Full-profile crystal structure model refinement. As a tool for crystal structure model refining multi-phase Rietveld method [4] was used. An essence of Rietveld method is a modeling of experimental pattern by complex multi-parametric function:

$$Y^{\mathrm{mod}}(\boldsymbol{P}, \theta_j) =$$

$$= \sum_i^n \Omega_i(\boldsymbol{P}_L, \theta_j) * I_i^{\mathrm{calc}}(\boldsymbol{P}_S, \theta_j) + B(\boldsymbol{P}_B, \theta_j), \qquad (1)$$

where $\boldsymbol{\theta}_j$ – diffraction angle; $\boldsymbol{\Omega}_i$ – profile functions for diffraction lines i, dependent on profile parameters set $\boldsymbol{P}_L$, (positions, half-width, form, asymmetry of lines, etc.); I_i^{calc} – calculated integral intensities of lines, dependent on structure parameters set $\boldsymbol{P}_S$ (atomic coordinates, thermal motion parameters, etc.); B – function for background, dependent on background profile parameters set $\boldsymbol{P}_B$.

Firstly, pattern model is calculated from the approximate (initial) values of parameters $\boldsymbol{P}$, including model atomic coordinates in crystal cell. Exact coordinates and other parameters (including quantitative phase composition in case of multi-phase sample) are determined as a result of mathematical fitting of model pattern to observed pattern by structure and profile parameters least-squares method variation.

Formalizing the approach, we get a following mathematical optimization problem. Experimental data (powder pattern) represent a discrete sequence $\{\boldsymbol{\theta}_j, Y_j\}$ of size m, sorted by ascending of $\boldsymbol{\theta}_j$. Some class of parametric function $Y(\boldsymbol{P}, \boldsymbol{\theta})$ (Rietveld method functions) is given, $\boldsymbol{P}$ is a set of profile and structural parameters (a vector of size N), $\boldsymbol{\theta}$ – independent argument. Peculiarities of the problem are large dimensionality (can exceed 100 parameters) and non-polynomiality of functions.

With a given distribution of observed values of function $Y^{obs}(\boldsymbol{\theta}) = \{\boldsymbol{\theta}_j, Y_j\}$ and initial parameters approximation $\boldsymbol{P}_0$ the task is to find function Y^{mod} of class $Y(\boldsymbol{P}, \boldsymbol{\theta})$ and an optimal set of parameters $\boldsymbol{P}^*$ to satisfy condition (2).

LSM functional:

$$\Phi(\mathbf{P}) = \sum_j \left(Y^{\text{mod}}(\mathbf{P}, \theta_j) - Y^{\text{obs}}(\theta_j)\right)^2 = \\ = \sum_j \left(Y(\mathbf{P}, \theta_j) - Y_j\right)^2 \to \min_{\mathbf{P}}. \quad (2)$$

As a figure-of-merit of LSM solution, according to [4], weighted difference of calculated and observed patterns (profile R-factor) is taken:

$$R = \sqrt{\frac{\sum_j \left(Y^{\text{mod}}(\mathbf{P}, \theta_j) - Y^{\text{obs}}(\theta_j)\right)^2}{\sum_j \left(Y^{\text{obs}}(\theta_j)\right)^2}} \cdot 100\ \%. \quad (3)$$

A necessary condition of extremum for (2):

$$\sum_j^m \left(Y_j - Y(\mathbf{P}, \theta_j)\right) \frac{\partial Y(\mathbf{P}, \theta_j)}{\partial P_k} = 0, \\ k = 1, ..., N, \quad (4)$$

where P_k – k-th component of parameter vector $\boldsymbol{P}$.

However, due to non-linearity of functions $Y(\boldsymbol{P}, \boldsymbol{\theta})$ over parameters $\boldsymbol{P}$ derived system (4) cannot be solved analytically. Linearizing the system (4) by Taylor expansion at starting point $\boldsymbol{P}_0$ with truncating terms above first order, we can obtain a system of linear equations over N variables (non-linear least-squares method). Iteratively solving for $\Delta\boldsymbol{P}_1$, $\Delta\boldsymbol{P}_2$, … (refining values $\boldsymbol{P}$: $\boldsymbol{P}_1 = \boldsymbol{P}_0 + \Delta\boldsymbol{P}_1$, …), we will move towards $\boldsymbol{P}^*$. Solution process convergence is defined by proximity of point $\boldsymbol{P}_0$ to optimal $\boldsymbol{P}^*$. With starting point $\boldsymbol{P}_0$ declining and problem dimensionality N increasing the iterative method becomes unstable and starts to diverge. The bigger N (or the worse the quality of experimental data), the more precise $\boldsymbol{P}_0$ are required, which practical determination represents a serious obstacle.

Genetic algorithm of structure analysis. Effectiveness of evolutionary algorithms in complex non-linear global optimization problem solving was proven [2]. So the idea arose to combine the Least-squares method of seeking the minimum of functional (2) with evolutionary algorithm of objective function (3) optimization in order to solve above-stated problem. A two-level evolutionary algorithm comprising two distinctive genetic algorithms (GA) is suggested.

First level GA. The first level of proposed algorithm is a «conventional» hybrid GA [2; 3], dealing with binary representation of parameter values. Its chromosomes encode vector of sought parameters P, where binary representation accuracy is varied by user. In particular, fragments of chromosome define rounded with specified accuracy coordinates x, y, z of atoms of investigated material relatively to its elementary unit cell. Minimized objective function over P is R-factor (3), ideally tending to zero while converging toward a global minimum. R-factor is calculated unambiguously for each parameter vector P with given sampling $Y^{obs}(\boldsymbol{\theta})$ and in practice, depending on simulation and experimental error magnitudes, should come to about 5...10 % (defined empirically) in optimal point.

A flow-chart of first-level algorithm is shown in figure 1 on the left. Starting population is generated arbitrarily, so a priori given starting approximations are not required. Tournament selection of parents with varied tournament size is employed. Algorithm, besides standard genetic operators – recombination (1– point, 2 – point or uniform) and mutation, uses local search operator. The best individual and some randomly chosen individuals are subjected to LSM local descent over all coordinates (modified Newton–Raphson algorithm). Lamarckian concept of evolution [2; 3] is implemented, where parameter values found by the local search replace old ones.

Primary objective for this level is to find plausible (in the sense of R-factor) initial approximations of parameters $\boldsymbol{P}_0$.

Second level GA. Evolutionary algorithm of the second level is utilized for the searching and generating of LSM refinement strategy for initial approximations of parameters $\boldsymbol{P}_0$, representing a sequence of local descents on R-factor hypersurface. Bit strings $\boldsymbol{B}_i$ defining groups of parameters refined on current generation are used as this level individuals. The length of a bit string equals to a number of sought parameters N with each bit corresponding to certain parameter. Bit value on a position k of the second individual indicates whether to refine (= 1) or not (= 0) the k-th parameter on a current iteration. The values of parameters $\boldsymbol{P}$ for the every string are refined iteratively with non-linear LSM from (4). For example, string 101 means that equations (4) are constructed only for $k = 1$ and $k = 3$ and after solving of 2*2 system give increments for № 1 and 3 parameters, while parameter of index 2 is left unmodified. Thus, each $\boldsymbol{B}_i$ defines a search sub-space.

A flow-chart of second-level algorithm is given in figure 1 on the right. Initially this level GA individuals can be generated arbitrarily or according to some empiric scheme based on user-provided patterns sequence (masks imposed on $\boldsymbol{B}_i$). For assessment of the GA individuals for each $\boldsymbol{B}_i$ a relation to first-level $\boldsymbol{P}_i$ individual (one or many) is set. For $(\boldsymbol{B}_i, \boldsymbol{P}_i)$ pairs the LSM is applied according to above principles, with a result of $\boldsymbol{P}_i'$ – refined $\boldsymbol{P}_i$ values in accordance with $\boldsymbol{B}_i$ string. Level 2 objective function takes into account an performance of applied LSM: as figure-of-merit (fitness) of the 2nd level individuals the function (5) is taken:

$$F = \left[R(\mathbf{P}_i') / R(\mathbf{P}_i) + p\right]^{-1} \quad (5)$$

where p – a penalty for non-convergence (substantial increase of local search steps lengths).

Thus, the better the refinement process convergence, the higher the assessed individual fitness. $\boldsymbol{B}$ – individuals are recombinated and mutated without $\boldsymbol{P}$ – individuals altering. Results of that evolution are the refinement strategies of $\boldsymbol{P}$ – individuals.

Objective for this level is to carry out a sequence of refinements (local searches over dimensions specified by bit string) using the best solutions from the preceding level. Providing sufficiently suitable initial approximations $\boldsymbol{P}_0$, the refined $\boldsymbol{P}$ will converge to optimum. Unsuitable $\boldsymbol{P}_0$ with many refined parameters will not yield convergence; in this case, a subsequent executing of first level algorithm can give better initial approximations for second level. The best parameter strings $\boldsymbol{P}$ are returned to the first GA level for assessment and inclusion in next population $\{\boldsymbol{P}_i\}$.

The proposed algorithm involves a cyclic executing of both levels while stop criteria are not satisfied (computational resource is exhausted, min $R < R_{stop}$, mean $R < R'_{stop}$). One or many better and some randomly chosen individuals are transferred to another level. Evolution of trial structures on the first level provides a search for values suitable for second level minimization by an evolutionary sequence of local searches. Moreover, this approach affords overcoming of local minima, where LSM can fall to during second level performing. Thus, stochastic and deterministic search procedures are combined here mutually complementing and enhancing each other.

The algorithm has been implemented as a shell over a DDM console program incorporating Rietveld-like method [5]. For the purpose of the algorithm performance evaluation it was tested on single- and multi-phase samples with known crystal structure of component phases (samples 1, 2).

Sample 1. A determination of crystal structure of component phases and quantitative phase analysis of three-phase sample CPD-1h, given by Commission on Powder Diffraction of International Union of Crystallography at Round Robin on QPA [6] quantitative phase analysis contest.

Simultaneously, profile parameters, coordinates of atoms in general crystallographic positions and thermal atomic parameters (29 parameters in total) were searched through all possible value ranges. A convergence plot for two-level GA indicating the R-factor decrease during parametric and bit strings populations evolution is given in figure 2. It is clear that R-factor decrease is primarily provided with 2nd GA level, while 1st level efficiently leads out from local minima. An optimal solution was obtained after 5th full GA cycle. It was empirically drown that 3 generations on each GA level with population sizes of 20 1st level and 10 2nd level individuals are sufficient for reliable convergence of the method. Population sizes are comparable with the dimensionality of the problem that indicates an efficient usage of computational resource and substantial potential of the method. Time spent for the problem solving: 4 min 47 sec (CPU AMD X2 4400+).

On a final stage of the algorithm, the phase concentrations were calculated. A correspondence between true and found compositions serving as an integral quality criterion of obtained solution is shown in table 1. In the last table row the root mean square (RMS) is given.

It should be noted that RMS of phase analysis solutions from Round Robin on QPA for CPD-1 samples averages ~ 3 % mass [6].

Sample 2. Crystal structure of single-phase sample $Pd(NH_3)_2(NO_2)_2$ [7] determination.

All coordinates of atoms in general crystallographic positions (including coordinates of hydrogen atoms) and thermal atomic parameters (26 parameters in total) were searched simultaneously. A corresponding GA convergence plot is demonstrated in figure 3. As in previous case, 3 generations of each level were generated on a full GA cycle. Used population sizes: 20 individuals on the 1st level and 10

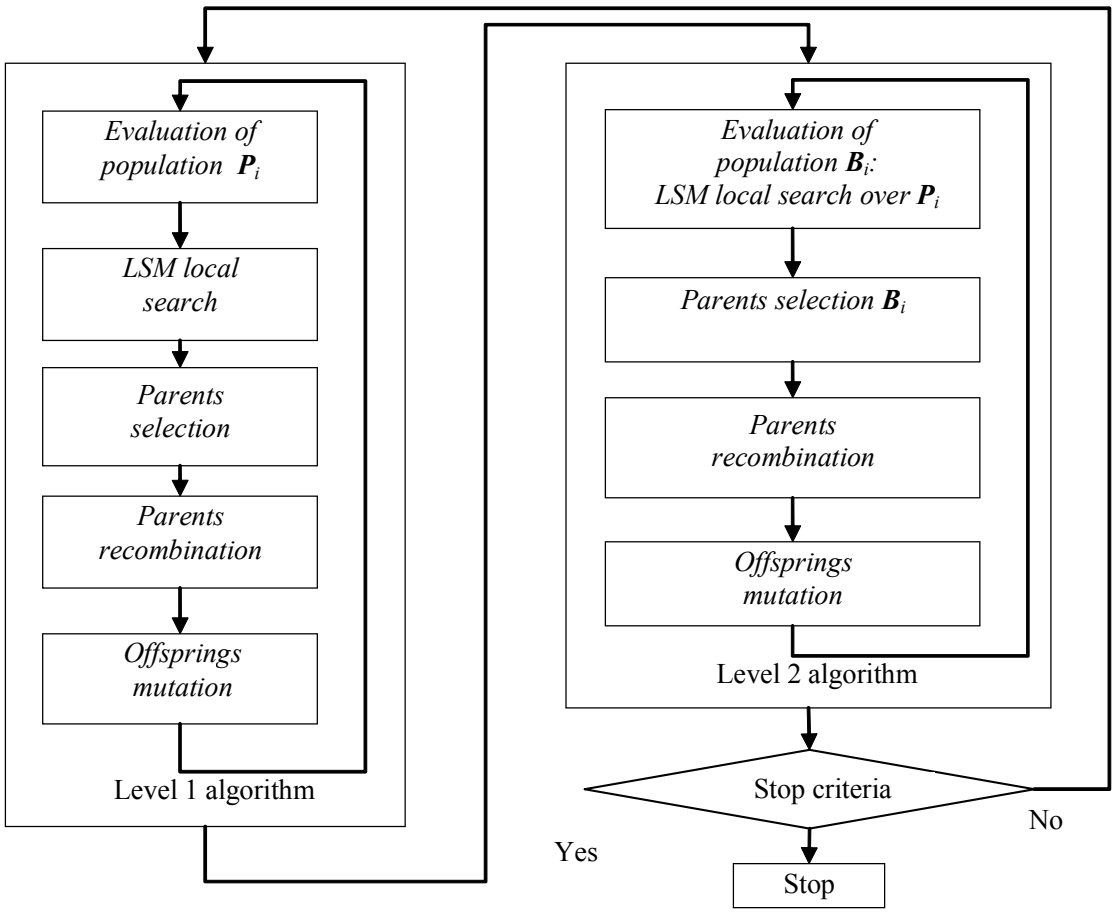

Fig. 1. Two-level GA flow-chart

on the 2nd level. An optimal solution was obtained after 3th full GA cycle. One can see that convergence here again is primarily provided by the 2nd GA level. Time spent: 4 min 21 sec (CPU AMD X2 4400+).

A correspondence between experimental and calculated X-ray powder patterns from the last GA stage is demonstrated in figure 4. It can be an integral quality criterion of obtained solution.

Found coordinates of the atoms (relative to the crystal cell axes) and thermal parameters compared to reference values [7] (designated with asterisks) are given in the table 2. Obtained maximum error for coordinates of the heavier atoms: 0.0015, for thermal parameters: 0,012, and for coordinates of the hydrogen atoms: 0.0170.

The accuracy of obtained solution suits the accuracy of reference model structure [7]. It should be noted that with GA the coordinates of hydrogen atoms were found, which, being the lightest of all atoms, is hard to locate with available powder pattern analysis methods.

Described two-level GA comprises search and refinement of crystal structures thus giving the possibility of automation of structure determination process. Important features of

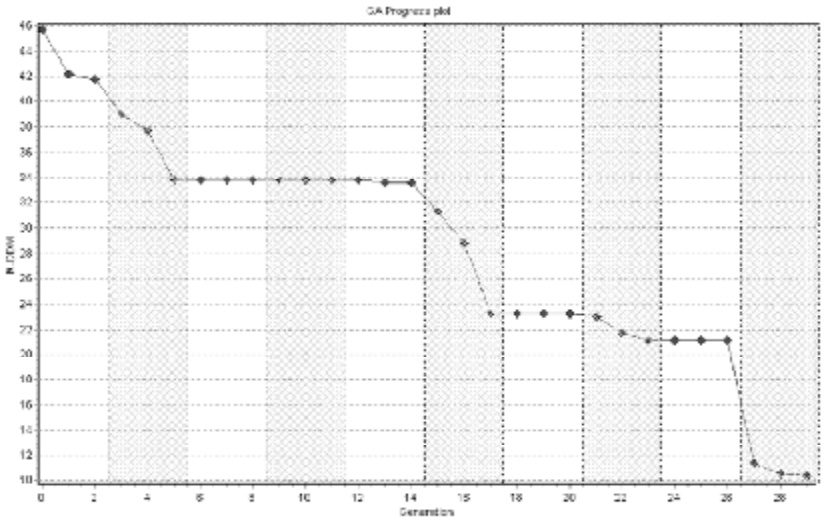

Fig. 2. GA convergence plot. The best found so far (to a current generation) solutions are designated (x-coordinate – the number of generation, y-coordinate – R-factor). Cross-hatching marks second-level GA executing

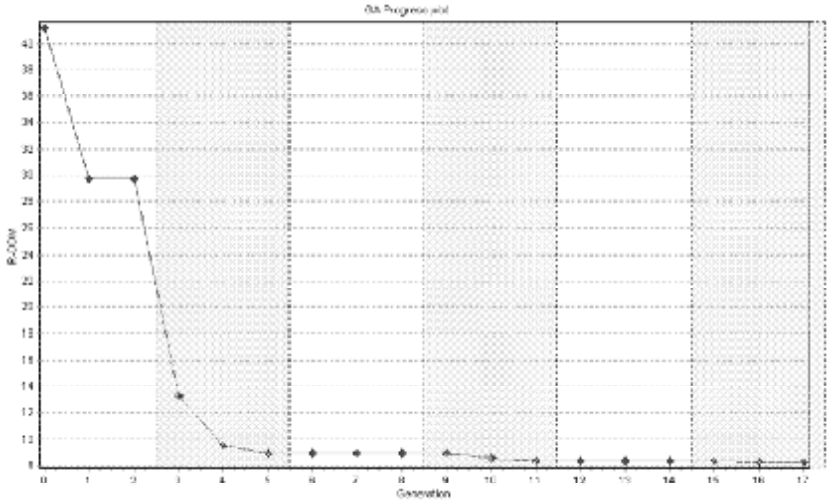

Fig. 3. GA convergence plot. The best found so far solutions are designated. Cross-hatching marks second-level GA executing

Table 1

CPD-1h sample composition

Phase	Formula	True (% mass)	Found (% mass)	Error (% mass)
Corundum	Al_2O_3	35.12	35.39	0.27
Fluorite	CaF_2	34.69	35.08	0.39
Zincite	ZnO	30.19	29.53	0.66
RMS				0.57

algorithm are, as well, the possibility of simultaneous search of profile and structure parameters, and in case of multi-phase samples, phase composition calculation. It seems that the key role here was played by the combination of first and second level algorithms. Apparently, proposed approach has substantial potential for further development.

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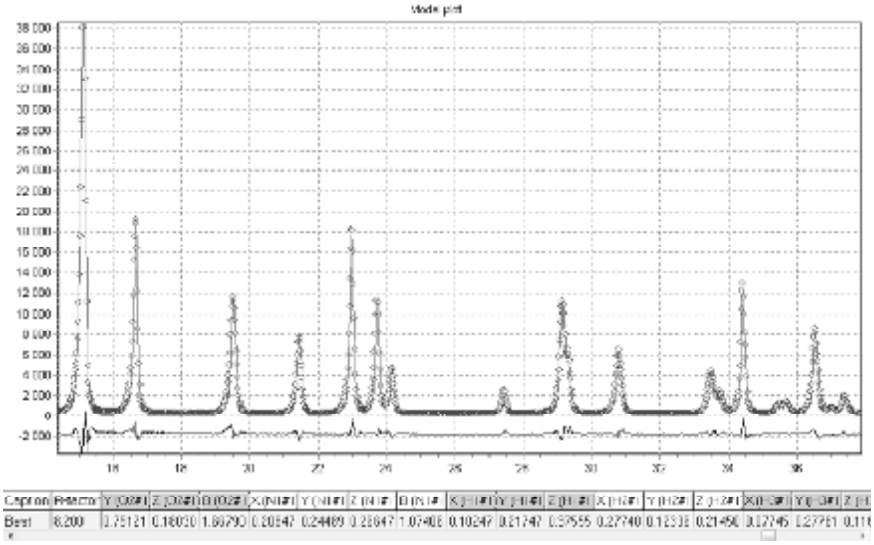

Fig. 4. Observed, model and difference X-ray powder patterns of the sample 2.
Observed data are designated with circles; difference curve is shifted down.
The model pattern is constructed using the best GA found values (given in the table at the bottom)

Table 2

Crystal structure of $Pd(NH_3)_2(NO_2)_2$ compound: reference and GA found

$Pd(NH_3)_2(NO_2)_2$. Space Group *P – 1* (№ 2) Unit cell: *a* = 5.4251(1) Å. *b* = 6.3209(1) Å. *c* = 5.0031(1) Å. alpha = 111.87(0)°. beta = 100.4(0)°. gamma = 91.37(0)°												
At.	X*	X_{GA}	|Δ|	Y*	Y_{GA}	|Δ|	Z*	Z_{GA}	|Δ|	*B**	B_{GA}	|Δ|
Pd	0.5000	–	–	0.5000	–	–	0.5000	–	–	0.484	0.485	0.001
N	0.3440	0.3448	0.0008	0.6970	0.6974	0.0004	0.3000	0.2999	0.0001	1.230	1.235	0.005
O1	0.1200	0.1205	0.0005	0.7270	0.7269	0.0001	0.2840	0.2835	0.0005	3.252	3.262	0.010
O2	0.4690	0.4688	0.0002	0.7910	0.7912	0.0002	0.1810	0.1803	0.0007	1.665	1.668	0.003
N1	0.2090	0.2085	0.0005	0.2450	0.2449	0.0001	0.2680	0.2665	0.0015	1.086	1.074	0.012
H1	0.1000	0.1025	0.0025	0.2220	0.2175	0.0045	0.3670	0.3756	0.0014	5.000	–	–
H2	0.2850	0.2774	0.0076	0.1260	0.1234	0.0026	0.2190	0.2145	0.0045	5.000	–	–
H3	0.0750	0.0775	0.0025	0.2770	0.2778	0.0008	0.0990	0.1160	0.0170	5.000	–	–

Note: Pd atom takes the special position in the center of cell, thermal parameters of the hydrogen atoms were fixed as they have insignificant impact on the calculations.

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A PRACTICAL APPROACH TO SOFTWARE PORTABILITY

This paper describes an approach to porting onboard software for communication and navigation satellites to new platforms that use various onboard computers and devices. The approach relies on the target(onboard) and the tool software stratification and strong typing and the Modula-2 programming language especial features.

Keywords: software engineering, satellites onboard software, cross-programming system.

The approach is being resolved by the JSC "M. F. Reshetnev "Information satellite systems" in collaboration with the Ershov Institute of Informatics Systems and the Excelsior, Ltd. (formerly XDS), via an approach based on architectural stratification and interface standardization both for the onboard software and the development environment and the Modula-2 programming language especial features [1], such as strong typing and separate compilation [2–7].

First of all, a stratification of the OSW was performed which allowed us to define and implement an OSW Abstraction layer that provides a standard platform-independent API (types and procedures) to application software (i. e. the software of satellite subsystems that solves functional problems and amounts to up to 80 % of the entire OSW). Portability of the application software to new hardware is ensured by the software development system whereas the use of a new operating system and drivers, by reprogramming the implementation modules for the OSW Abstraction layer.

Next, a stratification of the cross-programming system (CPS) was made which allowed us to define platform-independent and programming-language-oriented user interfaces: both for programming and testing/debugging needs, and the CPS Abstraction layer that provides a standard architecture-independent API (types and procedures) that isolates architecture–dependent parts of the onboard computers: CPS components implement code generation and instruction set simulator.

A successful implementation and an efficient use of both the OSW and CPS Abstraction layers proved to be possible to a great extent due to the strong typing and separate compilation properties of Modula-2.

Moreover, the use of a highly structured language provided an additional benefit, namely, a possibility to measure static and dynamic software component characteristics and to calculate criterions of software testing completeness for quality assurance.

Onboard software stratification. A canonical three-layer structure of the OSW was determined. The third layer – the application software – becomes platform-independent because its implementation only uses interfaces exported by the lower, second layer called the Abstraction layer. The first layer is the employed operating system, i. e. a real-time kernel and a set of drivers.

The canonical structure of the OSW Abstraction layer for the given problem area was determined by the analysis of functionality of several generations of satellites.

Three components are specified in the Abstraction layer:

– standard interfaces for a canonical set of abstract real-time kernel calls;

– standard interfaces for a canonical set of abstract onboard devices;

– standard types for a canonical abstract data set used to control subsystems of the satellite in various regimes.

The main features of Modula-2 – the strong typing and separate compilation – gave a possibility to implement the Abstraction layer as a set of Modula-2 libraries providing a complete and platform-independent API. It proved possible to define the data types independently of addressability, endian-ness, word size, etc., of various onboard computers.

The strong typing, e.g. enumeration types, provided a required level of abstraction for data types which is both maximally close to the problem field and also platform-independent to a maximal degree.

The separate compilation feature allowed us to standardize and freeze the API using definition modules, and made it possible to reuse all the functionally equivalent application software without any changes in the source code, which greatly simplified configuration management.

A Modula-2 cross-programming system adaptable to different target onboard computers. We developed a cross-programming system (CPS) based on Modula-2, which implements the code generation for some base computer implemented via an instruction set emulator. In this CPS, there were implemented platform-independent programming-language-oriented user interfaces as well as the CPS Abstraction layer that provides a standard architecture-independent interface with parts that depend on the architecture of the target onboard computer: the CPS components that implement code generation and the instruction set simulator.

Adaptation CPS for a new embedded computing system is performed by creating code generation and the instruction set simulator components only. The CPS ensures that all debugging information is provided at the level and in terms of Modula-2.

The assembly of the project into executable code is done via a standard CPS shell with the use of the necessary components of the commercial software development system. Another important fact is that application programmers can notice whether a switch to a different target computer (another command set interpreter) has occurred only through changes in the program operating characteristics as measured by the CPS, because all the user interfaces stay exactly the same.

The CPS also includes testing and debugging facilities that use platform-independent testing languages. The platform-independent dialogue and batch testing languages allow programming, executing and documenting test

procedures in the platform-independent terms of the programming language. The batch testing language allows one to reuse the test procedures with another platform.

The CPS runs efficiently under MS Windows 2 000/XP on Intel Pentium chips.

Such an approach was influenced by the XDS programming environment [5], and the XDS system was used as a programming environment for the CPS development and maintenance.

So, the architectural stratification of the OSW and CPS and the standardization of the two Abstraction layers ensures an easy adapation of the CPS to a new target computing platform.

An additional benefit of using a highly structured language. Our CPS allows one to obtain a complete set of measurements for the program unit being developed (including the size of stacks, the execution time, etc.) in order to evaluate some measures of source code quality and to calculate the C1 (all branches) and C (all decisions) criterions of unit testing completeness.

This is only possible with a highly structured language, so this quality allows one to implement in the CPS a complete check of the program execution process during the testing procedure and to make the testing procedure (especially under batch testing) independent of local changes in the source code of the program being tested.

The described technology of the OSW development results not only in a high level of reuse and portability of the OSW, but also a possibility to reuse all testing procedures for regressive tests of the OSW.

This is true not only for the OSW development, but also for the CPS. Moreover, it is possible to start the OSW development not waiting for adaptation of the CPS to a new target onboard computer by using the CPS available for the base onboard computer.

The measurement tools of the CPS that are based on the properties of the programming language allow one to achieve the high level of quality of the OSW components required for the spaceflight applications.

The standard and stable user interfaces of both the CPS and the Abstraction layer greatly simplify the maintenance of OSW by facilitating experience accumulation and transfer.

The technology successfully worked under development onboard software for Exspress-AM series communication satellites and for Glonass navigation system's satellites.

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THE POSSIBILITY ANALYSIS OF POWER INCREASE EFFICIENCY IN GENERATING DEVICES FOR ONBOARD RADIO-ELECTRONIC MEANS

A generalized analysis of a high frequency key generator is conducted. This analysis allows the power indicators estimation of the generator in a wide frequency range, and in scheme parameters.

Keywords: key generator, on-board system, resonance inverter.

In the issues of space development there is an important one of power supply maintenance for independent objects; these objects are intended for long-term presence in orbit or in interplanetary space. One of the working capacity maintenance ways of long-term space objects is the increase in power efficiency for the basic consumers – onboard electronic systems. This particularly concerns powerful generating devices for communication purposes.

For powerful radio devices the biharmonic mode generator had been widely used. With the advent of powerful solid-state electronics application, duple schemes of consecutive resonant inverters (class generators "D") [1] came into exploitation.

The possibility of energy conversion efficiency increase with an upset loading, was discovered by E. P. Khmelnitskiy in the 1960s [2]. In foreign sources, generators of such type were known as class E generators, as in Russian they were identified as key generators with a forming contour [3]. Despite the fact that class E generators provide high energy conversion efficiency for limited key modes frequencies, in a variety of causes their application is limited, and they are still on the stage of experiment. The scheme analysis for a wide range of frequencies and scheme parameters generally, has a lower result.

A simplified scheme of the generator is presented in figure 1, where AE is the active element (transistor, lamp) working in the *key* mode; VD is a diode that provides recuperation of energy of jet elements in an opened key; L, C are the elements of a contour, defining the form of pressure on AE; L_k, C_k are the loading contours, which have been adjusted to the frequency of operating pressure.

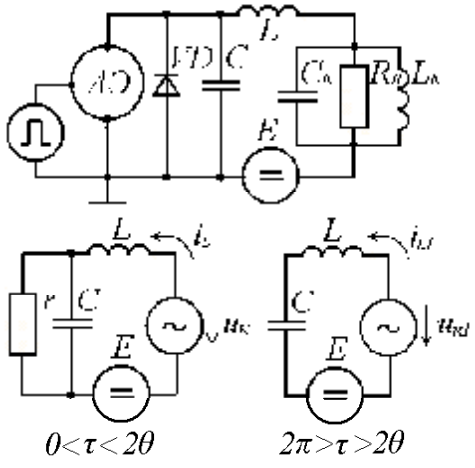

Fig. 1. Scheme of the generator

Supposing, that the unlocking and locking of AE is completely defined the by operating pressure (U_k), we will present the investigated generator in two equivalent schemes; they will show the processes happening in the generator in open and closed conditions of the AE. Here $u_к = U_к \sin(\tau+\varphi)$; $\tau = \varphi t$; 2θ – an angle corresponding to the time during which the AE is open; i_{L1}, i_L – currents in the external chain of the generator for corresponding equivalent schemes.

The differential equation for equivalent schemes becomes:

$$\frac{d^2 i_L}{d\tau^2} + \frac{1}{r\omega C}\frac{di_L}{d\tau} + \nu^2 i_L = $$

$$= \frac{\nu^2 E}{r} - U_k\left(\frac{\nu^2 \sin(\tau+\varphi)}{r} + \frac{\cos(\tau+\varphi)}{\omega L}\right), \quad (1)$$

$$\frac{d^2 i_{L1}}{d\tau^2} + \nu^2 i_{L1} = -\frac{U_k}{\omega L}\cos(\tau+\varphi). \quad (2)$$

The solution for these equations can be written down the following way:

$$i = \sigma + \xi\varepsilon_1 \cos(\tau+\varphi) -$$

$$-\xi\varepsilon_2 \sin(\tau+\varphi) + I_{11}e^{p1\tau} + I_{12}e^{p2\tau}..., \quad (3)$$

$$i_1 = I_{21}\cos\nu(\tau-2\theta) +$$

$$+I_{22}\sin\nu(\tau-2\theta) - \frac{1}{\nu^2-1}\xi\cos(\tau+\varphi), \quad (4)$$

$$U = -\xi\varepsilon_1 \sin(\tau+\varphi) -$$

$$-\xi\varepsilon_2 \cos(\tau+\varphi) + p_1 I_{11}e^{p1\tau} + p_2 I_{12}e^{p2\tau},$$

$$U_1 = \nu I_{22}\cos\nu(\tau-2\theta) -$$

$$-\nu I_{21}\sin\nu(\tau-2\theta) + \frac{1}{\nu^2-1}\xi\sin(\tau+\varphi). \quad (5)$$

The following designations are accepted here: $i = i_L\frac{\omega L}{E}$, $i_1 = i_{L1}\frac{\omega L}{E}$, $u = \frac{L}{E}\frac{di_L}{d\tau}$, $u_1 = \frac{L}{E}\frac{di_{L1}}{d\tau}$, $p_1 = -\frac{1}{\omega rC}$, $p_2 = -\frac{1}{\sigma}$ – roots of the characteristic equation (1); $\nu^2 = \frac{1}{\omega^2 LC}$, $\sigma = \frac{\omega L}{r}$, $\xi = \frac{U_k}{E}$, $\varepsilon_1 = \frac{p_1^2-(\nu^2-1)}{p_1+(\nu^2-1)^2}$, $\varepsilon_2 = \frac{\sigma\nu^4}{p_1^2+(\nu^2-1)^2}$, $I_{11}, I_{12}, I_{21}, I_{22}$ – integration constants.

Supposing that the generator mode had been established, we will define the integration constants, using the current continuity principle in inductance and in capacity pressure of contour LC:

$$i(0) = i_1(2\pi); i(2\theta) = i_1(2\theta), \quad (7)$$

$$u_c = u_{c1}(2\pi); u_c(2\theta) = u_{c1}(2\theta) \quad (8)$$

Here $U_c = E - U_k - U_L$. (9)

On the basis of (3)–(6) in conditions (7)–(9) we will receive:

$$I_{11} = A_1 + \xi(B_{11}\sin\varphi + B_{12}\cos\varphi);$$
$$I_{12} = A_2 + \xi(B_{21}\sin\varphi + B_{22}\cos\varphi);$$
$$I_{21} = A_3 + \xi(B_{31}\sin\varphi + B_{32}\cos\varphi);$$
$$I_{22} = A_4 + \xi(B_{41}\sin\varphi + B_{42}\cos\varphi). \quad (10)$$

In the last expressions the following designations are accepted:

$$A_1 = \frac{a_2b_3 - a_3b_2}{a_1b_2 - a_2b_1};\ A_2 = \frac{a_3b_1 - a_1b_3}{a_1b_2 - a_2b_1};$$

$$B_{11} = \frac{a_2b_{41} - a_{41}b_2}{a_1b_2 - a_2b_1};$$

$$B_{12} = \frac{a_2b_{42} - a_{42}b_2}{a_1b_2 - a_2b_1};$$

$$B_{22} = \frac{a_{42}b_1 - a_1b_{42}}{a_1b_2 - a_2b_1};$$

$$B_{21} = \frac{a_{41}b_1 - a_1b_{41}}{a_1b_2 - a_2b_1};$$

$$a_1 = 1 - e^{2p1\theta}\cos 2\nu(\pi-\theta) - \frac{p_1}{\nu}e^{2p1\theta}\sin 2\nu(\pi-\theta);$$

$$a_2 = 1 - e^{2p2\theta}\cos 2\nu(\pi-\theta) - \frac{p_1}{\nu}e^{2p2\theta}\sin 2\nu(\pi-\theta);$$

$$a_3 = \sigma[1 - \cos 2\nu(\pi-\theta)];$$

$$a_{41} = -\varepsilon_2 + q_1\cos 2\nu(\pi-\theta) + \frac{1}{\nu}q_2\sin 2\nu(\pi-\theta);$$

$$a_{42} = \varepsilon_2 - q_2\cos 2\nu(\pi-\theta) + \frac{1}{\nu}q_1\sin 2\nu(\pi-\theta);$$

$$b_1 = -p_1[1 - e^{2p1\theta}\cos 2\nu(\pi-\theta) + \frac{p_2}{\nu}e^{2p1\theta}\sin 2\nu(\pi-\theta)];$$

$$b_2 = -p_2[1 - e^{2p2\theta}\cos 2\nu(\pi-\theta) + \frac{p_1}{\nu}e^{2p2\theta}\sin 2\nu(\pi-\theta)];$$

$$b_3 = -\frac{p_1}{\nu}\sin 2\nu(\pi-\theta); \qquad \varepsilon_3 = \varepsilon_1 + \frac{1}{\nu^2-1};$$

$$b_{41} = \varepsilon_2 - q_1\cos 2\nu(\pi-\theta) + \nu q_2\sin 2\nu(\pi-\theta);$$

$$A_3 = \sigma + A_1e^{2p1\theta} + A_2e^{2p2\theta};$$

$$A_4 = \frac{p_1}{\nu}A_1e^{2p1\theta} + \frac{p_2}{\nu}A_2e^{2p2\theta};$$

$$B_{31} = B_{11}e^{2p1\theta} + B_{21}e^{2p2\theta} - q_1;$$

$$q_1 = (\varepsilon_3\sin 2\theta + \varepsilon_2\cos 2\theta);$$

$$B_{32} = B_{12}e^{2p1\theta} + B_{22}e^{2p2\theta} - q_2;$$

$$q_2 = (\varepsilon_3\cos 2\theta - \varepsilon_2\sin 2\theta);$$

$$B_{41} = \frac{1}{\nu}(p_1B_{11}e^{2p1\theta} + p_2B_{21}e^{2p2\theta} - q_2);$$

$$B_{42} = \frac{1}{\nu}(p_1B_{12}e^{2p1\theta} + p_2B_{22}e^{2p2\theta} - q_1).$$

Substituting the values of integration constants (10) in equations (3)–(6), we will receive the description of an inductance current and pressure for the established generator mode.

For the definition of the generator's power indicators it is necessary to define the current of the first loading harmonic and the current consumed from the power supply.

$$I_1 = \sqrt{I_{1s}^2 + I_{1c}^2} = \frac{I_{1s}}{\cos\varphi} = \frac{I_{1c}}{\sin\varphi},\ \text{где } tg\varphi = \frac{I_{1c}}{I_{1s}}. \quad (11)$$

Here:

$$I_{1s} = \frac{1}{\pi}\int_0^{2\theta} i_L\sin\tau\,d\tau + \frac{1}{\pi}\int_{2\theta}^{2\pi} i_{L1}\sin\tau\,d\tau =$$
$$= \frac{E}{\pi\omega L}\left(\int_0^{2\theta} i\sin\tau d\tau + \int_{2\theta}^{2\pi} i_1\sin\tau d\tau\right) =$$
$$= \frac{E}{\pi\varpi L}[A_5 + \xi(B_{51}\sin\varphi + B_{52}\cos\varphi)]; \quad (12)$$

$$I_{1c} = \frac{1}{\pi}\int_0^{2\theta} i_L\cos\tau\,d\tau + \frac{1}{\pi}\int_{2\theta}^{2\pi} i_{L1}\cos\tau\,d\tau =$$
$$= \frac{E}{\pi\varpi L}[A_6 + \xi(B_{61}\sin\varphi + B_{62}\cos\varphi)]. \quad (13)$$

Parameters $A_5, A_6, B_{51}, B_{52}, B_{61}, B_{62}$ are defined by the following expressions:

$$A_5 = \frac{1}{\pi}[\sigma(1-\cos 2\theta) + \frac{A_1}{1+p_1^2}d_{12} +$$
$$+ \frac{1}{\nu^2-1}(A_3d_{13} + A_4d_{14})];$$

$$B_{51} = \frac{1}{\nu^2-1} + \frac{1}{\pi}[\varepsilon_3(\frac{\sin 4\theta}{4} - \theta) + \varepsilon_2(\frac{\cos 4\theta}{4} - \frac{1}{4}) +$$
$$+ \frac{B_{11}}{1+p_1^2}d_{11} + \frac{B_{21}}{1+p_2^2}d_{12} + \frac{1}{\nu^2-1}(B_{31}d_{13} + B_{41}d_{14})];$$

$$B_{52} = \frac{1}{\pi}[\varepsilon_2(\frac{\sin 4\theta}{4} - \theta) - \varepsilon_3(\frac{\cos 4\theta}{4} - \frac{1}{4}) +$$
$$+ \frac{B_{11}}{1+p_1^2}d_{11} + \frac{B_{22}}{1+p_2^2}d_{12} + \frac{1}{\nu^2-1}(B_{32}d_{13} + B_{42}d_{14})];$$

$$d_{11} = 1 - e^{2p1\theta}(\cos 2\theta - p_1\sin 2\theta);$$

$$d_{12} = 1 - e^{2p2\theta}(\cos 2\theta - p_2\sin 2\theta);$$

$$d_{13} = \cos 2\nu(\pi-\theta) - \cos 2\theta;$$

$$d_{14} = \sin 2\nu(\pi-\theta) + \nu\sin 2\theta;$$

$$A_6 = \frac{1}{\pi}[\sigma\sin 2\theta + \frac{A_1}{1+p_1^2}d_{21} +$$
$$+ \frac{A_2}{1+p_2^2}d_{22} + \frac{1}{\nu^2-1}(A_3d_{23} + A_4d_{24})];$$

$$B_{61} = \frac{1}{\pi}[\varepsilon_3(\frac{\cos 4\theta}{4} - \frac{1}{4}) - \varepsilon_2(\frac{\sin 4\theta}{4} + \theta) +$$
$$+ \frac{B_{11}}{1+p_1^2}d_{21} + \frac{B_{21}}{1+p_2^2}d_{22} + \frac{1}{\nu^2-1}(B_{31}d_{23} + B_{41}d_{24})];$$

$$B_{62} = -\frac{1}{\nu^2-1} + \frac{1}{\pi}[\varepsilon_2(\frac{\sin 4\theta}{4} + \theta) + \varepsilon_3(\frac{\cos 4\theta}{4} - \frac{1}{4}) +$$
$$+ \frac{B_{12}}{1+p_1^2}d_{21} + \frac{B_{22}}{1+p_2^2}d_{22} + \frac{1}{\nu^2-1}(B_{32}d_{23} + B_{42}d_{24})];$$

$$d_{21} = -p_1 + e^{2p1\theta}(p_1\cos 2\theta + \sin 2\theta);$$

$$d_{22} = -p_2 + e^{2p2\theta}(p_2\cos 2\theta + \sin 2\theta);$$

$$d_{23} = \nu\sin 2\nu(\pi-\theta) + \sin 2\theta;$$

$$d_{24} = \cos 2\theta - \cos 2\nu(\pi-\theta).$$

The electricity consumed from the source:

$$I_0 = \frac{1}{2\pi}\int_0^{2\theta}\frac{U_c}{r}d\tau = \frac{1}{2\pi}\int_0^{2\theta}\frac{E-U_k-U_L}{r}\times$$

$$\times d\tau = \frac{E_a}{2\pi\omega L}\int_0^{2\theta}\sigma[1-\xi\sin(\tau+\varphi)-u]d\tau \qquad (14)$$

U is defined by expression (5).

Result of the integration (14):

$$I_0 = \frac{E_a\sigma}{2\pi\varpi L}\{2\theta+\xi[\cos(2\theta+\varphi)-\cos\varphi](1-\varepsilon_1)+$$
$$+\xi\varepsilon_2[\sin(2\theta+\varphi)-\sin\varphi]+$$
$$+I_{11}(1-e^{2p1\theta})+I_{12}(1-e^{2p2\theta})\}. \qquad (15)$$

The efficiency of the first harmonic is defined by the known parity [3]

$$\eta = \frac{1}{2}\xi\frac{I_1}{I_0}. \qquad (16)$$

$$\text{As } \xi = \frac{U_k}{E} = \frac{I_1R_н}{E} = \frac{I_{1s}R_н}{\cos\varphi}, \qquad (12)$$

$$\text{that agrees } \xi = \frac{R_н[A_5+\xi(B_{51}\sin\varphi+B_{52}\cos\varphi)]}{\omega L\cos\varphi}. \qquad (17)$$

On the other hand,

$$tg\varphi = \frac{I_{1c}}{I_{1s}} = \frac{A_6+\xi(B_{61}\sin\varphi+B_{62}\cos\varphi)}{A_5+\xi(B_{51}\sin\varphi+B_{52}\cos\varphi)}. \qquad (18)$$

The system of the transcendental equations (17), (18) allows us to define the required value of o.

From the conducted analysis we can see, that direct calculations of the generator's power indicators are rather labor-consuming, because of the bulky calculations and the impossibility of an analytical solution for this system of equations (17), (18).

Therefore in each separate case it is expedient to resort numerical methods by using computer calculations.

As an example, we have executed the PEVM energy conversion efficiency calculation. The generator for the special case is $\theta = 90°$ and $R_H = 5r$.

Figure 2 shows the generator's energy conversion efficiency dependence from the frequency and the LC contour parameters on a plane of variables (p_1, p_2).

As a first approximation $|p_1| \approx \frac{1}{\omega rC}$; $|p_2| = \frac{r}{\omega L}$; $p_1p_2 = \frac{\omega_0}{\omega}$; $\omega_0 = \frac{1}{\sqrt{LC}}$.

In the frequency characteristics of the generator's energy conversion efficiency it is possible to receive surface construction planes (figure 2), corresponding to specific relation values of $\frac{p_2}{p_1}$; energy conversion efficiency schedules. The function $\frac{1}{p_2} = \frac{\omega L}{r}$ is presented in figure 3.

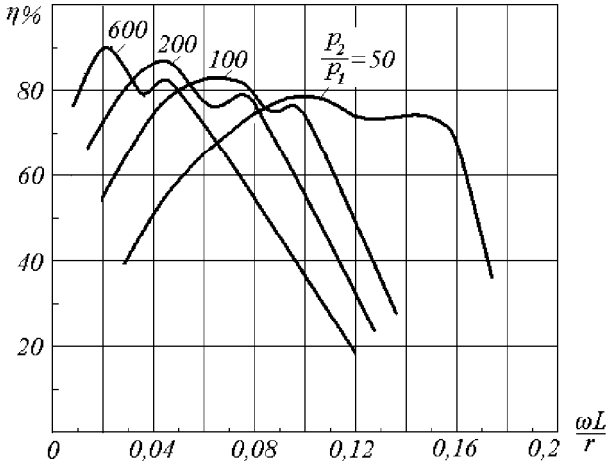

Fig. 3. Frequency characteristics of the generator

Here as in figure 2, the special case $\theta = 90°$ and $R_H = 5r$ is considered.

The conducted analysis states that direct calculations of the generator's energy features are rather complicated. The reason for this is the excessive calculation size and the analytical impossibility of solving equation systems (17), (18).

It is advisable to use numerical methods together with calculating devices for each case.

In conclusion we can say that it is possible to considerably increase the generator's energy conversion efficiency; in comparison with standard power converters, the energy conversion efficiency of which does not exceed 40...60 % for high frequencies.

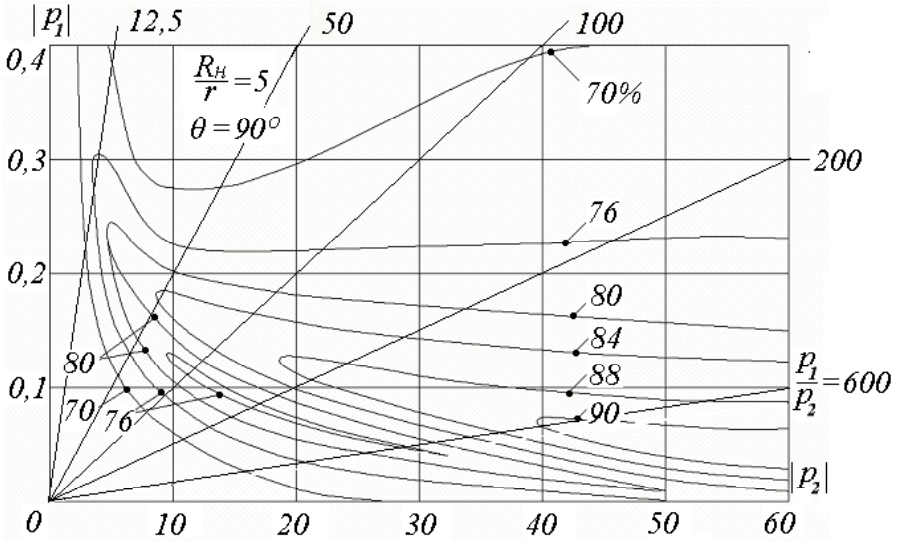

Fig. 2. Energy conversion efficiency of the generator

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DEVELOPMENT OF MECHANICAL TEST PROCEDURE FOR THE FUEL BELLOWS TANKS

The mechanical qualification and acceptance test requirements are considered for the fuel bellows tanks. Some procedural mistakes taking place during these tests are described.

Keywords: spacecraft, tank, storage and feed unit, mechanical tests, resonance.

For decades the fuel storage/feed units based on the bellows tanks are successfully used in the monopropellant propulsions of the domestic spacecrafts (SCs). In order to use the fuel storage units for new generation SCs (i. e. to be exposed higher mechanical loads) there was a necessity to perform supplemental mechanical tests to prove their durability.

SC hardware ground test plan includes the acceleration, vibration and shock tests [1; 2]. The tests levels are based on the data obtained from hardware operating conditions analysis, equipment mass and its allocation on the SC.

The storage and feed unit (SFU) manufacturer has to procure off-the shelf tanks from other supplier and then has to equip it with supplemental hardware in order to obtain the SFU as an item of SC propulsion.

During the SFU development testing, bellows of two tanks were corrupted (along an external crimp weld) when they were exposed to mechanical environment. This damage occurred directly along the weld, and not in an area around the weld; it was typically if the weld was well done i. e. this damage designated an insufficient quality of the join. It is necessary to note that such welds in the tanks are critical because they influence the strength of the whole assembly; the thickness of weldment isn't great, while the total length of weld may be hundreds of meters long. However, all the delivered tanks for the integration of the SFUs have passed the acceptance tests at the manufacturer's site.

In order to analyze the failures of tank bellows and to generate the levels of durability and acceptance tests, supplemental mechanical tests of two SFUs had been conducted. This work is meant to review all the test results and to identify the possible procedural mistakes that have made it impossible to detect manufacturing flaws during the acceptance tests of tanks.

Test Objectives. During the test campaign it was necessary to achieve a set of mutually complementary objectives:

– to detect the rupture sources of tank bellows;

– to develop a technique for determination of low eigenfrequencies of the bellows located inside a tank;

– to estimate an influence of test procedure on the test data;

– to confirm or exclude an influence of the test hardware (fixture, tools, control system, etc) to the test results;

– to update the durability/acceptance test levels for tank and SFU.

Test equipment and mechanical loads. The following mechanical tests were performed:

– resonance search within a frequency range of 5 Hz to 2,000 Hz with level of 0,5 g and a scanning rate of 2 octave/min;

– sine vibration within a frequency range of 5 Hz to 2,000 Hz with levels of 1 to 12 g;

– random vibration within a frequency range of 20 Hz to 2,000 Hz with levels of 0.02 to 0.2 g^2/Hz;

– quasi-static loads with levels of ±10 g;

– shocks with levels of ±40 g.

The test specifications were generated proceeding from the SFU operation conditions at levels of the SC and in compliance with an approach as described in [3; 4]. They have met the requirements as established in [1; 2]. The tests were conducted in few phases changing the levels and duration of loading. The following equipment was used:

– centrifuge C-400;

– shock test bench ST-800;

– vibration shaker LDS V894/440.

Beforehand, the test equipment and test fixture were subjected to approval. The equipment's low eigenfrequency is about 1,000 Hz. All the test hardware corresponded to the test standards according to the test specification accuracy and provided the mechanical loading of the SFU and was measured with the following tolerances:

– vibration acceleration amplitude: ±10 %;

– vibration acceleration power spectral density: ±6 dB;

– vibration frequency: ±2 % within a frequency range of 5 Hz to 2, 000 Hz;

– vibration acceleration RMS value: ±4 %;

– shock acceleration: ±15 %;

– linear acceleration: ±10 %.

Description of Tank Design. For the following analysis and identification of the bellows failures let us consider a design of the bellows tank. Figure 1 depicts its schematic diagram. The tank consists of a cylindrical case *1* with spherical bottoms *2*. The bellows *3* is welded on the aft of a cylinder *1*. A fluoroplastic ring *4* is installed on a free end of the bellows to provide gliding for the bellows on the case *1* along an axis and to restrain sideward shift. Minimum clearance *5* exists between the case and bellows. A gas cavity *6* is formed in the spherical bottom at a side of fluoroplastic ring *4*. Bellows are filled with a simulator of fuel (water).

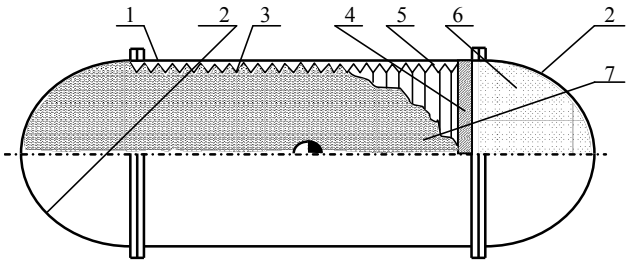

Fig. 1. Schematic diagram of the tank

Estimation of SFU eigenfrequencies. After the first phases of testing it became clear that the shock and quasistatic (linear) loads can not be a source of SFU failures, not speaking about the damage of tanks through loads without loss of bellows tightness.

These results are in compliance with the calculated stresses in the elements of tanks and they show that maximal stresses in bellows at the specified loads should be from 8 to 10 times less than the ones allowed. Before testing we also evaluated the low eigenfrequencies for the bellows and tank. The value of low eigenfrequency for the bellows is 8 Hz. Numerical analyses of stresses and eigenfrequencies were performed in accordance with reference [5].

The evaluation of low frequency for the tank case as in [6] gave a value of about 300 Hz. Eigenfrequencies for the SFU reinforcement (the control points are the following: *1*, *2*, *4*, *7*) are within a range of 150 to 500 Hz (these results were obtained during earlier tests of the SFU). Thus the test fixture, whose eigenfrequencies are above 1,000 Hz, could not impact on strength of low-frequency bellows as well as on the tank and SFU reinforcement responses. This is why the main attention was paid to the analysis of SFU vibration loading and test procedures.

Vibration test procedures and plans. Figure 2 depicts the locations of accelerometers in the tank case for recording the accelerations during the vibration test (the non-labeled points stand for recording the accelerations along three directions). The objective of the first testing phase was to determine the low eigenfrequencies of bellows.

Since it was impossible to measure the frequency of the fueled bellows inside the air-tight tank under pressure directly, the experimental data about the eigenfrequency of bellows was gained by a method of indirect measurements.

To justify a possibility of performing such measurements a groove was made on one of a SFU specimen case in the field of sensor *5Y* and an accelerometer was installed on a plane of sensors *5* allocation.

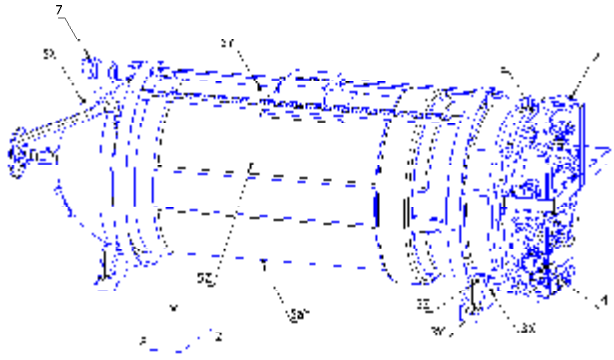

Fig. 2. Diagram of accelerometers allocation on the SFU

During the vibration test of this SFU by the wobbulator method [4] (the scan rate was 0,6 octave/min and level of load was 0.5 g), the accelerometer installed on the bellows and the accelerometers *5Y*, *5Ya*, *5Z* showed a presence of same frequency resonances. So using the indications of the accelerometers *5Y*, *5Ya* and *5Z* we can be judge about the eigenfrequencies of the SFU bellows. This effect can be explained easily: the gap between the bellows and the tank is small (~1 mm), when resonance phenomena arise, the bellows collide with the tank case at a resonant frequency, which is recorded by the accelerometers installed on the tank case.

The next testing phase was done to determine the lowest eigenfrequency of the fuelled bellows at levels of the SFU. The testing was conducted with the different scan rates of frequency (2 octave/min and 0.5 to 0.6 octave/min).

Test results. Resonant frequency search tests for the SFU with the fuelled tank conducted at the frequency scan rate of 2 octave/min have shown that no resonant frequencies exceed 17 Hz (ref. fig. 3). Thus, according to the conventional test procedures as described, for example in [7] a vibration test can be conducted starting from 10 Hz. Such approaches have been carried out at the tank manufacturer's site during the selective and acceptance tests' performance.

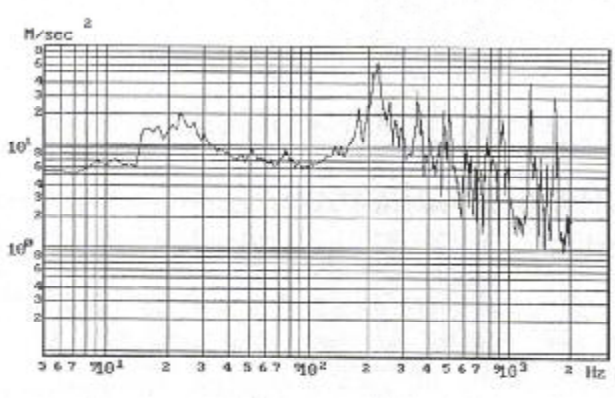

Fig. 3. Acceleration plot at point *5Ya* during resonance search test with scan rate of 2 octave/min

However, as it is shown in figure 4, when decreasing a scan rate down to 0.5...0.6 octave/min within a frequency range

of 7 to 8 Hz, a resonance appears (i.e. increasing a vibrational amplitude by 2 to 4 times), which is absent in figure 3.

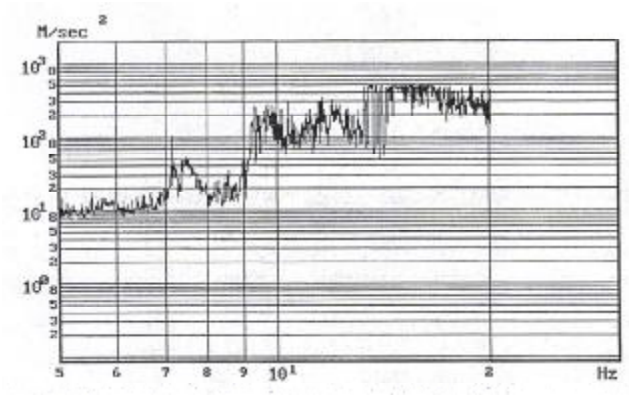

Fig. 4. Acceleration plot at point *5Ya* during resonance search test with scan rate of 0.6 octave/min

This phenomenon can be explained the following way: the bellows contain a bulk of fluid, which makes it fairly inertial. At a scan rate of 2 octave/min the resonances don't have time to develop which is mistaken as the absence of any resonant frequency. However, when decreasing a scan rate to 0.6 octave/min the bulk of fluid inside the tank is capable to develop the oscillations of both bellows and fluid in a low frequency range (i. e. resonance).

It should be noted that the vibration tests at the tank manufacturer factory were envisaged in accordance with a step acceleration method for every frequency sub-range from 10 to 2,000 Hz.

Then the vibration tests at the SFU manufacturer factory were conducted in accordance with the methodology providing smooth change of frequency from the lower boundary of 5 HZ to the upper of 2,000 Hz with a smooth change of acceleration from 1 g to 12 g (wobbulator method). Also the wideband random vibration tests equivalent to the sine vibration with a power spectrum density level of up to 0.2 g^2/Hz were conducted.

Analysis of differences in the SFU and tank test procedures. The differences detected in the test procedures for the tank and SFU have required performing an additional analysis. Conducting the tests from a frequency of 10 Hz eliminated loading of the bellows with maximal strains within a range of resonant frequencies from 7 to 8 Hz, because the amplitude of displacement was inerasable to a square of frequency [7]. In addition, after passing an octave frequency range with step increasing of load, the shaker was switched off and it carried out a new load level setting up by the test control system. It had an attenuation effect on the occurring oscillations; when passing the next frequency range the significant expenditure of energy was required to cause the oscillations of bellows with fluid again.

A validity of this statement is confirmed by the response plot of point *5Ya* obtained from the results of SFU random vibration tests and depicted in figures 5 and 6. The lower boundary of frequency range was 20 Hz and the structural response was at noise level when performing the test with the PSD up to 0.05 to 0.07 g^2/Hz (fig. 5), within a range of up to 20 Hz. When increasing the PSD to 0.2 g^2/Hz (ref. fig. 6), the power injected into the bellows was sufficient to increase the low frequency oscillations even within a frequency range which was excluded from test specification (below 20 Hz).

So it became comprehensible that the rupture of bellows might be caused directly by environment vibration within a low frequency range of up to 10 Hz, which impacts on the low quality bellows weld areas.

As vibration within a range of frequency ranges to 10 Hz, which is not used for qualification, acceptance and selective tests of the tank at the manufacturing factory, the weld defects are not detected.

Test based on the wobbulator method (where a low boundary of frequency is 5 Hz) applicable at the SFU manufacturing factory have calculated the tougher loading of the bellows; compared with tests based on the method where stepwise acceleration is applied within the sub-ranges of frequency. So the hidden weld defects are detected the SFU test phase only.

We shall note that the method based on stepwise acceleration had been used during he 1960s and 1970s. Today this method is not recommended to use because the digital control systems are exploited in compliance with ESA and NASA standards [1; 2].

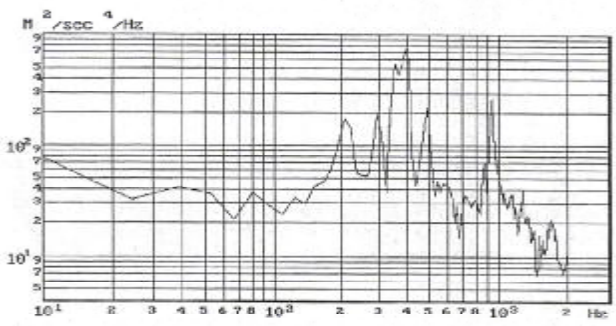

Fig. 5. Acceleration plot at point *5Ya* during a wideband random vibration test with PSD of up 0.07 g^2/Hz

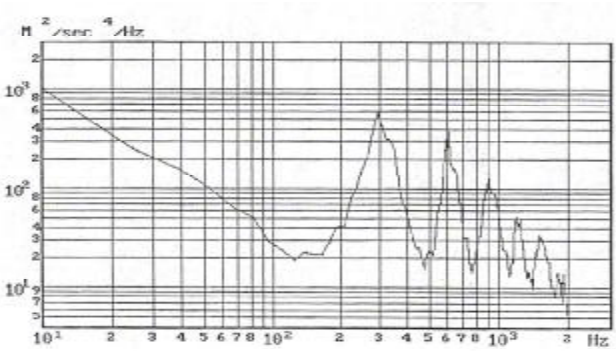

Fig. 6. Acceleration plot at point *5Ya* during a wideband random vibration test with PSD of up 0.2 g^2/Hz

The qualitatively higher vibration test procedures allow the detecting of bellow weld defects. It is necessary to note that no any requirements of existing test specification are formally disturbed at the tank production factory, but the applied acceptance/selective test procedure don't allow the detection of bellow weld defects.

At the same time, analysis shows that in ranges of intermediate and high frequencies a wideband random vibration environment is the closest (of physical nature) to

actual mechanical environment as a response of SC structure to acoustic loads during the launch phase for the SFU at level of SC [1; 2; 7; 8]. Wideband random vibration allows the loading of the SFU within a wide amplitude/frequency range without the damage of high quality fabricated equipment (fig. 6).

From the said above, we can make the following conclusions and recommendations.

The most probable cause of the tank's bellows destruction during the SFU mechanical tests was the low quality of bellows crimp welds which have not been detected at the tank production factory, combined with overloads at resonant frequency within a low frequency range (5 to 8 HZ).

During the acceptance/selective tests of the tank at the factory for the purpose of detecting hidden bellows weld defects, it is advisable to use the sine vibration test in low frequency range of 5 to 100 Hz (not less then 5 to 20 Hz) based on a wobbulator method with scan rate no higher than 0.5 to 0.6 octave/min.

It is advisable to use a wideband random vibration test with PSD of 0.05 to 0.07 g^2/Hz at the SFU factory during acceptance tests; and it is better to use a sine vibration test within a low frequency range and wideband random vibration test with PSD of up to 0.2 g^2/Hz for the qualification tests.

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GEO SATELLITE ATTITUDE AND ORBIT CONTROL: FIXED ORBIT CONTROL THRUSTERS

The paper describes the enhanced application of high-economical electro-jet orbit control thrusters for geostationary satellites; in particular, generation of controlling moments to the benefit of satellite attitude determination and control subsystems in the course of orbit control maneuvers ongoing. The scheme with thrusters fixed on a satellite body is analyzed. Possible orbit control session procedures are proposed on the basis of controlling moments generation. Advantages and disadvantages of the proposed approach are analyzed.

Keywords: spacecraft, propulsion subsystem, orbital control, attitude control, thruster allocation.

The performance of thruster subsystems dramatically influence the geostationary satellite platform characteristics. The mass of thruster units filled can achieve 15...20 % of a satellite mass, the power consumption of electro-jet thruster unit can be up to 4 kW; therefore even minor reduction of the thruster unit mass and the power consumption allows reducing satellite mass and increasing payload capacity. Taking this information into account, we believe it to be important and reasonable to consider issues of optimal development of satellite attitude and orbit control maneuvers using thruster subsystems. Such aspects usually become essential at the initial design stage of a new satellite design. In practice, solutions are mainly subjective, so their detailed examination and formalization is desirable.

There are three known concepts of attitude and orbit control arrangements using thruster units:

– individual thruster units to ensure attitude and orbit control;

– attitude control (creation of controlling moments) ensured by orbit control thrusters fixed on a satellite body;

– attitude control ensured by orbit control thrusters mounted on one- or two-step drives.

Each of these approaches has its advantages and disadvantages. The first approach is a traditional and simple one implemented on a lot of satellites, including satellites developed and manufactured by JSC ISS (former NPO-PM) [1]. This approach allows to individually and independently solve the ballistic task of controlling a SC center of gravity position (orbit control task) and a SC angular position (attitude control task).

The second approach promises a certain mass saving due to refusal of separate attitude control thruster unit, though it probably requires more complicated orbit correction maneuver procedures as the orbit correction task shall be accompanied with a task of controlling moments generation to allow ADCS wheel unloading. Such an approach is

employed for YAMAL-100 satellite [2]. It is worth mentioning that a minor supplemented attitude control thruster unit is still required, which will assist in generating controlling moments in the SC acquisition modes (after a booster separation) and in the safe-hold modes, in other words, in the situations when plasma thrusters shall not be fired due to intensive power balance.

The third approach is a modification of the second one. Possibilities of attitude control and redundancy are enhanced to a certain extent due to drives used; however, some mass increase is caused by additional mechanical and electronic units installed. Additional needs in thruster position orientation occur; structural strength, thermal modes, reliability and other aspects shall be analyzed and improved. Drive-based orbit control thrusters are mainly installed on foreign satellites [3].

We would like to note that according to any of the three approaches the main reliability requirement shall be met, in particular, a failure of a single item (a thruster, in our case) shall not cause the impossibility to solve a task, that is, impossibility to generate thrust in any of required four directions (North-South, West-East) and controlling moments along any of three axes.

Comparative analysis of various thruster subsystem designs can be performed in terms of the criterion of total filled masses of thruster units (or masses of variable components in comparison with the selected baseline design). It is also obvious that such analysis can be only possible for a certain satellite layout (a typical layout, for example).

Let us choose a scheme in figure 1 as a typical one, that is, individual attitude control and thruster units and orbit control thruster units. Consider the possibility to arrange attitude control and orbit control maneuvers taking into account the reliability requirements in the scheme with orbit control thrusters fixed. The efficiency of the scheme under investigation will be characterized by the difference between the filled thruster unit mass and the typical scheme.

Let a 2-m edge cube be a typical configuration of an unsealed satellite body (fig. 1). Satellites of the YAMAL family (RSC Energia) and satellites of the EXPRESS-1000 family (JSC ISS) are close to such configuration. On the North and South faces (axis *Z*) solar arrays are installed, the rotation axis of which runs through the SC Center of gravity or close to it. On the West and East faces (axis *Y*), as a rule, repeater antennas are installed (they are not shown in figure 1). That is why the location of orbit control thrusters on the diagonals of a square formed by cutting a satellite body with the plane *YOZ* is a justified solution. In particular, this solution is discussed in the paper [4]. It ensures the minimal impact of thruster jets impinging upon panels and antennas. Of course, other schemes are also possible, for example, the schemes with thrusters located outside the plane *YOZ*, however they are not the subject of this paper. Let's accept the most widely used Russian plasma thruster M-100 (Experimental Design Bureau "Fakel") as an orbit control thruster for the scheme considered.

Let us first consider the peculiarities of the baseline scheme. According to this scheme (fig. 1), the orbit control thruster lines of action nominally run through the SC center of mass. It is reasonable to perform the inclination correction by firing a pair of thrusters in direction $+Z$ or $-Z$, the correction of longitude and eccentricity – by firing a pair of thrusters in direction $+Y$ or $-Y$. With that, each thruster can contribute in generating thrust pulse along both *Z* axis and *Y* axis, depending on a pair of thrusters fired to which it belongs.

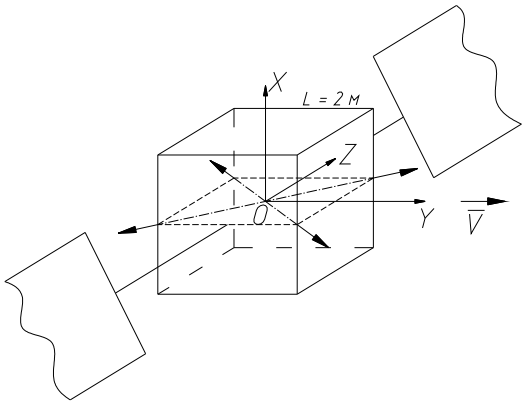

Fig. 1. Baseline orbit control thrusters: coordinate scheme and nominal thrust directions

The issue of a number of orbit control thrusters shall be considered separately. It goes without saying, that the minimal number of such thrusters is 4. Let us check whether the main reliability requirement is met in this case.

In case of failure of one of the pair of +Z thrusters, the inclination correction is performed by the pair of $-Z$ thrusters. The same situation occurs under the failure of one of the pair of $-Z$ thrusters.

The inclination correction can be performed using only one thruster (for example, $+Z$), however, in this case to compensate a pulse in the Y direction (due to availability of a thrust component along the *Y* axis) it is necessary in 12 hours, during the inclination correction, to fire a thruster having a component of the opposite sign along the *Y* axis (in this case: $-Z$).

In case of failure of one of the pair of $+Y$ ($-Y$) thrusters, the longitude correction is possible using the remaining healthy thruster. Then the pulse component in the *Z* direction will be reasonably used while selecting an appropriate time to fire thrusters within 24 hours.

Thus, actually 4 thrusters installed on the diagonals on the body edges within the plane *YOZ* ensure the orbit correction tasks in 4 directions with the main reliability requirement met. The failure of any thruster does not cause the impossibility to perform corrections in longitude and inclination.

However, we note that according to the scheme considered, under the simultaneous failure of two thrusters in the *Y* direction the longitude correction is impossible as the thrust generation in both $+Y$ and $-Y$ direction is required. The inclination correction (in the *Z* direction) using the remaining healthy thruster of the direction considered is also impossible in this case as there is nothing to compensate a thrust longitudinal component, which is a necessary element of the inclination correction maneuvers.

Taking all this information into account, at the design stage the decision most likely to be made is to install 8 orbit control thrusters (two thrusters along each diagonal). This decision is excessive in terms of reliability, because in this case longitude and inclination corrections will be possible

even in case of failure of two thrusters. But due to the fact that the failures can occur not simultaneously, they can be considered as two single failures caused by resource problems. So, for the baseline design let's assume to have 8 thrusters located pairwise, approximately in each diagonal direction within the plane *YOZ*.

When using orbit control thrusters fixed on a satellite body to generate controlling moments, it is obvious that the action line of each thruster thrust shall not run through the SC center of gravity but shall have a certain lever. As the controlling moments are necessary in some situations only, it shall be possible to generate thrust without moments when performing correction maneuvers. That is why the correction maneuvers shall be carried out using pairs of thrusters generating opposite moments. When it is not necessary to generate controlling moments, the thruster firing durations during the maneuvers shall be the same (provided the moments generated are equal). When it is necessary to generate controlling moments, the firing duration of thrusters of the pair considered shall not be the same. The moment pulse value is determined by the differences in thruster firing durations. Having in mind the necessity of pairwise thruster operation and satisfaction of the main reliability requirement, the total amount of orbit control thrusters for the scheme under consideration shall be at least eight. On the analogy of the baseline variant the thrusters (T1-T8) can be arranged in the diagonal directions within the plane *YOZ* (fig. 2), and the levers can be created by minor (for example first-order) deviations of thrusters within the corresponding planes (fig. 3).

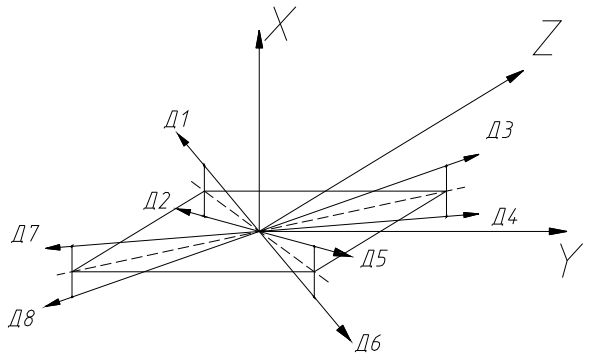

Fig. 2. Initial locations of orbit control thrusters according to the scheme with stable fixation of thrusters on a satellite body

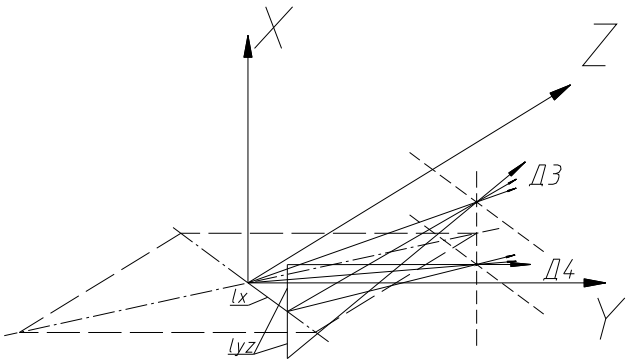

Fig. 3. Deviations of action lines of fixed thruster thrusts aimed at generating controlling moments (shown for T3, T4 only)

Under deviation by angle $\alpha = 1^{\circ}$, changes of thrust projection on the axes *Y*, *Z* can be neglected. With the thruster fired, the controlling moment is as shown below, for the chosen inputs of a satellite body geometrical configuration:

$$M = F \cdot L \cdot \mathrm{tg}\alpha = 8 \cdot 141.4 \cdot 0.01745 = 19.74 \approx 20 \text{ g·cm}.$$

When two thrusters generating the moments of the same sign are fired, the moment value is doubled. The sufficiency of 20 g·cm controlling moment can be estimated by comparing this value with the disturbing moments caused by orbit control thrusters fired. However, to compute the disturbing moments a satellite configuration shall be specified with sufficient details. It is difficult to do it in this paper as we consider a theoretical satellite. We know the disturbing moments computed for satellites of the EXPRESS-1000 platform: max disturbing moment was (along the *Y* axis) 14 g·cm, with average value of approximately 8 g·cm. In this case, the controlling moment of approximately 20 g·cm (based on the chosen inputs) is sufficient to ensure the control of SC angular position. It is also obvious that, in general, the excess of controlling moment over the disturbing moment can be provided by correct selection of deviation angle of the line of thrust action with respect to the COG direction.

With regard to the scheme investigated, let us consider the possibility of arranging the orbit correction maneuvers with simultaneous generation of controlling moments and satisfaction of the main reliability requirement.

In general, the task is solved by arranging the thrusters so that they could generate the correction pulses in the N–S and W–E directions ($\pm Z$, $\pm Y$) with and without controlling moments of both signs generated along three axes. We would like to note that the requirement of generating controlling moments along three axes is a little excessive. To control a GEO satellite angular position, it is necessary to generate controlling moments along the *Z* axis (pitch), and the controlling moments along the *X*, *Y* axes (yaw, roll) can be redistributed by wheel-based control system (taking into account SC orbital motion). In other words, it is enough to generate only controlling moments along the roll and pitch axes. However, in this paper we are interested in solving the general task of generating controlling moments along three axes. It is obvious that if there is a general solution then a simpler specific solution can always be found. Taking into account the condition of limited power consumption, we assume that not more than two thrusters can be fired at a time.

The initial scheme of orbit control thruster locations is assumed as a baseline (figure 2). It can be modified to generate controlling moments as shown in figures 3, 4, 5. According to the initial scheme, the thrusters are located on the body edges, the principle thrust generation directions are along the square edges formed by cutting a satellite body with the plane *YOZ*. In each direction two thrusters are installed close to each other. The thrusters are 8 in total. On the basis of overall dimensions of a thruster unit and the possibility of its installation on the satellite body, each thruster is installed so that its axis nominally runs through the center of gravity at a certain angle to the plane *YOZ*. Let us assume that the axes of thrusters T1, T3, T5, T7 are turned to the direction +*X*, and T2, T4, T6, T8 are turned to the direction –*X*, symmetrically (figure 2).

To generate controlling moments along the axis X (yaw), pairs of thrusters T1 + T2, T3 + T4, T5 + T6, T7 + T8 shall be rotated by a small angle, for example by 1є, along the axes

coinciding with the edges as assumed above. For the purpose of symmetry, pairs T1 + T2, T3 + T4 can be rotated to the +*Z* direction, pairs T5 + T6, T7 + T8 – to the –*Z* direction (fig. 4). Let it be the first rotation.

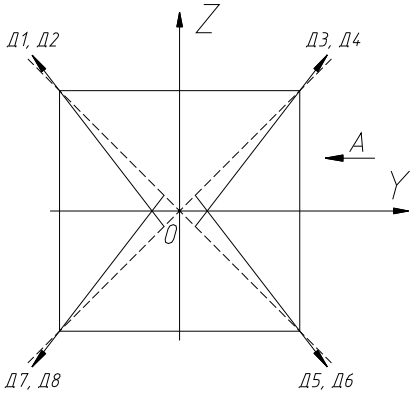

Fig. 4. Yaw control scheme

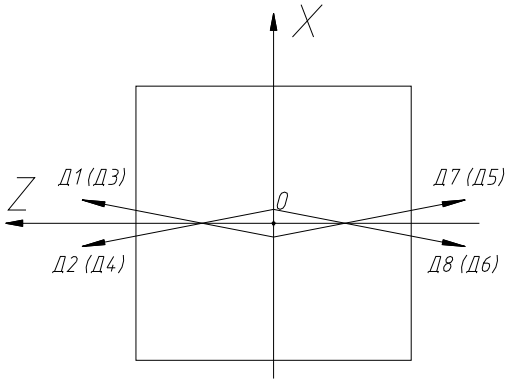

Fig. 5. Pitch and roll control scheme

To generate controlling moments along the axes *Z* and *Y* (pitch, roll), the thrusters shall be rotated by the same small angles to the +*X* and –*X* directions within the planes formed by their axes and the first-rotation axis (edges). Let it be the second rotation. For the purpose of certainty, let us rotate thrusters T1, T3, T5, T7 to the +*X* direction, and thrusters T2, T4, T6, T8 – to the –*X* direction (fig. 5).

According to the scheme considered, we propose the following procedure of generating controlling moments to be used while performing inclination and longitude corrections.

Inclination corrections: pulse generation in the South direction (–*Z*): correction session is divided into two steps, in particular, during the first step the thrusters T1 + T2 are active (time t_1) and during the second step the thrusters T3 + T4 are active (t_2). If $t_1 = t_2$, then the controlling moment is not generated, a "pure" thrust pulse is formed in the –*Z* direction. If $t_1 \phi t_2$, then the moment pulse $+M_X$ is generated, if $t_2 \phi t_1$, then the moment pulse $-M_X$ is generated. The total moment pulse value is determined by the difference between times t_1 and t_2. As with each pair of thrusters fired the moment is generated, then over the entire duration of the thruster activation (t_1 and t_2) the wheel-based control system shall maintain the specified three-axis attitude of a satellite. If the system capacity is not enough to solve this task, then the correction session can be divided into a larger number of steps (4, 6, 8…) with the aim to reduce the moment pulse during the operation of each pair of thrusters to an acceptable value. The correction maneuvers are performed by a pair of thrusters (T1 + T2) or (T3 + T4) to prevent generation of moments along the axes *Y*, *Z*.

Similarly, generation of thrust pulses in the North direction (+*Z*) is ensured by the pairs (T7 + T8) (t_1) + (T5 + T6) (t_2). With $t_1 \phi t_2$ the pulse of positive moment $+M_X$ is generated, with $t_2 \phi t_1$ the pulse of negative moment $-M_X$ is generated.

It is worth mentioning that as the thrusters have a thrust component along *Y* axis, a non-compensated thrust pulse in the longitudinal direction is generated at the expense of the difference between t_1 and t_2 while performing the inclination corrections. To compensate this pulse impact, a special longitudinal correction session is most likely to be required.

Longitude correction:

– generation of thrust pulse in the West direction: (T3 + T4) (t_1) + (T5 + T6) (t_2). With $t_1 \phi t_2$ the pulse of negative moment $-M_X$ is generated, with the pulse of positive moment $+M_X$ is generated;

– generation of thrust pulse in the East direction: (T1 + T2) (t_1) + (T7 + T8) (t_2). With the pulse of positive moment $+M_X$ is generated, with the pulse of negative moment $-M_X$ is generated.

Inclination correction:

Generation of thrust pulse in the South direction is ensured by the pairs:

(T1 + T3) (t_1) + (T2 + T4) (t_2). With the pulse of negative moment $-M_Y$ is generated, with the pulse of positive moment $+M_Y$ is generated.

Generation of thrust pulse in the North direction is ensured by the pairs:

(T5 + T7) (t_1) + (T6 + T8) (t_2). With the pulse of positive moment $+M_Y$ is generated, with the pulse of negative moment $-M_Y$ is generated.

Longitude correction:

Generation of thrust pulse in the East direction is ensured by the pairs:

(T1 + T8) (t_1) + (T2 + T7) (t_2). With the pulse of negative moment $-M_Y$ is generated, with the pulse of positive moment $+M_Y$ is generated.

Generation of thrust pulse in the West direction is ensured by the pairs:

(T4 + T5) (t_1) + (T3 + T6) (t_2). With the pulse of positive moment $+M_Y$ is generated, with the pulse of negative moment $-M_Y$ is generated.

Inclination correction:

Following the selected layout, during the inclination correction maneuvers the generation of "pure" controlling moments in pitch is impossible.

Longitude correction:

Generation of thrust pulse in the East direction is ensured by the pairs:

(T1 + T7) (t_1) + (T2 + T8) (t_2). With the pulse of negative moment $-M_Z$ is generated, with the pulse of positive moment $+M_Z$ is generated.

Generation of thrust pulse in the West direction is ensured by the pairs:

(T3 + T5) (t_1) + (T4 + T6) (t_2). With the pulse of positive moment $+M_Z$ is generated, with the pulse of negative moment $-M_Z$ is generated.

Inclination correction:

In case of failure of one "North" thruster, the inclination correction can be performed without any limitations according to the above procedures using the "South" thrusters.

Longitude correction:

In case of failure of one "West" thruster (for example T1), the pulse in the East direction can be generated by the pair T2 + T8 or T2 + T7. In the first case, the moment in pitch $+M_Z$ is generated, in the second case, the moment in roll $+M_Y$ is generated. The moments mentioned shall be compensated using a wheel-based control system within its capability scope, the duration of the thrusters firings can be limited. The value of the moment to be compensated can be reduced twice by firing only one thruster, for instance T2, T7, T8 instead of firing a pair of thrusters. However, during the activation of any of the thrusters mentioned above, the moments along all three axes occur.

The similar situation takes place in case of failure of any "East" thruster. Limitations imposed by the ADCS can be avoided by implementing additional thrusters of longitude corrections, with the line of actions running through the SC center of gravity. However it will result in increasing the number of the orbit control thrusters to be used up to 10.

Thus, we can conclude that with the considered orbit control layout scheme, the correction in longitude and inclination are possible with and without generation of controlling moments of both signs along three axes. Moreover, the redundancy is provided in case of failure of one thruster used for the inclination corrections (without any limitations) and in case of failure of one thruster used for the longitude corrections (with limitations imposed on correction duration depending on the parameters of the wheel-based ADCS system). However in comparison with the initial scheme, the planning of the orbit correction maneuver sessions becomes more complicated as both generation of the thrust pulses in the required directions and generation of controlling moments of a specified sign are required.

Let us consider the possible advantages of the above mentioned scheme of the orbit control thruster locations. Let us use 8 thrusters as shown in figure 2 without any additional longitude correction thrusters. As the controlling moments are generated while performing the correction sessions (due to minor deviation of thruster axes from the nominal directions), then the propellant is not spent for the purpose of generating moments in the process of satellite nominal operation. That is why in order to compare the initial scheme with the considered one it is quite sufficient to compare a filled mass of monopropellant AC (attitude control) thruster unit with a mass of gas-jet system ensuring the initial modes and emergency modes. Due to task limitations (the required total pulse is small), the simplest solution is to use the same propellant (gaseous xenon), which is used for the OC (orbit control) electric-jet thruster unit. In this case, no additional tank is required (if sufficient volume of electric-jet thruster unit tanks is available). Let us assume that the tank capacity is sufficient to fill additional gas, and perform the above comparison for satellites based on the EXPRESS-1000 platform.

Cold xenon gas-jet system:

Gas feed unit: 3 kg; additional AC thruster units: 6 × 0.5 kg = 3 kg.

The total pulse required for orientation purposes in the initial and emergency modes depends on satellite mass, nozzle locations, quantity of the above mentioned mode occurrences. According to the estimations, for satellites of 1...2 tons, 100...200 kg·s are required. Let us take the high value for the purpose of reliability. Xenon mass required to generate approximately 200 kg·s and specific pulse 25 s under temperature 20 °C is 8 kg; pipe mass is ~3 kg. Totally: 17 kg.

Monopropellant AC thruster unit:

Thruster unit: 1,9 kg × 8, totally: 15,2 kg; storage and feed unit: 16,3 kg; pipes: ~3 kg; propellant: 25 kg; pressurant: 0,15 kg. Totally: 59,65 kg.

Therefore, the difference in masses of considered propulsion subsystem configurations is approximately 43 kg. This value is the upper mass advantage estimate of the scheme with orbit control thrusters fixed, generating controlling moments, in comparison with the initial (baseline) scheme of individual independent attitude and orbit control thruster units with regard to satellites based on the EXPRESS-1000 platform. If an additional Xenon tank (16 kg) is required, then the advantage over the initial scheme is 27 kg.

Depending on the design of a specific platform, the mass advantage value achieved due to refusal of dedicated AC thruster unit and generation of controlling moments by OC thrusters can vary significantly. However, one can expect it to be 30...40 kg. With two additional OC thruster tanks installed in the scheme shown in figure 2 (one unit in the $+Y$ direction, the other in the $-Y$ direction) to ensure full redundancy of the longitude correction thrusters, then the advantage is close to the low value limit (30 kg).

The analysis has confirmed that the use of OC thrusters fixed on a satellite body with the aim of generating controlling moments is possible. Such solution can ensure mass advantage up to 30...40 kg (for a satellite of 1...2 tons) due to refusal of dedicated AC thruster unit. However, this advantage may cause dramatic complication of the orbit correction maneuver planning and implementation: each correction (up to 2 times a day over the entire lifetime) shall be planned separately with the involvement of specialists in charge of motion control and attitude control subsystem. Correction sessions shall be performed by pairs of thrusters only, it shall be ensured by TU power processing unit, and the required EPS power available. The correction sessions shall be divided into steps, the thruster firing duration shall be provided with the required accuracy, not less than several seconds or tens of seconds, at least. Coincidence of inclination corrections and wheel unloading operations requires additional longitude corrections. Automation of the correction sessions is rather difficult. The approach can be implemented only for the satellites not requiring rather long autonomous operation.

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RISK ANALYSIS AND THE ELEMENTS OF FLIGHT SECURITY

The problem of risk analysis for civil aviation airplanes is studied. We have investigated independent examples of risk analysis calculations for flight accidents.

Keywords: catastrophe, risk-analysis, expenditures, profit, accident probability.

Safety is an important issue in human activity of any kind. It is most important in the so called traditionally dangerous fields, such as aviation. Technical malfunctions, mistakes made by the crew and ground services – all these factors can be the cause of accidents occurring in aviation. However, the casualties and loses in the civil aviation are still less, than in other dangerous professions and fields of human activity. This relative security is achieved by scrupulous monitoring of this sector and by large expenditures; special attention is paid to the technical conditions of aircraft, and to the work of personal engaged in conducting the flights. The finances spent on the safety maintenance differ in origin, i. e. it is difficult to track all the expenditures. It is necessary to form and solve the problem of correlating the amount of spent monetary resources and the level of security achieved. Work [1] depicts a parabola of profit and expenditure resulting from resources, invested into the aforementioned security (figure 1).

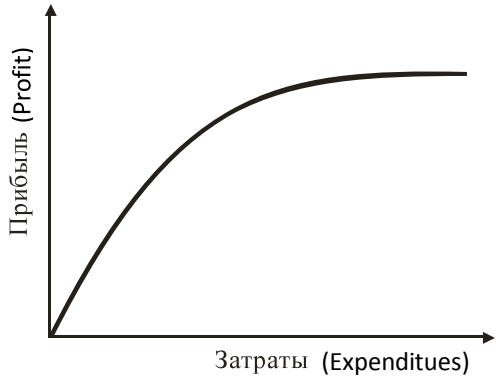

Fig. 1. Expenditure and profit

It would be necessary to notice, that the parabola is the same for all kinds of human activities. The only difference is that of profit and expenditure. It is said, that investments in security are reasonable only to the point, when expenditures are lower than profit. As profit, we see the decrease of loses from aircraft accidents that had been prevented by organized security activities – which of course, were invested into. The criteria of expenditure and profit equality is rather worthy. We do not consider here the aspect of moral.

The feature of the profit-expenditure parabola shows that the efficiency of the expenditures decreases as they increase. This is a good example of the idea that however high the expenses are, absolute security cannot be achieved. There is always the danger of an accident. The features of the parabola can be presented in the following exponential dependence:

$$\Pi_{\text{приб}} = 1 - e^{-(З - З_0)З}, \qquad (1)$$

where $З$ are the security expenditures; $З_0$ – primary (executed before) expenditures.

Dependences constructed with the help of (1) are shown in figure 2. They state that the greater the level of primary expenditures is $З_0$ – the greater the profit from additional expenditures. However, if there is a lower diapason of realized expenditures, the efficiency of them decreases. The primary expenditures level $З_0$ varies by branches and activities.

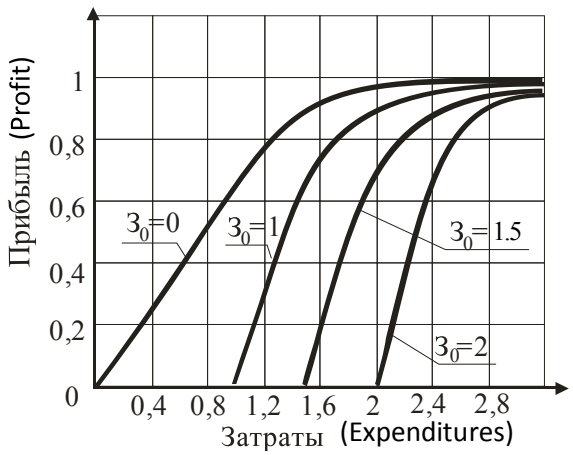

Fig. 2. Dependence of profit from security maintenance expenditures for various primary expenditures

Even though the proposed model (1) joins profit and expenditure, it cannot reveal the mechanism for forming them.

We have made an attempt to do so by investigating the expenditure increase for improving the reliability of aircraft from accidents.

We have studied the statistics of 50 accidents in the Russian Federation that have occurred during the last years with civil airplanes and helicopters. Reasons for 97 % of the accidents are connected to a negative human factor. 3 % resulted due to aircraft malfunctions, caused by flaws in the construction and production. 94 % out of 97 % cases of accidents are due to mistakes made by the crew. The other 3 % are results of low quality aircraft maintenance by ground and supply personal.

3 % of the accidents (from the total sum), resulting because of technical malfunctions are caused by engine breakdowns. We have not recorded accidents caused by errors in the aircraft's functioning systems.

Accidents, caused by malfunctions of the engines should be reviewed separately. The breakdown of an engine on a single-engine aircraft leads to disaster, if conditions for an emergency landing are impossible.

For major airliners with two or more engines, the breakdown of one engine usually does not result in a fatal accident. The time when 4-engine planes were considered to be safer that two-engine (a 4-engine plane can continue its flight with one engine down, while a 2-engine cannot) has long passed.

ICAO regulations state that planes with two engines must be able to sustain themselves in air for at least three hours in case of a breakdown of one engine. This time should be enough to finish the flight or to find a safe landing area.

Malfunctions are more dangerous if they result in fires onboard the plane, or cause destruction to the systems of the aircraft. These factors make it impossible to safely continue the flight. This has changed the concept of reserving engines onboard.

The modern aircraft industry lets us produce aircraft engines of both greater and lower thrust power with relative reliability. This catastrophically increases the possibility of engine breakdowns that will result in tragedy; the more engines a craft carries – the greater the risk. This led to constructing aircraft with two engines, the thrust power of which had been increased; naturally in craft, where two engines were enough.

Engines with greater thrust are much more expensive to produce. The cost of one kilogram of thrust is approximately proportional to the third level of increasing thrust.

These ideas make it possible to construct the parabola for expenditure and profit for the value of flight security, caused by the safety of the engines.

Let's look at the cost formation for the aircraft engines. The cost of one kilogram of thrust is proportional to degree k increasing its thrust n times.

Let's suppose that the basic engine has thrust P_0 and cost $Ц_0$. The plane has m_0 basic engines the thrust if which are:

$$T = P_0 m_0.$$

The cost of the basic engine installation is:

$$C_0 = Ц_0 m_0.$$

If we increase the engines thrust n times, the cost of one kilogram of thrust increases n^k times, increasing the total cost of the engine n^{k+1} times. When the thrust of the engine is fixed T there will be in n times less engines on the aircraft. The cost of the engine installation with fewer engines will be:

$$C_n = C_0 \cdot n^k. \quad (2)$$

To evaluate the losses from accidents let's state a possibility of engine malfunctions equal to10^{-9} for one hour of flight. In reality it is lower, but the standards of flight guarantee [2] dictates a given limit value of accident possibility, caused by aircraft malfunctions is equal to 10^{-9} fo one hour of flight. Let's suppose that loses resulted by one accident are equal to C_k and that the whole basic engine installation contains m_0 engines. Then the possibility of engine breakdown during one flight hour is:

$$Q_0 = 1 - (1 - 10^{-9})^{m_0}.$$

Increasing the engines thrust n times proportionally decreases their quantity in the installation and the breakdown possibility will be:

$$Q_n = 1 - (1 - 10^{-9})^{\frac{m_0}{n}}.$$

Then the possible loses from accidents will be

$$C_{kn} = C_k Q_n = [1 - (1 - 10^{-9})^{\frac{m_0}{n}}] C_k. \quad (3)$$

Expressions (2) and (3) in parametric form define the parabola of security expenditure – the loses from accidents in parameter n. It is expressed in (2) in the form of

$$n = \sqrt[k]{\frac{C_n}{C_0}}.$$

If we will place n in equalization (3) we will eventually have

$$C_{nk} = [1 - (1 - 10^{-9})^{m_0 \sqrt[k]{\frac{C_0}{C_n}}}] C_k. \quad (4)$$

Since C_0 and C_k are unknown to us, the change in expenditure and in loses, it is easier to find their values, using expressions (2) and (3) in shares C_0 and C_{kn}.

The calculation results for cases of price increase of 1 kg of thrust are proportional to the second and third step of engine thrust increase. They are presented in figure 3. We can see that when $k = 2$ and $k = 3$, there is a decrease in efficiency, reducing the amount of accident loses, and an increase of expenditure; this respects to the model of expenditure – profit in [1] when applied to flight security.

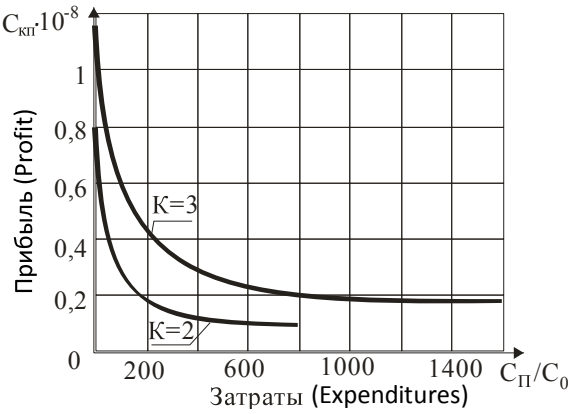

Fig. 3. Dependence of accident loses in the expenditure function

The study of expenditure and profit in cases with a constant number of *m* aircraft engines and the increase in thrust is of great interest. When the engine thrust is increased *n* times, the price of each kilogram of thrust increases by n^k times, the price of the engine n^{k+1} times. The cost of one installation will be:

$$C_n = C_0 n^{k+1}. \quad (5)$$

During this the common thrust of the engine installation increases proportionally *n*. The aircraft's flight mass, passenger capacity, and loses from an accident increase with the thrust, i. e.

$$C_k = C_{n0} \cdot n.$$

In this case (considering the risk) the loses will be:

$$C_{kn} = nC_{k0} \cdot Q_n.$$

Since there are two engines, the final calculated expression will be:

$$C_{kn} = nC_{k0}[1-(1-10^{-9})^2]. \quad (6)$$

The dependence of loses from accidents in the expenditure function from the increase of engine installation thrust is depicted in figure 4. Contrary to figure 3, loses from accidents here increase when the expenditures on engine installations increase. The loses in this case are connected to the increase in passenger capacity of an aircraft, while the reliability of he engines has not changes. With the increase of engine thrust – the price of the engine installation also increases, due to the possibility of accidents.

This can create a false notion that the amount of possible casualties from accidents decreases. In reality such a dependence feature of the engine installation from expenditure and loss, points out that beginning from some value of the expenditure (the engine installation) becomes so intense, that this solution becomes a dead end and no longer works.

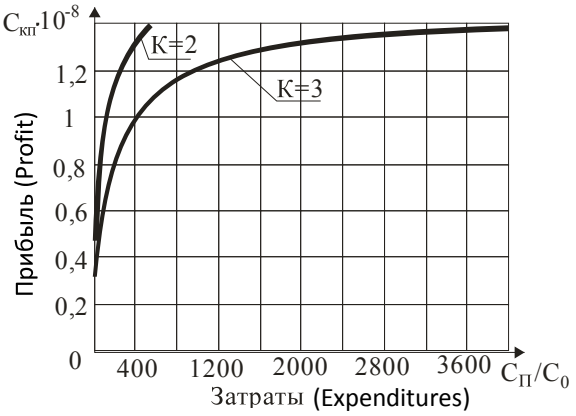

Fig. 4. Dependence of loses in the expenditure function for engine thrust increase

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OIL FROM THE JURUBCHENSKY DEPOSIT IS A POTENTIAL RAW MATERIAL FOR THE PRODUCTION OF JET A-1 AVIATION FUEL

The development of oil deposits in the Evenki Autonomous Area is connected with study of the properties and quality index of extracted crude oil and oil fuels.

The ecological requirements to oil products become more stringent today. Measures for lower oil extraction costs, oil processing and equipment exploitation are also to be met. Therefore, the study of crude oil and oil fuel properties is very important.

Keywords: oil, manufacturing of Jet A-1aviation fuel, hydrogen sulfide, thiols.

The Evenki oil was studied at different stages of oilfield development. Reportedly, the Yurubchen oil of the Baykit area has a low-sulfur (total sulfur 0.18…0.24 %), low-resinous (silica gel resins 2.50 to 4.76 %, asphaltenes – up to 0.10 %), paraffinic (paraffin 2.03 to 3.26 %) concentration. The potential content of the boil off fractions at temperatures up to 200 °C is 27.00 to 32.50 % and at temperatures below 350 °C – 54.60 to 67.00 %. According to the hydrocarbon composition group, the enhancement of fractions leads to increase of the aromatic hydrocarbon content 0 to 15 % while paraffin hydrocarbons predominate in all the fractions.

The Yurubchen oil is of high-gravity, low sulphuric and low paraffinic. It is rich in lighter fractions and is related to the methane-naphthenic class. Consequently, this oil gasoil meets the requirements of GOST R 52050–2006 «Jet A-1 air fuel gas turbine engines. Specifications» by sulfuric contents. Gasoil obtained in accordance with GOST 2177–99 (method B) has been preliminarily studied. With low contents of sulfur, the Yurubchen gasoil indicated elemental sulfur and trace quantities of thiols.

The availability of jet fuels that complies with the requirements of GOST R 52050–2006 has been studied, on the basis of the Evenki gasoil from atmospheric distillation of oil.

The following procedures have been accomplished**:**

– representative samples of oil have been selected;

– quality indices of the Evenki gasoil obtained through atmospheric distillation (boil off temperature of 180 to 300 °C) according to GOST 2177–99 (method B) have been obtained. Naphtha light end was studied for comparison (boil-off temperature of 40 to 204 °C);

– analysis of the corrosive activity of these fractions (i. e. the copper plate test, the content of hydrogen sulfide, methyl and ethylthiol tests, the total sulfur) have been carried out by standard methods.

It had been discovered that hydrogen sulfide was one of the corrosive agents of crude oil atmospheric distillation at all stages. This proves that the Yurubchen primary oil does not contain any significant amounts of hydrogen sulfide (GOST 50802–95 «Oil. The method for determining hydrogen sulfide, methyl and ethylmerkaptans»).

The defining of oil fractional composition implied its distillation in the ARNS-E apparatus and resulted in obtaining gasoline, gasoil and fuel oil. The boiling point of naphtha varied 40 °C to 205 °C and gasoil – 180 to 300 °C.

In the process of oil refining, hydrogen sulfide was released at the temperature of 100 to 120 °C up to the end of the process (at 300 °C). Elemental sulfur was detected in naphtha and gasoil.

Defining the corrosive activity was carried out according to GOST 6321 «Fuel for the engines. Test Method for Copper», see table 1.

According to the testing results, gasoline derived from the Yurubchen oil (Class 3a) mostly impacted on copper. The Yurubchen oil passed the copper plate test.

The Yurubchen gasoline (naphtha) and gasoil obtained from atmospheric oil distillation were tested for the total sulfur contents (GOST 50442 «Oil and petroleum products. The X-ray fluorescence method for determining sulfur») and for hydrogen sulfide and mercaptan contents (GOST 50802 «Oil. The method for determining hydrogen sulfide, methyl and ethylmerkaptanes»), see table 2.

Table 1

Determination of the corrosion activity of oil according to GOST 6321

The fraction of oil	Description of the plates color after the corrosion testing	Corrosion level, the classification
Yurubchen gasoline (naphtha)	Purplish-red spread on a brass-like color plate	Strong eclipse, 3a
Yurubchen gasoil	Deep-orange	Slight eclipse, 1b

Table 2

Mercaptans, hydrogen sulfide and total sulfur contents in the Yurubchen gasoline (naphtha) and gasoil

Oil sample	Mercaptans, hydrogen sulfide and total sulfur contents			
	Methylmerkaptan, ppm (% weight)	Ethylmerkaptan, ppm (% weight)	Hydrogen sulfide, ppm (% weight)	Total sulfur, ppm (% weight)
Gasoline (naphtha)	2.06 ($2.06 \cdot 10^{-4}$)	18.5 ($18.5 \cdot 10^{-4}$)	0.111 ($0.111 \cdot 10^{-4}$)	345 ($345 \cdot 10^{-4}$)
Gasoil	0.237 ($0.237 \cdot 10^{-4}$)	0.167 ($0.167 \cdot 10^{-4}$)	not found	485 ($485 \cdot 10^{-4}$)

Studies have shown the presence of sulfur fractions in gasoil: total sulfur – 485 ppm (under the maximum allowed under GOST 52050–2006). In addition, the presence of gasoil of methyl – (0.237 ppm) and ethylmerkaptans (0.167 ppm) was revealed.

The Yurubchen gasoil also contained a small amount of 1-octadekanethiol. It was found during the analysis of sulfuric acid fraction extract through chromatography-mass spectrometry (GC/MS) (H_2SO_4, 93 % extraction, diluting the extract with water, re-extraction diethyl ether). Organic sulfides were not present in the extract.

The corrosiveness of the Yurubchen oil light fractions results from the content of hydrogen sulfide, mercaptans, and elemental sulfur.

The initial presence of thiols (merkaptans) in the petroleum is usually low. In the Yurubchen oil, there was only ethylmerkaptan at a concentration of 0.136 ppm (GOST 50802 «Petroleum. Method for determination hydrogen sulfide, methyl and ethylmercaptans»).

Oil containing thiols is characterized by a high content of thiol and total sulfur in gasoline fractions with relatively low content of the total sulfur in the original oil. For the Yurubchen oil, the following ratio could be observed: the total oil sulfur – 0.196 %, total gasoline (naphtha) sulfur – 0.0345 % (GOST R 51947–2002 «Petroleum and petroleum products. Sulfur identification by the method for energy-dispersive X-ray fluorescence spectrometry»).

Hydrogen sulfide, mercaptans and elemental sulfur formed the Yurubchen oil gasoil as secondary decomposition products of organic sulfur compounds under thermal impact in the process of distillation.

Hydrogen sulfide is released under oil heating up to 120 °C and higher; the amount of hydrogen sulfide increases with elemental sulfur, for example, as shown in the following reaction:

$$RH + S \rightarrow RSH$$

$$2RSH \rightarrow RSR + H_2S$$

Based on the aforementioned research in conclusion we imply a possibility of additional methods for treatment (removal of elemental sulfur, demercaptanisation (sweetening), alkaline extraction of hydrogen sulfide), in order to adjust the fraction quality indices in accordance with the requirements of GOST R 52050–2006.

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RESEARCH THE INFLUENCE FINISHING CANAL SHAPE TO FLOW MEDIA FOR ABRASIVE FLOW MACHINING PROCESS*

Visual research flow media nature as with abrasive tool put in to practice. To establish facts the influence degree finishing canal shape and form losses for flow character. The guidelines for processing environment leveling developed.

Keywords: abrasive flow machining, improved surface quality, flow of abrasive media, visual research, form losses, cross-sectional shaped.

The analysis of constructional features of aircraft's details has revealed the presence wide nomenclature of passageways with cross sections of various shapes and the presence of different local resistances like blades, form losses, etc. 28 standard elements with different geometrical shape of cross sections, which can be found in aircraft, were discovered.

The main purpose of visual research was the fixing the process of abrasive media flowing in channel's different configuration and its flowing of different local resistances, and the fixing of pressure media's measurement Input P_1 and output P_2 sample.

The device was for the visual studies (fig. 1). It consists of the body *1*, in which the groove set specimens-simulators *2*, caps *3* and two adapters *4* and *5*.

For the experiments the media was used with this composition: Silicon rubber (GOST 14680–74) – 48 %, PTFE-4 – 2 %; black silicon carbide 53 C (grain size = 250 microns) – 50 %. Visually, the media of this composition has a dark gray color. On its surface, placed in a device, rectangular mesh size 15 × 15 mm and a depth of 2 mm, which is filled with white fused 25A with grain size = 250 microns, applied by the bursting pattern. White mesh has a good contrast with the surface of media, which provides a clear picture. The Scheme of application (fig. 2) simulates a chain of abrasive grains. Filming was carried out with a speed of 48 frames per second at high contrast, negative film.

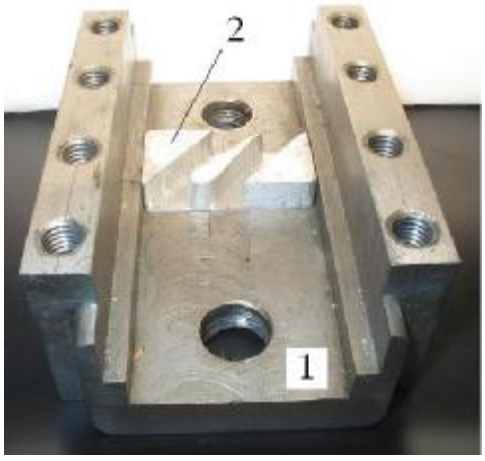
Based on studies of the flow on the waveform, film, photographs and scratches at the window 6 of Plexiglas identified characteristics of media, evaluated and the degree of deformation grid on, and direct observation of the flow. Figure 3 shows the flow patterns and schemes of the media in the tested channels. The arrows indicate the direction of flow, a dark color – the stagnant zone.

Each sample has a definite influence on the flow, the value of which can be expressed by the coefficient of local resistance ξ_m

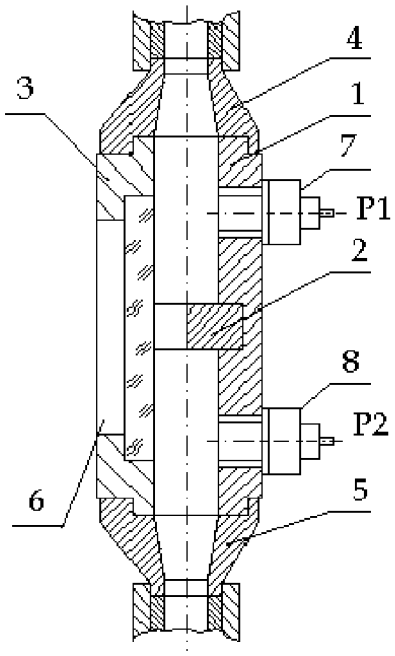
$$\xi_m = \xi_{cg} + \gamma_c/\mathrm{Re},$$

* The work within the federal purpose program "Scientific, scientific-pedagogical cadres Innovative Russia".

where ξ_{cg} – coefficient of configuration geometry flow; γ_c – dimensionless velocity gradient; Re – the Reynolds number.



a



b

Fig. 1. Fixture for visual research off abrasive flow machining: *a* – casing with model; *b* – fixture diagram

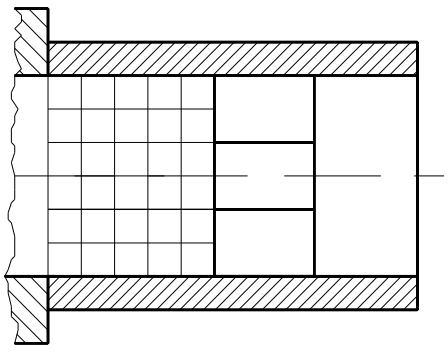


Fig. 2. The grid on the surface environment, modeling the chain of abrasive grains

For the case of AFM $\gamma_c = 0.01…0.1$ and Re << 1. It can take $\xi_m \approx \xi_{cg}$. Consequently, the coefficient ξ_{cg} characterizing the flow pressure loss in passing through this channel will determine the amount of local losses flux in AFM, i. e. $\xi_{cg} \approx P_1/P_2$.

Studies show that the greatest pressure loss experienced in the flow cone channels (№ 5...7). The coefficient ξ_{cg} takes values of 20.0...23.5.

Toothing with 12 triangular channels (№ 28) creates a pressure differential 5.2. For channels with different blades (№ 17...26) ξ_{cg} varies from 1.8 to 2.1.

When processing channels with a small inlet (№ 3, 4) pressure loss is reduced more than twice, but the magnitude of the coefficient ξ_{cg} – 8.4...10.0 remains significant. If the inlet channels with a small inlet is rounding or chamfer (№ 8, 9), the value ξ_{cg} reduced to 3.4...3.7.

For channels with local resistance (№ 10...15) the value has a value of 1.4...3.0 depending on the type of resistance. For the three parallel channels (№ 16) the pressure drop was 2.3.

These values ξ_{cg} can be used to assess the influence of the channel cross section shape and type of local resistance to the pressure drop of the working environment at AFM. The value ξ_{cg} in this case is relative, because it does not take into account the pressure loss along the length of the sensor 7 to the sample and from sample to the sensor 8 (fig. 1).

Figures № 4...12 show photographs illustrating the content of the film process medium flow through some of the samples. The direction of flow from left to right.

Sample number 1 (fig. 4) is a local narrowing the channel from the direct gap of half-cylinder. At the initial moment the flow in the center of the channel environment without encountering obstacles, begins the process of shear flow in a half-cylinder. Thus there is a deformation of the grid – elongation of the axis of flow and contraction in the transverse direction. In those places where the environment rests on the front side surface of the sample, the flow of environment is not present.

At this point in the environment the profile of media is changing and two zones with different conditions of deformation are formed. In the zone of shear flow observed steady shear flow. The character of variation of the grid shows a gradient flow, which can be described by the hydrodynamic theory. Stress of elastic chain can be described by the Kargin–Slonimsky–Rouse models [1].

In the second zone there is compression of the chain. The magnitude of compression depends on the elastic properties of the chain. Thus, in the medium two zones with different conditions of deformation are forming. In the first zone tensile stress is observed, in the second zone – compression stress.

When reaching a certain critical value, there is a shift environment in zone 1 on the medium in zone 2. Clearly the boundary between zones 3 is visible. At this point flow profile finally formed and in zone 1 tensile stress drops into the shear flow 4. This transition is clearly apparent in the oscillogram.

Then all of a large part of the media is fond of Zone 2 in the flow when the piston moving in the working cylinder. However, just before the obstacle in zone 2 of stagnation zone is formed. In the sample stagnation zone is not formed,

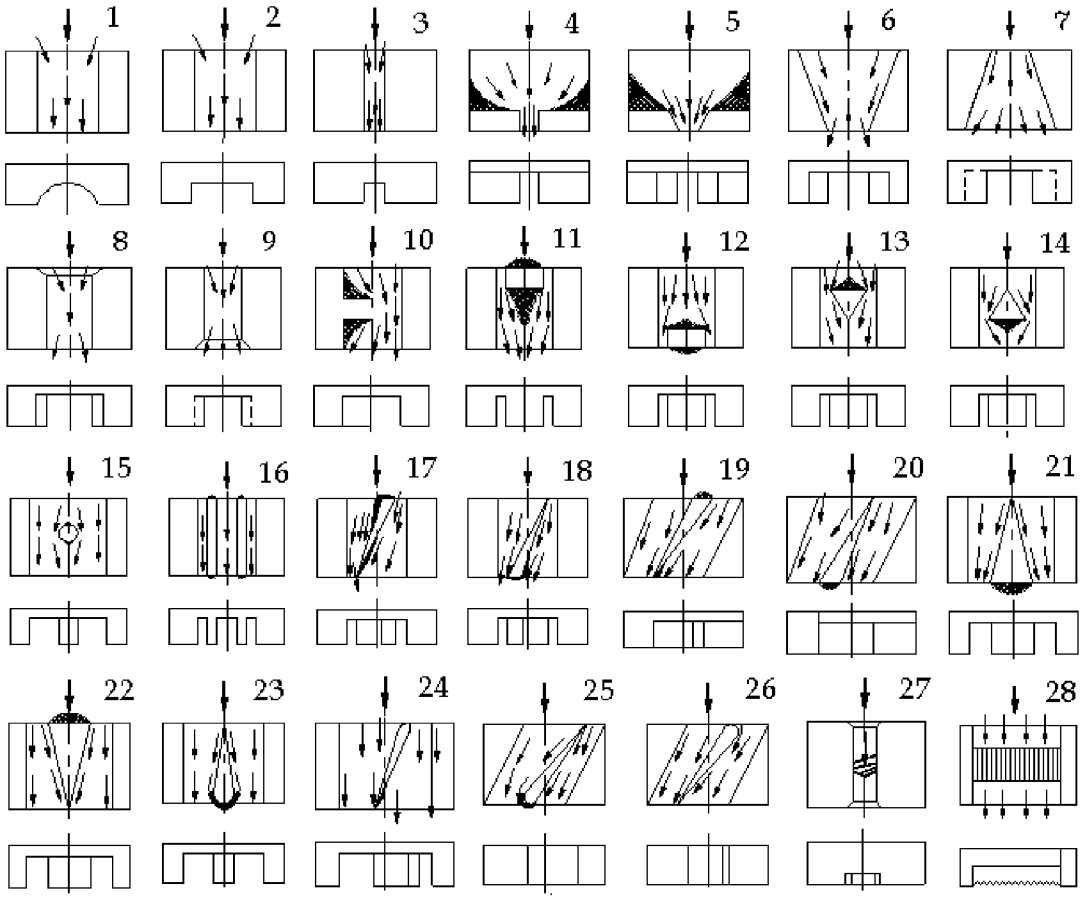


Fig. 3. Scheme of the flow media in the channels of Designs

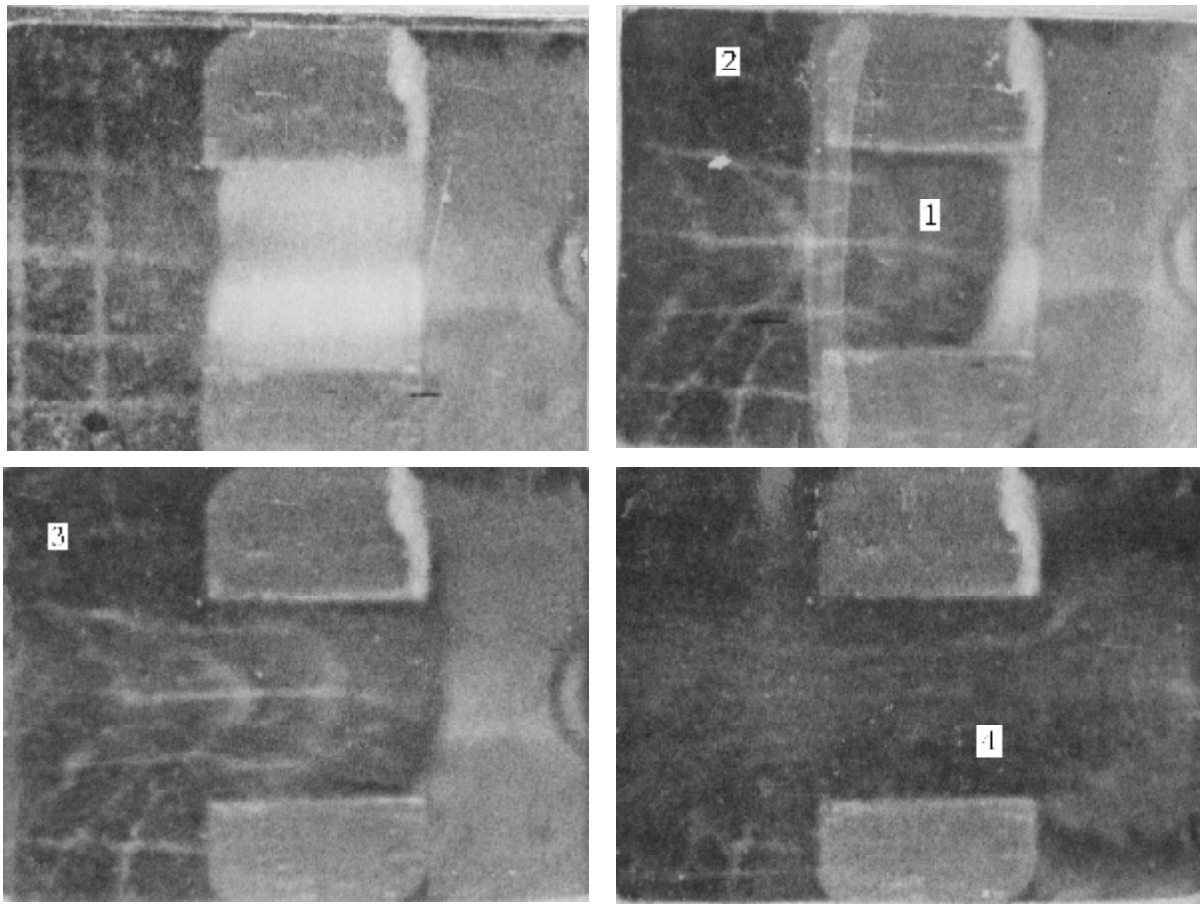


Fig. 4. The process of flow in the sample number 1

contact the media is carried out over the entire surface of the sample. The use of leveling devices is not required.

At the end of the medium the sample the effect of elastic recovery of the jet is observed, which is indicating accumulated in the flow of elastic deformations. This effect is described in detail previously [2]. Especially this effect is clearly manifested at the expiration of the channels of small dimensions, such as in samples number 3, 4 and 5.

If within the medium in conical ducts with variable cross-section flow pattern different. Consider the flow in a diffuser - sample number 6 (fig. 5) and in effuser – sample number 7 (fig. 6). Uneven treatment due to the nature of shear flow environment in the conical channel.

When the medium flow in the diffuser noticeable decrease in the rate of the conical part and a smooth restructuring of the flow profile. The normal stresses accumulate, and the tangent decrease. The pressure in the conical part increases and the flow rate and velocity gradient decreases. In steady the maximum flow pressure on the wall of the channel observed in the cross section with a minimum size, ie on the exit edge of the channel. If such a motion is possible to provide a uniform flow of the processing and removal of metal within a specified allowance in the cylindrical part of the channel.

At the entrance flow in a conical part effuser channel in the initial moment of time there is separation of high-flow environment of the tunnel wall. This phenomenon is a relatively short period of time 0.2...1.1 seconds.

At the same time, in the medium relaxation of accumulated stress occurs and the effect of elastic recovery of the jet begins to manifest itself, i. e. increase in its size and the gradual filling of the total volume of processed feed.

Instant transition from anguish to the free flow jet is for transition edge. At this point, the value of relaxation of elastic strain accumulated in the medium during the flow in the cylindrical part, is maximal. At the edge of the transition, there is a maximum pressure of the flow on the wall of processed feed.

The uniformity of treatment in the conical channel equalization without using special devices to make difficult, since the change in flow profile is directly processed channels. In the special case of flow can be identified based AFM unidirectional diffuser.

In flying apparatus there are details of structural elements, which can be attributed to local resistance. In these studies, these are examples of resistance number 10 ... number 15.

Channel flow with the lateral wall (fig. 7), characterized by displacement of the medium flow 4 from the central axis of the channel. In this case the inlet there are not two, but three dead zone 2. Two are inlet channel and one is front wall. Behind the observed flow separation from the wall of the treated feed. Because of the effect of elastic recovery is gradually filling the entire volume of the test channel, including and beyond the partition. After completing this section of the channel environment it appears dead space. The bulk of the flow slides along the border of this zone. Processed only the surface of walls, which is parallel to the main stream.

Another form of local resistance, which appears in the details of flying apparatus, is a rectangular resistance at the inlet and outlet channels (fig. 8).

Peculiarity of the flow in this sample is to divide the flow into two parts. Forming two zones of dilation 1 and three

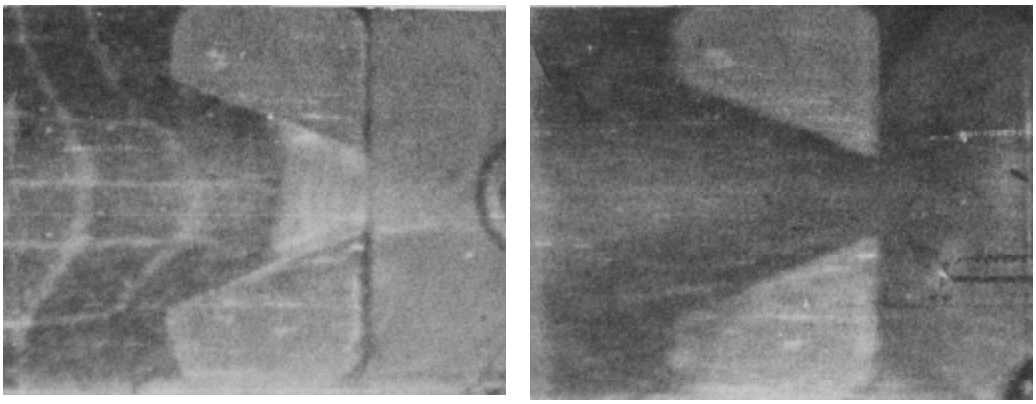


Fig. 5. The process flow in sample number 6 (cone)

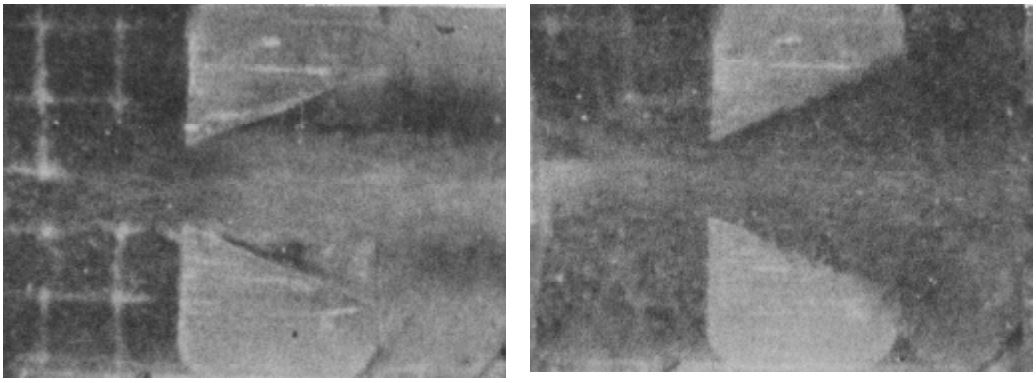


Fig. 6 Process flow of the sample number 7 (effuser)

compression zone 2. Two of these zones are located on the side of the entrance to the processed feed, and another – on the front surface of the rectangular resistance. After the start of shear flow formed two zones within 4 to form the output of the channel bands of elastic recovery 5.

Details of the flying apparatus are characterized by the presence of several parallel arranged relative to each other channels, with identical geometric characteristics. Figure 9 shows that the flow profile is formed at the entrance to the channels. On the flat front edges of the channels formed stagnant zones. Expendable Pressure-flow characteristics in the channels are almost identical.

Various blades are the basic structural elements of aircraft and rackets parts. In the studies presented samples of blades number 17 ... number 26.

The flow in straight rectangular channel with a sloping shoulder blade with a straight forward basis (sample number 17) is shown in Figure 10. Blade breaks straight rectangular channel into two parts with variable cross-section shape. In this case, in the channels among modes of deformation are different. In having a smaller area of the inlet the expanding part of the channel observed deformation zone 1 elongation medium.

In having a greater cross section of the inlet of a shrinking part of the channel in the central part of the observed elongation zone, which is to the walls of the channel is replaced by a zone of compression. Stagnant zone 2 observed on the surfaces perpendicular to the main direction of deformation of the medium.

After adjustment profile in the zones of tensile strain – compression of the deformation of 4 shear flow environment with the subsequent effect of elastic recovery 5. The main processing occurs in sections with a smaller area.

Another flow pattern is observed in AFM's environment inclined channel with sloping shoulders. Flow of the medium

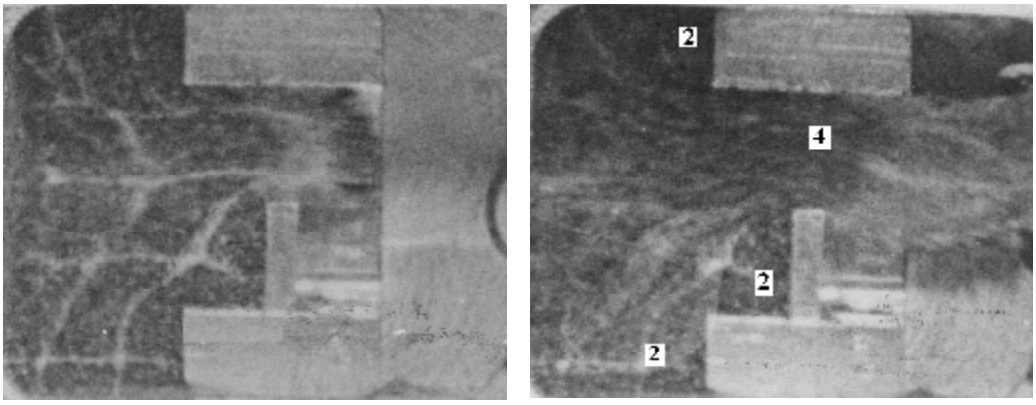


Fig. 7. The process flow in the sample number 10 (bulkhead)

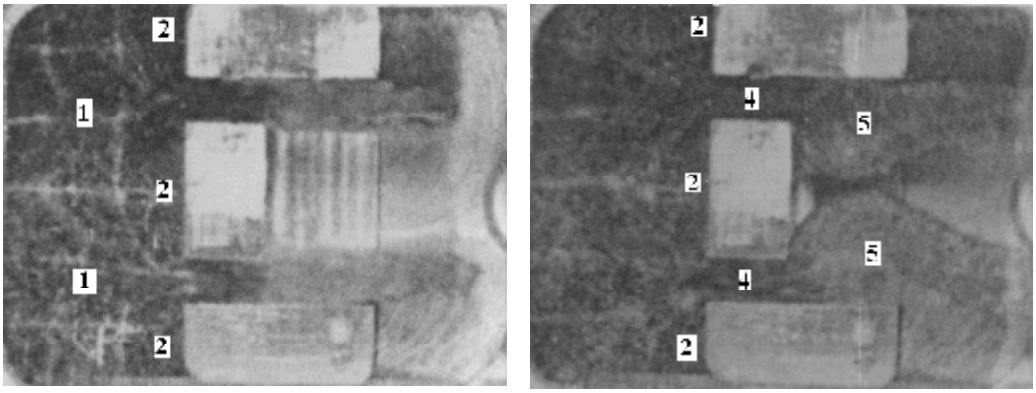


Fig. 8. The process flow in the sample number 11 (obstruction at the entrance)

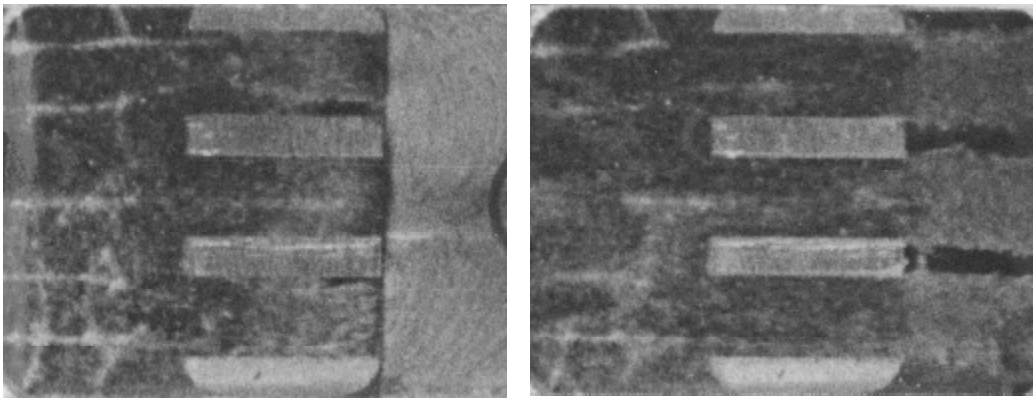


Fig. 9. The process flow in the sample number 16 (parallel channels)

in an inclined channel with a sloping shoulder blade with a straight forward reason – sample number 19 (fig. 11). Since the investigated channel has an angle of inclination relative to the central axis of the working cylinder, and changing the direction of flow.

Restructuring flow profile environment is at the entrance to the processed feed. There two dead zone 2 and two zones of dilation 1 are forming. After reaching a critical value in zones 1 strain is replaced by a shear flow in two parts, the channel also implemented a process of shear flow in zones 4 with subsequent elastic restoration of the environment in zone 5.

Flow separation with a sharp front edge is not observed. The entire surface of the channel is processing except for a direct cause shoulder at the entrance to the channel. The size of the stagnation zone 2 during the entire process of processing does not change.

In a separate group of flying apparatus parts are structural elements that have a large channel L length and small cross-section S with ratio $L/S >> 1$. When flow through a small cross section (fig. 12) in the channel has created a complex grains, preventing the flow shear.

The piston operating cylinder could not provide the necessary amount of shear stress and there was jamming Abrasives. For AFM such channels must use the abrasive medium special formulations with reduced viscosity.

According to the research design elements on the processing conditions can be divided into five groups.

The first group includes channels with constant cross section (№ 1.. 4, 8, 9, 28), which does not affect the flow. They have small values of the coefficient of the configuration flow ξ_{cg}. Chamfer at the entrance to the channel (№ 8) provides a smooth entry into the media channel, reducing the coefficient ξ_{cg}. Since the channel with beveled (№ 8) $\xi_{cg} = 3.4$ less than in this channel (№ 9) with a facet at the output $\xi_{cg} = 3.7$. For such channels adjustment stress-strain state of flux carried by a special technique.

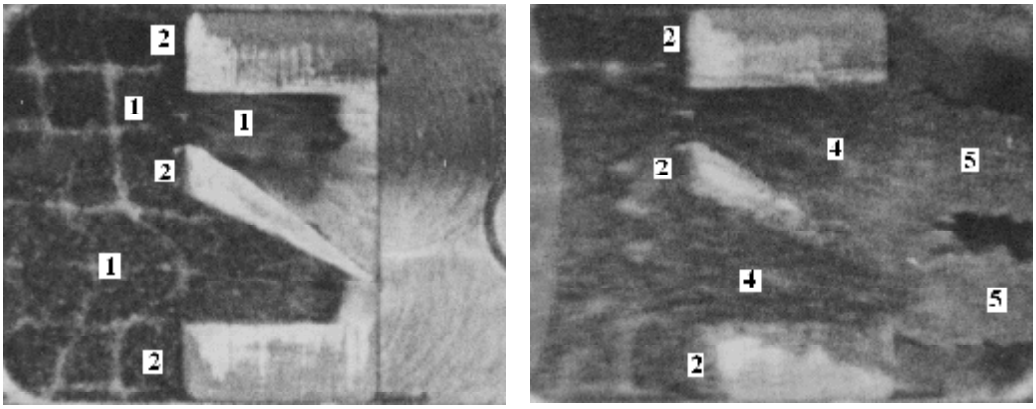


Fig. 10. The process flow in the sample number 17

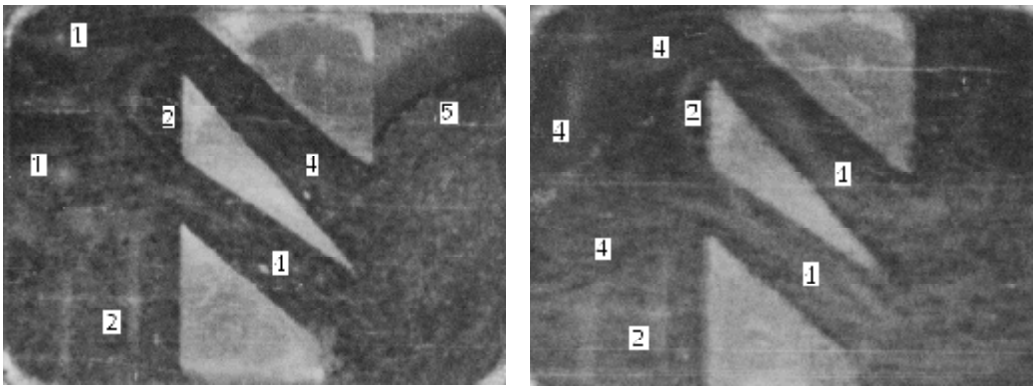


Fig. 11. The process flow in the sample number 19

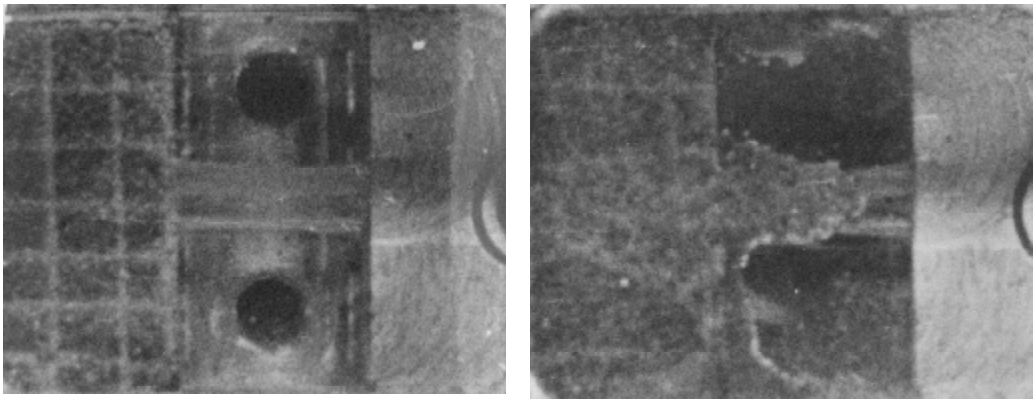


Fig. 12. The process flow in the sample number 23

The second group of cone channels, the loss of pressure medium in which the maximum. For the uniform treatment of such channels is recommended to change the flow regime of the cone to ring slit (№ 5...7) or to apply a one-way AFM (№ 6).

In the third group, consisting of a channel with the local resistance, AFM's still rough surface, perpendicular to the flow (№ 10...15). For processing to change the direction of flow through the leveling devices.

For a uniform treatment of channels with blades, which are the fourth group (№ 16...26), it is necessary to ensure an even flow environment in each of the channels, by forming the flow profile at the entrance of these channels.

In the fifth group included micro, requiring the use of working environments with low effective viscosity and low dispersion of abrasive filler (№ 27).

In analyzing the motion of individual abrasive grains in a flow is established that they move along the current lines. In steady flow the distance between neighboring grains is not changed. This confirms the supposition about the formation of elastic chains in the flow [1]. Established that the grain, into contact with the treated surface, the flow performs rotational motion. Studies education media vortices near walls or in the flow with the flow in the channel was not observed.

Research has identified the nature of the flow in channels of different media configurations and taken into account in calculating the roughness of the surface finish and performance of AFM on the previously developed technique [3].

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EXPERIMENTAL DETERMINATION FACTOR TO VISCOSITY, ELASTICITY AND PLASTICITY MEDIA FOR ABRASIVE FLOW MACHINING PROCESS*

Numerical values of factors of viscosity, elasticity and plasticity of a media are established. Experimental dependences of viscosity and elasticity of environment on degree of its filling and granularity of abrasive grains are revealed.

Keywords: abrasive flow machining, rheological characteristics, viscoelastic media, flowable abrasive particles, shear rate.

The one of the new types of such processing is abrasion-extrusion processing (AFM), which is consist in removing the layer of material from the surface of the treated channel at extruding under pressure through it, working environment, consisting of a viscosity and elasticity foundation, filled of solid working elements (most often – abrasive or diamond grains).

AFM is difficult process. In its implementation there are a number of physical phenomena that influence for quality and productivity of processing. For the introduction of abrasive extrusion processing in the production of specific details must be made a sufficiently large volume of experimental studies, related with determining the optimum composition of the working environment and modes of its extrude, caused by physical-mechanical and geometrical characteristics of processed channels. Such researching needs a lot of costs, which constituting up to 60 % of the total cost of implementing this technology in production.

The main parameters of technological process of abrasive extrusion processing is the volume of the working environment, pressure of the hydraulic system installation in burst and the host operating cylinder of installations for AFM, value (dispersion) and percentage (concentration) of abrasive grains in the working environment, its physical and mechanical characteristics, and also the number of processing cycles. The geometric characteristics of the processed feed have great influence on the quality and productivity of the process – its radius and length, area and perimeter of the cross-sectional and also initial physical and chemical properties of the surface layer.

Cutting ability of the working environment as abrasive tools depends of flow's conditions in the processed channel

* The work within the federal purpose program "Scientific, scientific-pedagogical cadres Innovative Russia".

and its viscoelastic and plastic properties. Viscous and plastic properties determine its fluidity, the elastic properties – stiffness. For the theoretical calculations of the flow characteristics of working environment with AFM it needs to experimentally establish dependence of the effective viscosity η, Poisson's ratio and Young's modulus of working environment of the degree of its filling and dispersion of abrasive grains.

Characteristics of the working environment depends on the degree of filling of the polymer base (*Ka* concentration of abrasive grains in the medium), of their size (*Ba* grits), and also of a pressure in filing cylinder P_{in}.

If the *Ka* and *Ba* are changed, changes are not only in the density c the medium and its viscosity, but also in its rheological characteristics – coefficients of tangential and normal stresses, flow velocity and shear rate, and also all the curves of the shear flow dependency of shear stress.

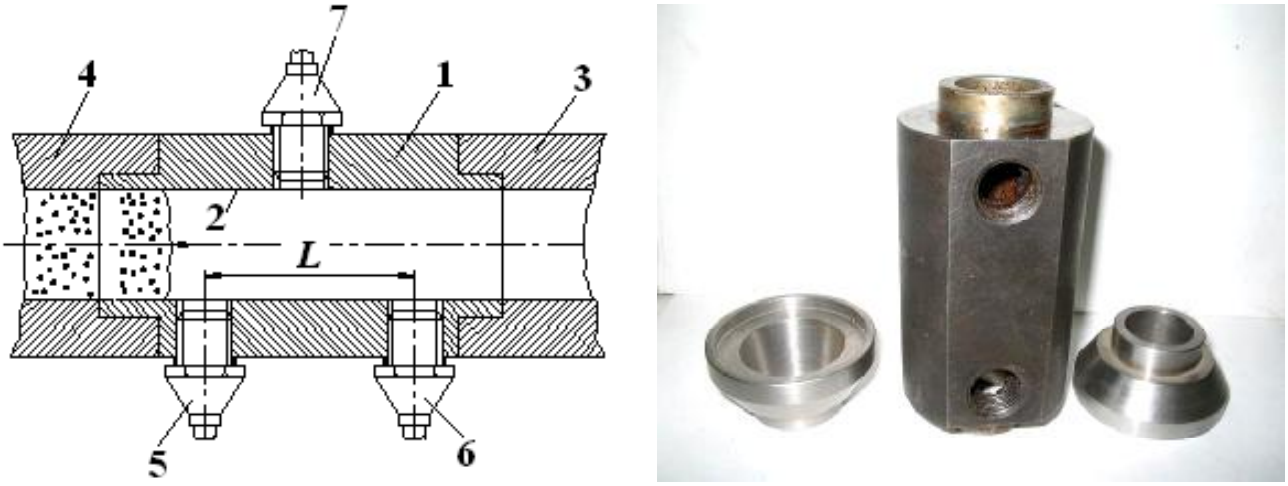
Because the nature of viscous flow abrasive medium at the extrusion processing a circular channel with big length the same to fluid flow in a capillary viscometer, for the researching of viscous properties a similar method was developed, based on the experimentally established values of maximum flow rate ω_{max} and drop of pressures ΔP on the section of a cylindrical channel L length and diameter d. Substituting the experimental values ω_{max} and ΔP in in the transformed Puayzel's formula for known L and d value of the effective viscosity η is defined.

$$\eta = \frac{\Delta P}{\omega_{max}} \cdot \frac{R^2}{8 \cdot L}.$$

For registration the parameters system of defined set of research was applied. Experiments were conducted on an experimental set UESH-25 with using a special device (fig. 1).

Device consists of a steel hull 1, which was subjected to heat treatment, with round channel 2 with 25 мм in diameter, coinciding with the diameter of working cylinders *3* and *4* UESH-25 – installation, with pressure sensors *5* and *6*, and also a temperature sensor *7*.

On the oscillogram (figure 2) pressure change in the current moment in sections of sensor *5* (P_1) and *6* (P_2) recorded. Time is defined on the oscillogram for step cutoff t_c = 0.2 с. On the line P_1 the start point of deviation from the zero level of evidence *1* is revealed. Similarly, the beginnings of the emergence of the pressure's environment at point *2* for the line P_2 is found. Through found points *1* and *2* vertical lines to the lines P_1 and P_2 are held pursuant. The distance t_c between the normals corresponds to the minimum duration of an environment from cross-section *1* to cross-section *2*. By the known distance between cross-sections (L = 0.07 м) and t_c maximum speed of flow ω_{max} is calculated in this section. Then find the point *3*,



a *b*

Fig. 1. Device for the study of viscous and plastic properties: *a*– scheme; *b* – the body of device with two adapters

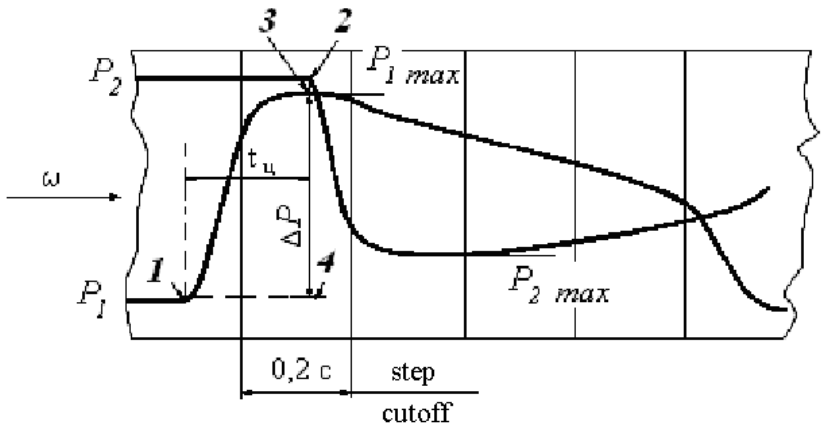


Fig. 2. Scheme of registration data on the oscillogram

which is intersection of the normal through the point *2*, lying on P_2 line, and point *4* by P_1 line.

The exact values of physical quantities t_c and ΔP were calculated taking into account the calibration of sensors and size of step cutoff t_c. The pressure difference between the two cross-sections $\Delta P = P_1 - P_2$ equal to the distance between points *3* and *4* on the oscillogram, multiplied by the scale calibration. Six experiments with randomization of time and temperature controlled environment was conducted for each experimental conditions.

The researching of dependence the coefficient η of *Ba* and P_{in} was carried out according to Kono plan ($m = 2$, $n = 3$). For the mathematical processing the coding variables $X_1 = Ba$; $X_2 = P_{in}$; $Y_1 = \eta$ was produced. Granularity *Ba* and the pressure P_{in} were varied factors. Each experiment was repeated six times with randomization time. Terms of experiments on the nine modes and experimental results are given in table 1.

As a result of studies found that the higher the degree of filling polymer base working environment by abrasive, the higher its effective viscosity. Bigger factor з observed when lesser magnitude filled with abrasives at equal weight's filling *Ka* abrasives of different grain *Ba*.

Increasing of P_{in} during extrusion of environment improves processing's conditions by increasing shear stress and flow rate of the medium and the velocity gradient.

Young's modulus and Poisson's ratio is characterized elastic properties of the working environment. Elastic characteristics of the medium depend of degree of filling *Ka* and dispersion of the filler *Ba*. The numerical values of these indicators are needed when calculating the contact working environment with workpiece and evaluated by change in length $l - l'$ and diameter $d' - d$ of sample of environment during its compression load *F* (fig. 3).

Guides axle *5* installed in bronze bushings of base *2* devices with interference, and in the sleeve weight plates *3* – with sliding landing. The sample of working environment is forming in the working cylinder of the experimental setup UESH 25, determined in a certain position that ensures its dimensional stability. The nominal diameter of the specimen before the deformation $d = 25$ mm, the nominal length of the specimen before deformation $l = 50$ mm. Cross-sectional area of the sample – $S = 0.00049$ m^2. Measuring the size of the sample was held by using calipers and micrometers.

The mass of weight plates and additional cargo were chosen so, that specimen is deformed predominantly elastically and linear dependence of its size on the applied load was carried. Total weight was 150 *g*. Waiting time was 3...10 seconds.

It is possible to experimentally determine their values, based on the definitions of Young's modulus and Poisson's ratio μ:

$$F = \frac{m_{load} g}{S} = E\frac{l' - l}{l};\ \mu = \frac{(d - d')/d}{(l' - l)/l},\ \text{и}$$

where m_{load} – mass of the applied load.

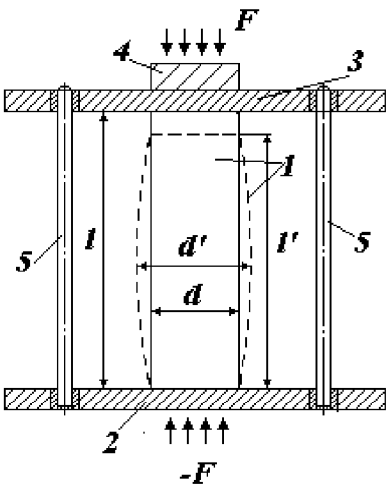


Fig. 3. Device and circuit measurement of Young's modulus and Poisson's ratio environment: *1* – sample of the working environment; *2* – base adjustment; *3* – weight bracket; *4* – extra weight; *5* – steered axles; *6* – micrometer

Table 1

Dependence the coefficient η of *Ba* and P_{in}

№	*Ba*, мкм	P_{in}, МПа	η, Па·с
1	300	9,0	36,892
2	400	9,0	36,093
3	500	9,0	29,215
4	300	7,5	32,368
5	400	7,5	30,402
6	500	7,5	23,204
7	300	6,0	27,283
8	400	6,0	24,166
9	500	6,0	16,223

Table 2 shows the results of studies of Young's modulus depending on the degree of the working media content and size of abrasive filler.

Experimentally determined (fig. 4) that an increase of *Ka* for more than 80 %, fixed abrasive in polymer-based environment is significantly reduced. This phenomenon leads to loss of yield and environmental fallout of grains of the polymer base that significantly impairs the conditions of abrasive-extrusion processing. Therefore, this figure was adopted for the boundary condition for the maximum degree of filling. The value of Poisson's ratio μ of the polymer base without abrasive filler – 1.34, for filling among its experimentally measured value varies in the range 0.4…0.42.

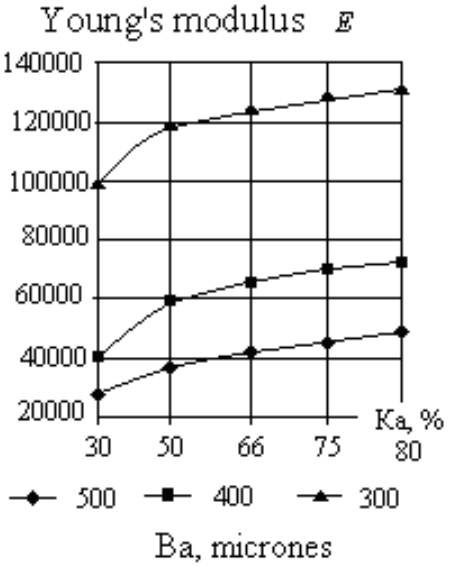


Fig. 4. Dependence of Young's modulus of the working environment on the degree of filling of abrasive grains and the quantity of abrasive filler

Young's modulus *E* increases with the degree of filling and reduced dispersion of abrasive grains. This effect is explained with the help of the transformed Kargin–Slonimsky–Rous model [1], which is describe the working environment as a visco-plastic medium full of elastic chains formed by abrasive grains and the polymer base.

In polymer-based unfilled chain abrasive grains are absent. Reduction of dispersion of the filler with the same mass filling leads to an increase in the number of abrasive grains in the medium. The greater the number of abrasive grains in the medium to longer chains occurs in the environment, length of segments which, in turn, decreases. Shorter segments of the chain cause its high elasticity and viscosity. The plasticity of the medium reduced.

To assess the cutting properties of the studied working media used the method of simplices with the same initial data and constraints, composition of the medium and P_{in}. The results of experimental studies abrasive extrusion processing showed that the optimum cutting ability, measured by the value of surface roughness after treatment or change in processing ΔRa, value of the material removed layer Δh, is achieved using a composition of the working environment in which the elasticity of the medium is maximal. The coefficients of viscosity and plasticity at the same time used to set the boundary conditions abrasive extrusion processing specific details. Numerical indicators of viscosity, elasticity and plasticity of the working environment depends on the geometric characteristics of the processed channel and the requirements of the surface layer of detail.

The developed technique allowed to determine experimentally the flow rate ω_{max} and the coefficient of effective viscosity з of media of different compositions with abrasive flow machinig process, which can be used to calculate the pressure-spending environment characteristics in the processed channels.

The degree of influence of filling abrasive *Ka*, *Ba* quantities of abrasive grains and the inlet pressure P_{in} of viscous, elastic and plastic properties of the medium were set. With increasing P_{in} and content of abrasive in the medium *Ka* environmental factors з increases. This is due to the fact that with increasing shear rate more intensively destroyed the spatial structure of the medium. The effective viscosity, shear and normal stresses become larger. So for a medium-grit $Ba = 400$ microns with $P_{in} = 6$ MPa – $\eta = 24{,}166$ *Pa*; with $P_{in} = 9$ MPa – $\eta = 36{,}093$ *Pa*, i. e. is 65...70 % more.

Table 2

Elastic characteristics of working environments

Ba, мкм	*Ka*, %	Young's modulus	Poisson's ratio
0	0	22,760	1.34
320	30	97,955	0.411
320	50	119,600	0.411
320	66	124,300	0.411
320	75	128,250	0.411
320	80	132,500	0.411
400	30	40,480	0.40
400	50	59,200	0.40
400	66	65,100	0.40
400	75	70,400	0.40
400	80	73,100	0.40
500	30	27,000	0.42
500	50	37,000	0.42
500	66	42,000	0.42
500	75	46,000	0.42
500	80	51,000	0.42

Experimental determination of the coefficients of viscosity, elasticity and plasticity allows for the theoretical calculations of accuracy, productivity and quality abrasive extrusion processing. Obtained numerical values of the elastic-visco-plastic medium allow the choice of contact of abrasive grains [2]. Having established contact on the proposed methods [3; 4] it possible to calculate the performance of AFM and the roughness of the treated surface details.

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MODEL-BASED STUDY OF OXIDATION PROCESSES IN A JET ENGINE FUEL LIQUID PHASE

The process of oxidation in hexadecane liquid phase as a conventional model of oil hydrocarbons is investigated. The oxidation product structure is defined by means of Chromatography/Mass Spectrometry.

Keywords: high-temperature oxidation, hexadecane, oxygen-containing organic compounds, jet fuel.

Aviation kerosene is utilized in aircraft engines as a fuel and also as a coolant. Therefore, it should have the property of strong stability against high-temperature oxidation.

It would be of interest to investigate the processes flowing in high-temperature jet engine fuel oxidation liquid phase.

Hexadecane (HD) is a conventional model of oil hydrocarbons (fig. 1).

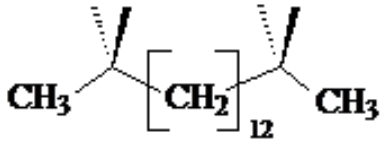

Fig. 1. Hexadecane

Hexadecane behavior in the process liquid phase oxidation was investigated by various authors and by different ways of reactor thermostatting [1].

The term "high-temperature" oxidation is usually applied to the processes flowing at the temperatures of 150 to 170 °C in case of hexadecane oxidation.

Previous research [1] has established that HD oxidation flowing at high temperature is an exothermal process.

At a certain moment, the so-called time-limited "thermal explosion" takes place in oxidation [1]. After the end of exothermal stage, the oxidation progresses at a lower speed. Under the assumption [2] it occurs owing to formation of polar nanophase (inverted microemulsion, "water in oil" – type) on the basis of primary and secondary hydrocarbons oxidation products.

The nucleus of such reversed micellar aggregate under the assumption [2] contains a small amount of mono- and polycarboxylic acids and alcohols (polyols). The average sphere includes mainly fragments of ethers and esters. The external sphere consists mainly of long hydrocarbon chains providing stabilization of micelle in the non-polar hydrocarbon environment (fig. 2).

Changes of the oxidized hydrocarbon phase structure has been experimentally studied [2] indirectly, through a method for water-stain solubilization, for example, methyl-orange (MeOr).

Judging by changes in MeOr band position taking place with a rising hexadecane oxidation degree, the authors [2] have assumed that the localization of stain molecules in the oxidized hexadecane polar nanophase corresponds to a moderately polar oxidation product layer containing chemical bonds of type C–O–C, or similar ones.

Shift of MeOr absorption band in the process of increasing hexadecane oxidation degree has been obtained [2].

At the stage of deep oxidation the mechanism of reaction is especially complex. The prime oxidation products are generated. The physical and chemical properties of system are developed and they determine the system operational performance.

If the polar nanophase formation in oxidized hydrocarbons really occurs, the exploitation under heat can result in the formation of a complex colloid structure capable of impacting the flowing processes, on the base of hydrocarbon fuels.

This reasoning gave an impetus to thoroughly study the structure and the dynamics of high-temperature hexadecane oxidation products formation by air oxygen, in a liquid phase.

High-temperature (150 to 170 °C) hexadecane oxidation in a liquid phase by air oxygen in a bubbler reactor was carried out through flying products (condensate) selection and with an air bath. It allowed investigating the initial stages of deoxygenation change process in the reaction mixture and condensate following 2, 4, 5, 6, 7, 8 hours of oxidation.

The oxidation product structure in a condensate and reaction mixture was defined by means of gas chromatography with mass spectrometric detection (GC/MS).

Gas chromatograph-mass spectrometer: Agilent 7890A Gas Chromatograph and 5975C Gas Chromatograph/Mass Spectrometer.

Permanganatometry Method for Hexadecane Oxidation Determination. The value of AO_{25} (deoxygenation/absorption of oxygen) corresponds to oxygen milligram quantity absorbed in 2 ml and conditionally counted on 100 ml of fuel at 25 °C and the reaction duration of 30 minutes [3].

25 ml of 0.1 N Potassium permanganate ($KMnO_4$), 10 ml of 20 % sulfuric acid and 2 ml of fuel were placed into a 250-ml glass conical flask with a sealing plug.

The flask was closed up and put into water under the temperature of 25 ± 0,5 °C for 30 minutes, without stirring it up. Upon time being over, the oxidation reaction was terminated through injecting potassium iodide (2 g) with distilled water (100 ml) into the flask. The mixture was stirred up, and the isolated iodine was titrated with 0.1 N sodium thiosulfate $Na_2S_2O_3$ at presence of 1 ml of 0.5 % starch solution (indicator). The quantity of sodium thiosulfate was equivalent to the quantity of potassium permanganate not reacted with fuel after 30 minute treatment:

$$AO_{25} = 0.8 \cdot (a + b) \cdot 100/2,$$

where 0.8 – oxygen milligrams isolated by 1 ml of 0.1 N $KMnO_4$ in the acid medium and absorbed by fuel; 2 – ml of fuel introduced into the reaction; 100 – ml of fuel for which the value of value AO_{25} was conditionally recalculated; *a* – 25 ml of 0.1 N $KMnO_4$ solution introduced into the reaction; *b* – ml of 0.1 N $Na_2S_2O_3$ solution utilized for titration of isolated iodine.

Dimension of AO_{25}: mg O_2 / 100 ml of fuel.

The metrological estimation of the method shows that the maximal deviation from the average parallel definition makes ± 2.0 % [3].

Then oxygen absorption was calculated from available data on sodium thiosulfate quantity utilized for titration.

All the data received during experiment are represented in tables 1–3 and the hexadecane mixture reaction and condensate oxidizability were demonstrated through diagrams (figures 3–5):

Hexadecane Oxidation Resistance. As follows from the diagram presented in figure 3, the amount of oxygen-containing compounds in the reactor eventually increases, and in the condensate the amount decreases. Probably it is explained by the fact that substances with greater molecular weight are formed during high-temperature oxidation.

In the oxidation of paraffins, compounds with a more complex chemical structure than simple acids (ketones, aldehydes, spirits or hydroperoxides), are always found. Occurrence of more oxidized products (for example, lactones) is not necessarily consequence of repetitive oxygen attack upon the products already containing oxygen. Similar oxidized products are formed at the minimal depth of conversion, too. Lactones are internal complex esters of hydroxy acids. Hydroxy acids are easily dehydrated at higher temperatures. Among the oxidation products, formation both γ-, and δ-lactones could be observed.

High-temperature (150–170 °C) hexadecane oxidation with air oxygen was investigated in a liquid phase as a model of hydrocarbon jet engine fuel, with sampling condensate and reaction mixture.

Values of AO_{25} parameter (absorption of oxygen) of reaction mixture and condensate received through hexadecane high-temperature oxidation were determined by permanganatometry.

The oxidation product structure was identified by means of a gas chromatography with mass spectrometric detection (GC/MS).

It was established that the amount of oxygen-containing compounds in the reactor eventually increases, and in condensate their amount decreases. Probably, substances with greater molecular weight are formed during high-temperature oxidation. Additional research are required to induce the law.

Among the hexadecane oxidation products, identified were: spirits, carbonyl compounds, carbon acids, esters of carbon acids and lactones (internal esters of г- and д-hydroxy carbon acids). Similar compounds can be a part of turned

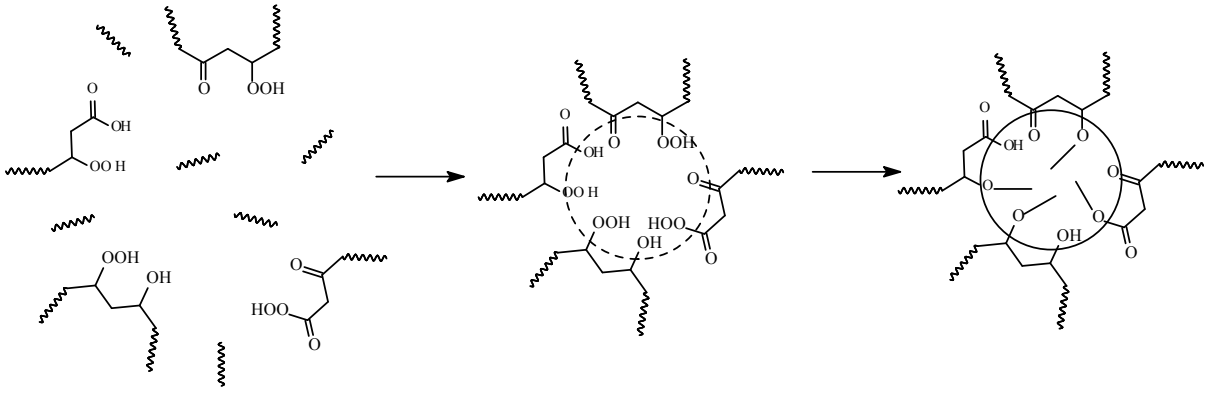

Fig. 2. Presumable structure of polar nanophase in the oxidized hydrocarbons

micellar aggregates, which impact upon physical and chemical properties and operational performance of jet engine fuels.

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Table 1

Results of AO_{25} Reaction Mixture and Condensate Determination Received at High-temperature Hexadecane Oxidation

Time of oxidation, *h*	Reaction mixture, AO_{25}, mg O_2/100 ml	Condensate, AO_{25}, mg O_2/100 ml
2	48	684
4	80	660
5	72	596
6	68	524
7	128	472
8	96	512

Table 2

Results of Chemical Composition Determination for Reaction Mixture Received at Hexadecane High-temperature Oxidation

№	Oxygen-containing compound	Amount, %
1	Heptanal	4.56
2	5-Methyl-2(3H)dihydrofuranon	2.20
3	Hexanoic acid	2.28
4	2,6-Dihydropyranon-2	1.05
5	5-Ethyl-2(3H)dihydrofuranon	1.50
6	Heptanoic acid	4.84
7	γ-Lactone 4-hydroxyheptanoic acid	2.49
8	Octanoic acid	7.72
9	δ-Lactone 5-hydroxyoctanoic acid	3.30
10	γ-Lactone 4-hydroxynonanoic acid	2.95
11	Decanoic acid	13.17
12	γ-Lactone 4-hydroxydecanoic acid	15.05
13	2-Undecanone	1.59
14	Dodecanoic acid	8.15
15	Tridecanoic acid	3.38
16	γ-Lactone 4-hydroxydodecanoic acid	3.00
17	Tetradecanoic acid	1.71
18	5-Pentadecanone	4.99
19	2-Nonadecanone	6.83
20	Pentanoic acid, tridecyl ester	2.34
21	6-Dodecanone	3.06

Table 3

Results of Chemical Composition Determination for Condensate Received at High-temperature Hexadecane Oxidation

№	Oxygen-containing compound	Amount, %
1	Decanoic acid	1.64
2	Undecanoic acid	2.19
3	Dodecanoic acid	3.65
4	γ-Lactone 4-hydroxyundecanoic acid	5.36
5	Tridecanoic acid	4.94
6	γ-Lactone 4-hydroxydodecanoic acid	3.99
7	Tetradecanoic acid	5.76
8	7-Pentadecanone	6.40
9	4-Hexadecanone	4.72
10	1-Tridecyn-4-ol	4.06
11	3-Hexadecanone	4.62
12	2-Hexadecanone	6.24
13	2-Heptadecanol	2.18

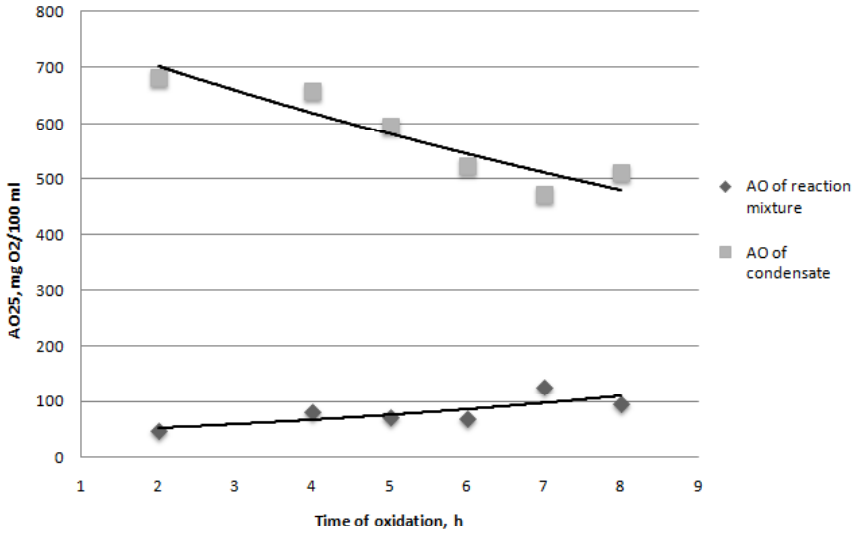

Fig. 3.Values of AO_{25} parameter (absorption of oxygen) in reaction mixture and condensate

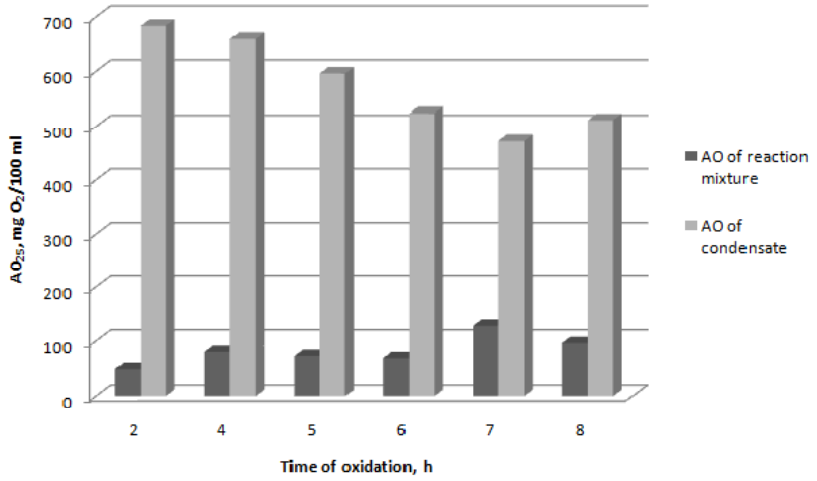

Fig. 4. Comparison of AO_{25} parameter (absorption of oxygen) for reaction mixture and condensate

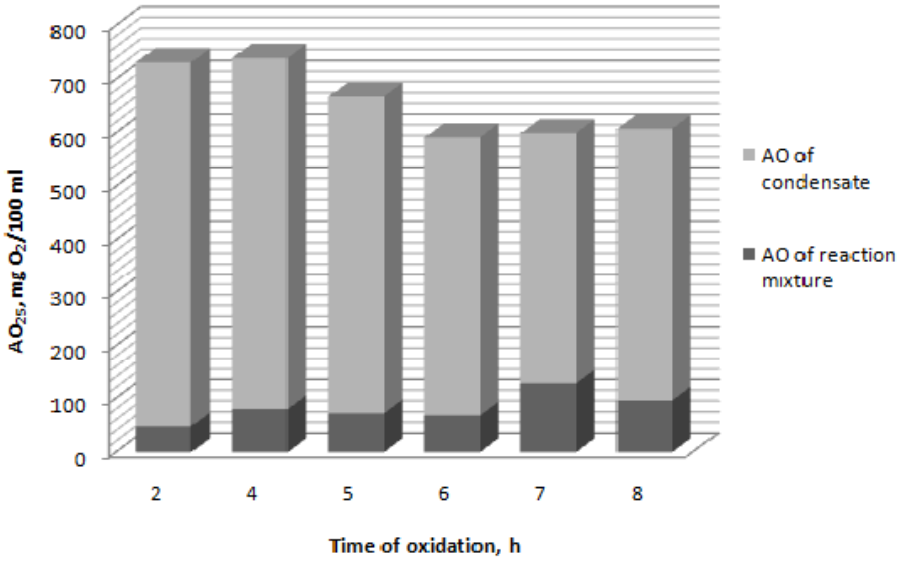

Fig. 5. The total AO_{25} parameter

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PRODUCT CHARACTERISTICS FORECASTING MODEL WITH SUPPORT VECTORE MACHINES

Numerical models with support vector machines are used for forecasting material's properties depending on their production parameters. The paper includes practical forecasting results.

Keywords: Forecasting model, vector machines, product characteristics.

Creation of materials with prespecified properties is currently one of the most challenging research areas. Solution of such tasks to some extent could give more freedom for designers from limits of available material properties and would disclose additional way of improving the designed machinery.

Preliminary author's research [1] has shown good prospects for numerical models of material's properties depending on their production technology at the example of wrought aluminium alloys' mechanical properties (hardness, elongation at break) dependence on their chemical composition.

As a next step in developing this idea a following problem was considered: the object of research was limited to alloys of Al-Mn and Al-Mg systems, while the sourcing database was extended by introduction of strain-hardening parameters.

Research area. Increasing the strength of aluminium alloys could be achieved not only with adding various alloying elements, but also mechanically with strain-hardening of cast slabs (peening, drawing) and heat treatment (tempering, ageing). This introduced the classification of alloys between thermally hardened and non-hardened [2].

Non-thermally hardened wrought alloys typically have relatively low strength (not far from pure aluminum's strength), high plasticity and corrosion resistance. They are used for products which require high plasticity – produced with forming operation.

Above mentioned group of alloys include Al-Mn alloys (domestic designation AMc, international 3XXX series) and Al-Mg alloys (domestic designation AMg, international 5XXX series). The alloys are supplied in form of sheets and also rolled and formed material, in annealed (soft) condition, or after strain hardening [2].

Problem statement. It is well-known that plastic strain of metal castings increases ultimate strength, while relative elongation decreases.

International standard EN 515–1993 [3] summarizes several existing strain-hardening modes used to achieve the desired mechanical properties of thermally non-hardened wrought aluminium alloys (tab. 1).

This designation is completed with strain-hardening degree identification (tab. 2).

Suggested mathematical model as problem solution. The dataset was prepared on basis of MatWeb material database (URL: www.matweb.com), in included 94 records (data points), containing information on chemical composition (percentage of Cr, Cu, Mg, Mn), strain-hardening mode and mechanical properties (Brinnel hardness and elongation at break) of regular wrought aluminium alloys of 3xxx and 5xxx series.

Basing on successful results of mathematical model development in [1] and taking into account similar origin of current problem it was possible to apply the same data preparation and data mining techniques.

Support vector machines served as the base of numerical model. It offered such features as solution stability (no risk of being caught into local optimum) and absence of overfitting problem, i. e. ideal adaptation of the derived model to training dataset thus decreasing general model efficiency [4].

As for result interpretation, formulation of dependence of output variable form input variables was not conditioned in the initial problem statement, so the solution of $f(x) = \sum_{i=1}^{Nc\alpha} (\alpha_i - \alpha_i^*) k(x_i, x) + b$ type is quite satisfactory [4].

Table 1

Strain-hardening technological modes for wrought aluminium alloys of 3XXX and 5XXX series (according to EN 515–1993)

Designation	Type	Characteristic
O	Annealed (with recrystallization)	Least strength and highest plasticity
H1	Strain-hardened only	Higher strength with lower plasticity
H2	Strain-hardened partially annealed	Applies to products strain-hardened or cold worked more than the desired level by partial annealing. The number following this designation indicates the degree of strain hardening remaining after the partial annealing process*
H3	Strain-hardened and stabilized	These products are strain-hardened to the desired amount and then subjected to a low temperature thermal operation which results in a improved ductility. The number following this designation indicates the degree of strain-hardening remaining after the stabilization treatment

*For example, product designation "5052-H36" identifies a product produced of 5052 alloy (Al, Cr 0,15…0,35 %, Mg 2,2…2,8 %) with strain-hardening and stabilization, hardening degree 3/4.

Mathematical apparatus of support vector machines, including its application to the problem of multiple non-linear regression, is well described in book [5] and paper [1], so it is not given here in detail.

The idea of method could be reduced to minimizing structural (expected) risk, apart from empirical one, i.e. developing such regression curve (plane), which will provide the best approximation of not only training dataset (which is normal for many alternative data mining techniques), but also the implied general dataset – all data points, including not yet registered ones.

According to the key SVM idea [6], empirical risk $R^{\varepsilon}_{\text{emp}}$ should be minimized simultaneously with vector weight coefficients' sum $\|W\|^2$, which expresses the dimensionality of the model. Therefore, developing of linear regression hyperplane $f(X,W) = W^T X + b$ requires minimization of

$$R = \frac{1}{2}\|W\|^2 + C\sum_{i=1}^{l}\left|y_i - f\left(X_i, W\right)\right|_{\varepsilon}.$$

Parameter C specifies relation between two summands of minimized function (i. e. relation of training error to model dimensionality).

In [5], [1] you can find the derivation of mathematical expression for the best fitted regression hyperplane for the case of non-linear regression:

$$f(X,W) = W_0^T X + b = \sum_{i=1}^{l}\left(\alpha_i - \alpha_i^*\right)k\left(X_i X\right) + b,$$

where W_0, b, α_i, α_i^* – parameters of optimal model; $k(Xi, X)$ – kernel function; X – the array of input variables.

Model verification was done with «leave-one-out» technique, which represents the extreme case of n-fold cross-validation, where n is the number of data point in the dataset. At every model testing iteration one data point is registered as testing dataset, while the rest – in training dataset.

For the case of regression problem, the average error of n model tests was accepted as general model adequacy [7]. Average model error was determined according to:

$$e\left(X,Y,f\right) = \frac{1}{n}\sum_{i=1}^{n}\left|f\left(X^*, Y^*, P, Xi\right) - Yi\right|,$$

$$Xi \notin X^*,\ Yi \notin Y^*,$$

where X, Y – input and output arrays of dataset; f – verified model; X^*, Y^* – training dataset at i-step of model verification (not including i data point); P – model parameters.

Such verification method provides the following advantages (for small datasets):

1. Intensive usage of the dataset, which increases the possibility of deriving most adequate model.

2. This is a determined procedure (since it does not apply random dataset splitting), which allows better estimation of model parameter influence on its adequacy.

Data source and data preparation. MatWeb [4] online material property database was selected as the most relevant source of uniform data, which could provide the biggest dataset with minimal data omissions (due to high sensitivity of mathematical model to data omissions), containing information on standard chemical composition and mechanical properties of the considered aluminium alloy types, taking into account strain hardening.

Dataset preparation from the initial database was done in the same manner as described in paper [1]:

– alloying element composition values were derived as the average between high and low percentage margins;

– brinnel hardness (dimensionless) and elongation at break (in %) were selected as output variables.

Data preparation procedure was modified according to changes in problem formulation. The quantity of considered alloying element was reduced from 6 to 4 (Cr, Cu, Mg, Mn), since the range of alloying elements in the studied alloy groups (3xxx and 5xxx series) is limited to only these ones.

Additional input variables were introduced to represent strain-hardening mode – 3 Boolean variables. The first one is "true" if strain-hardening is present, second one is "true" only for the condition "strain-hardened partially annealed", and third one is "true" only for the condition "strain-hardened and stabilized".

Such scheme allowed interpretation of qualitative factor "strain hardening mode" (4 possible conditions) into Boolean variables without missing its technological origins.

The basic dataset included 94 records (data points).

Practical results. Model parameters were adjusted in accordance with the recommendations in [6], which was used in calculations described in [1].

Gaussian function (radial basis function) of $K(X, X_i) = e^{-\frac{|X-Xi|^2}{2\sigma}}$ type was chosen as kernel function due to its good compatibility with regression models.

Increasing of regulating parameter C is accompanied with exponential growth of model dimensionality (and corresponding increase in consumed computational power), with simultaneous decrease of model error, which finally stabilizes at a certain level. Due to this fact, this value was fixed at $C = 1{,}000$, which enabled single model calculation to fit into sensible time (25…30 per 1 attempt) and provided acceptable level of average model error.

Experiments on forecasting model for "elongation at break" output variable showed no model adequacy changes at $C \le 100$. Parameter ε was selected within a frame of 5…15 % of output variable's average (different for each model), kernel function shape parameter (σ for this kernel type) – chosen by fitting.

Verification of the derived models for forecasting aluminium alloy's mechanical properties (considering strain-

Table 2

Designations of strain-hardening degree (according to EN 515-1993)

Designation	Characteristics
Hx2	1/4 hard
Hx4	1/2 hard
Hx6	3/4 hard
Hx8	Full hard (approximately 75 % reduction after a full anneal)
Hx9	Extra hard (limited to certain alloys and/or product forms)

hardening) has confirmed the correctness of idea of extension possibility for models in [1] by introducing additional technological input parameters, thus driving these models closer to practice. Figures 1, 2 show the results of optimal model verification (by average forecasting error), including detailed analysis by data sub-sets.

The study has confirmed efficiency of numerical models for forecasting material's properties depending on their production parameters. Comparing with previous studies on this topic, the model was significantly extended, now considering two groups of technological parameters of casting production: melt's chemical composition and casting's strain-hardening mode.

The paper includes practical forecasting results for 3xxx and 5xxx series wrought aluminium alloys' properties.

Practical results of the study demonstrate the possibility of creating «inverse» model, i. e. selection of technological parameters for production of materials with predefined properties, which would be of significant practical interest.

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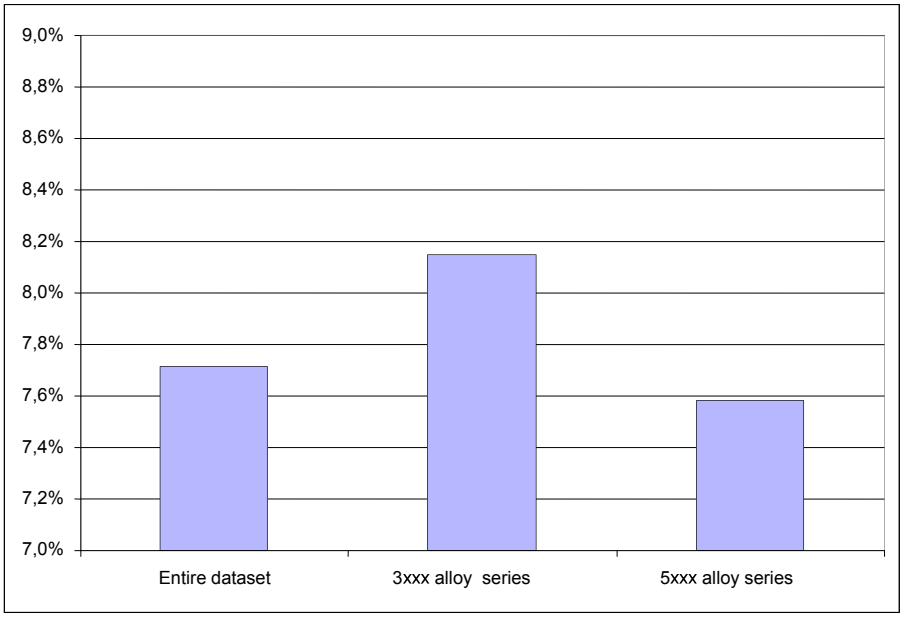

Fig. 1. Average forecasting error by alloy series

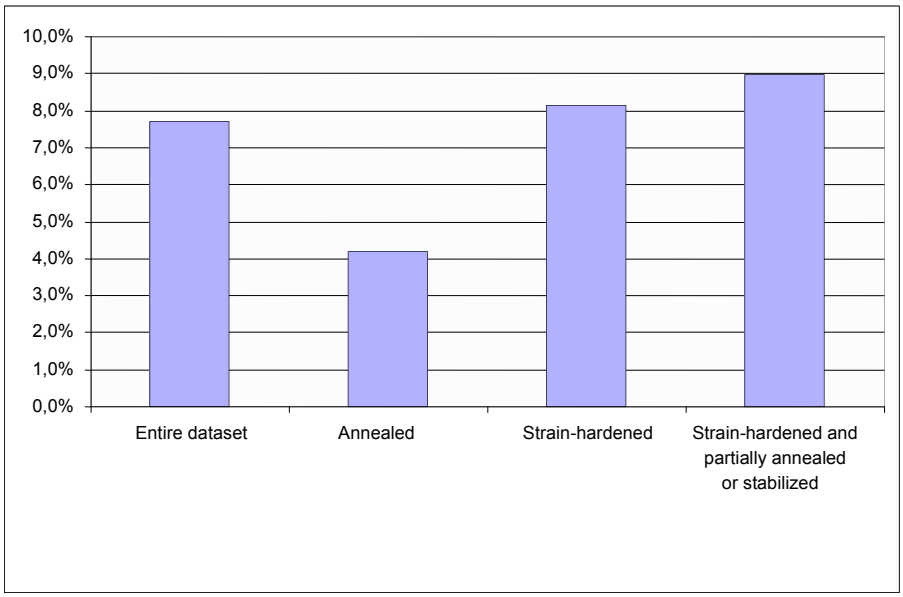

Fig. 2. Average forecasting error by strain-hardening mode

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THE ANALYSIS OF GENERAL TENDENCIES OF THE FOREIGN TRADE COOPERATION BETWEEN RUSSIA AND CHINA

The foreign trade cooperation between Russia and China in the system of market economy are considered. The offers for the foreign trade cooperation with purpose to increase the efficiency of a two side advantageous relations are resulted.

Keywords: tendencies, foreign trade, cooperation.

The main topic of the given work is defined by variety of forms of the foreign trade cooperation and foreign trade activities between Russia and China, an imperative need of their analysis and development of new approaches to the expansion and optimization of the system of market relations. The object of the research is a foreign trade transaction between Russia and China. The practical importance of the work is defined by the analysis of existing tendencies of the foreign trade cooperation between Russia and China and the offer of new potential ways of the foreign trade cooperation between Russia and China with purpose to increase the efficiency of a two side advantageous cooperation.

Among the internal factors of balance optimization of economic interests of Russia and China it is necessary to consider the aspects of generality and specificity of two countries which promote or, on the contrary, complicate practice realization of the known concept of complementarity of economic complexes of these two countries.

"It is possible to carry out the following basic elements of generality:

– transitive character of economy – from the plan-administrative dependence of the manufacturer on the state to the market form of connection regulated by the state and movements of the manufacturing factors;

– historical preconditions of fruitful economic cooperation;

– the big extent of the common border, trading-transport possibilities, communicative and other possibilities;

– other geo-economics and geo-political factors which are objectively pulling together our states in historically new conditions of the multi polar world" [1].

"Elements of specificity of two countries which promote realizations of the concept of complementarity concern (tab. 1).

The fact that the development of the international relations between Russia and China are inevitable – is obvious.

The fact that the sources of raw materials, energy and safe transport ways are necessary to fast-growing economy of China is not a secret no longer.

The Chinese experts ascertain: "Russia is the partner of China with huge potential possibilities. 70 % of the Russian export is oil, minerals and wood" (URL: http://www.vostokmedia.com)

"In exchange, according to the Chinese customs statistics for 2007–2008, the main articles of the Chinese export to Russia during the specified period were (fig. 1):

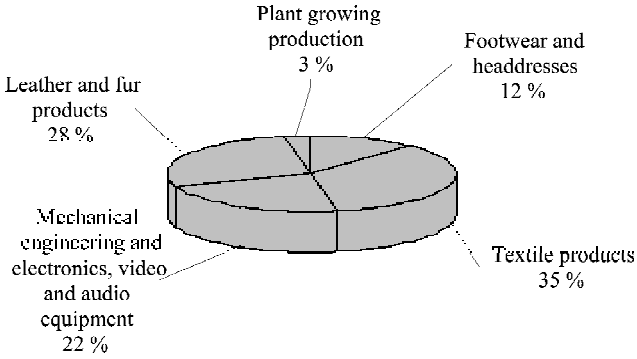

Fig. 1. The shares of the Chinese export to Russia in 2007–2008

Table 1

Elements specificity of the foreign trade activity between Russia and China

Russia	China
Reduction of an export potential as a result of decomposition of the USSR	Demographic problem: overpopulation, redundancy of a manpower, in particular, in areas joint to the Russian Federation
Unprofitable structure of the Russian export characterized by the export strategy of the energy and other natural resources, raw materials and the goods with the low added cost	Raw material problem which pushes China to import raw materials from Russia
The crisis state of domestic investment sphere does not allow to introduce modern technologies in manufacture of competitive production without support from the outside	The problem of the intensification of the economic growth, which high rates are based on the extensive basis, at low productivity of a live work, high energetic and production capital intensities
Oversaturation of the Russian market by the import consumer goods, absence of the sufficient state stimulation of the home producer	A problem of quality of exported production, incomplete conformity to its world standards
The low cost price factor of the Russian high technology production in comparison with the western	Strict position of some West countries concerning terms and conditions of application of know-how and high technology equipment by China
	The advantages of the Russian know-how and high technology equipment in front of high cost of the same in some West countries [1]

– footwear and headdresses – 1. 061 billion dollars;

– textile products – 3.26 billion dollars;

– mechanical engineering and electronics, audio- and video equipment – 2.008 billion dollars;

– leather and fur products – 2.532 billion dollars;

– plant growing production – 0.275 billion dollars" (URL: http://www.vostokmedia.com).

In exchange, for the similar period of time, China imported from Russia the following production (fig. 2):

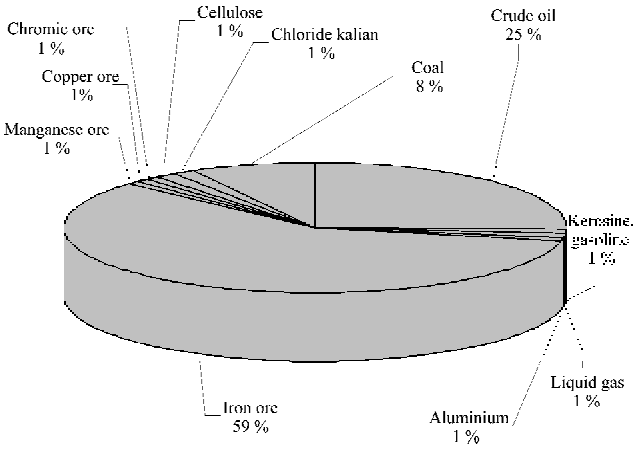

Fig. 2. The shares of the Russian export to China in 2007–2008

Thus, the foreign trade of Russia and China can be characterized by:

– the further growth of the foreign trade turnover and volumes of export operations;

– growth of volumes on the basic commodity positions in export structure of the country;

– inadequacy of export-import positions.

The Russian exporters should recognize that Russia has turned to a raw appendage and a commodity market of roughly developing Chinese economy. The Chinese market already is almost completely lost for the Russian goods with the high added cost. Crude oil and round wood dominate in volumes of the Russian export. The pleasant exception is made by production of the chemical industry which while is still highly demanded in China. Thus, the Chinese partners dictate to the Russian export companies the price at which they agree to get our production.

"China is resource dependant, but in a condition to replace the Russian gas or black oil and coal because already possess a large stocks of it in China. As for the Russian Federation – there no choice are left. Without the Chinese contracts Russia cannot solve a problem of an export diversification of resources not to be exclusively adhered to the European market», – has drawn an unfavorable conclusion Sergey Sanakoev – the head of the Russian-Chinese centre of economic cooperation" (URL: http://www.ecolife.krsk.ru/content.asp?id = 391).

"Raw export is a central part of trade relations of China", said the president of the Institute of a energy policy Vladimir Milov, "Theoretically we can increase export of energy resources to China in 2010 by the sum of 6–11 billion dollars. However, there is a serious problem – Chinese are ready to pay for our resources the price practically twice low, than that on which it is favorable to us to sell it to them" (URL: http://www.ecolife.krsk.ru/content.asp?id = 391).

"The similar problem exists in the sphere of oil export. Now the annual volume of deliveries of oil of Russia to China does not exceed 10 million tons a year, whereas in 2010 it is possible to reach 20 million tons", – added Mr. Milov. As he said, for this purpose it is necessary to create a corresponding infrastructure, for example, civil-engineering designs of an oil pipeline Russia–China with branch to Pacific ocean to continue to master the East Siberian deposits more actively. «"As for the gas deliveries to China the problem rests against absence of the arrangement on the price. We could begin delivery right away and fulfill the volume of gas export to 3 billion dollars per year by 2012 in a cost expression", he said» (URL: http://www.vostokmedia.com).

Last years, the favorable tendency was outlined in economic cooperation between Russia and China, concerning goods turnover structure – goods turnover structure has begun slowly, but gradually varies – the share of technical machinery industrial production is growing. The structure of the Russian export also has changed – is not only delivering raw materials to China, but also a hi-tech production. Besides, the government supposes to approve the program of development of the Russian-Chinese cooperation in 2010, providing further diversification of the Russian export towards increase of deliveries of highly technological production.

One more prominent aspect of two countries interaction is an investment cooperation and realizations of the joint projects, one of which, for example, is the building of "the Chinese business centre in Moscow". So, "…on December, 12th, 2006 the general director of Chinese international investment company "Hua ming" Mu Hua dun and the director of the main botanical garden of the Russian Academy of Sciences Alexander Demidov have signed in the Moscow mayoralty the agreement on ground rent of the territory of the main botanical garden of the Russian Academy of Sciences for the project «the Chinese business centre in Moscow". At the ceremony of signing the contract there were the ambassador of China in Russia Lju Guchan, the chairman of the committee of foreign trade activities in Moscow – Valery Kuzin, the chairman of a board of the Russian-Chinese centre of economic cooperation – Sergey Sanakoev, and also representatives of both Chinese and Russian business structures and mass-media. This joint project reflecting high level of two countries relations, will not only help to improve the two side cooperation in all spheres, but will also strengthen the friendship and mutual understanding between the people of two countries. It is planned that the complex will include five-star hotel, office building of a class "A", the modern exhibition centre, a trading complex, a garden-park in traditional Chinese style" (URL: http://ru.ruschina.net/news/page_13038/rch/lkjhhg/).

The great role favoring such step was carrying out "a Year of Russia in China". "A Year of Russia in China has caused an interest among the Chinese party" – the trade representative of the Russian Federation in China – Sergey Tsyplakov has declared: "…not only the interest grows between Russia and China, but also a goods turnover" (URL: http://ru.ruschina.net/news/page_13038/rch/lkjhhg/).

At the same time experts warn that the good indicators hide serious problems. Experts specify that the present growth continues to follow the account of increase in deliveries of the Russian energy resources. And it is not a unique problem. "Lately annual level of a gain of a trade turnover of the Russian Federation and China made approximately 30 %. This year decrease in rates is observed", told the head of the Russian-Chinese centre of economic cooperation Sergey Sanakoev to "RBC daily". "Unfortunately, even this growth is provided not simply by increase of energy deliveries, but also a rise in prices for raw materials. It is necessary to pay attention not to increase in volumes of trade, but to the share increase in export to China of technical machinery and hi-tech production" (URL: http://www.ecolife.krsk.ru/content.asp?id = 391).

The reason of such position, to the opinion of the president of the Institute of an energy policy is an active lobbyist policy of the Chinese authorities and the extremely passive behavior of a Russian side.

Thus, accurate strategy of the state which would allow using possibilities of China in interests of the country is necessary to Russia. To reach this purpose – it is necessary, in the first, to stop expansion of Chinese-dealers on the Russian market, to expand the markets and capacities, actively involving investments from China, to be fixed in these markets at the expense of own technological innovations. For this purpose it is necessary:

– to master narrow niches of specialized hard to copy technologies;

– to think out the ways of protection of technical decisions;

– to load Chinese orders for accessories, transforming them from competitors into contractors;

– to buy the Chinese industrial actives [2].

Development of the international relations between Russia and China is inevitable and the main task of these relations is – to combine economic possibilities with strategic interests of both countries, observing rules of law of both parties.

Researches and conclusions of the given work give possibility of application of its positions in activity Chinese and Russian legal and the physical persons connected by the foreign trade relations.

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ANALYSIS OF RISKS OF THE FOREIGN TRADE TRANSACTIONS BETWEEN RUSSIA AND CHINA

The foreign trade transactions in the system of economic activity between Russia and China are considered. Recommendations about conducting the foreign trade transactions with China with the purpose to increase the efficiency of it are resulted.

Keywords: risk, foreign trade transactions.

The urgency of the given work is defined by an imperative need of a deep research of the foreign trade relations and communications between Russia and China with the purpose to increase the efficiency of bilateral cooperation. The object of the given research work – risks of the foreign trade transactions. The practical importance of the work consists of the specific proposals and recommendations on conducting effective communication with the purpose of realization the successful foreign trade transactions between Russia and China.

The favorable geographical position, developed logistical network, availability of customs coordination are among the reasons of the effective business cooperation between Russia and China. But along with the establishment of good neighboring cooperation there are a lot of legal risks which Russian companies can face conducting the foreign trade activity with China. The knowledge of the legal aspects of foreign trade of China will allow to avoid unjustified and unexpected expenses (see in the figure).

Legislative difference of the partner countries. One of the most serious legal risks which are commonly faced by businessmen from different jurisdictions – is the difference of the legislation of the countries regulating common legal issues. Searching for the profit the business partners from different countries do not pay much attention to the initial stage of relations – to a stage of coordination of terms of the contract. A lot of ridiculous problems outflow difficulties and unexpected consequences in mutual relations.

Reliability of Chinese parties. "The allowing order of conducting business for the enterprises existing in China essentially narrows a circle of the subjects, having the right to conclude transactions of the international purchase and sale. Therefore it is necessary to check a legal status of the enterprise of the foreign counterpart both its financial and

commercial reliability, and also correctness of registration and the level of authorities of representatives of the foreign counterpart to carry out negotiations and sign contracts according to constituent documents and powers of attorney" [1]. Recently it was a severe requirement because this could directly influence the decision of the Russian Tax Inspection on compensation of the export VAT.

Features of the international trading contract. The foreign trade contract of purchase and sale is the commercial document concluded between the parties on which the seller is obliged to give the goods in the property of the buyer, and the buyer is obliged to accept and pay for it. An indispensable condition of the contract of purchase and sale is transition of the good property right from the seller to the buyer. The contract is made in writing in two languages, each of which is valid.

If negotiations are conducted in different languages, common language problem is an important stage of negotiations. Knowledge of foreign language is not the only problem. It is very important to choose a well prepared translator, possessing equally good both foreign, and a native language, possessing high language culture and ability to feel the language nuances which misunderstanding can lead to serious problems. Good knowledge of a foreign language, on the contrary, will simplify procedure of the coordination and signing of the foreign trade contract; will gain the partner marking aspiration of the co-operating party to find common language.

Divergence of legislative bases. "In Chinese legislation, for example, there are no legal definitions of such terms as the offer and the acceptance that threatens with possible negative consequences. Chinese legislation does not contain also instructions, allowing finding distinction between the offer and an offer call.

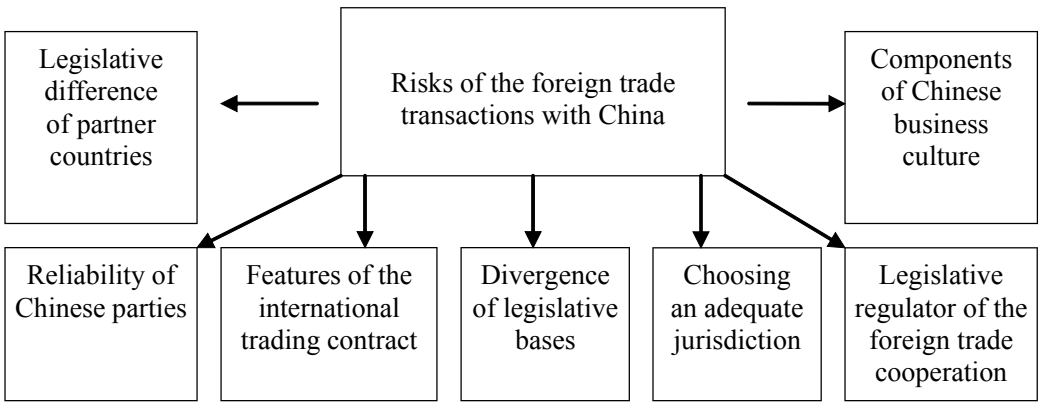
It is not recommended for the Russian enterprises to conclude the international contract of the purchase and sale by fax. The matter is that, applicable to such agreements the Viennese convention of 1980, understands as the written form only messages on telegraph and the teletype, and the higher judicial body of Russia considering economic disputes, in one of the decisions has defined that if the Convention names only two above-stated means of telecommunication the fax does not below to this list" [1].

Choosing an adequate jurisdiction. Choosing an inadequate jurisdiction for the resolution of dispute, no less than the inadequate applicable substantive law, can lead to unexpected expenses for suits, the sum of expenses can considerably exceed the sum of loss. That is why the development of as much as possible correct formulation of the arbitration disputes and the reservation on an applicable law is, perhaps, among the key points of the contract's terms. At the initial stage of creation of the text of treaty provisions it is necessary to reflect the consequences of a choice of this and the country of the applicable law. It is also necessary to check up the contract's positions on conformity to norms of an applicable law which will be selected in case of conflict occurrence between the contract parties. To carry out the dialogue with the foreign counterpart it is possible only with the assistance of experts in this sphere. Therefore at a stage of the contract's coordination and concluding the terms of the agreement it is expedient to involve professionals.

Legislative regulator of the foreign trade cooperation. The modern trade basic legal regulator between the different countries cooperation are – INCOTERMS 2000 (the international rules of interpretation of trading terms) and the Convention of the United Nations of 1980 on international contracts of the purchase and sale of the goods. However, recent times the trade between the countries entering the "socialist" camp was regulated by the universal conditions of deliveries (CUD) which had an interdepartmental character. Such document was also singed by the USSR and Peoples Republic of China (CUD USSR–PRC).

"The first edition of this document has been accepted in 1950. It was corrected in 1957 and in 1970. The last edition which has come into power since July, 1st, 1990, essentially differs from previous (CUD USSR–PRC) and has features of the international interdepartmental agreement which was signed by the authorized bodies of each country. The operating text of CUDUSSR-PRC covers the important questions of trading practice: basic conditions and terms of delivery, quality and quantity of the goods, transport instructions and notices on deliveries, order of payments, sanctions, claims, the bases of clearing of responsibility, arbitration" [1].

The question about whether CUD USSR–PRC has kept powers accordingly the subject of application and at absence of the consent of the parties of the contract is open. The matter is that "…assignment of Russia concerning this document has not been issued, and in interstate agreements which Russia and China have concluded in 1991 and the next



Risks of the foreign trade transactions with China

years, the relation to it is not expressed. So, the attitude towards CUD USSR–PRC has facultative character, anyway the priority is given to the rules of the Vienne convention of 1980" [1].

Now, the contracts are basically formed on the base of conditions of Incoterms 2000, which allows unifying the external economic relations not only between the Russian and Chinese business partners, but with the partners from other countries.

Components of Chinese business culture. The role of national traditions. Planning a business trip to China or concluding business relations with the Chinese partners it is necessary to pay attention to a number of customs of conducting business activity with the Chinese partner:

1. The organization of business meetings.

Planning a visit to the business partner from China, or arranging the business meeting it is necessary to know that in China, as well as in other countries, the working day begins at 8:00 o'clock in the morning and lasts till 17:00, from Monday till Friday. A lunch break, as a rule lasts from 12:00 till 14:00. Actually everything is "closed" during this period, including the lift and telephone services.

Chinese are very responsible celebrating the national holidays, such as: new year, May, 1, or and other state holidays. Throughout a week, during celebration any of these holidays all firms and enterprises do not work.

2. Conducting business dialogue.

Referring to somebody it is accepted to use a professional rank or a post with a surname, for example: Director Van or General Chen. If the person has no title – the madam, etc. plus a surname.

Negative answers are considered as impolite. Instead of "it is impossible" use "I will think about it". The same concerns, if the same is addressed to you. When the Chinese partners politely speak "no problems" or "it is not a serious problem", that means that the problems exist and you should learn more about potential questions which can arise» (URL: http: //www.chinadata.khv.ru/scit_ma.htm).

It is necessary to know that in Chinese business culture the collective thinking prevails, therefore, do not hurry the Chinese partners to momentary decision-making, it is necessary for them to consult and think once again about everything.

The strong accent in Chinese business culture is paid to hierarchical relations. If among the delegation there is no vip persons the decision or the answer to your offer will not be accepted before delegation departure.

3. Business gifts.

"The today's official policy of Chinese business culture forbids to present gifts as the gesture of illegal action. Therefore, if you wish to present a gift to your business partner it is necessary: to make it in confidential atmosphere; in a friendship context, instead of business" [2].

"Traditions of gifts acceptance in China consist in refusal of a gift reception three or even more times before its final acceptance. Chinese do that not to seem greedy. When the gift is accepted, the one who presented should express gratitude. The wrap should be red, which is considered as a happy color in China. Pink, gold, silver papers – are possible to use for gift packing. Yellow, white, black or dark blue colors are unacceptable, as far as they have a negative connotation in Chinese culture" (URL: http: // www.chinadata.khv.ru/scit_ma.htm).

If a party from Russian follows all traditions of the Chinese business dialogue the Chinese party will respond to such co-operation with a successful reply and expectedly conclude a business agreement.

In the conclusion, it is important to notice once again that the important problem of Russia and China is harmonious character of mutual cooperation based on their cultural identity.

Russia and China are the two countries, each with the unique history, culture, traditions and specificity, therefore the most effective possibility of mutually advantageous coexistence should be carried out taking into account legislative rules of both countries, and the standard international bases.

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THE THEORY OF REAL OPTIONS IN THE ESTIMATION OF CONSECUTIVE INNOVATIVE PROJECTS

Approaches to the estimation of efficiency of the investment projects including consecutive improving innovations are considered, the choice of methodology of real options for the estimation of such projects is proved and its application is shown by the example of an abandon option for the project.

Keywords: real options, estimation, investment projects, innovations.

On novelty level two types of innovations are distinguished – radical (basic) and improving innovations. Radical innovations are aimed at adoption of new generations of machines and materials, essentially new technics and technology, they make such considerable changes in processes, products or services that lead to transformation of the existing markets or sectors or create the new markets and sectors. Improving innovations are aimed at evolutionary improvement of the properties and parametres of processes, products or services, they serve a purpose of distribution and perfection of the mastered generations of technics and technology, creation of new models of machines and variety of materials, improvement of parametres of the produced goods, services and their manufacturing techniques [1]. Distinctive feature of the majority of innovative projects is constant improvement of an innovative product (improving innovations), that allows to mark out certain generations of development of technology. In many projects the innovative product of one generation is considered as a platform (base) for the future generation of innovative products. The approach is offered to the estimation of innovative projects the outlet of which is limited (the demand is set by certain limits which is typical for a number of innovative sectors) and where the competition exists. The competition is the important factor as it is the competition that forces the manufacturer to launch constantly innovative products.

Let us assume there is a company which plans to launch innovative products $P_t = 1, \ldots, T$ through equal time intervals t, where T is the life-time of the technology. Each of the subsequent products P_{t+1} is the improvement of the previous product P_t and after the beginning of manufacturing of a new generation product P_{t+1} manufacturing of a previous generation product P_t ceases. Initial investment expenses for launching of each product P_t make up I_{t-1}, and the net cash flow from selling of one product makes up C_t. One of the major factors of uncertainty for the company is the demand for the product in each period (x_t) and it is known that the demand under good conditions makes up x_{t+} and x_{t-} under bad conditions. In the first period the probability of high demand is q_1 and the probability of the low demand is $(1 - q_1)$. For the subsequent periods the following is valid:

– if the demand for the product P_t was high, the probability of the high demand for the product P_{t+1} makes up q_{t+}, and with the probability $(1 - q_{t+})$ it will be low.

– if the demand for the product P_t was low, the probability of the high demand for the product P_{t+1} makes up q_{t-} and with probability $(1 - q_{t-})$ it will be low.

On the basis of the information above it is possible to draw the following decision-tree of the cash flows (fig. 1).

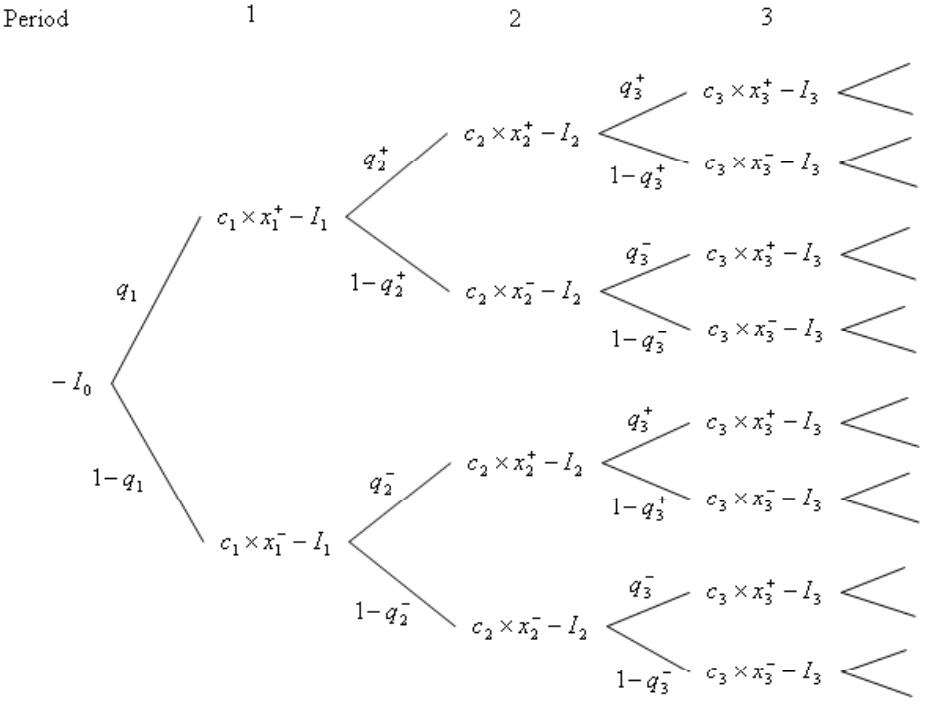

Fig. 1. Decision-tree of cash flows for consecutive innovative projects

According to the NPV method for estimation of the appropriateness of the project realization it is necessary to determine cash flows for each period considering the probabilities, i. e. expected cash flow of the period 2:

$$f_2 = q_1 \cdot (q_2^+ \cdot (c_2 \cdot x_2^+ - I_2) + (1 - q_2^+) \cdot (c_2 \cdot x_2^- - I_2)) +$$
$$+(1 - q_1) \cdot (q_2^+ \cdot (c_2 \cdot x_2^+ - I_2) + (1 - q_2^+) \cdot (c_2 \cdot x_2^- - I_2)). \quad (1)$$

After that each of the expected cash flows should be discounted to the initial time period at the discount rate k (where k is set from the outside, as expected rate of return from alternative investments). Formula of NPV looks as follows:

$$\text{NPV} = \sum_{t=0}^{T} \frac{f_t}{(1+k)^t}. \quad (2)$$

The project is accepted if NPV ≥ 0 and is rejected if NPV < 0.

At the same time the main disadvantage of NPV method is that it does not consider the possibility of management of the project to make changes during its implementation, for example, to expand or reduce production capacity, to temporarily shut down the project with the subsequent renewal of activity, to abandon the project etc. Implementation of these measures influences NPV positively and reduces the risk of the project. For the projects implying constant renewal management decisions may include the measures of the choice of the best period of time to launch a new product, switching over to different technologies etc. [2; 3; 4] Strategic net present value of the project (NPV *) consists of two summands:

– net present value of the project without options (NPV);

– value of options of the project (ROV).

The formula for the strategic (expanded) net present value looks as follows:

$$\text{NPV*} = \text{NPV} + \text{ROV}. \quad (3)$$

Let us consider the opportunity of the abandonment of the project by the example of the decision-tree in figure 1. The decision-tree should be analysed from the end. It makes sense to abandon the project, if discounted cash flows are less than investment expenses:

$$I_{t-1} < \frac{q_t \cdot x_t^+ + (1 - q_t) \cdot x_t^-}{1 + k}. \quad (4)$$

The given check should be carried out in each node of the decision-tree, moving from right to left from the end of the tree (period T) to its beginning. In each node it is necessary to sum up the cash flows of the period and the future cash flows discounted to this period. The decision-tree of cash flows is transformed to a following decision-tree of value (fig. 2).

As a result of the carried out analysis economically inefficient branches of a tree will be cut downwhich leads to the modified tree of cash flows, for example, as following (fig. 3).

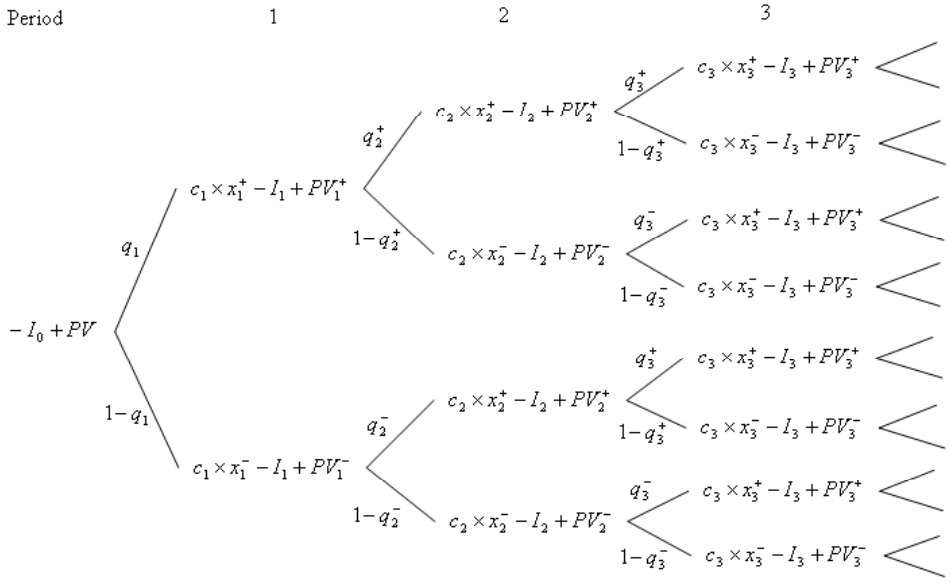

Fig. 2. Decision-tree of value for consecutive innovative projects

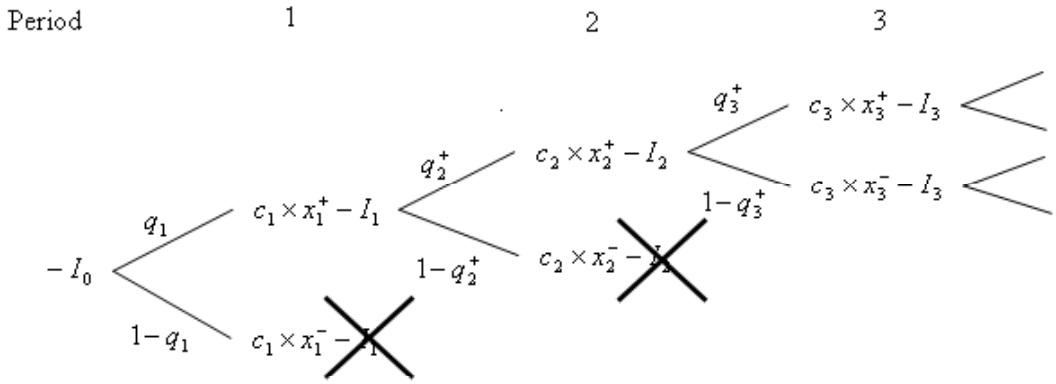

Fig. 3. Modified decision-tree of cash flows for consecutive innovative projects

According to the method of decision tree analysis (DTA) for the modified decision-tree of cash flows the expected cash flows are calculated and then are discounted to the initial moment of time at the rate k. That is:

$$\mathrm{NPV}_{\mathrm{DTA}} = \sum_{t=0}^{T} \frac{f_t'}{(1+k)^t}, \qquad (5)$$

where $\mathrm{NPV}_{\mathrm{DTA}} \geq \mathrm{NPV}$.

A shortcoming of the decision-tree analysis (DTA) is that it does not provide any instructions on modifying the discount rate of the project in connection with the risk reduction through exclusion of the unfavorable branches. To solve this problem it is possible to use real options approach (ROA) which allows not only to take into account the flexibility of management decisions but also to correct the discount rate according to the theory of financial options [3; 4].

Let us consider the following numerical example. The company plans to launch two consecutive products P_1 and P_2. Investment expenses for launching the product P_1 make up 1,000 c. u., those for launching the product P_2 make up 2,000 c.u. The cash flows of product P_1 will make up 700 c.u. at favorable demand, 300 c. u. at unfavorable demand, for product P_2 they will make up 5,500 c.u. and 2,000 c. u. accordingly. The probability of favorable demand for product P_1 is 50 %, of unfavorable demand 100 % – 50 % = 50 %. The probability of demand for product P_2 depends on demand for product P_1. If the demand for product P_1 was high the probability of a high demand for product P_2 makes up 80 % (the probability of low demand is 100 % – 80 % = 20 %). If demand for product P_1 was low the probability of a high demand for product P_2 makes up 30 % (probability of low demand is 100 % – 30 % = 70 %). The discount rate of the projects of the given branch of industry (k) makes up 30 %, risk-free rate (r) makes up 10 %. It is possible to present a decision-tree of cash flows of the project in a following way (fig. 4).

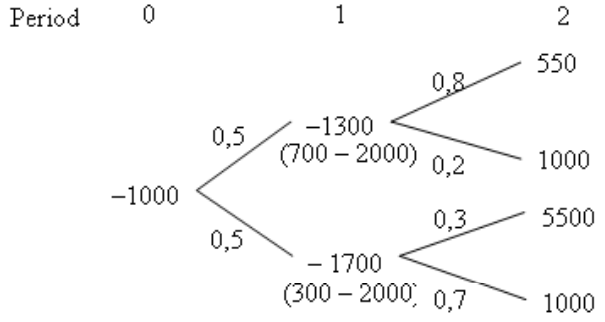

Fig. 4. Decision-tree of cash flows for the company

Estimating the project with the NPV criterion it is possible to come to a conclusion that the project is inefficient:

$$\mathrm{NPV} = -1000 + \frac{0.5\cdot(-1300)+0.5\cdot(-1700)}{1+0.3} + \frac{0.5\cdot(0.8\cdot 5500+0.2\cdot 1000)+0.5\cdot(0.3\cdot 5500+0.7\cdot 1000)}{(1+0.3)^2} = -98. \qquad (6)$$

To take into account the abandonment option we will build the following decision-tree of value (fig. 5).

Analyzing a decision-tree of value it is possible to make a conclusion that in case of the low demand for the product P_1 investment in the product P_2 is inefficient as the net present value of such project is negative ($\mathrm{NPV}_1^- = -I_1 + \mathrm{PV}_1^- = -2000 + 1808 = -192$ c. u.). The modified decision-tree of cash flows taking into account the abandonment option at low demand for the product P_1 will look as follows (fig. 6).

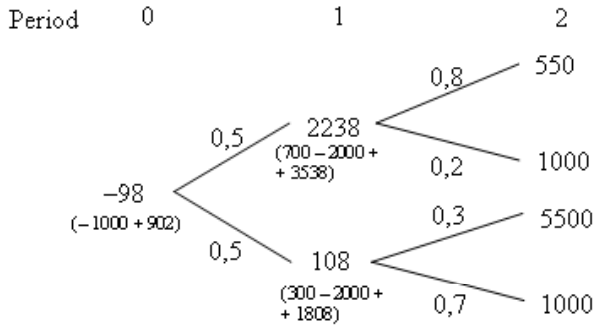

Fig. 5. Decision-tree of cash flows for the company

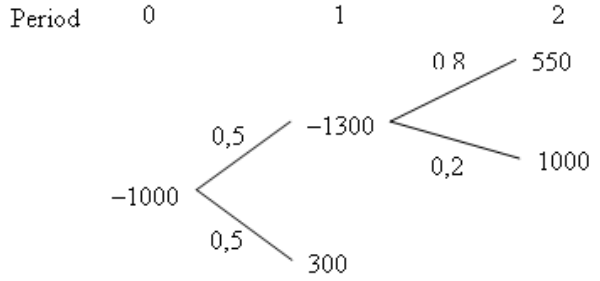

Fig. 6. Modified decision-tree of cash flows for the company

The net present value according to the decision-tree analysis (DTA) is then worth:

$$\mathrm{NPV}_{\mathrm{DTA}} = -1,000 + \frac{0.5\cdot(-1,300)+0.5\cdot 300}{1+0.3} + \frac{0.5\cdot(0.8\cdot 5.500+0.2\cdot 1,000)}{(1+0.3)^2} = -24 \text{ c. u.} \qquad (7)$$

The value of the option is worth:

$$\mathrm{ROV}_{\mathrm{DTA}} = -24 - (-98) = 74 \text{ c. u.} \qquad (8)$$

At the same time despite of the fact that the risk of the project has been lowered due to the reduction of dispersion of the cash flows, the discount rate remained invariable. To modify the discount rate it is necessary to take advantage of the theory of real options and risk-neutral approach. The risk-neutral approach assumes the determination of the risk-neutral probabilities for the cash flows of the project for the purpose of discounting the additional value of the project appearing as a result of management flexibility at the risk-free rate (as this value does not imply an additional risk). From figure 5 it follows that the present value of cash flows in period $t = 0$ makes up 902 ($S = 902$), which is obtained by weighing the value of the project in period $t = 1$ by the actual probabilities in case of favorable ($S^+ = 2{,}238$) and unfavorable ($S^- = 108$) scenarios and discounting the result at the interest rate of 30 %.

The risk-neutral probabilities can be found as follows:

$$p = \frac{1+r-d}{u-d}, \qquad (9)$$

where $u = S^+/S$, $d = S^-/S$.

In the example (fig. 7) $u = 2238/902 = 2.48$; $d = 108/902 = 0.119$; $p = (1 + 0.1 - 0.119)/(2.48 - 0.119) = 0.415$ or 41.5 % (fig. 8).

The abandonment value of the project will look as shown in figure 9.

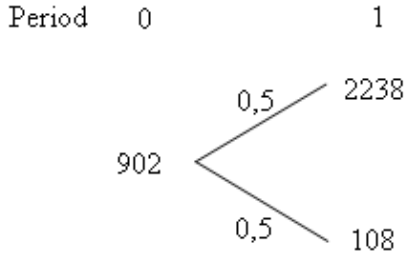

Fig. 7. Present value of the project using the actual probabilities

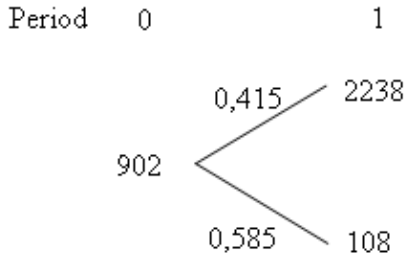

Fig. 8. Present value of the project using risk-neutral probabilities

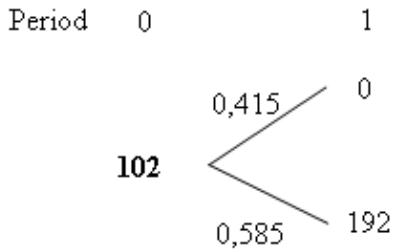

Fig. 9. The value of the abandonment option

Thus, $NPV_{ROA} = NPV + ROV_{ROA} = -98 + 102 = 4$ c. u.

Comparison of results of an estimation of consecutive innovative projects is presented in table.

The classical assessment criterion of the investment projects (NPV) indicates that the project is economically inefficient. At the same time the abandonment option is built into the project of launching the product P_2 in the case of the low demand for the product P_1. There are two ways of the estimation of the existing opportunity to terminate the project (the real option to abandon): a method of the decision-tree analysis and the method of real options analysis. The method of DTA underestimates the option value as it does not consider change of the project risk. The cash flows of the projects are discounted at the cost of capital of the project k = 30 %. The present value of the option in this case makes up 74 c. u., and expanded NPV is – 24 c. u. The method of real options considers reduction of risk of the project by using the risk-neutral probabilities and discounting the cash flows at the risk-free rate r = 10 %. Defined according to the method of real options the value of the option to abandon makes up 102 c. u. This leads to the fact that the strategic net present value of the project becomes positive (NPV = 4 c. u.), therefore the project can be recommended for implementation.

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Comparison of results of an estimation of the consecutive innovative projects received by various methods

	Traditional method NPV	DTA method	Real options' method
Traditional NPV	–98	–98	–98
Real option value to abandon the project ROV	–	74	102
Extended (strategic) NPV	–	–24	4

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EFFICIENCY OF THE ORGANIZATION STAFF WORK: SYNTHESIS OF ORGANIZATIONAL BEHAVIOUR

There have been described several types of workers behaviour and their influence on the productivity in organization. There is presented a number of issues which make it possible to determine the type of staff behavior and possible ways to control this behavior.

Keywords: organization behavior, motivation, efficiency, productivity, loyalty, staff

Human resources management department, or depending on the size of the company scale, department on work with the personnel is to solve a number of very important issues connected with the staff of the organization. One of such issues is revealing type of behaviour of the employee, one does not consider type of the person, and directing this behavior to a channel of increasing productivity of this or that worker.

In our opinion, the result of work of the employee in the organization is determined by behavior and does not depend on the person. There is an opinion that it is exactly the type of the person that predetermines success and productivity of the worker. While hiring the person they use the test for personal qualities check in which basis there lies the assumption that that answers to questions will predict behavior of the worker in the course of performance of works. As a result of work of a test complex it is possible to predict approximate indicators of work of the person and to make the forecast of its further development. In the course of research the number of tests of executives of higher and middle rank have been carried out with the purpose to define the type of personality. It should be noted that companies taking part in the researches are distinguished by the stable indicators of successful development during the number of years. Result – four executives with different type of personality and personal qualities, but all of them achieved good results in their work and work of their companies. How to explain it? One of executives – timid, quiet, not showing character. Another – the bright leader possessing charismatic lines etc. In work of any company we are interested its productivity first of all, i.e. indicators of work of the company. Thus, it is possible to summarize, that productivity is not a consequence and work of personal qualities.

The basic difference between the person and behaviour is that the traits of character in greater degree are fixed at early age and subsequently change a little. Giving due to the fact, that in a current reality our world changes and develops very quickly, what means that the work also should not be static and invariable, otherwise consequences will not keep themselves waiting long. On the basis of the researches done in the different countries, it is possible to draw a conclusion that personal qualities of the person are formed up to three-year age and do not change after that.

Human will be human, he can't change his traits of character, but he can change his activity. The main factor influencing and predetermining the labor productivity is behavior. The employees classification on basis of the type of personality is of great interest due to the fact that instead of research of big number of behavioral characteristics it is possible to limit oneself to its small set.

The term «personality» speaks about the set of traits of character. One can describe the personality with words opened, easily adapting, inquisitive, flexible, dominating, timid etc. These words give the description of the person and show, how it is perceived by the outside people. But these general traits not always can predict behavior of the worker in this or that situation. When different employees face the same problem on work, their reaction is far from being unequivocal.

Many personnel department managers consider the use of various tests justified. Supporters of personality tests believe, that thanks to them people start to think about their behavior, about behavior of other people and as a result – efficiency of their work raises. On the other hand, various researches in this area have shown, that less than 20 % of persons are inclined to analyze their behavior and extrapolation on their own work efficiency. The basic motive in behavior of the person on a workplace, is the working situation into which he gets, and it is also important, that to the extent the situation changes, the behavior of the person changes as well.

Nobody strives for defeat when it is possible to achieve success. The employees change their behavior depending on the working situation which they face showing traits of character of various personality types simultaneously. Description of personality types is, to our mind psychological projection. Traits of character can not predict the labor efficiency as people adapt themselves to various situations much quicker than it is prescribed by types of personality. Personality tests cannot predict how a person will act in this or that working situation and don't do it. The key factor here is the behavior on the working place.

The employee behavior depends on the requirements, job description, the work itself. In our study we have asked employees of various companies several questions about what influences the work results most, especially at two last jobs. As the result – the answers differed, what proves the opinion, that despite of one and the same of type of personality, the problems were solved differently. In the process of the working situation solution we each time adapt ourselves to new situation and adapt our behavior to this or that situation.

The understanding of own personality gives a choice of that behavior at which one feels himself most at ease. The person shows, how he will behave, with other things being equal, that is if there were no requirements to an exact working

situation. Classification of types of personality gives the workers the justification not to adapt the behavior to a changing situation. While finding-out the reasons, preventing the employee to carry out the job task, he can tell, that he is not able to carry out exact operations, as it is noted in his resume. But, if his life depends on the performance of exact operation, no doubt, that he will do it accurately and in short term. If the worker constantly avoids the work he doesn't like, but which is necessary for the company, he will hardly learn to carry it out. On the other hand, if he likes to do something, he will do it more and more. This process is called practice, and practice is known to raise productivity and efficiency of work. One of the tasks of personnel department management, is to explain the worker that he should in any case do the work he dislikes because his skill and promotion depend on it.

Efficiency of actions of the worker depends on a working situation. Efficiency in work is result of performance of the necessary work during necessary time limits. The most difficult here is to define what is "necessary" in this or that situation. The multitude of books on management give hundreds of advices, but from experience it is possible to conclude, that there is no simple list of types of behavior which would be useful for successful executives and workers in their work. The ways leading to success are different. Studying of personal qualities of effective workers has not revealed correlation between any certain set of traits of character and success achievement. The principal cause is a variability of working situations. Attempt to define the list of models of the behavior leading to successful work faces hundreds the factors distinguishing one work from the other. To make work or to play a working role means performance of certain functions. All kinds of works have the certain behavioral requirements necessary for its effective performance. Each kind of activity has the set of these requirements. Behavior models differ one from the other, therefore for effective and successful performance of work it is necessary to have accurate idea of the behavior leading to increase of productivity, not to its decrease.

It is possible to present figuratively zones of behavior and requirements to a working situation as two areas. The more these areas overlap, the more we can speak about the productivity. Thus, productivity can change from low to high levels what directly depends on behavior of the employee and requirements to work. The productivity increase involves the behavior revision at the present moment and determination of what and how should be changed in the work for to meet the work requirements. The employees who can get adapted to new job or to functions change of the current job are doomed to low productivity. It is possible to confirm it with that fact, that if the enterprise will not follow in step with development of the segment of the market, will not introduce an innovation in work, it will shortly experience the crash.

But how to make the worker change his behavior as to increase productivity of his work? The decision to change behavior in itself results either from aspiration to an ideal, or in a critical situation. The employee himself will never change behavior if he is not forced to do it by circumstances. Some changes in behavior can be casual, but in most cases they result from that model when behavior change is welcomed by a management or on the contrary, is punished. It is possible to say that the behavior is modified by the consequences which the worker feels.

Any change of behavior leads to productivity increase. Employees will not change something, that leads to decrease of productivity. Here it is possible to divide concept of increase in productivity in sharp and continuous one. The first kind has radical character and is connected with the big level of the losses, the second is constant and protects the organization from any threats. The sense of continuous increase of productivity consists not in sharp lifting of indicators at first, and then in their recession, it consists in continuous increase of indicators of work. Productivity increase is focused directly on the employee, on what he can make and change, and also on what is in a range of his control.

Productivity increase is based on that fact, that the employee knows, what he does at the present moment. The main issue consists in the fact that the management does not know what workers do in workplaces, but they know exactly, what they expect as result. It results from the fact, that the management wishes to see result, but is not involved in process. But, according to the rank, the management gives advice and instructions what and how to do, as a result – dissatisfaction the worker and result. Instead of understanding work, the management often projects the feelings, desires and experience, without any adaptation to concrete conditions. A problem is that all works are different and also have different character of execution.

One of the key points in change of behavior of the worker is creation of such situation and conditions where the worker himself becomes the initiator of changes. If employees are trusted such changes upon one may fail to reach success. All of them come to work with their thoughts, vision and possible development of a working situation and try to do what meets their desires but not desires of company management. The task of the personnel department, a management consists exactly in estimation of situation and its modeling. There are two types of "relation" to workers – to consider their opinion or to ignore it. In the first case we see a picture when all changes are imposed from above without due adaptation to working process and as result – the blocking of changes leading to decrease of productivity. In the second – the management expects offers from workers, realizing, that nobody but them, knows better how to organize work. As a result it is possible to observe continuous increase of productivity.

For productivity increase one must focus on employees activity, their behavior kinds. We speak not about the various styles of behavior but about specific things they do and decisions they make. One of the problems of style notion – the leader's, management, behavior style – is that the styles description looks like personality types description. If one gives the leader's style description closer consideration, he can see that it is the traits of personality but not the behavior style consideration. For example, "orientation at people" describes attitude, but what attitude must be shown to see this orientation? For to see the changes one must be able to measure the behavior. Otherwise if you give the worker the task to change anything in his work, for example to become

more friendly to the customers, you won't be able to control the fulfillment of this task.

For to change behavior of employees a management should have the accurately formulated aim and criteria of behavior at present moment on which it is possible to build strategy of increase of productivity. They should have the detailed card of behavior which will serve as a manual for behavior change in such a way as to stimulate the increase of productivity .

The productivity is the result of usage of combination of some types of behavior of the executive aimed at productivity support and its acceleration. Both behavior types may manifest themselves in different ways. The main ways of their activity are concentration on action, person or system and their combination as well.

The behavior oriented at the action is characterized by initiative, personal example, inspiration and installation of feeling of interest, outlining of specific goals and problems, monitoring of productivity against objects in view, attention to details, timely performance of the schedule of works. The behavior focused on the person, is characterised by distribution of duties and the accountability, creation of teams, the organisation of training and personal development, help and support provision. The behaviour directed on system, is characterised by coordination activity, integration of productivity and results, long-term planning, creation of conditions for work of systems for productivity, rather than against it, the analysis and an estimation. No one of these types of behavior is not more effective, than others; all depends on a situation.

The behavior directed on action, person or system, differs depending on an object in view: to accelerate productivity or to support it. The behavior focused on action, necessary for acceleration, includes initiative display, a personal example, enthusiasm and energy creation. If it is necessary to support productivity, the behavior includes accurate statement of a problem, the coordination of the purposes and fidelity to them, monitoring of productivity against objects in view, attention to details.

The behavior focused on the person necessary for acceleration, includes distribution of duties, trust creation, creation of strong mutual relations in a team, creation of fidelity to the purposes and interests of the organization. If it is necessary to support productivity, the behavior includes creation of culture of the help, support, loyalty and feeling of "family" in work, and also maintenance of the worthy relation to people.

The behavior focused on system necessary for acceleration, includes creation of effective structure and an infrastructure, reception from systems, processes and procedures of additional profit, coordination of activity of separate people and groups, integration of results of various teams, departments and divisions, maintenance of long-term strategic thinking. If it is necessary to support productivity, the behavior includes maintenance of a continuity of process, predictability, rationality and stability. It also includes creation of frameworks in which limits the organization works: a communication network, productions, financial systems and monitoring systems, definition of works and roles, compensatory systems, procedures of purchase, distribution system etc.

Some actions are known to accelerate productivity, others support it and there is a third type – it gives negative consequences and reduces productivity. This behavior hinders changes, destroys vision and impedes achievement of objects in view and problems. Such behavior is called blocking productivity.

The blocking behavior impedes changes, undermines vision and hinders achievement of the purposes and problems. We are witnesses that people often do it, we are subject to it ourselves, but one speaks about such behavior in principle and does focus on it. However results can be destructive for productivity. One of results is when employees "give up work".

The reason of blocking behavior are the external reasons and influences. This point is not connected with the person. It appears as a result of frustration, uncertainty, uneasiness, threat, humiliation, the power or control lack. The most negative aspect of blocking behavior is not that the group of people in the organization wastes time and efforts in vain, performing unproductive or counterproductive work, but the negative influence, which such behavior has on others. The blocking behavior is extremely infectious.

The blocking behavior almost always correlates with feeling of loss or a power and control lack. The behavior which result in people feeling humiliated, unnecessary, undemanded, causes the reaction sharply distracting attention and energy from efficiency and creation. The fear, uncertainty and frustration are negative motivating factors.

If you want to lessen the blocking behavior of the employees, the best way is to listen to opinion of the people of personnel department which diagnosed such behavior by means of diagnostic behavior questionnaire. If you want to change behavior and to raise labor productivity, find some time and effortsfor it. You cannot change behavior of employees and own one, until you don't know precisely, what are you doing at the moment. And you will not change the behavior, until you recognize and understand what you do.

The reasons of blocking behavior may be external, but treatment for them – internal. You should do something with it. It's you who should understand what makes your behavior blocking and try to cope with the reason. To get rid of the reason is much more effective, than to treat symptoms. One can understand the manifestation of blocking behavior; but to continue it after you have understood, what is happening is inexcusable.

The behavior blocking productivity is reaction to this or that threat. In working conditions it can be threat to a self-estimation of the worker, competence, knowledge and abilities, reputation etc. Reaction is connected with some loss, and this reaction is shown by struggle, leaving or submission. If in the behavior connected with acceleration and maintenance of productivity the person has insignificant influence, in definition of types of blocking behavior the person plays a considerable role, especially if it is subject to threat.

The protectively-aggressive behavior is observed basically as reaction to an encroachment to a self-estimation. Consequences of protectively-aggressive behavior are long term and also are able to cause serious consequences. The protectively-aggressive behavior is often the displaced aggression. It also can be reaction to pressure from above, made for productivity increase, and on inadequate

productivity from below or as result of the high standard which others cannot reach. However whatever was the reason of frustration, rage or irritation manifestation but reduces the productivity. Like spoilt children, the employees persistently showing defensive-aggressive behavior, know, that they will not be punished for bad behavior. They constantly do it because they understand, that nobody will rise and oppose them, will not tell, how their behavior is perceived by others and what results will be.

The main reason for avoiding the conflict behavior is the understanding of a conflict situation as advantageous or losing with expectation of high probability to lose in it. This type of behavior is focused on how to avoid contradictions, risk, not to cause negative opinion of associates, not to express the people negative opinion on their work, not to act with constructive criticism and, in general, to try to direct the agreement to those points of view and decisions which others have adopted, whether they real or not. The people working with colleagues and manifesting such behavior may face very big problems. They will not hear the real decision; will not hear fair opinion; will not receive an adequate feedback, as they are. They just do not know, where they are, and as result of it they are afraid, upset and often angry. And thus leads to the further waste of efforts.

The main reason of the behavior showing itself in avoidance from responsibility is the fear of criticism or punishment for the mistake made. The organisations punishing for mistakes, have a disproportionate high percent of people which show the behavior connected with avoiding the responsibility. The behavior connected with avoiding responsibility, is reaction to stress, threat, uncertainty and frustration. It holds the person away from a source of discomfort. The behavior connected with avoiding responsibility, is manifested in shrinking to own shell, decrease in participation in the disputes, obvious loss of interest. The people with experience of such behavior, learn to be unnoticeable, sometimes to extreme degree. This is the behavior of a chameleon which merges with a background and flees from potential risk. Such behavior mainly is reflection of management where not enough respect is shown to people or of irresolute and easily changing the positions management which criticizes and punishes for mistakes, in other words of just bad management.

The blocking behavior costs very much. The energy spent for blocking behavior, is the energy which could be directed at increase of productivity or its support. Due to its infectious nature the blocking behavior creates waves of the further such behavior which spreads on the whole organisation.

Any discussion about continuous increase of productivity should concern a motivation question. The main principle of change of behavior consists in the fact that people change because they want it, but not because someone wants it from them. The question, of course, is why do they want changes?

There are many wrong ideas concerning motivation. For example that motivation is the trait of character it either exists or not. The main thing that creates motivation is the money. Or that people get motivation from the event that excites them. Certainly all depends on him who passes this important for them message.

The motivation is a desire to direct the energy on purpose achievement. The higher the motivation is, the more energy you are ready to spend. The motivation is not trait of character. It is characteristic for everyone. It is difficult to understand motivation of the person as performance of one and the same action can have different motives. When we say, that someone does not have motivation, we mean, that they do not have motives to do what we consider, they should do. The logic and motivation have very weak link. More often, than it seems to us, the motivation to actions is based on emotions, instead of the logic. The falsity of idea that the logic argument can create motives to actions, is based on the assumption, that process of thinking is the same in everybody and if we consider something as logic the others also do it.

As for external stimulus, such as the salary, the award, privileges (or even negative stimulus as threats), the great number of researches testifies that they have a small influence on efforts or productivity or do not have it at all. The motivation is rather inward state, than what one person does for another. People have a motivation to do something when they want it and when they want it, they will do all without the help. The motivation can appear and disappear. There are days, when we are extremely motivated on actions, and days when we would like to have a rest. The motivation is based upon what we are, what we wish to be, what we need and what pleasure do we get from work, therefore it depends on the person and the purpose.

Payment and reward from the outside are sufficient to convince the person to spend time in the organization, but they are not enough to convince them to give all for achievement of the purposes of the company. The motivation proceeds from such factors, as a challenge, an achievement recognition, feeling of importance and possibility to make the significant contribution. Payments and privileges only compensate time outlay; they generate neither initiatives, nor movement forward.

There is a strong link between motivation and behavior. We do something when it gives us pleasure or is well paid, and we stop something to do or we avoid it, when there is no payment when it is not pleasant for us or it is unpleasant. We think that something that gives us the pleasure and payment, is motivating, and we do it in great volume. Therefore if you look at dominating, repeating behavior, you can draw a conclusion, that it is exactly what motivates people to activity. The more from this we integrate into work, the more motivation it will bring.

There are many researches proving, what managers expect from subordinates, and how managers project these expectations, what is reflected in behavior and productivity.

Motivational dynamics of expectations includes a self-estimation, feeling of achievement and other moral compensations. As people react sensitively enough to expectations, it is very important, that those who write and speak about them, themselves believe in them. We inform people more often about bad expectations, than about good, and they don't like it much. And we also do not understand that those expectations which to us seem unreasonable, will not be motivating, they will rather make reverse effect, effect of blocking behavior.

Behavior change helps to determine what motivates workers and executives. The first question which rises is "What are you doing at present to cope with work?" In motivation terms the following question: whether "Do you like what you do, and does it give to you pleasure?" If it not so, obviously you have no motives for it. The third question "What should you do to be more effective on work?" raises the mainproblem, whether your present work is motivating for you. If what you should do, still does not bring to you pleasure and does not give you compensation, then find such work which will give it to you.

At the modern stage of personnel department development diagnostics and management of the organization staff behavior. The more thorough and full is the diagnostics of behavior and exact measures taken together with the organization management aimed at staff labor productivity support and increase the quicker will the organization reach the success in achieving the purposes in view.

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THE ANALYSIS OF THE MAIN DIRECTIONS OF THE FOREIGN TRADE COOPERATION OF KRASNOYARSK REGION WITH CHINA

The tendencies of the foreign trade cooperation between Krasnoyarsk region and China in the system of market economy are considered. The offers for the foreign trade cooperation with purpose to increase the efficiency of two side advantageous relations are resulted.

Keywords: foreign trade, cooperation.

The urgency of the given work is defined by variety of forms of the foreign trade cooperation and foreign trade activities between Russia and China, an imperative need of their deep analysis and working out of a new approaches to trade expansion in the system of market relations. The object of the work is a foreign trade of Krasnoyarsk region and China. The practical importance of the work is defined by the analysis of the already existing directions of the foreign trade cooperation of Krasnoyarsk region with China and the offer of new potential ways of foreign trade cooperation of Krasnoyarsk region with China with purpose to increase the efficiency of bilateral advantageous cooperation.

According to the indicators of goods turnover throughout a number of years China is included into the five of the basic trading partners of Krasnoyarsk region.

The favorable geographical position, the developed transporting network, an availability of the customs coordination caused by close frontier position of the given territories, is the reason for active business cooperation between Krasnoyarsk region and the Chinese provinces.

It is possible to express schematically the basic directions of the foreign trade relations of Krasnoyarsk region and the Peoples Republic of China (fig. 1):

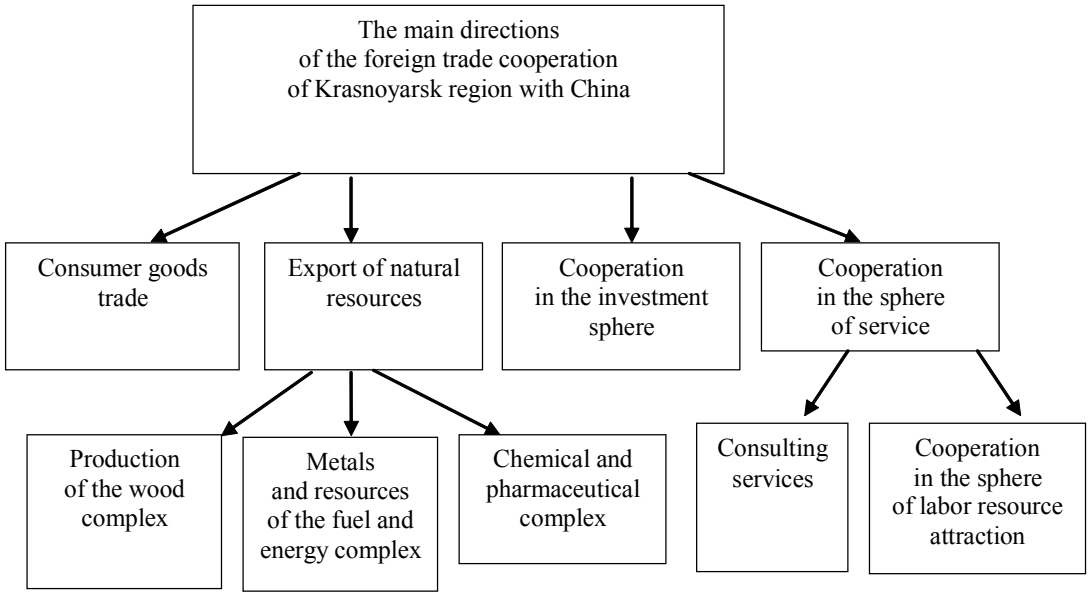

Fig. 1. The main directions of the foreign trade cooperation of Krasnoyarsk region with China

Analyzing already existing tendencies of cooperation of Krasnoyarsk region with China it is possible to note the most successful and perspective directions of bilateral relations based on advantageous cooperation of Krasnoyarsk region with China in the sphere of the foreign trade (fig. 2).

Cooperation in innovative sphere. For last years there were an objective economic preconditions for successful development of science in Siberia which could become one of the most perspective spheres of cooperation with China. "The Siberian scientists carried out many research works which at corresponding investments could become an investment product" [1]. "Our technologies are cheaper then American and European, and, of course, Chinese are very interested in their purchase" (URL: http://www.recipe.ru).

So, in particular, in Krasnoyarsk, on the basis of SIFTI and scientific – technological centre "Magnitogidrodinamika", on the base of recently created Siberian Federal University and other research centers, such as FSUO CBC "Geophysics", nowadays exist many unique innovative research works. Experts of scientific – technological centre "Magnitogidrodinamika", for example, have developed the innovative project on manufacturing of high-quality alloys from nonferrous metal, SIFTI has developed such innovative technology, as foam glass, being absolutely inert material is suffers no influence by time. Besides it, foam glass is remarkable by its manufacture recycling of beaten glass. And such unique projects are a lot.

"However our weak point is marketing. We do not know what and in what volume it is necessary for China" – said the president of Tehnoconsult group company Sergey Simaranov (URL: http://www.recipe.ru). While there is no legal and contractual base, it is too early to speak about any research cooperation with foreign countries. Besides, absence of coordination between the customer and the executor does not allow starting realization of this cooperation.

For realization of cooperation in the innovative sphere the administration of Krasnoyarsk region should decide what is possible to produce and what is not. Besides, it is necessary to separate innovative sphere from scientific cooperation. And create a network of partners in China which would help in realization of this project. Cooperation between partners from Krasnoyarsk region and China in the field of science, "…joint commercialization of innovative production and its advancement on the markets of China, creation of joint ventures for realization of concrete innovative projects would allow the domestic enterprises to realize the scientific and technical potential and to receive a real return from means, enclosed in creation of high technology production; to make use of experience of China in the sphere of commercialization of the high technological production and its resources for industrial introduction of the researches and master the specific market of China" (URL: http://www.sbras.nsc.ru/np/vyp2004/pr02.htm).

Export of natural resources. The second important aspect of cooperation touches upon the export of natural

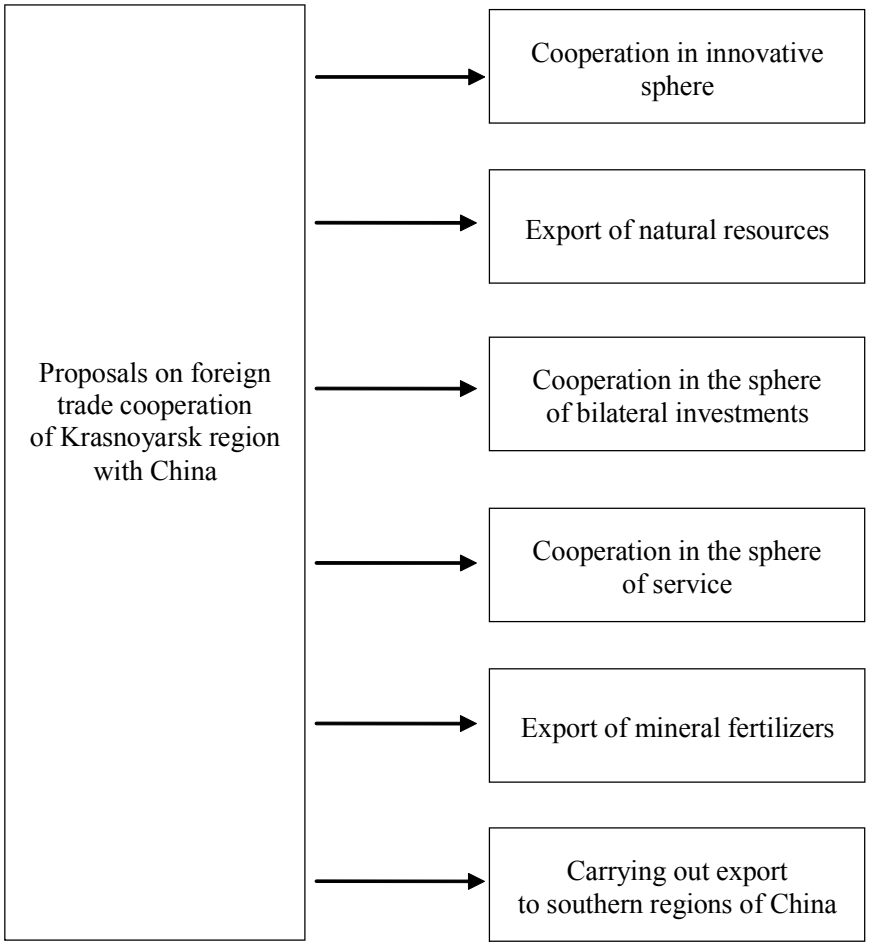

Fig. 2. Proposals on the foreign trade cooperation of Krasnoyarsk region with China

resources. Vicinities of the Yenisey River are rich in natural resources. Among them – gold and platinum, coal, iron ore, nickel and bauxite are much presented here. A lot of new oil fields and gas are also opened. "A deposit of Krasnoyarsk region is five times more than deposits in Khanty-Mansiysk and Tyumen regions" (URL: http://www.inopressa.ru/faz/2007/03/12/15:12:14/aluminium).

Analyzing the abovementioned, it is possible to draw conclusions that, firstly, export of natural resources to China will bring considerable income to treasury, secondly, will allow to solve important for a national economy a problem of a diversification of export of natural resources. For maintenance of export delivery of natural resources a hi-tech infrastructure of oil- and gas pipelines, corresponding electric mains which could be in the long term built and constructed by means of the investments involved from China are necessary.

Cooperation in the sphere of bilateral investment. Investment appeal of domestic enterprises depends on the strategy chosen by each company. Today foreign investors are ready to divide risk with existing proprietors of the enterprises and to get shares of those companies which possess high potential of the growth, clear strategy of development and the management, capable to realize this strategy. A real obstacle in a way of investments into the domestic industry is not so much deficiency of the capital, but a lack of the investment attractive offers corresponding to requirements of professional investors. The objective and complex information on investment appeal of the enterprises is necessary for potential investors and other participants of investment process.

Activization of investments into the industrial activity, occurs by means of creation of joint ventures. So, in 2006 the delegation from Shanghai came to Krasnoyarsk to carry out negotiations with the Joint Stock Company "Krasnoyarsklesomaterialy" on a theme of creation of joint venture and both side investments for building of capacities for manufacturing of saw bar plates. Till now – the cooperation is at a project stage.

To sum up it necessary to repeat that the Chinese investments can be involved in building hi-tech infrastructure of oil and gas pipelines, electric mains, for maintenance of deliveries of export of natural resources on the territory of the Peoples Republic of China, and also used for creation of joint ventures in the field of deep processing of resources.

Considering the sphere of investment cooperation from outside China, it is also necessary to note deep interest in realization of the given kind of activity. Last years the financial market of China has had new active development. On March, 19th, 2007 the National bank of China has published «the report on the international financial market of 2007" in which "…the features characterizing financial development of the financial market of China during this period was marked:

– activization of the further building of an infrastructure of the financial market (in the country the interbank monetary market, a bond market, bill fair, share the market and the insurance market operations);

– increase the efficiency and safety of the Chinese financial market;

– reform deepening in financial branch of China, increase in quantity of financial products, diversifications of forms of transactions;

– continuous increase of level of openness of the financial market to an external world, strengthening of communications between the domestic and world financial market by expansion of a share of participation of foreign investors in the Chinese financial market, and is mutual-active participation of the Chinese investors in the world financial market;

– expansion of scales of the financial market (during the period January – September, 2007 in the interbank monetary market of China the volume of transactions has made 6 368,45 billion yuan, with a gain for 364,4 percent)" (URL: http://www.chinadata.khv.ru/scit_ma.htm).

As far as China is quickly integrated into economic and a financial system, stability in its own financial sector becomes extremely important for economic.

The management of China rigidly supervises outflow of the capital from the country, however now in the conditions of an abundance of the capital in the country and credit crisis in the markets which are the basic consumers of the Chinese export, the decision on plentiful foreign investments from outside China sees the most reasonable.

Cooperation in the sphere of services. Cooperation in the sphere of services could become another direction of bilateral cooperation.

A. The recreational potential of Krasnoyarsk region is great. Natural recreational resources (the seas, the lake and rivers, mineral waters, picturesque landscapes) are various. Many territories practically are not damaged by a civilization – demand for such territories all over the world constantly grows. Appeal of Krasnoyarsk region as an object of tourism is defined, first of all, by following factors: the historical and cultural development of region which inseparably linked with history and culture of all Russia; a geographical position, allowing making our territory a starting point of tourist routes across Siberia and the Far East. Besides, in our region many international events and competitions on various kinds of sports are regularly held.

The most perspective cities are: Krasnoyarsk, Divnogorsk, Minusinsk, Yeniseisk, Shushensky and Ermakovsky areas. The tourist program should include such projects, as: "Krasnoyarsk – the centre of tourism of Siberia", "the Sayan ring", "Yeniseysk – the spiritual capital of Siberia". Creation of the mountain-skiing centre in "Bobrovij log", development of ecological tourism on the basis of reserve "Stolby" are planned. In the conditions of a frequent technogenic accidents in China, the given sort of cooperation sees logical, the offered tourist programs – unique. The given sort of cooperation will promote formation of the tourist industry and development of all infrastructure of Krasnoyarsk region.

B. Transport services. The favorable geographical position of Krasnoyarsk region and presence of three transport corridors give possibility of rationalization of world transport interrelations. In meridian direction the territory of Siberia is crossed by the navigable river Yenisey, in width – the Trans-Siberian railway. The big prospects are connected with use of the HUB and development of cross-polar aviation routes which can give high economic benefit.

C. Attraction of experts and manufacturers from the Peoples Republic of China, instead of dealers.

In connection with the high rates of increase of volumes of building projects, realization of grandiose projects, such

as completion of Boguchansky Hydro-electric power station, building of aluminum factory, pulp-and-paper industrial complex, and development of the Vankorsky deposit a problem of a labor shortage has appeared. Insufficiency of labor defines by conditions and seasonal prevalence of carried out works. "Among the declared vacancies, 23 % are necessary on building branch. And from among the people registered in the Center of employment – 75 % the woman. A lack of labor of Krasnoyarsk region is possible to solve by attraction of citizens of Uzbekistan, Tajikistan, Kirghizia, Armenia, Korea, Turkey and China" (URL: http://www.newslab.ru/news/187107).

Cooperation in the given sphere is favorable to both parties, because the territory of Krasnoyarsk region has a high requirement for attraction of foreign manpower, and for the China, overpopulated and possessing a problem of workplaces and low wages the given kind of cooperation also has attractive character.

However, involving Chinese citizens for realization of projects, it is considered of much importance not to admit compact settlements of the Chinese migrants, giving priorities to their disperse moving. In that case they are could integrate fast into our society, learn the language, norms of behavior and culture.

Export of mineral fertilizers. Insufficiency of China – our benefit. One of the basic consumers of nitric fertilizers is China, having a climate favorable for agriculture. All know that nitrogen – one of the pivotal components of all vegetation on globe. Therefore without application of nitric fertilizers the further progress and agriculture development – one of components of economy of the Peoples Republic of China is impossible. Manufacture of fertilizers in China is a well developed business though the quality of the Chinese fertilizers obviously concedes to the Russian.

"The requirement of China for nitric fertilizers (in recalculation on a carbamide) makes about 48 million tons a year – only for manufacture of a foodstuff of internal consumption, without export" [2].

"Having taken the advantage of insufficiency of China in the field of qualitative mineral fertilizers the Russian enterprise Akron, having two industrial bases in Great Novgorod and the Smolensk region constructed a retail network for sale of fertilizers in the Peoples Republic of China" (URL: http://www.knfmp.ru/press/ss52005.html/).

But demand of the market of mineral fertilizers in China is so great that allows to use this niche as strategic for an exit on the Chinese market.

There is a number of the advantages connected with opening of manufacture of mineral fertilizers in Krasnoyarsk territory. Priority advantage is deposits of raw materials for manufacture of fertilizers, in China there is a lack of kalian and sulfurs – which they have to import from Russia and other countries. The second positive aspect which is standing up for an establishment of the external economic relations between Krasnoyarsk region and China in the field of mineral fertilizers is that in the Krasnoyarsk region, on the basis of Krasnoyarsk factory of nonferrous metals named after V. N. Gulidova catalysts grids are produced, which are necessary for manufacturing mineral fertilizers. There is no similar manufacture in Krasnoyarsk territory.

"Krasnoyarsk's catalysts grids purchase such powerful enterprises, as Nizhniy Novgorod's "Akron" making 25 percent of all nitric fertilizers" (URL: http://www.knfmp.ru/press/ss52005.html/). Close position of two interconnected manufactures will also add a number of competitive advantages.

For this purpose one factory can be located in a suburb of the regional centre (for example, in capacities of "Krastjazhmasha" industrial zone), and another – in Nazarovo, on the basis of the Nazarovsky power station.

Realization of the given project can put forward Krasnoyarsk region to the world's leader on export of nitric fertilizers.

Carrying out export to southern regions of China. In China there are special free economic zones operate. Their activity is directed on liberalization and activization of the foreign trade activities. Their economy has high degree of openness to an external world, and customs, tax and investment modes are favorable for realization of internal and external investments.

Many enterprises in search for concessionary terms consider these zones as a potential source of possibility to receive an extra profit.

In China "…the following administrative economic formations with preferential modes operate:

– 5 special economic zones: Shenren, Chzhuhaj, Shantou, Sjamen, Hainan, and also new area Pudun (Shanghai);

– 32 zones of economic and technological development in Beijing, Shanghai, Guangzhou, Tianjin, Dalian, Harbin, Urumchi, Wuhan, Chungking, Hangchow, Shenjan, Changchun, Yingkow and other big cities;

– 15 zones of free trade in Shanghai, Tianjin, Dalian, Guangzhou, Ningbo, Chzhantszjagan, Haikou, Sjamen, Fuzhou, Tsingtao, Shantou, Chzhuhaj and Shenchzhen;

– 14 zones of frontier economic cooperation in Dandun, Hejhe, Sujfenhe (Heilongjiang province), Manchzhouli, Erljan, Huejchun (Jilin province), Inin, Bole, Tachen, Pinsjan, Dunsin, Zhujli, Vantin, Hekou (Yunnan province) (URL: http://www.nalogi.net/1997/199708_2.htm).

As it was mentioned above, prospects of cooperation of China and Krasnoyarsk region are mutual, such as: innovations, investments, export of goods of deep processing, import of the qualitative goods and many other things. Speaking about one of components of bilateral cooperation – export – it is important to underline the possibility for export of goods of deep processing and, secondly, for export of goods from Krasnoyarsk region to the south of China, instead of the north, as it is now. It will allow Krasnoyarsk exporters to trade on equal terms and for competitive prices, receiving privileges from realization the trading activity on special economic territories, instead of dumping the goods on border for the low price established by Chinese.

For this purpose, Chamber of commerce of the Russian Federation has the representative for rendering assistance in search of business partners, in particular, in Shanghai where the representation of the Chamber of commerce of the Russian Federation is located.

In the conclusion it is important to notice once again that the important problem of Krasnoyarsk region is optimization of the foreign trade and economic relations with China with

the advantage for economic development of Krasnoyarsk region, expansion of trade and economic relations not only in the sphere of raw materials, but also in the field of industry, tourism, formation, investment and innovative sphere.

Researches and conclusions of the given work are lead to the concrete recommendations about the increase of efficiency of the foreign trade activity, the analysis of new potential ways of the foreign trade cooperation between Krasnoyarsk region and China, and give possibility of application of its positions in activity of the Chinese and Russian foreign trade enterprises.

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PROCESS PROGRAMM REALIZATION OF THE CAPITAL REPRODUCTION FUNDS

Program realization of simulated model of capital stock reproduction in PowerSim Studio is described in this article.

Keywords: reproduction, simulated model, capital reproduction funds.

Wide development of automation of management depends on constantly increasing complexity and multiple-factor problems of reproduction management of a fixed assets at different levels of an economic management, necessity of processing thereupon huge weight of the information at high accuracy, labor-output ratio, tight timetables of carried out calculations and recurrence of their carrying out.

Now at the machine-building industry enterprises ERP-class automatic control system, and a variety of the dedicated systems created specially for management by separate processes (MES, SCP, EAM etc.) are used. The ERP-system carries out the central role, consolidating data on all activity of the company, the system is responsible for the finance, logistics, relations with suppliers and clients, human resource management, granting of the consolidated statements on key parametres of activity of the company to leading managers. The ERP-system integrates specialized decisions – MES carries out an operational administration manufacture, SCP is engaged in planning and optimization of a chain of deliveries and manufactures, EAM operates a fixed assets.

However there is a number of processes which cannot be automated by means of traditional decision-making systems (ERP-class). ERP systems don't allow to consider multi-variant approach of decisions of problems, risks and uncertainty, to carry out scenario planning, to do conclusions about stability of systems, to reveal unevident dependences and time logs between investigated characteristics.

The systems of decision-making support created on the basis of the theory of system dynamics will be successfully applied in this case.

While using the theory of system dynamics company activity is described in the form of mathematical model in which all business problems and process are represented as the system of the interconnected estimated indicators. Possible directions of development different processes in the company allow to reveal and analyze creation of the similar visualised model.

It is possible to estimate profitability of investment projects, to choose priority directions of business development, to analyze influence of external macroeconomic factors on profitability of projects, to estimate influence of risks-effects on results of activity by means of dynamic modeling. Also the theory of system dynamics allows to create imitating models of industrial systems for an estimation of possible consequences of accepted decisions. So it is possible to optimize material, financial and information flows of the company (both on strategic, and on operational levels) to carry out their consolidation on the enterprises and business segments.

Model development begins with the analysis of the enterprise activity. The descriptive model of the enterprise is built under expert opinions, on historical data, under shown requirements of a management and the future users of model. So-called cognitive model reflecting relationships of cause and effect and a set of mathematical dependences between various sizes is created. Simultaneously a lot of already existed at the enterprise formulas, tables etc are actively used.

The consolidated mathematical model which is realized by means of visual programming is built. The estimated model is created at this stage. Model verification is made by means of testing examples, checking of historical data, using of expert tests.

Program realization of process of capital stock reproduction on the basis of a method of system dynamics is considered in the article.

At the first stage the description of the basic reflective contours of relationships of cause and effect arising in the course of capital stock reproduction is given.

Basis of imitating model of the equipment reproduction of the enterprise in the natural form the reflective contour of a feedback "the Equilibration under the influence of a log of decisions realization", allocated with a framework (makes fig. 1). It is interpreted as follows. The size of necessary equipment capacity of the enterprise must

correspond to the production program. At production program change it is necessary to make of the decision on respective alteration and capacity of the equipment. It can be increase in capacity at the expense of acquisition of the new equipment. It is inexpedient to get the equipment at once. It is necessary to wait, as the increase in quantity of the equipment in operation can be possible, the capacity at the expense of being under repair and installation of machine tools is possible either. Such delay is a log of adaptation which allows to adapt fund for changes of the factors defined by the decision-making procedure. The considered decision will affect a current production capacity level of the enterprise not at once, it will affect with the delay in one period of modeling. The executed specification of this contour is presented down below.

Basis of model of capital reproduction funds in the cost form is also the reflective contour of a feedback "the Equilibration under the influence of a log of realization of decisions" (fig. 2). It is described as follows. The size of the monetary fund necessary for replacement and repair of the

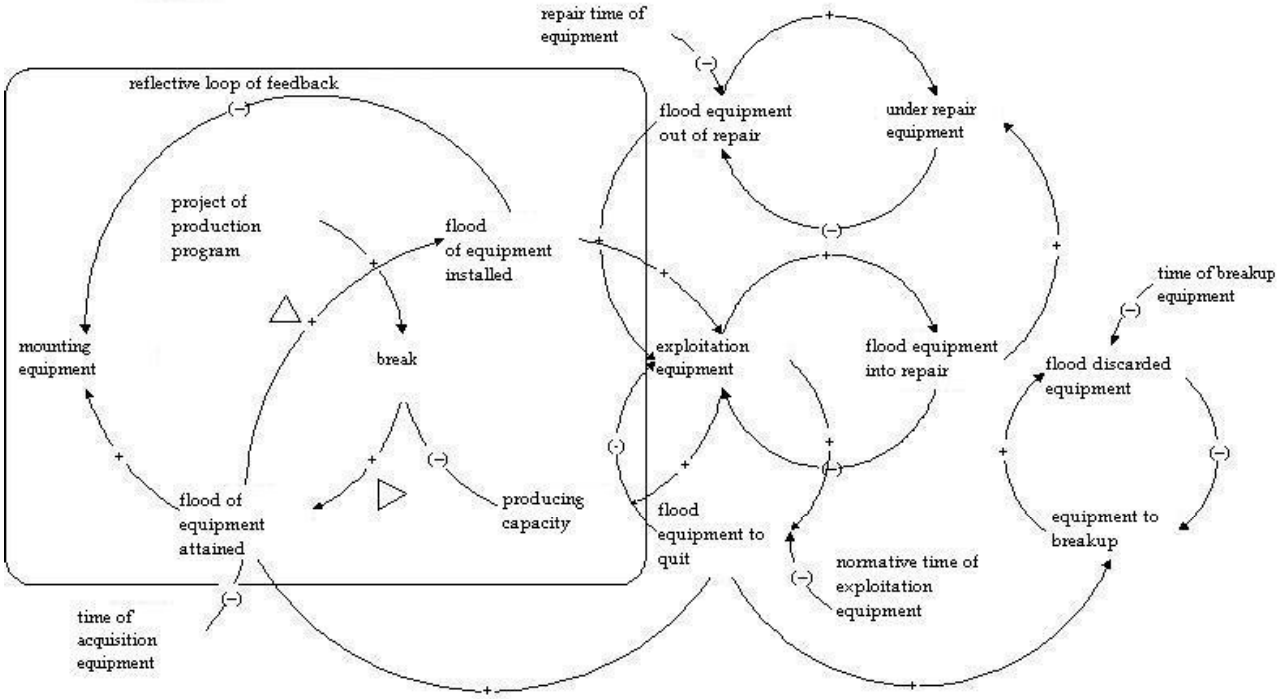

Fig. 1. Ideogram relationships of cause and effect of reproduction in the natural form

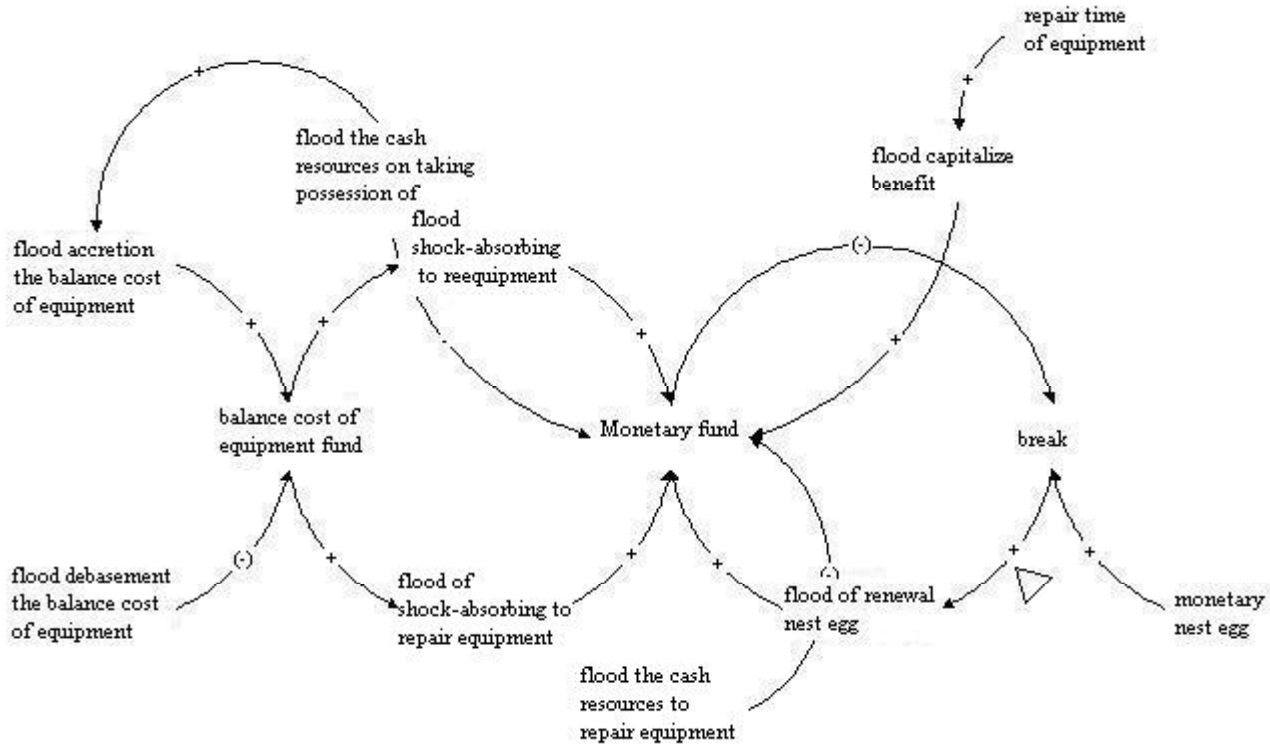

Fig. 2. Ideogram relationships of cause and effect of reproduction of the equipment in the cost form

equipment, must correspond to current and strategic requirements of the enterprise. At insufficient level the monetary fund should replenish as at the expense of internal (amortization, profit etc.), it can also happened at the expense of external (credits, budgetary funds etc.) sources. But it is inexpedient to borrow missing money resources on acquisition of the new equipment or repair of the available at once, as receipt of money resources from internal sources is possible: depreciation charges or deductions from profit. Such delay – an adaptation log – allows to adapt fund for changes of the factors defined by the decision-making procedure. The made decision will affect current level of monetary fund of the enterprise not at once, it will affect with a delay in one period of modeling time.

The contours of a feedback presented above are the cores in model, other contours ensure functioning.

At the second stage program realization of process of capital stock reproduction is carried out.

The most widespread software products used for realization of system dynamics models are PowerSim and Ithink.

PowerSim and Ithink are compact, object-oriented packages of applied programs with the Desk-Top-external interface. They provides graphic, computing and information support to high level system analysis procedures of difficult processes of the organization of management, business, the finance, a policy, etc.

The PowerSim possesses the most developed tools of difficult processes modeling of the organization in comparison with Ithink. Besides, the optimization tool of modeled processes is built in into operational environment of package. As package PowerSim is integrated into widespread system (class ERP) SAP. Therefore the given software product has been chosen for realization of imitating model of management of capital stock reproduction.

The imitating model of the basic production assets reproduction consists of two submodels of co-operating share streams: submodels of reproduction of the basic production assets in the natural form (fig. 3, 4) and submodels of capital stock reproduction in the cost form (fig. 5). The basic is a reproduction submodel in the natural form.

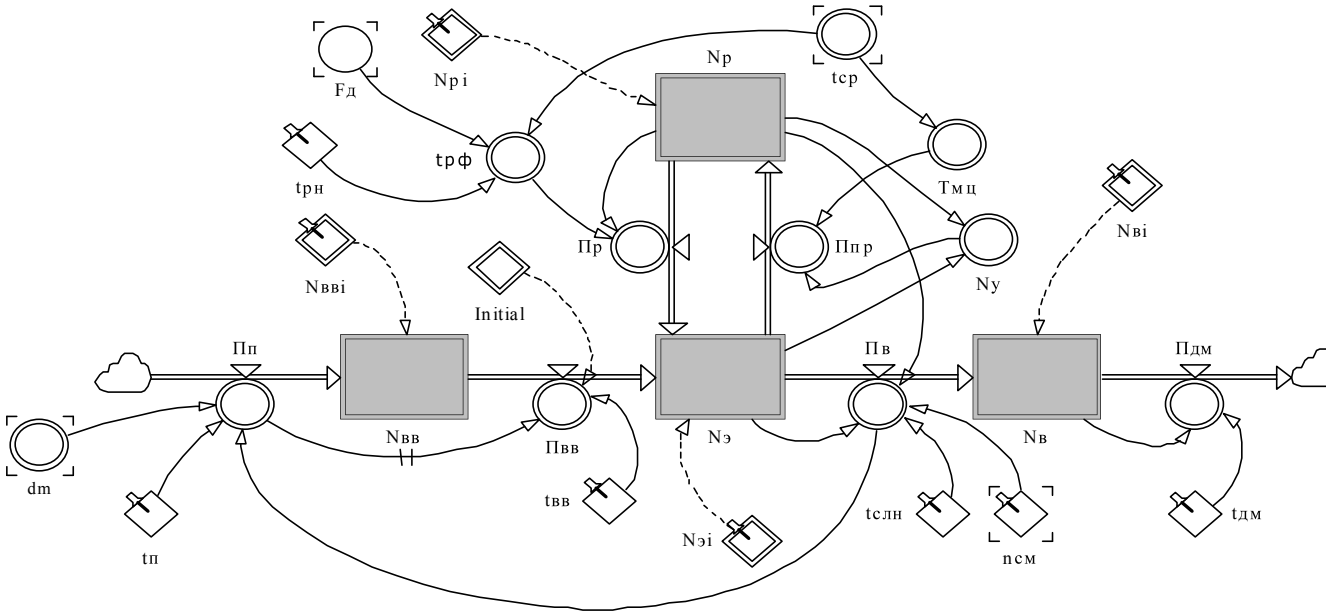

Fig. 3. Ideogram the auxiliary contour, describing stages of reproduction of the equipment in the natural form

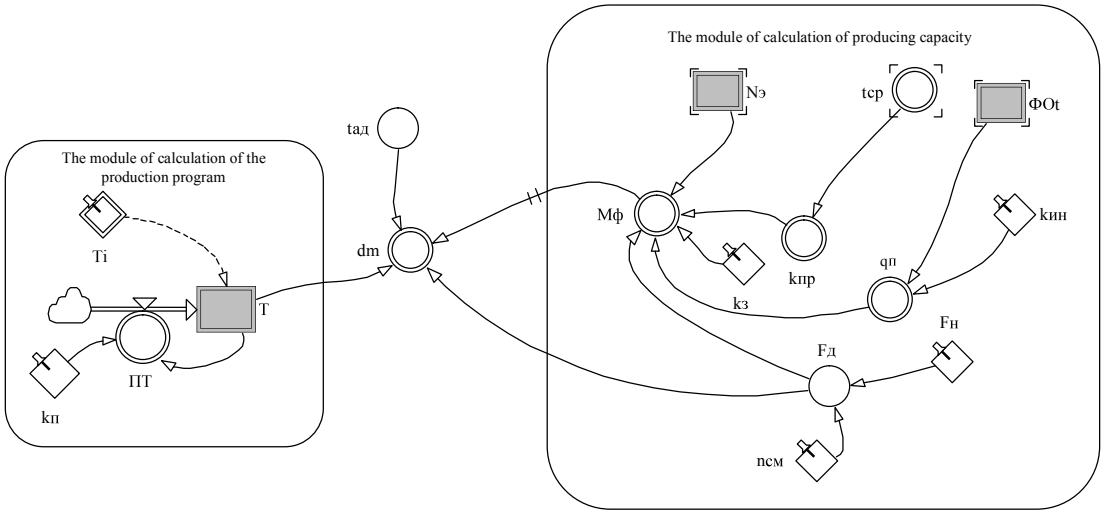

Fig. 4. Ideogram the basic contour of reproduction of the equipment in the natural form

In conclusions the constructed imitating model of reproduction of the equipment is skeletal (base) model. To this model it is possible to add various submodels for calculation of other characteristics or parameters. Functioning of skeleton model of the equipment reproduction of the enterprise will be for these parameters a source of the initial information which can be transformed to any necessary kind. Also it is necessary to notice, that the developed model can be adjusted actually on any type of the enterprise, therefore it is possible to consider it typical.

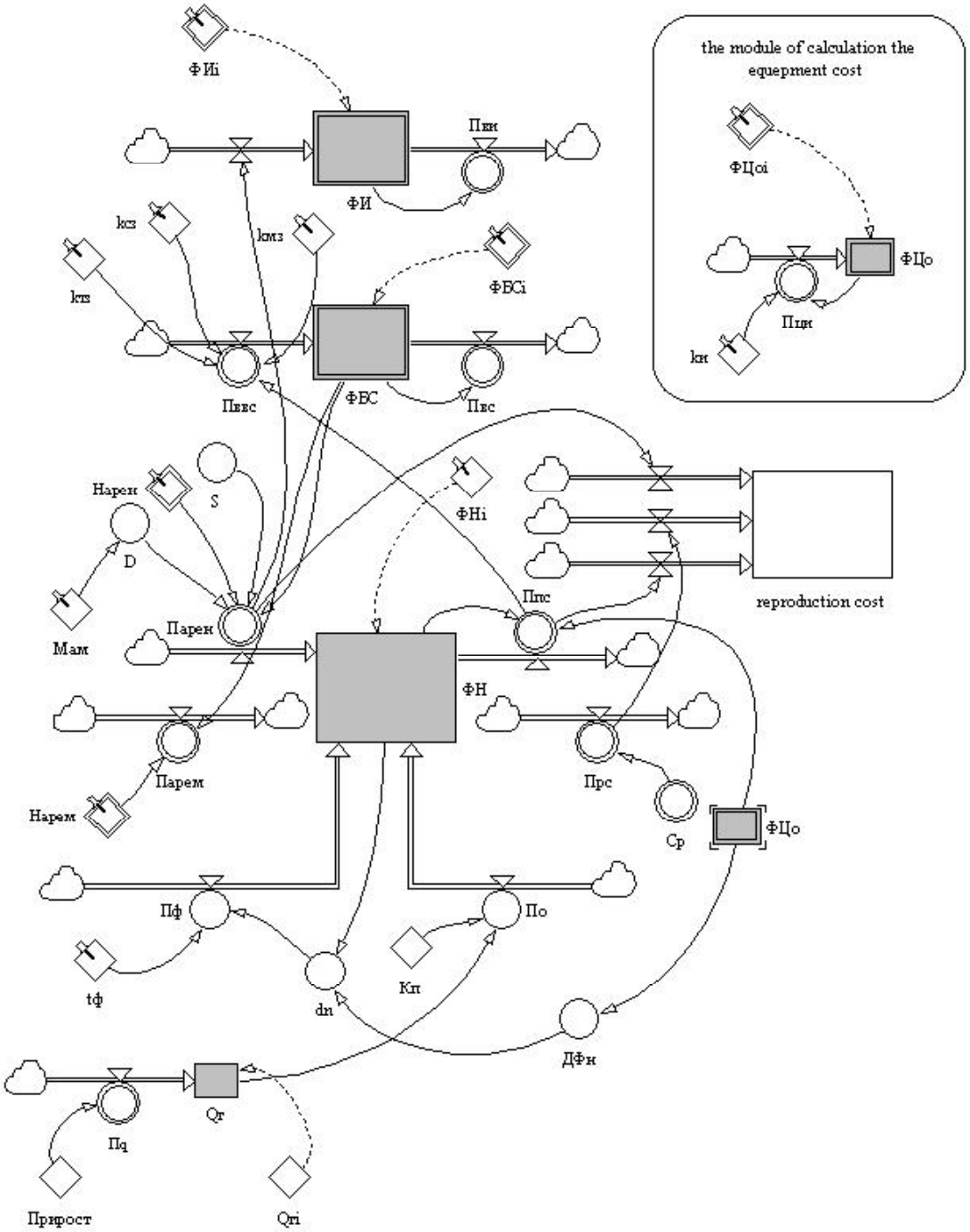

Fig. 5. Ideogram equipment reproduction in the cost form

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TO THE QUESTION ON INNOVATIVE DEVELOPMENT OF THE RUSSIAN ECONOMY

Several conceptions of innovation methodology, formed on the institutional level are being reviewed. Their level of methodological interpretation and the possibility of their use as a base for development of methodological instruments are being analyzed.

Keywords: innovative type of development, national innovative system, innovative socially-directed type of economics development, innovative model of economics growth, model of innovative sociall-directed development.

Russia nowadays is facing a problem of the prompt transition to innovative type of development of economy. Authors of scientific researches generally understand such development of economy, where knowledge and its commercial realization play the main role in the steady growth of the gross domestic product, as the given type of development, where knowledge manufacturing becomes the basic resource of stable economy growth. As the basic competitive advantage of the socio-economic system developing on innovations, allocated is the possibility of its advance modernization on the basis of accumulated or outsourced mental potential.

Realization of transition to innovative type of economy development demands deep understanding of innovative development processes, well-grounded methodological and methodical base. In this respect the great interest of modern researchers to innovative subjects becomes clear.

While disputing and forecasting on the given topic in the field of modern economics a number of widely used terms of innovation field were generated. Such terms include: innovative development, innovation, innovative activity, innovative business, etc. Despite wide discussion concerning the definitions of innovation terms, unfortunately, no unity of understanding of the given notions has been reached. At the same time, economic practice, having real requirement for those terms of innovations has actively started to use them.

In current documents accompanying the actual economic and economical activities in Russia (laws and sublegislative certificates, concepts, analysis, strategies, state-of-the-art reviews, etc) during last years various terms of innovation field are widely used.

It is possible to relate terms which are formed and used in documents on the state (municipal) level to backbone ones. The given terms set a vector, key parameters and principles of innovative development in the context of which applied concepts of innovations are formed. Those backbone terms include, for example: innovative type (way) of development of economy, innovative model of development of socio-economic system, national (regional) innovative system.

A number of derivative terms which designate objects and processes of real economic practice include: innovative project, innovative activity, innovative infrastructure, innovative enterprises and others.

Backbone terms, inherently, should form a methodological basis of innovative development and be supported by the basic macroeconomic and philosophical categories. Then the derivative notions generated on their basis, will be accurate and unequivocal. In our case, apparently, it does not occur.

Though, terms of innovation field have transferred from the area of research to the legal and economic spheres, it has not brought any clearness to their application. Still, even in state documents, intended to be a methodological and methodical basis of innovative development, different interpretations, illegibility, vagueness of definitions and formulations take place. In this connection there are considerable problems on the level of application, when economic and economic management players in real try to build system of mutual relations on the basis of the concepts which have not been finally developed, but fixed on the state (municipal) level. It is a rather serious problem and until it is solved, it is hardly possible to promote innovative development of national economy. To estimate the problem level we will consider the most essential documents which are used today as the basis for decision-making or as an example for new innovative documents design.

One of basic documents in the field of innovative development of Russia is the Concept of Long-term Social and Economic Development of the Russian Federation for the period till 2020, approved by the regulation of the Government of Russian Federation No 1662-r of November, 17th 2008 (further under the text – the Concept). The analysis of the given document is essentially important as for today it is the base document on the federal level fixing strategic directions of economic and technological development.

The given Concept, as well as any other concept is urged to fix in the institutional field a methodological basement and to generate, extendedly, the basic methodical approaches providing the decision of tasks assigned. It is necessary that the user will have received the accurate and clear answer to a question – "how to reach the concept purposes?"

The aim of the Concept of Long-term Social and Economic Development of the Russian Federation comprises "defining the ways and means of long-term maintenance (2008–2020) of steady increase of well-being of the Russian citizens, national security, dynamic development of economy, strengthening of positions of Russia in the world community" [1].

The priority problem of the Concept, assuring the achievement of the given purpose, is the transition of the Russian Federation to innovative type of development. The developer of the Concept (further under the text – the Developer) does not give any special definition to the given

concept, but speaks about the value of the innovative way of development: without it "formation of the competitive on a global scale national innovative system" is impossible. Besides, according to the Developer to switch to innovative type of development is possible if:

– to provide "an increase of professional requirements to staffs, including the levels of intellectual and cultural development";

– to generate "national innovative system, including such elements as the system of scientific research and development integrated with higher education flexible for the economic inquiries, business engineering, innovative infrastructure".

As we see, the circular reference takes place: the innovative way of development should provide the national innovative system formation; in order to transfer to innovative way of development, in turn, it would be necessary to generate national innovative system. As a result of given incorrectness, both terms of the Concept, in essence, methodologically are not defined.

Indirectly, it would be possible to determine the essence of an innovative way of development if the concept of national innovative system, for example, proceeding from its internal organization was accurately formulated. The Developer of the Concept defines organizational essence of national innovative system as follows:

"The national innovative system represents a set of interconnected organizations (structures) occupied with manufacture and (or) commercial realization of knowledge and technologies, and a complex of institutes of legal, financial and social character providing interaction of the educational, scientific, entrepreneurial and noncommercial organizations and structures in all spheres of economy and public life".

When analyzing the given definition it becomes clear that it clarifies neither the essence of concept of innovative development type, nor the concepts of national innovative system. Definition is generated in such a manner that even the set of existent institutes, enterprises and organizations related to commercial realization of knowledge and technologies falls under the definition of national innovative system given in the Concept. Though, everybody realizes that in the Russian Federation such system practically doesn't exist at present. Moreover, the more specific definition in the selected format will give nothing as the simple enumeration of elements, without revealing of their consolidating methodological basis, does not allow to accurately define such a complicated object as national innovative system.

One more formulation which defines requirements for transition to innovative type of development causes interest. The legislator considers that "the innovative type of economic development demands creation of as many as possible favorable conditions for the enterprise initiative, increase of competitiveness and investment appeal among the Russian private companies, expansion of their ability to work in the open global markets in the conditions of rigid competition as private business is the basic motivating power of economic development. The state can create necessary conditions and stimulus for business development, but should not substitute business by own activity".

It follows from the given quotation that innovative type of development is not a simple set of certain factors, as that of maximum favorable conditions for the enterprise initiative, increase of competitiveness and investment appeal among the Russian private companies, expansion of their ability to work in the open global markets, the conditions created by the state and stimulus for business development, etc., but it is something else, however the occurrence of this (transition to innovative type of economic development) the presence of those listed specific conditions is necessary. The given observation is important as the authors believe it to be not just a simple legal incorrectness of the Developer. This formulation bares an essence of the methodological problem. On the one hand, there is absence of accurately formulated methodological basis allowing to particularly define the base term of an innovative family in the document, on the other hand, attempt of the Developer, in absence of such methodological basis, to indirectly define the concept essence, being of great necessity for real practice.

Apparently, absence of comprehensively well-grounded methodological base pushes the Developer to introduction of the additional terms duplicating the basic concepts.

Hence in our opinion, for more accurate statement of the essence of innovative type of development of the Russian Federation the Developer uses the term: innovative socially focused type of economic development (Russian Federation). The essence of the given type of development is not formulated by the legislator, but it is underlined that it is characterized by that "based on" (further under the text – "basic characteristics"):

A. "Modernization of traditional sectors of the Russian economy (oil and gas, raw, agrarian and transport), advance increase in volume of production in high repartitioned branches which up to 2020 remain the leading sectors of gross domestic product manufacturing".[1]

B. "Transformation of innovations into the leading factor of economic growth in all sectors of economy, 3–5 times labour productivity increase in the sectors which determine national competitiveness, 1,6–1,8 times power consumption decrease on the average".

C. "Formation of economy of knowledge and high technologies which are becoming one of the leading sectors[1] of the national economy, as compared to gross domestic product contribution with oil and gas and raw sectors by 2020".

What is it? Conditions of transition to the innovative socially focused type of economic development or it is also the characteristic of the given type of development?

In the section "transition Directions to the innovative socially focused type of economic development" the legislator specifies a complex of definite transformations (conditions) which are necessary to be carried out to assure the given transition, namely:

– development of Russian human potential;

[1] Under the economy of knowledge and high technologies we understand the spheres of professional education, high-tech medical care, science and experimental engineering developments, connections and telecommunications, science intensive subbranches of Chemistry and Mechanical engineering.

– creation of highly competitive institutional environment, stimulating entrepreneurial activity and attracting the capital to the economy;

– structural diversification of economy on the basis of innovative technological development;

– fastening and expansion of global competitive advantages of Russia in traditional spheres (power, transport, agrarian sector, processing of natural resources);

– expansion and strengthening of the external economic positions of Russia, increase of efficiency of its participation in the world division of labour.

Judging by the fact that transition conditions are defined more or less accurately, three "basic characteristics", listed above, are the essence of the innovative socially focused type of economic development of the Russian Federation. But then there is a number of following from the given characteristics questions.

Firstly, whether modernization of traditional sectors of the Russian economy, even on the basis of high technologies is the essence of the innovative socially focused type of economic development of the Russian Federation? If it is so, how can such a choice of directions be proved, apart from tradition and our inability to create something else? Besides, why will modernization of the given sectors of the industry lead to innovative type of economy development? After all, both earlier and current modernizations in particular directions on the basis of high technologies took place, but generally they did not result in innovative development of economy.

Secondly, what is the purpose of formation of economy of knowledge and high technologies which, according to Concept DCER of the Russian Federation, should have become one of leading sectors of national economy by 2020? Should the economy of knowledge serve the modernized traditional sectors or there are other variants of application of its potential? Who is the end user of the economy of knowledge production?

This document does not give any answers to the above questions. Basically, this is hardly the end of the question list of them. But the criticism of the given particular document is not the aim of the authors of the present article. The purpose of above question set is to demonstrate the insufficiently developed methodological basis on which the Developer of the document relies and the fact that introduction of specifying terms to the Concept does not make the interpretation of the basic terms of innovation field clearer.

Throughout research we will consider one more basic term of the Concept – the innovative model of economic growth. It is not defined as well, but in the context of the document it is used as a synonym of innovative type of development of socio-economic system. The Developer opposes concept of innovative model of economic growth to the concept of export-raw model of economic growth of socio-economic system. In terms of development models the purpose of socio-economic development of Russia is considered as "transition from export-raw to innovative model of economic growth". Such transition, intended by the Developer is provided "with formation of the new mechanism of the social development based on the balance of enterprise freedom, social justice and national competitiveness" [1]. Thus, the Developer, in this case, relies on the concepts "enterprise freedom", "social justice" and "national competitiveness".

In the definition of enterprise freedom, social justice and national competitiveness the Developer limits it only to the declaration of notions, which is understandable, because these questions have not been solved even on the fundamental scientific level, they are still being widely disputed and will be disputed for a long time. How can they be taken as a principle of such conceptual document? Therefore, definition of transition to innovative model of economic growth does not clear up the concept of innovative model of economic growth and does not help with clearing up of other concepts of an innovation family.

The analysis of the basic terms of the Concept will be not full if not to consider the term: model of innovative socially focused development. The given term is a derivative, specifying the term innovative type of economic growth and innovative model of the economic growth, used in the Concept, and therefore, according to nature of transitivity, it at least should partially define the term of innovative type of development. The Developer gives the following definition to the above term:

The model of the innovative socially focused development of the Russian Federation is such model of growth which "along with the use of traditional competitive advantages in power and raw sector assumes creation and activation of new factors of the economic growth satisfying the calls of the long-term period. It is a breakthrough in the increase of the human capital efficiency and creation of comfortable social conditions, liberalization of economic institutes and strengthening of competition of the business environment, the accelerated distribution of new technologies in economy and development of hi-tech manufactures, activation of the external economic policy". According to the given model the Developer suggests considering the exit of the Russian economy "on a trajectory of long-term steady growth with average rate of about 106,4–106,5 percent a year" as criterion of actual development.

Analyzing the above definition it is again possible to ascertain that it does not cause major objections. But the considerable amount of various variants of development falls under it and, therefore, it does not bring any methodological clearness to understanding the essence of neither innovative type of development, nor innovative model of economic growth. As for the set of criterion of growth it is possible to say that they are certainly desirable. However, as practice shows, they can be reached without the leading role of innovative factors.

Apart from the above listed, the term of innovative technological development used in the Concept is of great interest. The given type of development, intended by the Developer "should provide structural diversification of economy of the Russian Federation". In turn, the structural diversification of economy is necessary as one of the directions providing transition to innovative socially focused type of economic development. Innovative technological development assumes the following:

A. "Formation of national innovative system, including such elements as the system of scientific research and development integrated with higher education flexible for

the economic inquiries, business engineering, innovative infrastructure, institutes of intellectual property market, mechanisms of innovation stimulation etc.".

B. "Formation of the powerful science and technology complex providing achievement and maintenance of leadership of Russia in scientific research and technologies in priority directions".

C. "Creation of the global competence centers in processing industries, including hi-tech manufactures and economy of knowledge".

D. "Assistance in increase of the leading branches of economic competitiveness via private-state partnerships mechanisms, improvement of conditions of the Russian companies access to the sources of long-term investments, provision of economic branches with highly professional staff of managers, engineers and labour force, support of export with high added cost and rational protection of domestic markets taking into account the international expertise in the field".

As we see, again the given concept relies on the term of national innovative system which methodologically is very poorly developed. Besides, measures on formation of a powerful science and technology complex and creation of the *global* competence centers are allocated in separate points, which also cause questions. Aren't the given measures included into number of measures on creation of national innovative system, don't they demand unified methodology, and accordingly – the unified identifying name and unified coordination? But if they are included, why are they divided? Or is the national innovative system an abstract object in general which is not planned, and as consequence is there anybody responsible for it?

There is a set of important questions associated with this term as well. Most of them come to the following: what is the difference between the measures listed in this document and unified by the term innovative technological development, and those which had been planned before but were not unified by this term? At first sight there is not any.

Apart from the backbone methodological concepts there are some applied terms of innovation field are used. Among them are: innovation, innovative company, innovation potential etc. However as this conceptual document is aimed at the formation of the general conceptual field, mentioned here applied terms have not been explained yet (except some indirect explanations).

In general this document seems a heroic attempt of the Developer to combine both the development of methodological basement and basic innovative toolkit of RF socio-economic system. As we have already mentioned, documents of this kind should only consolidate the methodology, the most attention should be paid to methodical issues. The development of methodological base is the competence of science. The statement could have appeared only due to the absence of suggestion on the fully worked out innovative development methodology from Russian economic science.

At the same time, as it has been mentioned, in economic and economical activities there is a huge requirement for a methodological and methodical basis of innovative development. Therefore the life pushes economic players to independent development of the given subject. On the level of subjects of federation and on municipal level many documents which are urged to help solve a problem of insufficient methodological and methodical security of innovative development for particular territories and business entities are developed.

The most developed in the given aspect is methodological and methodical security of Moscow city. The Moscow law on innovative activity and variety of decisions of Moscow government form a legal field provide methodically innovative development of the city economy and also give an example for similar documents design in other regions. We will consider in more details the Law of Moscow city (further under the text – the Law) on innovative activity [2].

In the Law the following basic terms are used: innovative activity, production of innovative activity, the innovative policy of Moscow city, the innovative program (project), the innovative program of Moscow city (the complex program of innovations), the subject of innovative activity.

In general, it is necessary to conclude that the basic principles are formulated accurately enough and unequivocally to advantages of the given Law. In many respects thanks to accurately formulated definitions of the basic Law terms. Thus, outwardly, the law looks quite a worthy methodical tool.

At the same time, while making a more profound analysis of definitions of the basic terms we see that their list is generated with the support on two base terms which are postulated in the form of axioms. These terms are – innovative activity and production of innovative activity (innovations) (further under the text – "basic terms"). Thus, in this case they act as methodological basis of the document. Their definitions are resulted in the table.

Actually, definitions of the given terms are not the invention of the authors of the Law. They successfully sublimated all scientific experience accumulated by the researchers of innovations. But despite it, the given definitions do not contain one most important thing – unequivocal, methodologically grounded criteria which would allow, while putting into practice, to separate innovative activity from not innovative and innovations from not innovations.

Let's take for example an introduction of scientific and technical achievement which was mastered abroad, which was not used in our country and is being introduced here only now, from what point to what can we consider it as innovation? Or another question: whether it is necessary to

Basic terms of the Law of Moscow city on innovative activity

Basic term	Characteristics
Innovative activity	The activity directed at introduction of scientific and technical or science and technology achievements in technological processes, the new or advanced goods, the services sold in the internal and external markets
Production of innovative activity (innovation)	The introduced scientific and technical or science and technology achievements mastered in manufacturing the new or advanced goods, services or technological processes

consider only scientific and technical or science and technology achievements new or advanced goods in the technological processes, the services realized in the internal and external markets as objects of innovative activity and how to treat other innovations? For example, those which are not marketed or arrive to the consumer via other, not market channels? A lot of similar questions can arise.

These points in question are not new and periodically discussed among researchers, what testifies again the insufficiently worked out methodological basis of innovative development, and results in lack of methodical toolkit.

The statement about insufficient readiness of methodological basis can seem disputable in connection with presence of a considerable quantity of works on the given subject both in Russia and abroad. In this respect it is possible to object that domestic researchers, unfortunately, generally follow those directions set by foreign researchers and not so often, as it would be desirable, select own author's directions.

To sum up, all the above said testifies firstly, the importance of conceptual and categorial tools both for the economics and for economic practice; secondly, the necessity to analyze the terms of innovative field used in economic and legal spheres.

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PROBLEMS OF MANAGING REPRODUCTION OF DEFENSE-INDUSTRIAL FUND AT THE MACHINE-BUILDING ENTERPRISES

The basic problems of managing reproduction of defense-industrial fund at the machine-building enterprises are considered by the authors.

Keywords: problems, reproduction, management, basic production assets.

The modern machine-building complex is a set of industries producing various cars, presented by actually mechanical engineering and metal working. The mechanical engineering consists of such major branches as power mechanical engineering, electrotechnical, machine-tool constructing and tool industry, instrument production as well as of some separate branches which are producing the equipment for extracting and manufacturing industry, building, transport, mechanical engineering, motor industry, tractor and agricultural mechanical engineering, etc.

Today the mechanical engineering in Russia numbers about 49,000 functioning enterprises and organizations that make about 55 % of all enterprises of the industry.

In the USSR the development in the sphere of mechanical engineering was put in life mainly in extensively, as it constantly involved additional labour, material and financial resources therefore the huge industrial machinery which was not of appropriate scientific and technical level and has been saved up and is inefficiently used. It has led to lowering of not only economic indicators of defense-industrial fund (DIF) reproduction, but also financial indicators of enterprises activity in general.

In their own turn technical possibilities and economic efficiency of machine-building complex functioning is defined in many aspects by the active part of its basic production assets. The mechanical engineering takes leading positions as per percentage of DIF deterioration which is 54.3 %. The factor of basic means retirement in this branch is larger than updating factor and as the result the majority of them function beyond the limits economically justified serviceability.

Updating DIF in present-day conditions is restrained by complicated financial situation at the enterprises of mechanical engineering and insufficient investment support of the state. The implementation of technical and organizational innovations is carried out at the machine-building enterprises as a rule in the basic production that results in disproportion between the level of the basic production and the level of maintenance of the fixed capital in an efficient condition. Operational expenses is one of the most meaningful issues of expenses at the machine-building enterprises that make 15 % of the production cost price. It results in low efficiency of DIF management that negatively influences the economic condition of the enterprise in general as labour productivity of industrial workers appreciably depends on the condition and working capacity of the equipment, duration of its idle times because of repair works. Besides, without timely and qualitative repair and service works for the equipment it is impossible to provide output of competitive products.

High wear and tear and obsolescence and also low technological level of the basic production assets cause low

degree of the equipment utilization. Low utilization of manufacturing capacities at the mechanical engineering enterprises quite corresponds to that fact that more than one third of them are not suitable for output of competitive products.

As a whole the general condition of the field is far from being satisfactory. As for now the management problem and the basic problems of machine-building enterprises are hardly fastened by DIF reproduction in one knot. Causes and effects are interrelated so that it is not always possible to differentiate one from another. According to the majority of experts one of the main reasons influencing growth of efficiency of DIF reproduction is the administrative factor.

In the developed economy practice at the mechanical engineering enterprises, questions of fixed capital reproduction are not different from the general managing problems and are solved independently by separate production and managing structures of different functions and levels of subordination [1]. Splitting to separate areas of management the process of DIF reproduction is carried out by services of the enterprise without due interrelation of the decisions taken, with no united centre to co-ordinate their activities. The topicality of the management problem for DIF reproduction is defined first of all, by the fact that at the enterprises the basic attention is still given to questions of technical development of manufacture and the problems of rational production processes are underestimated and become possible only at accurate interaction of all the resources, i.e. subjects, means of labour and the work.

It is DIF reproduction that should be considered as the most typical problem that prevents modern enterprises from their successful functioning in the conditions of developed market relations.

To create the effective mechanism of managing DIF reproduction at the machine-building enterprises, it is necessary to allocate, first of all, the real reasons of the given problem in this area and objects for perfection.

The majority of the machine-building enterprises are characterized basically by large vertically-integrated structures supervising the basic part of manufacture that has strongly affected the organization of management of process of fixed capital reproduction in general.

Long-term experience in usage of vertically-integrated structures management [2; 3; 4] has shown that they are most effective only at the enterprises where the management personnel carries out routine, often repeated and rarely varied problems and functions, solving standard administrative problems. Their advantages were especially shown in management of the enterprises in the stable external conditions characterized by small number of external factors and low level of their influence on the organization.

However the quantity and complexity of problems of equipment reproduction management is constantly growing in dynamically varying modern market conditions. A huge role in the given process is performed by the time factor, binding to accelerate efficiency in taking administrative decisions.

Between the beginning of work and the end result, between initial raw materials and the end-product there began to appear more and more links in a united chain of works that inevitably led to growth of an intermediate link of directing bodies. As the result there appeared a huge hierarchy each level of which consistently expanded "administrative capacity" of the higher that finally has led to bureaucracy. It resulted in huge losses of efficiency of the general activity and its separate functions. Thus the greatest reserves of activity efficiency of each function, and all the process in general are put on joints of links of the united chain of works for the end result achievement, and as in the sphere of coordination of joint actions providing an efficient management and rationality of resources costs.

The management focused on function is based, first of all, on separated, not co-ordinated use of the enterprise resources preventing them from receiving high economic benefit and reaching high enough indicators.

The important indicator of development of any control system is the characteristic of communications between its structural elements. The characteristics for the majority of the enterprises of mechanical engineering are separated enough, broken operating industrial links between functional departments. And to achieve strengthening and reunion of these communications at such an organisation of management is problematic enough. Owing to that the regulation of works in the given organizational structures is realised through functions, the management of functions is carried out "from top to down" through vertical hierarchy. Taking basic decisions occurs at management top level, and the only "owner" (terminology ISO) of all processes in the company is the "first person" of the company: CEO who is individually responsible for quality of the end result and terms [5].

Managers of lower level take responsibility only for performance of separate actions (functions), instead of for all the result of the activity (business process). They are not responsible for work from the beginning till the end, their activity lies only within the limits of functional area. To speak formally, the work for them cannot be simply defined in any other way [5].

Realization of each function is provided with corresponding division which acts as a structural element in the general process of DIF reproduction. The divisions which are at one hierarchical level, but in different functional zones cannot affect activity of the neighbouring divisions because of lack of regulation in their mutual relations in any way. Employees of these divisions as are not "co-owners" of the general result of work, they simply do not understand the role in this process, and interaction among employees of the department has chaotic character. The isolated position of each service in the enterprise leads to an unjustified competition between functional departments and organization divisions, the system of estimation of their activity is carried out by results of function, and criterion of productivity of functional division is the opinion of its chief. That means aspiration (subconscious or realized) of each worker to please the chief, instead of preparing on time the information for colleagues from the neighbouring department, which is necessary for performance of certain work, and furthermore for the client.

All the aforesaid does not allow to provide and show, on the one hand, awareness of the personnel of the contribution to the end result of the activity, and on the other hand, does

not allow to provide certain responsibility for this contribution. Performance of functions is carried out as if in a vacuum, as there is lack of attention of the interested parties. And these parties naturally have their own point of view on what the success of the general activity is. As the interested parties (consumers) of process of DIF reproduction, as a rule, are internal consumers (departments and services), they like magnets are constantly attracting on themselves the possibilities of the given process. Isolation of divisions and services from each other leads to monopolization of decisions, substitution of target reference points of the organization on functional target reference points. With the lack of interests balance of the parties "the management field" of the reproduction process is constantly made to be dissymmetric.

This disbalance of interests results in isolation of functional divisions, separation, and sometimes discrepancy of views on the given process at taking administrative decisions. Thus, the achieved goals contradict to each other. For example:

– the personnel which is responsible for process of DIF reproduction, is not connected with financial and economic services, therefore has no idea of how the acquisition of the new equipment, the market position of the enterprise, and will change the financial result;

– at the equipment choice the technological estimation of its application to the definite nomenclature of details to define the set of necessary options is not carried out. Therefore in real manufacture one has to face the necessity for more purchases (it is frequent its cost is close to cost of the base complete set), or expensive already bought options happen to be out of use;

– "planned" re-equipment is poorly connected with specificity of products which are planned to be produced with the new equipment, and is focused on preservation of the developed technology;

– the tendency of "scrappy" updating leads to complications in service of the equipment of various manufacturers and problems of kitting up with spare parts.

The superficial analysis of the status in the field of DIF management leads to a formalistic approach of creation and functioning of system of DIF reproduction and quality of the done work.

The analysis of undertaken measures on improving management of DIF reproduction has shown that one of complicated questions on a way of creating effective structure of DIF management are: weak delegation of powers and responsibility for the decisions taken, the complicated system of coordination on levels of that site of work where it is carried out.

To take any decision, irrespective of its importance, participation of the higher chief is required. In his own turn, that chief co-ordinates prospective decisions at higher level and etc. First of all it is efficiency and uninterrupted operation of the result of all work that suffer from such mechanism of «management», the speed of decision-making is decreased. So the decisions to define the organization of the fixed capital at the best are developed in the course of the one-alternative decision, the operative ones are taken, as a rule, by intuition on the basis of workers' experience with taking into account available recommendations of practical character.

Rather low degree of differentiation of powers and responsibility in office hierarchy (the fact of functional barriers), unwillingness of managers to expand a circle of objectively solved problems of management to incur responsibility for taking decisions leads to decrease in motivation of all employees of the organization on improvement of the general activity, to lack of workers' initiative to independently search for ways out and decisions of the problems fixed to them.

The analysis of practical activities of the machine-building enterprises has shown that workers remain within the limits of duty regulations, within the limits of standard methods. The less possibilities of handling their work the employees of the organization have, the less responsibilities for result of this work they get. For example, if the manager individually defines working conditions for employees, the latter will have almost always only formal duties which only need to be carried out. Thus employees will not feel responsible for performance of the functions, owing to that requirements for work are already in advance predetermined, and processes are supervised. They perform the work according to formal duties, but do not raise any initiative, they do not take risks and do not show feeling of private responsibility. Many formal duties are given in the form of "oral messages" and not fixed on paper. As the result there are complications connected with definition of responsibility, duties of each employee, the control and reporting mechanism. Such conditions do not create preconditions to gain credentials and there is nothing for employees to do but to go on carrying out the tasks from above.

It is necessary to underline that if the employees incur obligations, they are not always capable to do them at full, and it is made by following reasons:

– the limited outlook of the employees which does not go beyond division, organizational problems that belittle the general organizational purposes and problems to the functional ones;

– the lack of professional knowledge, especially if business concerns a highly specialized field of activity;

– banal shortage of time because of great volume of carried out duties;

– restriction of possibility of professional development for functional and especially linear managers (the latter get free from specialized administrative functions, focusing the attention on problems of merely manufactures);

– problems in managing general training of employees.

It is necessary to take into consideration that the share of trained and motivated personnel in total number is insignificantly small, and for normal functioning of the enterprise the highly-skilled personnel is required. It is the management of the general training that defines the personnel structure and in essence forms the future shape of all the collective of the enterprise. The organization should strive for their employees to master the trade and also "broaden" getting deeper, mastering neighbouring trades. As the inspection of the enterprises shows in mechanical engineering low qualification of personnel causes about 70 % of spoilage and 30 % of breakages of the equipment, also 35 % of productivity decline [4].

According to the opinion of the majority of experts one of principal causes for more than half of problems of the personnel

efficiency at the enterprises is the insufficient information. Thanks to improvement of quality and efficiency of the information which is received by employees, it is possible to raise efficiency of activity of the company by 20 and even by 50 % [4]. In structural divisions of the organization the information generalization is provided "from below upwards", and also its concrete definition is "from top to down". Formation of communication networks and creation of conditions for successful functioning of communications in the organization make one of the major problems of management.

Now at the enterprises of mechanical engineering employees of the administrative personnel use no more than 1/3 circulated information [1]. It testifies that information streams at the enterprise and communication with the external world are broken. However just information for effective work is not enough, but also communication links are necessary. The main objective of communications at the majority of the enterprises is transferring orders and the control of their performance, instead of providing the clear picture of the given information which is the subject of exchange. With hierarchical, subordinated structure of management for DIF reproduction at the machine-building enterprises communication streams are not so important, this structure is intended basically for written, formal kinds of communication channels and for vertical stream of messages from the head to subordinates. However, for the information going "from top to down" it is necessary to get through all intermediate levels of management hierarchy so that to overcome difficulties of communication streams. It is a difficult process as each stage of passing is simultaneously a point where the sense can be either deformed or completely lost, or execution of decisions is detained. The weak feedback, prevalence of one-side exchange of information bring with them a number of discrepancies, distortion and lack of confidence in correctness when interpreting messages.

Structural divisions are characterized by stable relations in the department. From the point of view of reception and processing of the business information structural divisions consider themselves self-sufficient. Due to numerous contacts among employees of the division, constant information interchange and possibility of its fast check, employees neglect external relations with other functional divisions and mistrust the information received from outside, they basically analyze the internal information, limits of the received and proceeding information become more rigid. Such condition of structural divisions finally negatively affects processes of integration into the organizations. Dissociation, closeness and mistrust are organization characteristics where there are basically interconnected communication networks creating barriers to free overflowing of information in the organization. Barriers on the way of information exchange can be a consequence of an overload of communication channels as well. The manager absorbed by processing of the given information and necessity to provide information exchange, is not in a proper condition to effectively react to all the information. He is compelled to eliminate less important information and to leave only that which seems to be important for him. Unfortunately, the way the manager understands the importance of the information can differ from the way the employees view that.

Duplication of functions, problems and powers inevitably leads to parallel streams of information, its distortion and movement delay at taking administrative decisions. As the same information comes to divisions of the organization and to its management from different sources information duplication too is inevitable. Besides the more levels there are in the organizational structure, the greater the probability of information distortions is as each level filters and corrects the handed over information. The irrational structure can cause conflicts among various divisions and separate heads that naturally create serious problems at information exchange and taking administrative decisions.

In such conditions the question of distribution of orientation ideology to requirements of the client and the end result of the organization activity becomes problematic; decision-making processes on improvement of the general activity aimed at the end result, and first of all the top management does not co-coordinate decision-making processes with all other aspects and criteria of activity of the enterprise. The revealed problems of management of DIF reproduction and their reasons force to reconsider basical principles of designing organizational structures and to go to orientation not on functions, but on processes.

In the conditions of dissociation, backwardness of operating industrial communications it is important for each employee of the enterprise to realize the necessity of perfection in organizational structure of management for the sake of solutions for mutually advantageous problems, to understand the current situation inducing them to joint actions. Here again the process-oriented approach to management of DIF reproduction comes to help. The management focused on processes is based, first of all, on complex (integrated) use of resources of the enterprise, allowing to receive high economic benefit and to reach high enough indicators [5]. The focus on the consumer, release of competitive production and providing services of high quality with stable indicators should become the basis of the process-oriented structure of management. This sort of the organizational structure becomes that tool which helps to make it possible to create the effective mechanism of management of reproduction of the fixed capital at the machine-building enterprises.

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SUSTAINABLE DEVELOPMENT OF THE AGRO-ECONOMIC SYSTEM: ESSENCE, TERMS AND CONCEPTS

Conceptual apparatus and terminological special features in the question of the sustainable development of the agro-economic of systems are examined. The ways of transition to the sustainable development are revealed: planning and organizing of development of the agro-economic systems; improvement of social and economic conditions of villagers; development of self-government; production diversification; accelerated development of alternative activities and others.

Keywords: stability, rural, agrarian, development, social and economic levelling off, ecology.

In 1992 at the Conference of the United Nations on environment (Rio de Janeiro), the thesis about the socially and economically balanced development which does not destroy the environment and provides continuous progress of society was officially proclaimed. The concept "sustainable development" was accordingly introduced. The main meaning of the verb "sustain" according to the Oxford dictionary is "maintain". With reference to development of the mankind the concept "sustainable development" means the development which does not put irrevocable damage to the environment. The term "sustainable development" was widely adopted in the legislative practice of our state and fixed in a number of normative documents. For instance, in the Concept of Transition of the Russian Federation to Sustainable Development confirmed by the Decree of the President of the Russian Federation from 01.04.1996 № 440, society's sustainable development is defined as development "providing well-balanced achievement of social and economic objectives and solution of problems of preservation of the favorable environment and potential of natural resources with the aim of satisfaction of needs of today and future generations".

Preservation of the favorable environment and potential of natural resources of out planet is concerned in the first place with activity of people in different industrial fields and in particular in agro-economic industry, which provides the population of the earth with food.

The legal vacuum appeared in the system of the agrarian legislation after revocation of the Federal law "About state regulation of agroindustrial manufacture" from July 14th, 1997. Nevertheless, at the end of December, 2006, the vacuum was filled with the Federal law № 246-FZ from 29.12.2006 "About agricultural development". In the given law the term of agricultural production defines as a set of economic activities in cultivation, manufacture and processing of agricultural production, raw materials and foodstuff including provision of corresponding services.

In the same law (item 5) definitions of the concepts "the state agrarian policy" and "a sustainable development of rural territories" are given. The state agrarian policy represents a component of the state social and economic policy directed to sustainable development of agriculture and rural territories. The sustainable development of rural territories is their steady social and economic development, increase in volume of agricultural output, increase of efficiency of agriculture, achievement of full employment of villagers and increase of level of their lives, rational use of land.

The aforementioned testifies that because of relatively inexact translation from English of the concept "sustainable development" the confusion was brought in interpretation of the concept of stability. Stability from the angle of survival rate of mankind and maintenance of a positive trend in non-uniform (with accelerations and delays) social and economic and technical development.

Therefore it appears that it is possible to understand sustainable agricultural development not only as stability in the sense of social and economic and technical development, increase of volume of output and its efficiency, but also as stability providing well-balanced development from the position of potential of natural recourses. This development is achieved by means of restrictions or reduction of production which is capable to do much harm to the environment. On a big time interval it is expedient to aspire to increase the efficiency of agrarian manufacture on the basis of energy- and resource-saving technologies, to use renewable resources and with obligatory preservation of the environment. Hence to emphasize the difference in this terminology, it is justified to replace the term "sustainable agricultural development" to "sustainable development of agroeconomic system" according to the first approach to the definition of stability, or to sustainable development of "agroecological system" – according to the second approach. "Agroeconomic" literally means "economical use of the land" and consequently economics of the manufacture connected with the usage of land and animals.

It is possible to explain this replacement of concepts by the fact that nowadays some scientists treat the concept "agriculture" more widely than before. Agriculture historically is understood as the manufacture connected with use of the land and animals. But in those days peasantry was engaged only in this kind of agricultural activity. Now the situation is different – in the country there is a complicated infrastructure with electric networks, roads, objects of public service buildings, etc. Construction and other organizations expand agricultural framework including branches which are not directly connected with use of land. Not long ago it was considered that the goals of sustainable agricultural and rural development are identical. However, for the current period of time agricultural manufacture is not the basic sector of economy in rural regions in developed countries. From 1983 to 2003 in the countries OECD (Organization for Economic Cooperation and Development) agricultural employment of the population was considerably reduced, especially in the countries where the agricultural sector initially made a considerable part of economy: in Turkey from 52 % to 34 %, in

Greece from 30 % до15 %, in Spain from 20 % to 5 %. In Russia in 2000 agricultural production, forestry and hunting altogether employed 13,9 % of the population, and in 2006 this figure decreased to 10,6 %. In connection with the changes in "Reform of the uniform agrarian policy of the European Union" 2003, the accent shifts from an agricultural production to development of rural economy and preservation of the environment which reflects transfer from the branch approach to territorial with the focus on interaction of agriculture and environment. Peculiarity of the labour market in the countryside of developed countries is the fact that the population in the country occupied in nonagricultural production is on the increase. For example, in Japan 60 % of farmers are only partly occupied in the agricultural production, and this number of farmers are mostly pensioners who are engaged in agricultural sector of economy after retiring from other branches of economy. In 2003 in the EU countries 54 % of farmers worked part-time in the agricultural production.

The given tendencies are caused first of all by the fact that the agricultural production is not the main sector of economy in rural territories.

Changes in social and economic spheres (in EU countries and OECD) for the last decades led to reorientation of state policy in development of rural territories: use of the territorial approach when there is less support from producers of agricultural commodities.

Therefore, the manufacture connected with use of land and animals can be called agrarian (Agrarian (agrarius – from Latin.) – relating to land property; Agro (agros – from Greek) – used in compound words relate to land). It is less known term, but more adequate to its essence and indicating the specific activity. The adjective "rural" derives from the Old Russian word "settlement – a place where people have settled". Thus the word "rural" as the derivative from the words "settle", "occupied by people" should relate to everything connected with territorial settlement of people, instead of activity with land and use of animals.

Later together with the development and urbanization of large settlements, the concept of a city took shape, and by the word country the territory outside cities occupied by people was meant. Talking of a city we mean only the urban territory. The concept of territory is mainly connected with certain borders rather than with any other factors. Therefore, though by a countryside and rural territory we mean practically the same, nevertheless by analogy with the concept "the urban territory" we see it is more acceptable to use the concept "rural territory" in official materials. Thus, rural territory is the land outside the urbanized territories occupied by people and characterized by the common signs (natural, historical, etc.).

Close to the term agrarian, which is a foreign word, is the genuine Russian word village. In the narrow, historically developed meaning of the word in the Russian language as a small agricultural settlement, one of kinds of rural settlements, "village" existed in the northeastern part of Russia in 14 century and therefrom extended to the other areas of the country. The other kind of rural settlement similar to a village was selo (there is no equivalent in English) which was bigger than a village and there lived a lord of the manor or there was a church; smaller settlements also had their own names. In its broad meaning "village" covers not only all kinds of settlements where its inhabitants are mostly occupied in agriculture but also the complex of social and economic, cultural and domestic, and natural and geographical features and living conditions. A village was usually treated as a social and economic category opposed to a city. Social and economic peculiarity of "village" is determined by the direct connection of its inhabitants with the land, economic development of the territory and use of its natural resources in various branches of agriculture. Because of this, villages are scattered, rather small in size, adapted to the environment in their activities; work there is seasonal and cyclical, relatively not various; public and cultural services are lower than in a city. A village was characteristic of stability of its way of life, traditions.

In geography and ethnography a village is characterized taking into account its features of territory, i. e. a type of settlement of a district, size or density of settlements, form of their spatial organization. Specific combinations of types of settling and the form of settlements are especially emphasized: for mountain areas the so-called focal type of settling is usually characteristic with concentration of settlements in the mountain isolated valleys and at the same time it is a chaotic vertically-step arrangement of structures.

In the modern scientific theory by territory is meant a certain part of social (population), natural (including natural resources and ecology), economic, infrastructural, cultural and historical, spatial potentials of the state, which is in jurisdiction of subfederal or local (municipal) authorities. Thus, territory or territorial formation is a set of spatially identical parts of social, natural and other potentials of the state which can be ruled both by the state and authorities or self-management of this territory.

The territory can be called a regional system. In the modern special literature it is suggested that we should call regions system-conglomeratic structures, for which the concepts "unity" and "integrity" are ideal, not real. Region is the social and economic spatial integrity characteristic for structure of manufacture, presence of all patterns of ownership, concentration of population, workplaces, conditions of the spiritual human life, having local management of the territory (area, region, republic).

Modern writers-economists consider that territorial development cannot be fully carried out in the form of spontaneous self-development or "self-adjustments to stability". Practice shows that in large regional systems the conflict of interests is obvious, and smaller ones cannot resist to external destructive influences. It is clear that regulation of processes of territorial development cannot be "disconnected regulative actions" in the sphere of economics, preservation of the environment.

The basic index of territorial stability, according to Russian economists, is equilibrium, i. e. a special proportion for each regional system which shows its potential and provides stability and social orientation for development of the system. Social orientation can be considered to be the major indicators of territorial stability, "the most obvious and till now the least considered index of territorial development – estimation of a vector and quantitative parametres of regional situations, first of all how they influence level and quality of life of the population".

Taking into consideration the modern understanding of a fully-fledged sustainable development of territories of

regions, the sustainable development of rural territories can be characterized as uniform improvement of positive social indicators (improvement of living conditions of the population, literacy, health) in full conformity with economic and ecological development of a rural region. At the individual motivation level these indicators will be shown in growth of life satisfaction of the population of rural territories, their own social and economic prospects and prospects of the children, corresponding growth of indicators of satisfaction of the basic living conditions in the country.

The analysis of development of rural territories in new social and economic conditions supposes research of presence of social factors without which the sustainable development of rural territories is impossible. On the one hand, it is obvious that the sustainable development of rural territories determines external, major restrictions of natural resources (they are for the remote prospect), on the other hand, possibilities of social and economic development of rural communities, development of managing subjects, natural arrangement and many other things. It is very wide spectrum of problems which (in Russia and some other countries) is considered now from various perspectives. In one case ecological aspect is mostly regarded, in the other – social and economic.

The category "social progress" was developed both by Russian and foreign scientists. The member of Russian Academy of Sciences D. S. Lvov in his report at the meeting on the topic the sustainable development in Johannesburg stated that the three basic problems hampered the progress of the mankind: social stratification and enormous growth of poverty in the world; accelerated growth of technogenic accidents; deterioration of qualitative structure of the population of the Earth together with quantitative growth of the population. (The shorthand report of parliamentary meetings on the theme: "Results of the World meeting on the sustainable development in Johannesburg and objectives of the Russian Federation on September" 24th September 2002, p. 11–13). A category "social progress" was defined as dialectic interrelation of the spiritual and consumer origin in personal and motivational sphere of a person in his interaction with the world and other people [1]. At the end of the nineteenth – beginning of the twentieth centuries Russian scientists, noting complication of public relations, underlined necessity of closer interrelation of social elements in order to achieve social progress of the community. "Progress does not consist of only infinite division. For organism formation it is necessary that parts, bodies were in close connection between themselves..."

In application to the Russian reality, social progress of rural community should have integrity, harmony of consumer and cultural wealth in community development as a whole, that is in other words, not only growth of life standard of countrymen but also culture development, especially its spiritual origin.

Among qualitative social categories not the last place is occupied by the concept of "social equality". There is the question of explaining division of rural citizens into rich and poor from the perspective of social justice, stability of community, possibilities of its social progress. That is not a secret that millions of inhabitants of rural territories lost their right for education, medical treatment, and recreation. On the other hand, it is not clear whether all wealthy countrymen received social benefits according to their social services. The traditional pre-reform concept of social and economic development of the community interpreted social equality exclusively in the sense of destruction of classes. Now the question about social inequality as an engine or a brake of social progress in the Russian science remains open. We can only point out to the fact that wealth of some people justified by their social services to the rural community and poverty of the others is considered by the countrymen as social injustice and is more likely to promote social destabilization of rural community and its social regress.

Realization of principles of social progress and a social equality in regard to occupation of rural territories in practice by the state and society means assistance of the state in introduction of worthy living conditions for citizens of all rural territories, providing them with approximately equal possibilities for receiving of leading social services such as education, public health services, culture, consumption of material benefits.

Russian scientists repeatedly said that without providing citizens of the countryside with decent living conditions and destruction of a scandalous social and economic inequality, the concept of development itself (not mentioning the sustainable development) does not make any sense. There is no steady transition to new living conditions for countrymen because a lot of them while possessing high social and economic qualities do not show labour activity and mobility, and are at a loss to find for a worthy place for themselves in abruptly changed agrarian economy. It leads to reduction of sources of labour potential of rural territories of different level and fast development of such socially negative phenomena as constant unemployment, poverty, decrease of marriages and births, increase of abnormal and illegal behaviour, suicides, social contradictions and conflicts. In their turn the mentioned socially negative phenomena sharply reduce quality of life in villages, destroy foundations of education of the main productive forces of rural territories, block the formation of sustainable development.

It is accepted that the principal reference points of the social regional policy include: population of rural territory, life expectancy, proportion between the average income of the population and the cost of living, share of the population with incomes below the cost of living of population of rural region, consumption level of the basic foodstuff (the scientifically proved norms of food), rate of unemployment in a region. Researchers consider qualitative characteristics of life of the population of rural territories the following: factor of ageing of the population, birth rate, life expectancy. The indicators pointing out to decrease of the standard of living are increase of death rate at an able-bodied age due to unnatural reasons, level of infectious and parasitic diseases, drug abuse, alcoholism.

Studying of foreign experience of formation of analytical basis of indicators of development of rural territories and social and economic stability (instability) of regional population shows that unemployment, poverty of the population of rural territories are considered in the first place as indicators of driving motive of change in stability of agricultural population in direction of instability. The driving motives of process of stabilization of rural territories are: growth of the population, overall fertility rate, growth of the population of school age. The latter is considered by means

of indicators of number of excellent pupils, sex indicators at schools for children of various races, etc.

The important source of steady social and economic development of rural territories is also preservation and stimulation of people's health. Here among indicators there are: access to drinking water, health improving and medical procedures, base improving procedures. The economic driving motives are international cooperation on strengthening of sustainable development in countries and internal political relations (indicators of national income, export and import).

The main objectives of the state agrarian policy of the Russian federation as they are stated in the federal law "About agriculture development" are the following:

– increase of competitiveness of Russian agricultural production and Russian producers of agricultural commodities, providing quality of goods;

– providing sustainable development of rural territories, employment of rural population, increase of living conditions, including labour remuneration for people occupied in agriculture;

– preservation and reproduction of natural resources used for needs of theagricultural production;

– formation of effectively functioning market of agricultural production, raw materials and food which provide increase in profitability of producers of agricultural commodities and development of the infrastructure of this market;

– creation of a favorable investment climate and increase of volume of investments in agricultural sphere;

– supervision over a price index for agricultural production, raw materials and a price index for industrial output (services) used by producers of agricultural commodities, and maintenance of parity of indexes of such prices.

In the government program of development of rural territories of the Russian Federation for 2008–2012 there are a number of indicators of sustainable development (see the table).

The components of sustainable development of agroeconomic systems are as follows: the problem of social and economic development, natural arrangement, preservation and development of a cultural and historical heritage, etc. Social and economic development, in turn, is connected with the problems of development of a civil society and economic and industrial supply of a worthy standard of living and activity of countrymen. It is important not only to understand how the problem of sustainable development of agroeconomic systems is structured but also what problems are the most topical, without solving of which it is impossible to go on to sustainable development. In V. M. Bautin and K. A. Kozlov's work (URL:http://agromagazine.msau.ru/index.php) the most important problems are emphasized:

– planning and organization of development of rural territories on the basis of self-development beginning from the municipal unions;

– all-round involving of active representatives of rural society in the process of self-government;

– diversification of agrarian manufacture, accelerated development of alternative kinds of activities in rural territories;

– development rural (not only agricultural) consulting activity;

– marketing of rural territories, etc.

There are various conditions and possibilities of development of agroeconomic systems in Russia. Therefore without estimation of potentials of certain territories it is impossible to develop the strategy of development of a region, branch, rural territories. Without classification of types of agroeconomic systems according to their soil and climatic, economic and geographical potential it cannot be made. On the country scale, for example, it is necessary to understand the following:

– on what territories there will be effective agrarian manufacture;

– what territories have potential for development of alternative kinds of manufacture and other enterprise activity of people (for example, places for recreation for numerous urban population, places of conducting traditional highly artistic crafts);

– in what territories it is necessary to support life and some not very effective activity of people from political and other strategic reasons, in particular to keep control over territory;

– for what territories it is important to close some of activities apart from those connected with development of forestry and use of forest, etc.

To solve the listed problems it is necessary to create a new multidimensional scientific direction and corresponding disciplines. It is also essential to introduce organizational and legal registration of activity to switch to sustainable development of rural economic systems. Conceptual device and terminology play important roles, they are necessary to be developed and used correctly in scientific activity and lawmaking.

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Activities for sustainable development of rural territories and their financing from the federal budget (billion of roubles)

	2008	2009	2010	2011	2012
House building, provision of young families and experts with places to live in	4.5	10.4	12.9	16.3	17.5
Water supply	1.0	3.2	5.4	5.8	6.1
Gasification	1.2	2.3	3.0	3.4	3.6
Other activities	0.6	2.1	2.7	2.9	2.9
Complex building and improvement of pilot territories	–	1.1	1.2	1.2	1.2
Total:	7.3	19.0	25.1	29.6	31.3

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ON THE PROBLEM OF THE STATE ANTI-CRISIS POLICY INSTRUMENTS IN RUSSIA REFINEMENT

The article covers the main instruments, forms and methods for the state regulation of the market economy. It features the anti-crisis measures (instruments of anti-crisis state economic regulation) taken by the Russian Government to minimize negative consequences of the world financial crisis. The main macro-economic indices and some dynamic prognoses in Russia within the next few years are provided.

Keywords: world crisis, state regulation, macro-economic prognoses, anti-crisis measures.

In the modern society quite a number of socio-economic problems can hardly be solved on the basis of only pure market instruments. It assumes an active use of all state influential levels. The choice of the state economic regulation tools, types and the forms of their use cannot be made at random. The regulating instruments must be supported by the strictly adjusted theoretical basis of a chosen strategy and the ways of economic development. The general trend of the state economic regulation is defined by the main aim of the whole economic policy and is directed at its realization. For this purpose, a state uses different forms and methods to be the instruments of a state economic regulation, the whole complex of which forms its mechanism. At this point the state has methods of direct as well as indirect influence on the economy at its disposal.

Their difference, as it is known, is that the methods of direct influence are implemented with the help of their administrative resource support, while indirect method of regulation is implemented only by economic means, among which measures in the field of fiscal, financial credit, international monetary, customs policy, state regulation of enterprise and others take an important part.

The fiscal policy is an important tool for macroeconomic stabilization of economy achievement. Manipulating with the expenses and taxes of the state one can stimulate the business activity as well as influence unemployment and inflation. However, the usage of the tool that is not properly regulated (unreasonable taxes, excess expenditures, etc.) transforms any fiscal policy into a factor which destabilizes the economy [1].

A monetary policy is very significant, since changing money supply the state can influence the prices, investment processes and consumption, production volume and economic growth rate. The monetary policy as well as the fiscal one can be a means of either stabilization or destabilization of economy. Without efficient, optimally arranged monetary policy the struggle with inflation is doomed to failure [1].

All the tools of carrying out the economic policy are interconnected; they are not isolated from each other; therefore making decision in one sphere it is necessary to consider the influence on the others. The government uses various forms of direct and indirect influence on the economic processes to conduct the state policy approved by appropriate democratic procedure. In existing scientific publications and in special textbooks are mentioned: appropriateness of using such forms of market economic state regulation as direct government control of some branches, objects; tax regulations; monetary control, which is the influence on money circulation; budgetary management that is distribution of state budget funds among various areas of their use; control through forming various state programmes and government order; price regulation; regulation of working conditions, employment relations, remuneration of labour; social regulation (including state social insurance); government regulation of environment protection and environmental restoration; governmental antimonopoly regulation; government external economic and currency regulation [2; 3].

Under the conditions of radically changed system of economic relations, where the government ceased being the only owner of production means, it is still in the center of economic and social development of the country, not as a direct entrepreneur of the country, which defines the character and rates of economic growth, but as a main partner, global manager against other subjects of the market.

The government influences economy mainly through legislative acts, regulating the tax system, allotment of public investment, subsidies, benefits, loaning, realization of large-scale social and economic pragrammes.

Crisis as one of the cycle phases in the production relationship system is a hard trial for the economy of any country, especially for Russia which has not finished the whole complex of radical socio-economic changes on the way to the development of the economic market relations. Crisis can be considered as a dialectical unity of the limit and development stimulus. On the one hand, crisis is a brake for economic development, shown in prices and stock prices falls, production drop, employment reduction, enterprise profitability decline (both in production and service spheres). On the other hand, in crisis situation some bases of restoration of broken laws of economy impulse and its further development, transition into a new phase of the production cycle are built. Meanwhile, spontaneous market mechanism for the solution of existing contradictions in the modern conditions of economy globalization have positive effect, but there are not enough means for the exit from this phase in the shortest time with less economic and social loss for the society [4].

As it is known, the first large-scale crisis regulation at the governmental level was conducted in the USA to escape the Great Depression of 1930s. Governmental crisis management was put into effect here in the following fields: financing and subsidizing of corporations on the verge of

bankruptcy, compulsory amalgamation of organizations, governmental regulation of agriculture which fell into decay, organization of public works and issue of unemployment benefit, credit control.

Financial crisis is today's reality for the world economy. It is very important to mention that American financial system has become a very strong catalyst in this extremely difficult period of global crisis [5].

In October – December 2008 when the world crisis began to influence Russian economy, our government began to carry out anti crisis measures.

The anti-crises measures at the first stage permitted not to let crisis spread, its transition to the forms that threaten the economy operation foundations and, averted its collapse. The first-priority package, undertaken by the Russian Federation Government to combat world economic crisis development has been put into effect in the following directions [6]: exchange rate policy, banking system support, financial market support and Russian enterprises protection from hostile takeovers, tax and budgetary policy, tariff policy, population employment assistance, residential housing and people encouragement in real estate market, business activity support in the real economy sector: oil industry, automobile production, agricultural engineering, defense-industrial complex, SME (small & medium size enterprises), air transportations, retail trade, agricultural industrial complex, infrastructural projects, organization of crises management support.

Global economic crisis in all countries leads to production decline, unemployment growth, reduction of population income that aggravates social tension in the country, demanding from the state prompt and quite effective positive problem solution. The adoption of anti-crisis management Program of the Russian Federation government for 2009, where the experts', Russian Federation citizens', parties representatives', public and political organizations' opinion has been taken into account to a certain extent, has become an adequate reaction to these problems. It has been mentioned in this document that the Government will bear the highest responsibility for all their actions in order not to provide wrong inducements, business and people motivation distortion, which undermine long-term development plan. The priority for relying on private initiative, private economy sector as an important factor to overcome crisis phenomenon in economy development will be retained. Meanwhile, it is supposed that the role of the state will be gradually decreasing in accordance with the staged crisis escape.

The main anti-crisis measures of the Russian Federation Government and the Bank of Russia to revitalize Russian economy in 2009 will contain the activities intended for [7]:

1. Strengthening of social security, preservation and creation of working places.

1.1. Social security.

1.2. Education support.

1.3. Health care, physical education and sport.

2. Preservation and improvement of the industrial and technological potential.

2.1. General support of the real sector and cooperation with backbone enterprises.

2.1.1. Backbone enterprises support.

2.1.2. Measures of tax stimulation.

2.1.3. Demand support.

2.1.4. Assistance to improvement of access to financial resources.

2.2. Support for certain economic sectors.

2.2.1. Agriculture.

2.2.2. Support for projects of automobile industry and agricultural machinery.

2.2.3. Provision of the financial support to the enterprises of defense industry complex.

2.2.4. Transport complex.

2.2.5. Civil housing construction and communal services.

2.2.6. Timber processing complex.

2.2.7. Other sectors.

3. Business administrative pressure reduction.

3.1. Lowering of the administrative barriers when implementing enterprise activity.

3.2. State support of small and medium enterprises.

4. Improvement of the national financial system.

4.1. Expansion of the resource base and increasing the liquidity of the bank system.

4.2 Improvement of access to the bank credits for the real sector enterprises.

4.3. Financial reorganization of the bank system.

5. Interaction of the Administration and the Subjects of the RF in anti-crisis measures implementation.

5.1. Subsidies, supporting the measures providing well-balanced budgets of the Russian Federation Subjects.

5.2. Expansion budget loans opportunities.

One of the positive features of the world financial crisis is that it served as a catalyst for the implementation of the long-awating objectives and projects in the field the tax relations improvement. In October and November 2008 the RF Federal Assembly adopted a number of Laws implementing the anti-crisis program. These Laws stipulated both direct and indirect effect on the stabilization of the country economy and the exit from the crisis. The implementation of these large-scale amendments to the RF Tax Code has appeared to be possible within the overspread anti-crisis policy. It should be noted that the effective stimulus here was the RF President's Appeal to the Federal Assembly, in which the Head of the State emphasized that the financial-economical crisis is to be positive for Russia, as Russia possesses the considerable financial means for anti-crisis measures [8].

The major parameters of the anti-crisis economic and social policy in the RF have manifested in a number of adopted official documents of different levels including both the Message on the budget policy in 2010–2012 signed by President on May 26, 2009 and the official Statement of Administration representatives, including RF President, RF Prime Minister, the Heads of different Ministries responsible for the corresponding spheres of activities.

Among the main objectives of the country budget policy for 2010–2012 the following ones were emphasized by RF President [9]: provision of the fulfillment of the social obligations, limiting the budget deficit for preserving macro-economical stability and constant fulfillment of the social obligations, transition to the mode of tough budget saving; determining appropriate forms of supporting the real sector

of the economy and the financial system, raising the efficiency of the economy and labour productivity; provision of significant quality improvement in public services for citizens; modernizing the net of services to the citizens with the help of the state budget; improving technologies of State purchase; determining the economically proved level of the tax burden and the tax system, corresponding to the modern stage of the Russian economic development and fostering the development of enterprises, the search and application of the advanced technologies; providing the well-balanced expenditure competence and resources for its implementation at each level of the public authority, determining the responsibility for inefficient budget expenditure, creating the stimulus for own profit potential expansion; completing the formation of the reliable and well-balanced retirement system based on the insurance conditions of the resource provision permitting to provide the appropriate living standards of the aged citizens; determining and implementing the complex of measures for forming the "barrier-free" environment for the disabled.

The main directions of tax relations improvement in 2010–2012 in the budget message are [9]: modernization of the Russian economy and provision necessary level of budget system income; structure and level of taxation have to reduce distortion and have a positive influence on structural changes in economy, to form comfortable conditions for the development of business activity; business must show the highest extent of responsibility while discharging duties in the process of tax payment; in 2009–2011 the tax system optimization must be continued; it is necessary to analyze the result of the insurance payment increase in pension and medical insurance system for the financial status of the organizations and to determine if there is possibility for tax decrease to soften the potential negative effect; since 2010 it is necessary to double the maximum amount of income that allows to apply the simplified taxation system from 30 millions to 60 millions rubles per year; to increase the maximum interest value on liabilities considered as expenses in accordance with current interest rates; to establish temporary special working procedure with the liabilities of organizations making it possible upon requests of tax payer to utilize all available tools for tax payment terms; also it is reasonable to develop the institution of changes in terms for tax payments (granting of deferral, installments, investment tax credit); it is necessary to take measures for mobilization of additional budget income and simultaneous reduction of expenses related to liability compliance including introduction of modern technologies of tax management.

According to April 1, 2009 data, the volume of the Reserve Fund in our country accounted for 4,117 trillion rubles, while the National Well-being Fund went down by 1,6 per cent to 2,869 trillion rubles, but the inflation rate in the Russian Federation according to the data of the Federal Agency of the state statistics accounted for 6,6 %. In accordance with the estimation of the Finance Ministry of RF, the projected income of the subjects of Russia in 2009 will go down by 1,1 trillion rubles compared with the last year or by 18 per cent respectively. In that case the regional budget deficit is to be partly covered by the federal funds (URL: http://www.prime - tass.ru/news).

Anti-crises measures of the government of RF to stabilize the economy has worked efficiently, S. Stepashin, the chairman of Chamber of Accounts confirmed, at the session with Prime-Minister of RF Vladimir Putin, while reporting the inspection results of fund expenses, assigned for anti-crises activities. "Assessing the results of inspection one can say that the government regulations to stabilize the system worked – banking liquidity raised, a number of industrial enterprises improved. Governmental measures made credits more accessible to economy. If in March, only 25–30 per cent of enterprises could use credits, now due to cuts in inflation and CB refinancing rate, they came to 45 per cent. In total, the regulations were timely and our monitoring proves that" summed up Stepashin (URL: http://www.prime-tass.ru/news/0/{8D3B9BF6-7C9F-4C22-8A7E-F03B97CBE300}.uif).

Nevertheless, "the goal of VAT decrease is still on the agenda, regardless of the opinion of some officials. That's absolutely true. Nowadays there is a shrinkage of payments to the budget. Moreover, the shrinkage is substantial. In this situation the price of any mistake may be very high. None of the analysts is able to predict the result of this or that tax reduction. The Government is not intended to give up the chance of tax burden reduction in appropriate situation. It's not obligatory to give up this idea, the question is when to start implementing it. "In crisis period one should behave carefully with the tax policy", said the Head of the State at the meeting with "Unified Russia" party members" [10].

The Minister of RF Elvira Nabiullina expects the economy to revive by the end of 2009. She states that there is a number of factors which make it possible to optimistically regard the trends of economy growth restoration, such as: restoration of domestic consumer demand and investment demand. In its turn discoursing about the measures for getting the economy out of crisis, the minister pointed out the necessity of changes in the Russian taxation system (URL: http://www.prime-tass.ru/news/show.asp? Id = 884546&ct = news).

According to the forecasts of the deputy of the minister of finances – Secretary of State Serguei Shatalov – the tax burden on business in 2011 as a result of replacement of unified social tax by insurance fees will increase by approximately 800–850 billion of rubles. In May 2009 the Government of the Russian Federation approved a set of laws abolishing unified social tax and its replacement by the insurance fees from 2010. In this connection it was decided to postpone till 2011 the increase of insurance payment rate from the current 26 % to avoid the excessive increase of financial burden on business in crisis conditions (URL: http://www.minfin.ru/ru/press/speech/index.php? id4 = 7366). Federal budget expenses in 2010 related to unified social tax replacement by insurance fees will make up more than 1.7 trillion rubles and further on will decrease, said the head of the Ministry of Health Care and Social Development Tatiana Golikova according to the results of the government session.

According to the main version of the forecast the fall of Gross Domestic product by estimation of the Ministry for Economic Development in 2009 % will make up 6 % (2.2 % according to previous forecast) and in case of pessimistic scenario – 7.4 %. According to the latest basic forecast of the Ministry for Economic Development the average annual

price for the oil brand Urals in 2009 is expected at the level of $45 a barrel (previous forecast $41 a barrel) Inflation by all the versions is forecasted in 2009 at the level of 13 %, in 2010 – 10 %, in 2011 – 7–8 %, in 2012 – 5–7 %. The average annual exchange rate as per optimistic scenario is forecasted as follows: in 2009 – 34.1 rubles for a dollar, in 2010 – 35.4 rubles, in 2012 – 37.3 rubles for a dollar. Export by estimates of the Ministry for Economic Development in 2009 will make up 260.4 billion USD and import by estimates of Ministry in 2009 will float depending on scenario within the limits of 198.2 –206.8 billion rubles (URL: http://www.edinros.ru/news/text.shtml? 79385/100096).

In average, 100–150 thousand of Russian graduates can come across the problems of employment in 2009. "The figure is very impressive, and we must do our best to soften this problem. First of all it concerns the question of stimulating business to employ new workers" declared the President of Russian Federation D. Medvedev at the meeting with Khabarovsk State University students (URL: http://www.nr2.ru/society/233091.html).

According to the information of the Ministry of Economic Development the decrease of Gross Domestic Product (GDP) may be from 4 % to 8 %. "We are working both at pessimistic and optimistic scenarios. It seems to us, a lot will depend on the efficiency of our actions. The Ministry of Economic Development revised its prognosis concerning the decrease of World GDP from 0.3 % to 1.4 %" declared E. Nabiullina (URL: http://www.economy.gov.ru/wps/wcm/myconnect/economylib/mert/welcome/pressservice/review/doc1242627372897). The reduction in industrial production in RF in 2009 may run up to 4.5–6 % according to the prognosis of R. F. Minister of Industry and Trade V. Khristenko.

A special role in a number of anti-crisis measures is given to the support of small and medium business, that will increase contribution to GDP of RF: 2012 – by 1.5 times (up to1/3 of GDP), the number of small and medium companies per 1,000 people will grow by 15 % (up to 11.4 companies). "Such trend corresponds to the main strategic task in the development of small and medium business until 2020 – to approach the economically developed countries by main indicators, that is: share of small and intermediate companies in GDP – not less than 40 %, the number of employees in small and medium companies – not less than 50 % of the population involved in the economy" reported the Head of the Ministry for Economic Development E. Nabiullina at the briefing of the Government Presidium session (URL: http://www.economy.gov.ru/wps/wcm/myconnect/economylib/mert/welcome/pressservice/news/doc1242663218628). These indices are target indicators of the project layout: "Small and medium businesses development". It is one of the projects of the RF government for the period till 2012, which was considered at session of presidium and will be further developed by the ministry.

Realities of a modern level of social and economic relations development in the Russian Federation, expansion of world economic crisis impose the necessity of state economic relations regulations quality improvement. One of the most real ways of this undoubtedly relevant and important goal achievement is implementation of scientifically well-grounded state economic policy. It is necessary to notice that now the quality of economic policy in the Russian Federation as a whole and in its separate constituents cause well-grounded criticism both from scientists and from Russian business community, that demand further perfection of each effective tool in system of anti-crisis measures. While doing this, on the one hand it is necessary to perceive critically the experience accumulated in other countries and on the other hand to rely on deep research of corresponding processes and follow recommendations of Russian scientists and experts.

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FACTORS OF SUSTAINABLE DEVELOPMENT OF THE AGRO-ECONOMIC SYSTEM

Reserves and factors which ensure stabilization and subsequent sustainable development of agro economic system are analyzed. The priority direction of sustainable development policy of agro-economic system, which is based on five interconnected components, based on the use of economic tools of nature-conservation activity of agricultural tenant farmer stimulation is emphasized.

Keywords: sustainable development, agro-economic system, environment, agricultural land, rural territories.

Sustainable development of the system in the conditions of formation of marketing relations is one of the basic requirements of successful reforming and functioning of multistructure economy. In most cases sustainable development means development when material and spiritual needs of present time are satisfied, and possibility of the future generations to satisfy the demands is not threatened. Thus "sustainable development strategy" is understood as a harmony achievement between individuals on the one hand, and between nature and society on the other hand. The survival and the subsequent sustainable development of the system essentially depends on the fact how territories can conduct an economy in a new way, saving up nature and owning resources as much as possible; to use savings and high technologies, to receive high economic results at the limited natural resources.

World social and economic practice shows that destabilization inevitably accompanies any community at a transitive stage. However, each community has reserves and factors providing stabilization and the subsequent sustainable development of the system, and their realization can be operated (fig. 1).

In many works of the Russian scientists the macroeconomic factors influencing destabilization of different territories are analyzed, problems of weak-developed, depressive and problem regions are researched; measures on alignment of distinctions in a condition of their sociolabor sphere are developed. Emphasis is made on the problems of stagnation and destabilization of rural areas. As a result studying of reserves and factors of a sustainable development of rural territories as the major element of the social and economic organization of Russian agrarian sphere often remains behind the frameworks of scientific research.

Absence of sustainable transition to new conditions of rural territories population's vital activity is expressed in the fact that the essential part of their inhabitants, possessing high social and economic qualities, does not show labour activity and mobility, and many of them are at a loss to find a worthy place for themselves in sharply changed multistructure agrarian economy on the stage of its reforming. It follows in reduction of labour potential sources of rural territories of different levels and progressing development of such socially-negative phenomena as chronic unemployment, poverty, birth rate decrease, increase of indicators of abnormal and illegal behaviour, suicides, social contradictions and conflicts. In turn, the specified socially-negative phenomena sharply reduce life quality in the village and the personal factor of agrarian manufacture, brake social and economic development of the main productive forces of rural territories, block formation of their sustainable development.

Presence of preconditions of a sustainable development of the agro economic system depends on developing conditions of rural industrial manufacture which promote to

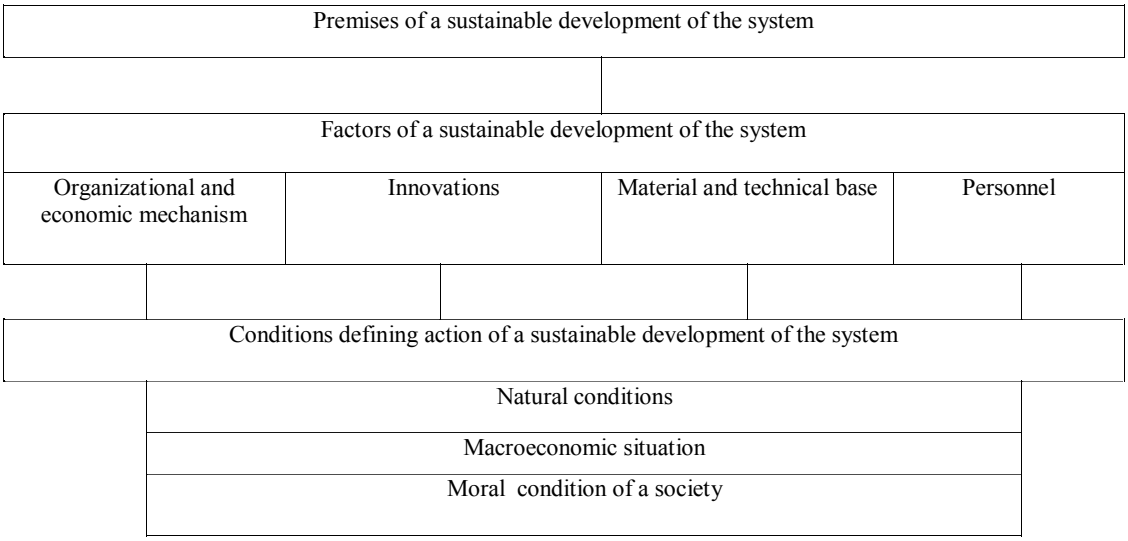

Fig. 1. Preconditions and factors of a sustainable development of the system

performance of its problems. These preconditions may be subdivided into three groups: those which are not depended upon mass regulation; those which are partially regulated by means of these or that factors; those which are completely dependent on accepted measures on agriculture development and the accomplished agrarian policy.

The first group consists of the conditions developing under the influence of nature and climatic factors not subjected to the man's concern: land supply, quantity of precipitations, length of the vegetative period. Their influence at a modern level of science and technology development cannot be eliminated in more or less significant scales though it can be weakened in a certain measure. The second group includes conditions which are formed by simultaneous influence of natural and economic factors, but can be regulated to some extent: soil fertility, structure of plots, labor supply. The third group includes the conditions developing as a result of realization of certain measures on agriculture development: material and technical resources supply, solvency of manufacturers of the agricultural goods, personnel qualification, possibilities of innovative development, functioning of the food market.

According to the nature of each of these conditions groups, differentiated approach is necessary in consideration and use as preconditions of a sustainable development of the agro economic system. If conditions of the first group is a reality which is perceived as it is, then according to the conditions of the third and partially the second groups we can speak about creation of corresponding preconditions of maintenance of a sustainable development of the agro economic system. Preconditions become factors of a sustainable development of the agro economic system in such an extent as qualitative and quantitative change of initial conditions.

The actions providing use of factors and their activation form ways of a sustainable development of the agro economic system. The organizational and economic mechanism, innovations, material base as factors of development of the agro economic system would function more successfully the fuller peculiarities of natural features of rural industrial manufacture will be considered and reflected, namely: supply of preservation and increase of soil fertility, increase of drought resistance of agricultural crops, struggle against soil rehumidifying. Academician V. V. Miloserdov underlines, that "another mechanism of interaction of science, agriculture and government is essentially necessary. There is a necessity of organizational and methodical reorganization of the institutes and the Russian agricultural academy as a whole. Today scientists-economists should pass to a new stage of scientific research and introduction of the results in manufacture – on designing with all its attributes: project working out, its binding to nature and economic conditions, delivery "on a turn-key basis", "scientific support" [1].

Growth of productive forces of the agriculture, occurring on the basis of scientific and technical progress, includes increase of soil fertility, biological potential of efficiency of plants and animals; labour productivity, change of its character by manual skills replacement with the mechanized one; growth of material elements by expansion of scales of application and qualitative perfection of means of production (fig. 2).

It is considered historically that the land is one of the major elements of productive forces. Before recent time there was a unique approach to use the land for the agricultural purpose. It was based on the fact that "from the point of view of modern science achievements, receiving of production from a unit of the agricultural area is in several times more than the reached average indexes" [2]. Growth of fertility of soil and crop capacity as a result of scientific and technical progress included as the basic links optimum for each agricultural zone is the following: ways of soil processing, complex use of fertilizers, crop rotations, protection of plants, land reclamation. Along with this approach, studying of world experience shows, that agriculture entered a phase of transition from the period of constant growth of manufacture to the period of the ecological restrictions caused by necessity of preservation of sustainable rural economic systems. According to M. Minasov, "economic mechanism of a sustainable development of agrarian and industrial complex is the mechanism providing synchronism of interaction of participants of manufacture with nature, biosystem action, system of risks, including nature and meteorological. It is possible on this basis to make a conclusion that increase of stability of agriculture is one of the directions of growth efficiency of agricultural production and the branches of processing industry connected with it" [3]. In a variety of definitions of a concept "sustainable development" of agro economic system the position of the European Union which is supported in WTO is the most comprehensible for Russia. According to this position, agriculture sustainable development should be considered as the multifunction system which purposes are not only commodity output manufacture, but also the decision of ecological, economic and also social problems of each concrete region.

Strategic aims of the agro economic system development should promote to full use of farmlands. That means delivering as a property to the subjects of Federation unused shares and reserve funds of redistribution of the land, to realize the priority right of state acquisition of the areas subjected to sale, provided by the current legislation. Their inclusions in authorized capital that will allow increasing the sum of own means of the organization, can be a result of land receipt estimated in a monetary estimation, and it can be more attractive to investors. It is necessary to notice, that for the present stage of development of the agro economic system the main thing consists not in change of patterns of ownership, but in perfection of the organization of manufacture, creation of more favorable development conditions.

Direct economic regulators in the given area are rent payments (the ground tax and a rent), grants for manufacture ecologically clean production, compensatory payments on compensation of ecological expenses, penalties for infringement of the ecological legislation, insurance of ecological risks, grants, capital investments. There are also indirect economic regulators created by the market, such as increase of normative (and, as consequence, market) prices of the ground area at the expense of a favorable ecological component, or an additional profit received for the account of increase of the prices for ecologically clean agricultural products, from the sale of collateral production (for example,

wood, berries, mushrooms extracted in afforestations on farmlands) or increase of efficiency of farmlands owing to stabilizing influence of especially protected natural territories, for example.

For the 1st of January, 2008, the area of the land of agricultural purpose was 39,865.9 thousand hectares in Krasnoyarsk region. The area of this category in comparison with the previous year increased by 31,254.1 thousand hectares at the expense of association of Krasnoyarsk region with northern territories.

Comparative distribution of the land of agricultural purpose involved in an agricultural turn, for the period of 2006–2007, and also changes for 2007 are given in table 1. The areas of the plots in the structure of the lands for agricultural purpose occupy 4,924.6 thousand hectares or 12.4 %. Only part of agricultural lands – 4,556.1 thousand hectares or 11.4 % from a total area of the occupied land for agricultural purpose is involved in an agricultural turn, 368,5 thousand hectares are in redistribution fund and are not used at present. In the structure of agricultural lands the arable land occupies 60.1 % (in 2006 – 57.8 %), deposits – 2.5 % (in 2006 – 2.6 %), long-term plantings – 0.5 % (in 2006 – 0.7 %), haymakings – 13.6 % (in 2006 – 14.4 %), the area of pastures – 23.3 % (in 2006 – 24.5 %).

The area of non-agricultural lands in the structure of the lands for agricultural purpose is 34,941.3 thousand hectares. These are lands under buildings, constructions, farm boundary roads, woods which are not in the wood fund, closed water reservoirs, and also areas intended for service of an agricultural production. In 2007 tundra vegetation areas, not included into other areas in the territories of Tajmyrsky Dolgano-Nenets and Evenki municipal areas appeared in the given category. They are used by the small natives of the North for rearing of deer, hunting and fishing.

The areas of agricultural lands in 2007 increased by 55.0 thousand hectares. During 2007 increase of the total area of fund of redistribution on 25,131.7 thousand hectares occurred as a result of the region unification (24,451.1 thousand hectares), transfer of the lands of agricultural enterprises and citizens' refusal from using and renting of the ground areas (680.6 thousand hectares), that as a whole on redistribution fund makes 25,682.2 thousand hectares or 64.4 % from a total area of the lands for agricultural purpose.

For the 1st of January, 2008, in Krasnoyarsk region, the disturbed lands, basically among the industry ones, in number of 16,540 hectares have 249 managing subjects (the enterprises, the organizations, private businessmen) on the territory of 39 areas and 7 cities of the region. In 6 areas of the region there are 245 hectares of the disturbed lands. In Tajmyrsky Dolgano-Nenets municipal area there are 183 hectares of the earlier disturbed lands which belonging is not established documentary. In the branches of economic

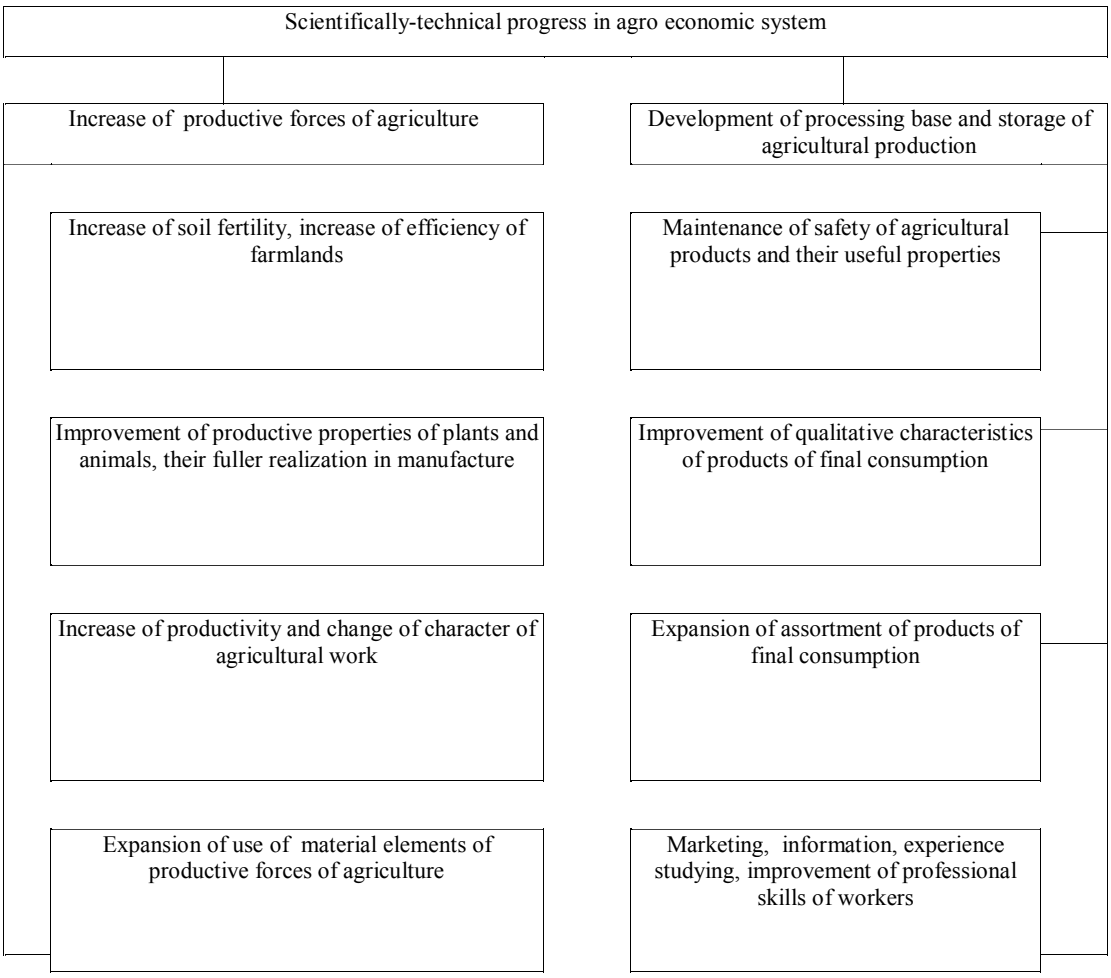

Fig. 2. Directions of scientific and technical progress in agro economic system

activities the greatest areas of the disturbed lands are 12,546 hectares or 75.6 % from their total quantity in the region "fall" to the enterprises of gold mining (6,073 hectares), coal industry (4,710 hectares), black and nonferrous metallurgy (1,763 hectares).

During 1991–2007 as a result of economic activities 23,469 hectares of the lands were disturbed. During the same period 21,717 hectares of the disturbed lands are fulfilled, recultivation of the area of 20,465 hectares was made (tab. 2) among which 1,409 hectares or 6.9 % of arable lands from total of the restored lands, other agricultural grounds – 2,034 hectares (9.9 %), wood plantings of 15,730 hectares (76,9 %), water reservoirs and on other purposes of 1,292 hectares (6.3 %).

In 2007 works with infringement of a soil cover of 260 hectares were done on the territory of the region. At the expense of specifications the area of the distributed lands increased by 1,169 hectares. Among them: nonferrous metallurgy – 285 hectares, coal industry – 44 hectares, gas industry – 59 hectares, geological prospecting – 576 hectares, buildings of highways – 2 hectares, other branches – 20 hectares, and also at the expense of the areas with unknown ownership – 183 hectares. At the expense of specifications the area of the distributed lands on electric power industry branches (75 hectares) and agriculture (56 hectares) decreased on 131 hectares.

In 2007 the enterprises recultivated 255 hectares of the disturbed lands from which an arable land is 11 hectares that makes 4.3 % of total recultivated lands, pastures and hay makings – 44 hectares (17.3 %), wood plantings – 176 hectares (69.0 %), industrial building, reservoirs and other purposes – 24 hectares (9.4 %). It was removed and stored 421,000 m^3 of fertile soil layer.

As a whole over the region in 2007 the area of the distributed lands increased by 1,298 hectares from which 1,137 hectares (676 hectares and 461 hectares accordingly) were on a share of Tajmyrsky Dolgano-Nenets and Evenki municipal areas.

Soil as the environment factor, can be a source of secondary pollution of underground waters, atmospheric air, agricultural production. Pollution and the subsequent destruction of soils are caused either a local influence of a source on soil, or atmospheric carrying of toxin in an aerosol phase. Chemical pollution is accumulated in soil, as well as pathogenic micro flora and helmints' eggs that creates danger for people's health.

Soil pollution on the territory of Krasnoyarsk region in comparison with indicators across the Russian Federation remains stably high. The results of laboratory researches spent by establishments of Gossanepidnadzor during 2000–2007 testify to stably high chemical pollution of soil in the of industrial buildings and road junctions (tab. 3).

The situation with pollution of soil of inhabited territories of the occupied places of Krasnoyarsk region is characterized as unsuccessful. According to microbiological indicators there is a decrease in a share of unsatisfactory tests from 25.5 % in 2004 to 9.8 % in 2007. Epidemiological situation on parasitic pollution of soil of inhabited territories is characterized as stably satisfactory; the share of positive findings during 2004–2007 did not exceed 2.8 %.

Selective researches of soil tests done on the territory of Krasnoyarsk region testify to presence of the centres of chemical pollution (tab. 4). On the separate territories of Krasnoyarsk region specific gravity of soil tests of inhabited territories not meeting sanitary norms in 2007 was: in Minusinsk area – 71.4 % (in 2006 – 40.0 %), in Krasnoyarsk – 61.5 % (in 2006 – 65.0 %), Norilsk – 12.3 % (in 2006 – 83.0 %), Lesosibirsk – 5.0 % (in 2006– 31 %).

The basic contribution (to 99.0 %) in total pollution of soil in Krasnoyarsk bring arsenic and benzapiren, excess of fluorine is emphasized. In Norilsk the raised concentrationof nickel, cobalt, lead and copper in soil is marked. In Achinsk – maximum concentration exceed nickel, arsenic, copper.

During the last years a level of microbic pollution of soils in Krasnoyarsk region is high. The reasons is absence of the general regional and territorial programs directed on reduction of production wastes and consumption, maintenance of the rational organization of systems of gathering, recycling and destruction of firm and liquid household waste, absence of the centralized system of the water drain in a number of residential areas of cities and rural settlements, presence of

Table 1

Distribution of the land of agricultural purpose in 2006–2007

The name of land (thousand hectares)	Years		Divergence
	2006	2007	
Total area, including:	8,611.8	39,865.9	+31,254.1
Agricultural lands, among them:	4,910,1	4,924,6	14,5
Arable land	2,958.3	2,958.2	–0.1
Deposit	125.3	125.0	–0.3
Long-term plantings	26,1	26.1	0
Haymakings	664.2	669.6	+5.4
Pastures	1,136.2	1,145.7	+9.5
Wood lands	2,797.4	3,656.0	+858.6
Wood and shrub vegetation	177.7	2,741.3	+2,563.6
Under water	37.6	2,985.6	+2,948.0
Building areas	23.3	24.1	0.8
Under roads	40.5	40,5	0
Bogs	130.0	7,031.6	+6,901.6
Disturbed lands	0.7	0.9	0.2
Other lands	494.3	18,461.3	+17,966.8

not authorized dumps of production wastes and consumption.

Hence, the priority direction of a policy of a sustainable development of agroeconomic system should be based on five interconnected components:

– economic regulation – use of economic tools (taxes, grants, indemnifications) stimulations of nature protection activity of agricultural land users;

– ecological education – development of ecological values among population and involving of countrymen in decision-making process;

– technique and technological policy – working out of ecological specifications and technologies, technical maintenance of nature protection activity of agricultural commodity producers;

– ecological monitoring – control over a condition of all natural components, including ground resources;

– legal and organizational state maintenance of ecological activity of the subjects of agricultural relations.

The combination of measures of state regulation and wildlife management market mechanisms in the agro economic systems should follow the principle: "disturbance of nature protection requirements conducts to reduction of profit of land users". Provision of economic incentives of nature protection actions in agrarian sphere provides two ways at present: either budgetary funds are directly allocated for it (as a rule, through federal and regional target programs) which source are payments for using the land and penalties for infringement of the ground legislation; or at the expense of the budget, losses are fully or partially compensated to proprietors of the lands caused by decrease of their incomes by transferring the lands under the state and municipal afforestations or other nature protection objects, and also expenses for use and protection of the lands are compensated.

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Table 2

Dynamics of the distributed and recultivated lands in 1992–2007

Year	Distributed, hectares	Fulfilled, hectares	Recultivated, hectares
1992	2,928 1112	1,112	1,138
1993	1,621	614	1,896
1994	1,364	1,570	1,671
1995	1,796	1,853	1,856
1996	1,493	988	1,041
1997	1,047	1,963	1,197
1998	679	950	967
1999	471	463	682
2000	621	2 538	2,305
2001	830	1,011	701
2002	1,184	1,390	1,118
2003	1,226	1,098	1,782
2004	1,226	1,241	724
2005	1,195	887	824
2006	2,484	1,031	1,072
2007	1,298	907	255
Total	23,469	21,717	20,465

Table 3

Results of researches of soil in the zone of influence of industrial enterprises and road junctions in Krasnoyarsk region in 2000–2007

Indicator	Share of the tests which are not meeting sanitary requirements, on years, %							
	2000	2001	2002	2003	2004	2005	2006	2007
Sanitary-chemical	42.9	19.4	79.5	53.3	50.0	75.0	38.0	23.8

Table 4

Results of soil research of inhabited territories of Krasnoyarsk region

Name	Share of soil tests which are not meeting hygienic specifications, %			
	2004	2005	2006	2007
Krasnoyarsk Region				
Sanitary-chemical	45.5	51.5	35	16.9
Microbal	25.5	22.9	13	9.8
Parasitic	2.8	2.3	0,8	2.6
The Russian Federation				
Sanitary-chemical	11.4	10.4	8.6	n/d
Microbal	16.3	15	14.2	n/d
Parasitic	2.6	2.4	2.1	n/d

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EVALUATION METHODS OF THE EFFECTIVENESS OF HUMAN CAPITAL USE IN THE ORGANIZATION

The use efficiency of organizational human capital is considered as a background of organizational added value implementation. The most known methods of the use effectiveness of human capital are discussed and analyzed.

Keywords: human capital, intellectual workers, use efficiency, evaluation methods.

Functioning of the modern organizations takes place in the conditions of global financial and economic crisis and is characterized, as a rule, by negative results. However, the modern business environment represents not only the crisis moment, but also a real possibility for organizations to reach the next stage of development. For this purpose, it is necessary to concider the financial crisis as a chance to reconstruct the control system and to create the effective mechanism, capable to make complicated administrative decisions in any conditions. A basis of the organization development is the company personnel, or the human capital. Investments into the human capital, capable to develop new technologies, methods of work and to transform them into an attractive commercial product, are admitted by leading world corporations and scientists to be the most favorable ones to increase the enterprise competitiveness. The market success more and more depend on business orientation for the client, the unique commercial offer, but in particular on the efficiency of the organization personnel use that demands adequate methods of human capital evaluation that is poor studied. The present article is dedicated to the problem consideration.

Nowadays the human capital is understood as a body of knowledge, practical skills and creative abilities of the company employees, directed to perform current tasks. The other components are moral values of the company, workmanship and general approach to business. Today the human capital value is defined by the fact that technical, technological and financial possibilities of the enterprises and the countries cannot be a competitive advantage any more. There are not any serious restrictions in purchasing the technologies or capital formation. The main restriction of any business now is a human resource; therefore, it requires constant development, control and creating conditions for effective use. The role of the human factor increases because of the increasing share of branches and scope of action based on a high skilled labor: the fast-growing high technology sector of the industry, the service sphere, which share growth became an appreciable branch shift in the modern economy, including the domestic one. Besides, the increase of interest to the human capital is connected with the transition of many countries to the new type of economy – the economy based on knowledge.

In the conditions of economy of knowledge, traditional management methods do not always show the efficiency. There is a necessity to consider the new manufacture factor – the intellectual capital embodied in the organization personnel or in intellectual employees. The value of intellectual employees in a modern organization is defined by:

– they are a considerable share of the personnel;

– they create competitiveness of the organization;

– they are a key source of development.

Inapplicability of traditional management methods and the necessity of their updating is connected with the intellectual employee's characteristics:

– handling the information and knowledge in work and the ability of their processing into finished products, new knowledge;

– independence of professional activity from the means and conditions of production;

– personal identification more with the profession than with the particular organization or workplace;

– poor working control because of selling the results of the intellectual activity to the employer whereas the achievement process is hidden;

– in many aspects differs by uncertainty and simultaneously supposes various variants of problem solving;

– considerable social mobility;

– high ability for self-organization, therefore their autonomy and independence do not cause damage to the company, on the contrary, the increase in the share of such employees in the organization reduces for the need in managers;

– priority of intellectual development, instead of maximization of personal wealth etc.

The category of intellectual employees usually includes programmers, lawyers, designers, advisers, experts, analysts, experts in marketing and representatives of other professions capable to create a finished product without any physical means of production and the enterprise. The importance of this employee category for the organization and their characteristics initiate the search for new administrative influences on intellectual employees, including the definition of evaluation methods of the intellectual employees' use efficiency, as of the basic part of the modern organization personnel.

The resources limitation, basic for necessary performance of effective processes, is a challenge for those spheres of the economy which enterprises found their activity on the use of human resources, in the first place, the high technology branches, because in this area the use of more qualitative and, accordingly, more limited resources is required. All abovementioned concerns, first, the expenses of human labor and the finance as maintenance of such activity demands qualified employees and big capital expenses. Hence, it is necessary to evaluate all assets of the organization needed for the corporate purpose achievement.

Before analyzing methods of efficiency evaluation, it is necessary to specify the concept of "efficiency" in the authors' interpretation. Efficiency is a relative effect, the process potency, defined as the relation of effect; result to costs, expenses providing its obtaining.

Now there are a lot of approaches and methods for evaluation of personnel management efficiency. Let us consider the main ones and analyze them from the point of view of applicability to intellectual employees.

The basic methods of intellectual work evaluation, used in practice, may be divided into three groups: quantitative, qualitative (or descriptive) and combined (or intermediate) ones.

Quantitative methods of evaluation include mark, coefficient, methods, the method of rank order, the method of pair comparisons, the system of graphic profile, the method of «experiment», etc. Qualitative (descriptive) methods include the system of oral and written characteristics, the standard method, matrix and biographic methods, the method of a group discussion. The examples of the combined methods are the method of stimulating evaluations, groupings of employees, testing. The following methods are the versions of combined ones, combining quantitative and qualitative evaluations.

The evaluation of "360 degrees". The evaluation of "360 degrees" is data acquisition about the person's actions in real working situations and about shown professional qualities. The information thus, is received from the people communicating with this person at different levels: the chief, colleagues, accessory manufacturer, and clients. Getting information from the people co-operating with the evaluated employee at his workplace makes the evaluation "360 degrees" a reliable enough tool. The applicant for the post can be enlisted as the expert: he is asked to evaluate his professional qualities to use these data further to correct his self-appraisal and create the plan of his individual development in common.

Many west oriented companies use a five-point scale for evaluation of business qualities of the personnel with the following description:

5 – skill level, allowing to show this quality in super difficult conditions, to develop its standards and to train others;

4 – level of expanded experience, allowing to show this quality not only in standard, but also in difficult conditions;

3 – level of basic experience, allowing to show this quality in the majority of working situations;

2 – level of development when this business quality is shown far not always, but the employee already understands the importance of its manifestation and tries to develop it;

1 – this quality is not shown.

Evaluation method according to decisive situation. To use this method the experts on evaluation prepare a list of descriptions of employees' "correct" and "wrong" behavior in typical situations – "decisive situations". These descriptions are divided into subdivisions according to kind of work. Further, the expert prepares a registry for every evaluated employee where he/she records behavior examples for every subdivision. Later this registry is used for evaluation of the employee's professional qualities. Usually this method is used in evaluations, which are made by the chief, not the colleagues and subordinates.

Method of rating behavioral instructions. It is based on using "decisive situations" from which the required professional and personal qualities that become criteria of the evaluation are deduced. The estimator reads the description of some evaluation in the rating questionnaire criterion (for example, engineering competence) and puts a mark in a scale according to the evaluated employee's qualification. The method is expensive and labor consuming, but accessible and clear for employees.

Method of supervision over behavior scale. It is similar to the previous one, but instead of the employee's behavior definition in a current decisive situation the estimator fixes on a scale the quantity of cases when the employee's behavior has been unusual earlier. The method is labor consuming and requires essential material costs.

Method of questionnaires and comparative questionnaires. It includes a set of questions or descriptions of the employee's behavior. The estimator puts a mark opposite to the description of that trait which, in his opinion, is inherent to the employee, otherwise leaves a blank space. The sum of marks gives the general rating of this employee's questionnaire. Leaders, colleagues and subordinates use it for evaluation.

Interview. This technique is borrowed by HR departments from sociology and can include those methods of evaluation, which are up-to-date in the organization at the moment.

Self-appraisal. Self-appraisal is a process by means of which people "measure" their own efficiency, skills, abilities and other qualities. Companies use the self-appraisal method

as a part of techniques for overall performance, the evaluation-360 and even in the course of selection. Approximately 5 % of the American companies use some kinds of self-appraisal as a part of evaluation process of overall performance of their employees. For example, some law enforcement bodies use the self-appraisal method as a part of evaluation process of their employees as very often they work alone and nobodycan evaluate their work by some criteria. In other companies the self-appraisal method is used to gather initial information for the chief who is going to evaluate overall performance of employees. Other companies compare and discuss the results of the employees' self-appraisal and evaluation of the same employees by the chiefs.

As a whole, among all the variety of methods of personnel use evaluation quantitative methods of intellectual labor evaluation are mostly widespread, especially the mark, coefficient and mark – coefficient methods. Their advantages are objectivity, independence from the experts' personal relation to the employee, possibilities of result formalization, parameter comparison, result ordering and use of mathematical methods [1].

The efficiency of personnel management is defined, proceeding from volume, completeness, quality and timeliness of performing the functions assigned to employees. Corresponding criteria and indicators are necessary to define the level of personnel management efficiency. Choosing evaluation criteria it is necessary to consider, first, what problem solving evaluation results are used for and, second, what employee category the criteria are established for, taking into consideration that they will be differentiated depending on complexity, responsibility and character of the activity Performance of established standards or service standards with appropriate quality of work and decreasing the costs arising because of increased staff turnover, unreasonable idle times, etc can be used as criteria in the field of personnel management efficiency.

Thus, the personnel management efficiency evaluation consists of two components: the economic efficiency characterizing achievement of the company purposes using the personnel based on the principle of economic expenditure of available resources, and the social efficiency characterizing the degree of need expectation and interests of the wage laborer.

Some economists suggest considering the following as the components of economic efficiency of personnel management:

– parity of work results and the personnel costs, considered from the point of view of the set organizational purposes;

– the components reflecting the contribution of the personnel into long-term development of the organization. They include stability that affects continuity of staff, reliability of employees' work, absence of intensity and conflicts; flexibility that means the personnel's ability to adapt for new conditions, to promote organizational changes and to be ready to conflicts if it is necessary for implementation of innovative concepts.

Overall, success of the organization activity assumes the most effective usage of all available resources, first of all, human assets. However, the ways of effective usage of human assets differs radically from other resources usage as in this case it is provided with people's motivation or influence on their purpose. Specificity of intellectual employees' motivation is that their purposes and interests include both economic and creative components. The motivation of the intellectual employee depends on his/her efficiency, i. e. on his/her ability to reach the target. If his/her work loses efficiency, very soon the desire to work and to be of benefit disappears [2]. So, increasing efficiency of human capital use should become a priority direction of the modern organization management.

Complexities of the human capital efficiency evaluation are connected with its differences from the physical capital. Therefore, the manual worker shoul provide effectiveness, productivity, i. e. he should be capable to carry out the tasks correctly, but their adequacy does not refer to him. The manual worker's activity can be evaluated according to the quantity and the quality of the product. The brain worker does not produce physically felt finished articles that can be easily accounted according to their quantity and quality. The brain worker's product is knowledge, ideas and its practical implementation is possible when someone will use it to achieve particular results. In other words, the employee engaged into some intellectual activity, should give efficiency to his/her work (and not only his/hers, but also his/her colleagues' work results). In turn, the efficiency of the intellectual employee embodying the human capital of the organization is expressed in his ability to solve its actual problems, and the way of increasing the organization success is increasing of such employees' efficiency.

The changes also concern such a traditional indicator of personnel use efficiency, as labor productivity. Therefore, productivity of the intellectual employee is defined by the following factors:

1. Productivity requires the answer to the question: "What is the production target?" – as specificity of intellectual work means definitely the end result, for example, the design project, and the problem to achieve this result is usually assigned to the employee. In other words, he has to set the production target to himself.

2. The employee bears full responsibility. Intellectual employees should manage themselves and they need independence to perform their duty.

3. Continuous innovative activity should become an integral part of mental work and be included into a brainworker's production target; he/she should be responsible for introduction of innovations as changes and improvements are an attribute of creative activity.

4. On the one hand the brainworker should study constantly, and on the other – to learn constantly. The reason of the first activity is the motivation of self-improvement and development, and of the second one – the excess of the intellectual employee's knowledge level in the organization and the necessity to pass on a part of his knowledge to his/her colleagues for productive functioning of the department and the organization as a whole.

5. The brainworker's productivity is not defined by quantity or volume. At any rate, it is not the main criterion. The basic measure of productivity of the intellectual employee is the quality of the set task solving [3].

Thus, the abovementioned evaluation methods of efficiency of human capital use of the modern organization, namely, of intellectual employees as its basic part, their special features and the complexities caused by these features, testify to the necessity of further research of this problem to update the evaluation methods and to maintain more successful functioning of the organizations at the expense of effective use of their human capital.

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COST ESTIMATION INFORMATION SYSTEM OF APARTMENTS AT SECONDARY HOUSING MARKET AS A MANAGEMENT INVESTMENT TOOL

The aspects of objects' investments appeal are studied. The basic estimation methods of the real estate market are analyzed. A method of information system construction objects' cost estimation of investment is proposed.

Keywords: investments, information systems, modeling, estimation of real estate cost.

The main goal of the research is to study the database management for selling one-bedroom apartments in Krasnoyarsk, to estimate the objects' cost in real estate market, and to create competent investment capital.

The most consistent definition for investment is a long-term placement for the investor's future welfare. The main purpose of investing is seen as an attempt to achieve a final result (welfare), expressed in monetary terms.

In other words, the degree of investment efficiency is determined by the comparison of resource flows expressed in the form of cash and results of its use.

This process of comparison in general economic practice is called investment analysis or the analysis of investment effectiveness.

The process of analyzing investments is typically devoted to the following objectives:

– identification of economic investment feasibility, i.e. the identification of the absolute excess of the nested resource results;

– identification of the most effecient alternative investments;

– identification the most efficient portfolio.

In the majority of cases, to analyze the investment means to justify the investment decision, to be taken by the investor.

The advantages of real estate investing. According to the information provided by VCIOM, most inhabitants of Russia (51 %) deem to think that the best investments are in real estate purchase. This leaves behind the acquisitioning of gold and jewels – 19 % and money deposits in SberBank (17 %). Even during the financial crisis, the Russian real estate market was least exposed to devaluation. Investment in real property is always investment in real assets.

The term "investment (placements) in real estate" is often understood as the acquisition of finished residential or nonresidential facilities that are bought for the resale purposes. This definition does not include real estate, bought for immediate use by the buyer, for example, for housing or business (with the exception of rent).

In addition the acquisition of unfinished projects isn't an investment in real estate, in this case it's investment in construction. Advantages of investment in real estate for clarity will be given in comparison with bank deposits and securities, such as shares in companies, mutual funds, etc.

The main and indisputable advantage of investment in real estate is its reliability. A bank may be ruined; a company's purchased shares can fail. Real estate risks are significantly less. It is impossible to lose, it can not be stolen, defaults and other economic shocks can only slightly change its price, which is usually temporarily. It is subject to risks, caused by natural disasters; is also at risk by recent judicial proceedings, involving environmental legislation violations (in greater extent this applies to houses).

Another fact, which makes investment in real estate attractive as a possibility of savings, is an extremely rapid increase in its value or, as experts say – rapid capitalization. What was bought last year, today costs half, and sometimes twice as expensive, depending on the location. The analysis of the price of a housing square meter in major cities shows that the capitalization of urban apartments has an average of 65 % per year increase. Not all successful companies can boast about such income increase. It is also important not to forget that real estate may bring an additional stable income, for example, if it is being leased. Resource increase in rental rates is

sufficiently larger. However, we can ask a question of what is better in real estate investing?

The definition of object investment attractiveness for the real estate market. Investment attractiveness of property is determined by the ratio of investment and the market value of an object (the price for which the object can be sold is understood as the investment cost dependence).

The attractiveness of property is affected by the following factors: risks, which are to be faced, the level of demand, the ratio of projected outcomes and costs, the level of competition, the duration of the project, as well as the needs for capital.

Several other factors directly affect the investment value of the object. First is the location parameter, which determines the degree of relevance of the building pillar in the future. It includes:

– prestige of the district;
– social environment;
– infrastructure: transport and social facilities;
– ecological situation in the region.

There are also some more important factors such as architecture, design and space planning solutions, as well as the technical condition of the building and characteristics relevant to the object itself, for example, the house and an apartment:

– architecture and specialness of the project;
– external attractiveness of the building;
– apartment planning;
– ceiling height;
– number and size of apartments in the house, on a floor;
– technology of the construction;
– materials bearing and protecting designs;
– finishing of the facade and public areas;
– house engineering: plumbing and electrical equipment, waste disposal, air conditioning, air ventilation, elevators;
– home infrastructure: size, landscaping and fencing area, security, parking lot, social infrastructure, service components, the condition of the entrance;
– physical wear and tear of the house, noise, clean air and water;
– characteristics of the apartment windows;
– presence of loggias, balconies in the apartment;
– the stage of construction, completion [1].

The factors aforementioned will determine the investment attractiveness of the property value.

The main methods of investment project evaluation. In world practice, the methods generally used for assessing housing are based on economical factors (personal income, population, the state securities market, etc.), as well as on the technical features of the object itself (conditions of windows, doors, the house in general, etc.). Recently for the residents of more developed cities have been effected by the location factor, this says that the dispersion of prices in the markets of primary and secondary housing market in one area is not great. Ten years ago, researches in the Krasnoyarsk region have shown the importance in assessing the value of the apartment.

Generally there are three approaches, to obtain results of the object value.

The cost approach is based on the principle that an informed buyer would pay a price greater than the cost of rebuilding the property having a value, which is the same for the property being under consideration. This approach requires the definition of several types of the estimated assets wear: physical, functional and wear and tear, received as a result of external influence or economic obsolescence. Also, the calculation with "model" estimates, SNIP, etc. taking into account all the actual additional costs, determined as a composite demand of the building in general and isolating the cost per unit area of the apartment leading to a large error in calculations.

The comparative approach is based on the principle that a well-informed costumer does not pay for the property more than the purchase price of another property which has equal value. This approach serves to assess the market value of the project volume, based on the data from the market transactions. Comparable objects, which were sold or at least, offered for sale, are considered. After that, adjustments which are made for differences – so-called corrections, which exist between the assessed and comparable objects, are to be made. An adjusted price allows to determining of the most probable selling price for the estimated object as if it was offered in an open and competitive market.

In a "passive" sales market, some conclusions can be drawn from the information of price proposals, which characterize the existence of the markets, offering such facilities.

The main problem of the comparative approach is the difficulty in obtaining necessary information, the choice of an analogue, which is adequate in assessing the object, taking in account the mismatch degrees and the numerical values of the analogue characteristics and estimated objects. If sufficient information is accessible, it is efficient in the framework of this method to justify by the construction and the use of a statistical model or parametric pricing models, expression-mental dependence of the average price of the object on the composition and values of its technical characteristics.

The income approach can define the cost of income-producing property by means of calculating the amount, quality and duration of benefits' receipt so, that this facility will bring over the forecast period. As a result of expected future income from property analysis and the income from sales at the end of the projection period, the valuation date to the current value is discounted. The income approach is based on the expectations principle, according to which the potential purchaser concludes the property value, depending on the expected returns, which can be obtained in the future from the property ownership. This approach analyzes the possibility of real estates to generate some income, which is usually expressed in the form of income from exploitation and income from a possible sale at the end of the ownership period. In relation to the object of evaluation it could hypothetically suggest that it is not acquired as an "apartment for living", but as an object for profit retrieval by putting it in the lease and subsequent (possible) sale [2].

The incorrectness of the income approach is primarily detected by the fact that the apartment will be used exclusively for residential purposes, so the future owner does not plan zero tolerance to lease it for profit. Lease Agreements, in the vast quantity of cases are not registered

anywhere; payments is made in such payments, which are not considered as a monetary transaction by the government, making it difficult to gather reliable information on the amount of rent and rental rates for similar objects.

In this study we have constructed models based on the method of sales comparison.

Developing an information system for evaluating investment objects. The main objective of the research is the calculation automation of single room apartment's evaluation in Krasnoyarsk.

The housing market of Krasnoyarsk was chosen as a substantive research field. We have studied only one-bedroom apartments at the secondary housing market due to the extremely large issue.

Despite the fact that housing markets vary depending on their geographic location, the general idea of modeling can be used for different cities. We must keep in mind that each city should be separately studied.

The cost analysis of one-bedroom apartments selling in January of 2009 showed that the distribution is close to normal, while there is the presence of right-sided asymmetry (the right branch of the maximum ordinate longer than the left). This means that there are apartments, with both high and low values with a homogeneous market.

Most of the apartments' prices vary from 1,150 to 1,850 thousand rubles. This shows that the bulk of the market furnished apartments is less than the average value of 1,681 thousand rubles. Usually the reasons for this are differences in location. Only a small share of the market accounted for residential facilities, designed to meet high customer demands and apartments that have low consumer properties. These apartments are large and are situated in elite parts of the city.

To calculate the cost of apartments in January 2009, we need to build models with the application of regression analysis to determine the significance of parameters.

We have adapted three models, used in world practice:

The additive model:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + \\ + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12}. \quad (1)$$

The multiplicative model:

$$Y = b_0 \cdot X_1^{b_1} \cdot X_2^{b_2} \cdot X_3^{b_3} \cdot X_4^{b_4} \cdot X_5^{b_5} \cdot X_6^{b_6} \times \\ \times X_7^{b_7} \cdot X_8^{b_8} \cdot X_9^{b_9} \cdot X_{10}^{b_{10}} \cdot X_{11}^{b_{11}} \cdot X_{12}^{b_{12}}. \quad (2)$$

The combination model:

$$Y = X_1^{b_1} + b_0 \cdot X_2^{b_2} \cdot X_3^{b_3} \cdot X_4^{b_4} \cdot X_5^{b_5} \times \\ \times X_6^{b_6} \cdot X_7^{b_7} \cdot X_8^{b_8} \cdot X_9^{b_9} \cdot X_{10}^{b_{10}} \cdot X_{11}^{b_{11}} \cdot X_{12}^{b_{12}}, \quad (3)$$

where X_1 is the prestige factor of the area. Possible values are represented in table [1].

X_2 is the apartment planning. Values of a variable defined for the apartment type "khrushevka" ($X_2 = 1$), "leningradka" ($X_2 = 2$), "improved planning" ($X_2 = 3$), "stalinka" ($X_2 = 4$), "new planning" ($X_2 = 5$), "individual planning" ($X_2 = 6$).

X_3 is the variable for the material out o which walls are built. The samples included apartments, the wall material from a monoblock piece ($X_3 = 3$), concrete panel ($X_3 = 1$), and brick ($X_3 = 2$).

X_4 – the floor. We used two groups of apartments, depending on the floor – apartments on the first floor and those on the top ($X_4 = 0$), as well as apartments on the other floors ($X_4 = 1$).

X_5 – amount of stories.

X_6 – the total area in m^2.

X_7 – living space (living rooms, bedrooms) in m^2.

X_8 – kitchen space in m^2.

X_9 – presence of a telephone line. If there is one – $X_9 = 1$, if not – $X_9 = 0$.

X_{10} – water closet. Combined – $X_{10} = 1$, separate – $X_{10} = 2$.

X_{11} – balcony/loggia. If there is a balcony and a loggia – $X_{11} = 3$, only a loggia – $X_{11} = 2$, only a balcony – $X_{11} = 1$, neither are present – $X_{11} = 0$.

X_{12} – cooker. Electric – $X_{12} = 2$, gas – $X_{12} = 1$, none – $X_{12} = 0$.

Y – apartment price in thousands of rubles.

$b_0 \ldots b_{12}$ – coefficients of regression.

We have obtained these results, using the given information:

For the additive model:

$$\begin{array}{lllllll} Y & = 153{,}308 & + 47{,}699X_1 & + 59{,}832X_3 & + 27{,}947X_6 & + 23{,}236X_8 & + 99{,}695X_{12}. \\ & (64{,}000) & (3{,}530) & (18{,}145) & (2{,}366) & (7{,}400) & (10{,}171) \end{array} \quad (4)$$

For the multiplicative model:

Coefficients of prestige of districts

Rank	Name of district	X_1
1	Akademgorodok	7.68
2	Center – Severniy – Kopylova St. – Zheleznodorozhnikov St.	7.09
3	Vzletka	6.07
4	Studgorodok – Predmostnaya Sg. – cinema "Yubileiniy"	5.19
5	Vetluzhanka	3.87
6	Kosmos – L. Ketshoveli St. – Krasnomoskovskaya St.	3.54
7	Regional hospital – BSMP	3
8	Svobodniy	2.71
9	Zelenaya Roscha – Solnechniy	2.73
10	Zaton – Pokrovka	2.41
11	Kalinina St. – Severo-Zapadniy – Pashenniy	2.04
12	Torgoviy center – Rodina – TUZ – Sputnik – Ocean – Badgey	1.42
13	Cinema "Enisey" – "Enisey" station	0.93
14	Pervomayskiy – Zlobino	0.8
15	KrasTEC	0.25
16	Vodniki	–1.11
17	Cheremushki – Energetiki – Shinniki	–1.98

$$Y = 119{,}845 \cdot X_1^{0{,}033} \cdot X_3^{0{,}080} \cdot X_6^{0{,}617} \cdot X_8^{0{,}144} \cdot X_{10}^{0{,}051} \cdot X_{12}^{0{,}082} \quad (5)$$
$$(17{,}195)\quad (0{,}004)\quad (0{,}017)\quad (0{,}052)\quad (0{,}039)\quad (0{,}021)\quad (0{,}011)$$

For the combined (mixed model):

$$Y = 46{,}846 \cdot X_1 + 98{,}379 \cdot X_3^{0{,}062} \cdot X_4^{0{,}039} \cdot X_6^{0{,}671} \cdot X_8^{0{,}114} \cdot X_{12}^{0{,}117} \quad (6)$$
$$(3{,}540)\quad (14{,}719)\quad (0{,}017)\quad (0{,}019)\quad (0{,}055)\quad (0{,}039)\quad (0{,}012)$$

The data for single room apartments in Krasnoyarsk was obtained from sites of real estate companies in the city (URL: http://gilcom.ru/objects/sale?page=6; http://www.profdom.ru/search_variants). This was a compilation sample file in Microsoft Office Excel, containing information of about 2,000 apartments. For data processing an application in Visual Basic had been made. This program removed all incorrect data from the initial table. So, the study involved 1,060 one-room apartments in Krasnoyarsk. The developed program can also convert qualitative data into quantitative.

A regression analysis was conducted, using computer programs STATISTICA 6,0 and EViews 5,1 determined the factor significance.

An adequacy check for each regression equation was performed; it included:

– calculation of the F-statistic (the Fisher criterion);

– calculation of the determination coefficient, R-square;

– checking the conditions of the Gauss–Markov.

The studies have shown that the most appropriate and relevant models, which have unbiased estimates of the coefficients, are the additive and combined models. The most significant factors effecting the price of the apartment are:

– the coefficient of district prestige – it is always the most important factor;

– the construction materials (quality of the property);

– the total area of the apartment;

– the kitchen area;

– the cooker type – a factor, effecting the apartment safety.

The regression model results have shown that there were parameters excluded from the features of objects, such as the apartment planning and living space because of their insignificance.

The Informative System "Apartments" had been created, allowing the automation of calculating the cost of an apartment in the selected model evaluation.

Its main advantage is the interaction between developed applications with software products such as STATISTICA and EViews. It improves the accuracy of the calculations, and furthermore eliminates the need for users to understand the interface of statistical analysis.

The program has the following structure of referenced data:

– general directories that contain the numeric equivalents of apartment qualitative parameters. Data from these same directories was used in the calculations.

– Directories containing the model for calculating the housing prices.

Applications automate the management and data processing. This way it is possible to isolate and refine the two function subsets: implementing the service functions and implement the basic functions of information processing.

Services include:

– user authentication;

– maintaining of the calendar, which is used when creating reports.

The main functions include:

– maintenance of manuals;

– options to edit the database, including entering and deleting information;

– searching;

– sorting;

– creating a report in the calculation of the cost;

– exporting of the database into Excel.

If it is necessary the user can add other options in the directory (the variables in the model), pre-coded qualitative information into numerical values. Simulation will take place on the same principle.

The main advantage of IS "Apartments" is an opportunity to recalculate the model, as well as user-defined factors influencing the value of the property, based on available databases.

Cost-effectiveness from the use of IS «Apartments» reduces the annual market-rate of work factor to 98,7 %. Payback period for implementation is 9,5 months [2].

The results can be used by realtors agencies, professional real estate assessment, City Department of Real Estate, tax authorities and individual citizens.

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THEORIES OF ESTIMATION OF DIFFERENTIATION FOR REGULATION OF SOCIAL-ECONOMIC DEVELOPMENT OF THE CITY AGGLOMERATION

Theories of estimation of differentiation of social-economic development of territorial units in city agglomeration are discussed in the article. Approbation of the given methods helped find out successfulness of the regulation of municipal development of administrative-territorial units in Krasnoyarsk agglomeration, set the goals of regional policy on peculiarities of development of the phenomenon of differentiation.

Keywords: regulation, social-economic development, city agglomeration, estimation of differentiation.

To determine successfulness of regulation of social-economic development of administrative-territorial units (ATU) in city agglomeration (CA), to set the goals of regional policy according to peculiarities of development of the phenomenon of differentiation of social-economic development of ATU in CA is possible only at trustworthy estimation of the situation which allows the mechanism of regulation of social-economic development of ATU to function in CA. The given approach lets estimate and analyze differentiations of social-economic development of ATU in CA at three stages, each stage is focused on solving the specific tasks (fig. 1).

At the first stage complex estimation of the level of social-economic development of ATU in CA is conducted. Comprehension of the problems of social-economic development of ATU in CA and working out the ways of solving them become possible when using the data achieved during the analysis of social-economic condition of the unit and revealing the degree of correspondence of factors with the criteria of regulation of social-economic development of ATU in CA. It allows to bring out disproportion and not used possibilities of social-economic development of ATU in CA for further grounding of the choice of regulations means.

As individual index of social-economic development of ATU in CA have different measurements, it is necessary to build integral exponent intending transition to uniform characteristics on the basis of methods of multimeasure assessment. Calculation of the coefficient of deviation of basic indexes of ATU in CA from corresponding indexes of supporting "point of growth" is done with the following formula:

$$X_{ik}^{j}(t) = x_{ik}^{j}(t) / x_{ik}^{n}(t),$$

where j – number of ATU in CA; i – number of the group of indexes; k – number of the index in the group; x – value of index of supporting "point of growth" in CA (criteria of regulation), x – value of index of ATU in CA, t – period of time.

Then integral index of the level of social-economic development of ATU in CA is calculated with the formula:

$$Y_{k}^{j}(t) = \sum_{k=1}^{n} X_{ik}^{j}(t) / n,$$

where n – quantity of indexes in the group.

In the capacity of the main criteria for making decision on support of ATU in CA grouping of ATU according to the level of development is often used. That is why at this stage grouping of ATU in CA according to the level of development is conducted. This helps determine the group of areas with different levels of development (tab. 1).

The given grouping is very important for the choice of ATU in CA using the coefficient of differentiation D_{ik}, defined as ratio of maximum value of the coefficient of deviation of basic index of definite ATU (x^{j}_{ik}max) to minimum value of the coefficient of deviation of basic index of another ATU (x^{j}_{ik}min):

$$D_{ik} = x_{ik}^{j}\ \max / x_{ik}^{j}\ \min .$$

Noting sufficient and constantly growing differentiation of social-economic development of ATU in CA, it is necessary to mention that difference in their development leads to instability, enhances susceptibility of the system to external fluctuations. However, differentiation of social-economic development of ATU in CA is not a threat to the existence of CA as a whole system, and is not an important condition of its development. So presence of differentiation does not say about regression or progress of social-economic processes, it only shows instability of the system and possible changes.

At the same time, for determination of the level of differentiation of social-economic development of ATU in CA it is offered to calculate the coefficient of non-uniformity $K(x,y)$, worked out on the basis of the formula calculating of the coefficient of proportional identity of Imbry–Pardy ($R(x,y)$):

$$K(x,y) = (1 - R(x,y)) \cdot 100\%,$$

$$R(x,y) = \frac{\sum_{i=1}^{n} X_i \cdot Y_i}{\sqrt{\sum_{i=1}^{n} X_i^{2} \cdot Y_i^{2}}},$$

where X_i and Y_i –values of indexes ADU X and Y; n – quantity of indexes used in calculation.

The given coefficient allows to compare two ATUs in CA along the whole complex of indexes. The closer the index of the coefficient to zero, the more similar ATU which are compared according to the level of social-economic development. Zero index shows that characteristics of social-economic development of ATU are identical or their changes happen proportionally for all indexes which are used in the calculation. Building the rating estimation with the help of the coefficient of heterogeneity lets find out similarity of ATU according to indexes and directions of social-economic development.

The third stage is used to assess needs and possibilities of diminishing of differentiation of social-economic development of ATU in CA. It is connected with determination of the characteristics of instability of social-

Table 1

Grouping of ATU in agglomeration according to the level of development

Level of development of ATU in CA	Deviation from supporting "point of growth", %
High	20
Medium	20–40
Low	40 and over

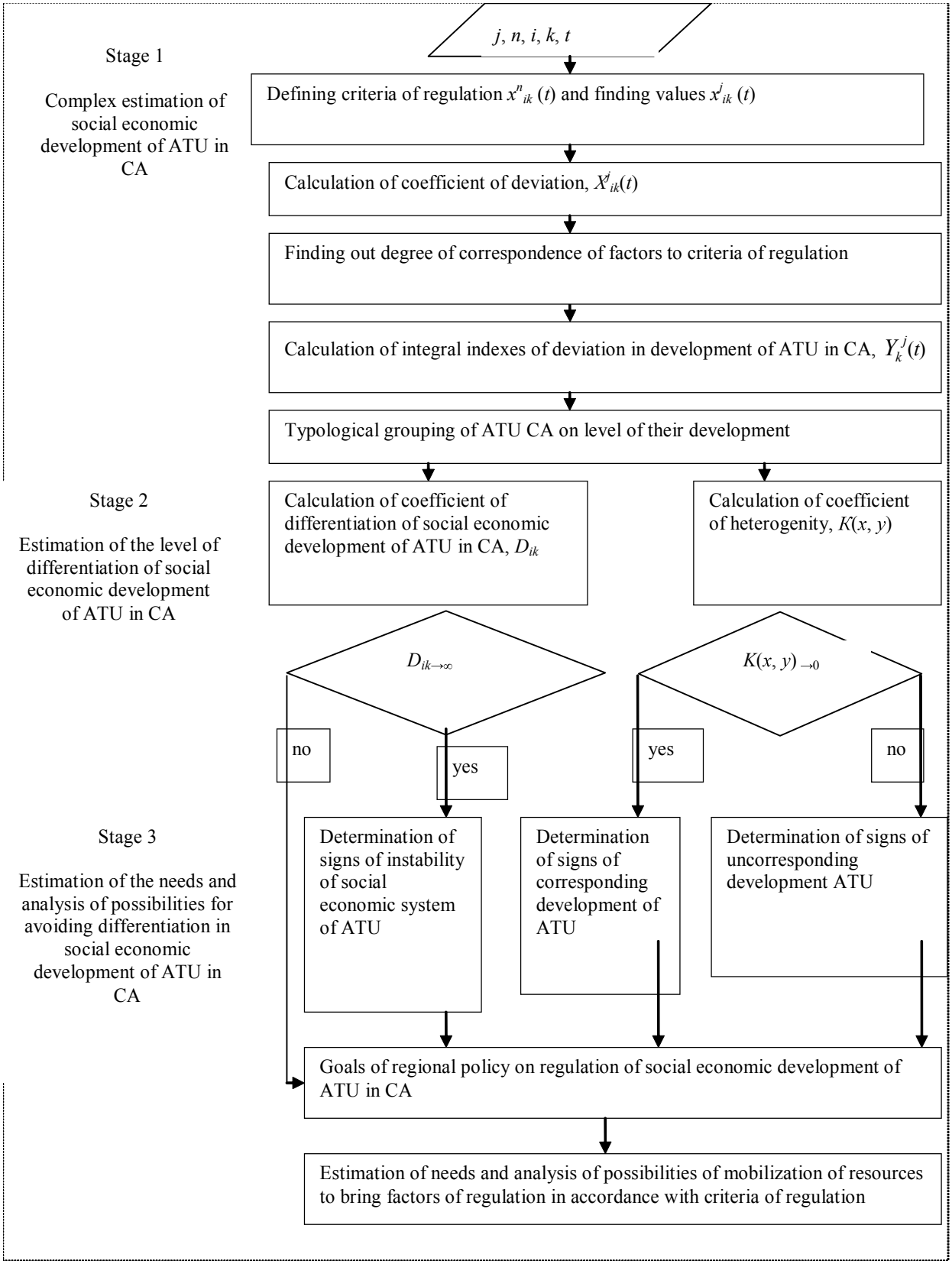

Fig. 1. Algorithm of methods of estimation of differentiation for regulation of social economic development of ATU in CA

economic development of ATU, and also defines characteristics of coordinated and uncoordinated development of ATU. The result of the third stage is assessment of needs and possibility of mobilization of resources to lead factors of regulation in accordance with criteria of regulation.

Such approach gives an opportunity to see the dynamics of growth of ATU in CA, changes of its main parameters, predict and prevent negative changes. It helps find out factual results of regulation of social-economic development of ATU in CA.

Using this approach the authors estimated differentiation of the level of municipal economy development of ATU in Krasnoyarsk agglomeration (KA). During the period 2005–2008 coefficients of deviation of basic indexes of ATU in KA were calculated. On the basis of received coefficients integral indexes of the communal development of ATU in KA were defined (fig. 2). Conducted calculation showed that according to the indexes of the level of communal development of AT Sosnovoborsk is on the first place among ATU in KA, Divnogorsk is on the second place.

Estimation of the level of communal development of ATU in KA allowed to find out groups of ATU with medium and low levels of development. Therefore Sosnovoborsk and Divnogorsk were referred to ATU with medium level of communal development; the rest territories have low level of development. It was also discovered that there are no essential changes in the level of communal development of ATU in KA. It let us make a conclusion that there is no effective regional policy.

Estimation of the level of differentiation showed considerable disproportioning in the level of communal development of ATU in KA: coefficient of differentiation is 40 %. This fact gives evidence of absence of balanced communal processes among ATU and of low results of structural policy of ATU in KA.

To find similarity or differences in communal development, ATU were compared in pairs on all parameters (tab. 2). System of indexes was taken into account at the calculation. Their dynamics shows communal economy of the territories. According to the results Divnogorsk and Sosnovoborsk, having the lowest coefficients of heterogeneity, considerably differ from other ATUs in KA. That fact that supports the results of studying their location with the help of integral indexes and demonstrates the greatest homogeneity with the indexes of Krasnoyarsk. Coefficients of heterogeneity in the pairs Emeliyanovskiy territory – Bereysovskiy territory and Sukhobusimskiy territory – Manskiy territory are close (0.8 and 0.7). The received coefficients show similarity in indexes and tendencies of development.

After estimation of differentiation of the level of communal development of ATU in KA it was found out that territories with medium level of communal development have essential agglomeration potential. The goal of the policy of regulation of communal development in these cities should be connected with development of their personnel and resources potential. In future these territories can also give essential growth of their own taxes basis. Territories with low level of development are

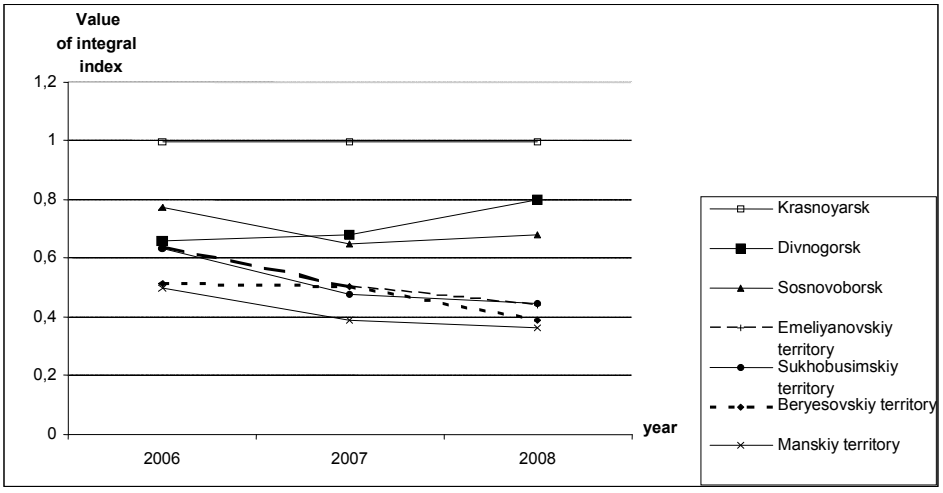

Fig. 2. Dynamics of deviation of integral index of ATU in CA from integral index of supporting "point of growth"

Table 2

Coefficients of heterogeneity of communal development of ADU in KA

	Coefficients of heterogeneity						
	Emeliyanovskiy territory	Sukhobusimskiy territory	Beryesovskiy territory	Manskiy territory	Krasnoyarsk	Divnogorsk	Sosnovoborsk
Emeliyanovskiy territory	–	–	–	–	–	–	–
Sukhobusimskiy territory	0.8	–	–	–	–	–	–
Beryesovskiy territory	0.8	0.6	–	–	–	–	–
Manskiy territory	1.0	0.7	1.3	–	–	–	–
Krasnoyarsk	4.2	5.5	4.3	5.7	–	–	–
Divnogorsk	2.3	3.1	1.2	3.4	3.2	–	–
Sosnovoborsk	2.5	2.4	1.7	3.1	2.5	0.7	–

characterized by low development of communal infrastructure. In future these territories will need budget support. This situation requires constant monitoring. There are almost no internal reserves of communal development and taxes basis in the territories. It is necessary to work out mechanisms to attract investments. The main projects in this case are importance of development of modern engineering infrastructure of agglomeration including such facilities and services as energy and heat supply, sewerage, and water supply.

Data obtained after estimation of differentiation of communal development of ATU in KA must become informational basis for making managerial decisions in realization of regional policy.

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DEFINITION OF PARTICIPANTS OF THE INVESTMENT PROJECT

For success of any investment project its careful planning is necessary. For this purpose it is necessary to consider interests of all persons which can affect its execution and results. Such persons form a social network of the project, some aspects of definition of such network are described in the present article.

Keywords: investment project, a monetary stream, social network.

Recently the term "the investment project" is used frequently. It means that the company gives great significance to the development of the manufacture, new manufacture, or gets assets, and expects to receive thus positive monetary stream or other material and non-material benefits.

There is a set of ways to estimate investment projects, one of them is the way of estimating the net present value of the project. However from the point of view of terminology in some cases use of the term "the project" is incorrect.

There are some definitions for what project is. The widest one is "limited on time and the unique actions focused on achievement of a specific goal".

The requirement of uniqueness differentiates projects and usual operational activity, and does not mean that the given actions are absolutely innovative. Actually it denotes that within the given time interval, with such purpose and such restrictions the actions are carried out unitary.

As for the project limitation on time, it is important that there are fixed dates of the project beginning and ending. Without precisely certain limits of time it is not possible to plan resources, including financial ones, and also impossible to make up the schedule of works.

The most important attribute of the project is the purpose (and defining the result of the project). One of the mistakes of investment projects formulation is orientation on getting the financial result (for example the profit). The result should be quantitatively measurable and unequivocally determined, and in case of defining the profit as the purposes of the project performing group of different projects are possible (for example if at the industrial enterprise the purpose of getting 1 million roubles of the profit from expansion of activity, it can be both usual activity as well as new business).

Thus the owner of the project does not limit executors who can independently define and realize projects.

However here is the so-called agency problem, i. e. a mismatch of the purposes of the proprietor of the project can affect the project result and the project executors.

To illustrate this problem we shall explain what groups of persons participate in the project and what the so-called "usability" or utility of the project denote.

First of all it is the customer of the project, or the proprietor of the project. It is necessary to specify, that the customer of the project is not always the owner of the enterprise where the project is realized. For example, for projects to improve the ecological conditions in the city or the region the customers of the project are the local authorities or the public, i. e. group of persons that use directly the result of the project. However in case the project is realized to expand the business or grow the cost of the concrete business by the customer may become the owner or owners of the enterprise. The interest of the project customer is targeted as a rule at the purpose achievement and results in terms of all restrictions, and probably economy of resources. If the purpose of the project can be achieved without finishing up the project and carrying out all the works of the project, then it can be stopped. Except for that customers can be interested in "long-term stability" results of the project. For example, if it is the ecological project, then the long-term preservation of ecological well-being is of great interest. Hence statement of the rigid purpose of the project and definition of desirable results and restrictions refer to the powers of the project proprietor.

Executors of the project is a group of persons who directly realize the project. Their purposes can not refer directly to the purpose of the project, for example, the hired managers involved exclusively in the project, are interested in finishing up of the project not later than target dates and with the stipulated quality only in case there are expectations of career growth or monetary compensation. If executors already work at the enterprise and results of the project can bring in their activity certain changes, for example, reduction of some workers after automation of the manufacture, the executors will be not interested in successful finishing up of the project.

Users of the project are people who will directly use results of the project (to work for a new manufacture, to

serve new technologies and so on). What they are interested in is that the results of the project would correspond to their expectations, would solve their problems, and thus would not render material or other damage. The users do not participate directly in execution of the project, but can affect the result of the project. In particular if to speak of the investment projects, for example, introduction of the automated system of class ERP, unwillingness of the users to work with the system and correctly reflect the data can minimize the expected economic benefit.

Other participants of the project (sometimes in the literature there is such a term as "stakeholders") can not be referred to the above-stated groups, but can influence the project or its results. So for example, according to the legislation while constructing objects (residential or industrial), it is necessary to meet public requirements or the project can be rejected or considerably changed (an example of such a project change can be the trajectory of the oil pipeline which was originally supposed to pass near the lake Baikal). This group of persons can have economic or non-economic interests and expectations within the project, and ignoring these interests can affect both realization of the project, and its results.

Actually all these groups form social network of the project, i. e. cover all the interested persons (the question is natural persons) and if while planning the project one does not take into account interests at least the most important ones, the project can turn to be unsuccessful.

For example, if to speak of investment projects at the enterprises that are vitally important for a city, sometimes it is possible to note the following: with changing the proprietor the new owner first of all tries to realize the projects that raise profitability of the manufacture. Among such projects there can be change of suppliers for external ones in relation to the municipal formation or the region, attracting better-qualified man power (including other regions), or just reduction of some specialists. However if the enterprise is vital to the city, it goes without saying it will be the largest (or the only) employer, and any measures touching interests of the majority of the employees will give negative reaction not only from them, but also from the local and regional authority, that in its own turn can entail additional financial loading on the project (in particular the owners may be forced to create additional jobs for the dismissed specialists of the company).

Apart from that it is possible for groups of persons (including legal persons) to participate in the project, for example, the credit organizations which are interested in the project due to the opportunity of getting income on the enclosed funds. Thus within the legal person there can be separate stakeholders, for example, the specialist who is engaged in delivery of credits and is interested in increasing of their quantity, the project is interesting to him/her as an opportunity to fulfill transaction which will affect his key parameters of efficiency.

The next prominent aspect is delimitation of the project. In investment projects the positive monetary stream from the project is usually defined. It means that limits of the project should include also activity which will follow the investment of the funds (for example if we calculate the project by investments in the new equipment, we should include in it also the production by means of this equipment, and handle these processes). However, frequently when planning projects this activity is ignored. So there are examples of investment projects when only investment charges are included in the budget but the ones for the start of manufacturing and the beginning of sales are omitted. Hence these funds were not involved initially and when the investment part was over, the investors immediately waited for a monetary inflow which was not possible.

Thus at planning investments it is necessary to determine the purpose and limits of the project as well as the social network of the project.

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DELIMITATION OF THE INVESTMENT PROJECT

Project's scopes and works management is the important component of any investment plan. One of the ways of project's risks minimization involves more exact definition of those works which should be executed for the benefit of project completion and desirable cash flow obtainment.

Keywords: the investment project, a cash flow, project works.

Process of structuring (decomposition) is an integral part of the general project planning process, its purposes defining. It also includes preparation of a general project plan and a matrix of responsibilities and duties. Thus, it is necessary to attribute the following to the primary goals of structuring:

– splitting the project into sections;

– distribution of the responsibilities among various elements of the project and coordination of works with structure of the organization (resources);

– exact estimation of required expenses – means, time and material resources;

– creation of uniform base for planning, estimating and control over expenses;

– transition from overall aims to the specific tasks which are carried out by the divisions of the organization;

– determination of work complexes (contracts).

Process of project structuring is, as a matter of fact, construction of hierarchical structure of works (a tree, in foreign sources – work breakdown structure, WBS), that is a consecutive multilevel splitting of the purpose for works to be executed to achieve the ultimate goal of the project.

While managing the cost of the project it is necessary to define cost of each work in the first place. Usually estimates are made under each section of works. The finer the structures, the more correct the calculation will be.

The layout showing the order of works is necessary for project time management, i.e. calculation of project finish date, minimization of time. To draw up the layout it is required to determine and specify the works. The more detailed are the works, the more optimal is the time plan of the project. If to operate with the integrated sections and to determine the order of works from their interrelation it is possible to miss reduction of time due to simultaneous works inside the section or due to works interrelations inside sections.

The level of detailed elaboration depends on the complexity of the project. In some cases it is recommended to split sections according to the need for resources: the nomenclature of resources for single work should not exceed 5 units, or number of project team members should not exceed 5 people. The other way the lowermost level size of works determination is the amount of time necessary for work, for example no more than 1 month. All works which term exceeds one month should be detailed.

It's important to note, that while detailing it is necessary to focus not on the stages of the project, but on the results targeted. Thus, probably to more fully determine the scope of actions for the project.

Frequently in many projects the time required for some kinds of works is not taken into account. For example, "financial support obtainment", "financial and accounting reports collection", "resources obtainment", "personnel provision", "sales promotion", "approval documentation collection". For some projects, for example in construction, the investment component is frequently external to the project. The current financing provision is the obligatory section of works, firstly, because it demands expenditures of labour, frequently – of single experts. Sometimes single experts responsible for project expenses, accounting or tax accounting are not stipulated. In case of a small project, as a rule, these functions are assigned to experts of the operating enterprise. However actual time spent on servicing the project is included into the project costs.

"Resources obtainment" includes signed contracts, delivery of a resource, its acceptance, storage, etc.; "personnel provision" includes search, hiring, training, certification of experts; "sales promotion" – marketing analysis, advertising, selling; "approval documentation collection", and other works which do not result obviously from essence of the project but without which the project is not possible.

Structuring can have "functional" and "organizational" attributes.

The functional attribute means that all works connected to marketing, for example, get in one section. The organizational attribute assumes that in the section of works all works necessary for the result are included.

For example, for the project "Construction of an apartment block and sale of apartments" works on personnel selection and training can be allocated into the section "qualified personnel provision", or can be distributed separately among "civil works", "marketing" and "selling". Similarly, if we plan to involve contractors or subcontractors, then the search, estimation of contractors and contractual work can be allocated into the separate section or distributed between those sections in which participation of external organizations is planned.

Under correct detailed elaboration of works the choice of attributes selection will not affect the further scheduling. However, if we unite personnel search in one work, without specifying kinds of personnel, the problems with definition of works interrelation at the further scheduling can arise.

While planning the budget of the project all works which are included into the project should be considered. For this purpose we use, as it was mentioned above, the standard tool – structure of decomposition of works (work breakdown structure).

However prior to construction of a tree of works it is necessary to determine the scope of the project, i. e. procedures to be included in the project.

For the project delimitation first of all it is necessary to analyze the purpose and the results of the project determined by the customer, and to take into account the usability of all project participants (not only those who participate in the project directly, but also those who enters into a social network of the project).

As an example we shall describe the project the equipment redesign for aluminum manufacture in one of monocities of Irkutsk region. The social network includes the following groups:

1. Shareholders (proprietors) of group of the companies which include the enterprise. The purpose of them is obvious – to increase aluminum production and decrease production costs (it is necessary to specify that in the given project marketing of the manufactured aluminum is not included into scopes of the project as it is carried out by the head company with the use of exchange trade tools. Otherwise it would be necessary to consider sales works within the project frameworks; hence if there was a task of "recoupment" or "a positive cash flow", the terms of the project necessary for calculated sales would be a bit extended).

2. Regional management. The purposes are as follows:

– inflow of investments into the region (for creation of a positive attractive to business image of the region);

– additional investments into projects on the territory of the region are investments into regional economy (as the part of works is done by local contractors, hence additional workplaces appear and the taxable base raises);

– preservation of social stability (if the project causes significant reduction of workplaces the administration will be compelled to take measures on employment assistance or benefits payoffs);

– purchase of new equipment will allow to lower anthropogenic risks.

3. The management of municipal formation (including deputies of a representative body) is interested first of all both in the increase of tax payments and in preservation of

workplaces without deterioration of living standard. Therefore if the project initiates reductions due to some processes automation, the municipal government will be against the project.

4. Workers of the enterprise who will use the results of the project. Their purpose is to preserve the workplace and working conditions, including financial aspect.

5. Managers of the enterprise, including those connected to the project. As a rule at the stage of creation any project initiates plenty of problems for those who don't work in it directly, i. e. don't have financial interest, but accepts this or that participation in its realization. For example, while attracting other workers of the enterprise to project team work it is necessary to take into account that heads of those divisions, whence experts are withdrawn, will be against the project as it complicates their operational activity. Hence the purpose of this group is to minimize the negative consequences the project.

6. The project head. If speaking about the invited external expert whose allowance depends on whether the project will keep within target dates, than he is interested in finishing the project in due terms but with the minimal quality. If the project head will continue to work on the created manufacture his purpose will be to achieve the maximum quality that will allow to reduce problems in project results operation.

7. Project team, i. e. direct executors. If the system of motivation is constructed incorrectly, the project delay can become the purpose of executors. Sometimes there are situations when executors are more interested in their own career growth, staying with the project till they receive some alternative offer.

8. The inhabitants of the municipal unit who aren't directly connected to the enterprise. Their purpose is to avoid deterioration of living standard, including ecological aspect. Unfortunately, many projects are not transparent for the public, and cause a lot of rumors. For example, in public opinion the above project was represented as ecologically harmful. Even statistics on sharp deterioration of health of the population was presented, where the described above project was referred to as among the main reasons.

9. Ecological and public organizations. Due to the fact that Irkutsk region bad ecological conditions each project is a subject to additional ecological examination. The purpose of such organizations is to avoid deterioration of ecological conditions.

10. "Agreeing" managers. Any project, especially investment requires resources, including financial. Frequently the existing personnel is responsible for the project support. In conditions of unlimited access to resources it is not a problem, but in the current situation, in particular, when the companies have not enough own means, and the credit organizations are not ready to finance projects without sufficient support, the problem of financing is sharp enough as the project actually competes for resources with the basic activity of the company. In the situation when companies have to pay for the electric power (for aluminum factories it is a big sum) and to finance a certain stage of the project the financial manager will undoubtedly give priority to payments on primary activity as they are in sphere of his direct responsibility. Thus the purpose of such manager is to service the project so it does not worsen operational activity, i. e. the project is not a priority in the given situation.

The ideal succession of events while planning projects will be considering the purposes of every interested group, however in usual practice it is necessary to build the system of priorities. It is important to note that if the project considerably contradicts with the interests of any group it can affect both the course of the project and the use of its results.

An example of such project can be a transfer of the oil pipeline on demand of the ecological organizations and public because of threat to Lake Baikal.

Another significant aspect is delimitation of the project. In investment projects the positive cash flow from the project is usually defined. It means that scopes of the project should include both after investment activity (for example if the project concerns investments in new equipment we should include both production on this equipment, and processes operation). However, while planning the projects, this activity is frequently missed. So, there are examples of investment projects in which only investment charges were put into budget supply ignoring the fact that to launch a manufacture and to start sales a certain volume of turnover means is needed. Hence, these means were not involved initially and after finishing the investment part investors were waiting for cash inflow which of course could not be received.

Thus while planning investments it is necessary to determine the purpose, the scopes of the project and its social network, and only then create the structure of decomposition of the investment project works.

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METHODOLOGICAL BASIS OF PROJECT PERFORMANCE ASSESSMENT FOR ROCKET AND SPACE INDUSTRY ENTERPRISES

The article identifies the main problems and directions of work improvement in the field of project performance assessment at the enterprises of the rocket-space industry, both on performance and project management efficiency.

Keywords: project management at the enterprises of rocket-space industry, integral estimate of the project performance.

Recently understanding and borders of use of the project approach in management, including Russian enterprises of rocket-and-space industry have been changing promptly. The necessity to increase activity effectiveness, aspiration to concentrate efforts and resources on the processes creating value, necessity to decrease unproductive expenditures force management of the enterprises to search for the methods increasing project management efficiency at the enterprises of rocket-and-space industry and considering their specific features. Uniqueness of used technologies, a great share of the high technology manufactures, government work, life cycle reduction of the equipment and the products produced by the enterprises (obsolescence), high specific level of the personnel competences, etc.

Activity efficiency ofthe enterprises of rocket-and-space industry in many respects depends on performance of their separate projects. The performance should be measured and analyzed regularly to reveal deviations, to define their influence on the project and to make well-founded administrative decisions. The results of measurements should allow to reveal problem areas both in the work cycle of producing a product of the project and in a the project management cycle. Besides there is a necessity to compare performance efficiency of different projects to find the most optimal decisions, both administrative and technological and to apply them to other projects. That will lead t the increase of project management efficiency s at the enterprise as a whole. Application of the given method demands considerable changes in the process of the enterprise management, introduction of management standards, work regulations, more exact planning, accurate statement of the project borders, etc. To improve quality of project management it is necessary to estimate project performance taking into account the specificity of the enterprises.

Project performance is the execution of the project plan at all phases of its life cycle. As project plan performance we understand not only performance of the project-focused works for producing a product at the stage of implementation, but also performance of accurately structured and regulated actions making managerial process of the project at all phases of its life cycle. In the course of the research the place of the project performance estimation in the project management system of the enterprises of rocket-and-space industry has been defined. This process belongs to the group of processes of the project performance control. The integral estimate of the project performance consists in the analysis of the indicator dynamics considering interference of the technology of the product production (result) and the technology of the project management at each phase of the project life cycle for the purpose of maintaining the efficiency of the project management system. The choice of the project result and the project management efficiency as a criterion of integral estimate is caused by several reasons. First, in the conditions of a fast change of requirements there is a necessity of constant, throughout the whole life cycle of the project, correlation between the level of result achievement and the level of expected effect and the quality of the project management. Second, creation of a qualitative database on the project results and peculiarities of certain projects management will allow to accelerate process and to raise accuracy of planning for the further similar projects management and will give the opportunity to get a notion of the results and peculiarities of management at each phase of the project life cycle of. Third, there will be a possibility to define borders of responsibility of a project team for the result received, including an intermediate one, to correlate stimulation fund with a real result and the project management efficiency. Fourth, there will be a possibility to compare various projects performance that will allow to raise the maturity level of project management at the enterprises of rocket-and-space industry and the further projects performance.

The author has offered an original estimation technique of the project performance at the enterprises of rocket-and-space industry. The technique allows to estimate the project performancein following major directions: getting a result at each phase of the project life cycle; project management at all phases of the project; correlating management efficiency at each phase with the result received; accounting influence of contextual restrictions on project performance; achievement analysis of the project delayed effects. In the case of deviations from the planned values of the indicators in the result and project management, it allows to establish the reasons of deviations by means of the analysis of the factors influencing the project performance at each phase of the project life cycle and correlation of these factors according to the degree and the zone of responsibility of the project team.

To record the innovative processes during the project performance the author introduces the concept of contextual restrictions. Contextual restrictions are the factors influencing the project performance environment, complexity of a problem, of the result value, the environment resistance. The more difficult the business problem, the more valuable its potential solution is, but fewer people are capable to understand it, without rendering resistance to the innovative idea.

To estimate project management at the concept phase the term of the delayed effect is used. It is that change of

environment which will come if the project team reaches its purposes. The effect can be shown not at once or not be shown at all by the reasons regardless of the team. Effects are the customer's ultimate goal, not the team's, therefore it is inexpedient to substitute the given concepts in the project.

Complex and multifactor character of the project performance process assumes the system approach for its estimation. To estimate the project results we have chosen traditional methods of the account of deviations on terms, budget and quality of the project product to construct the generalised index of the project result by means of estimation of arising deviations.

$$O_r = K_1 \cdot O_t + K_2 \cdot O_c + K_3 \cdot O_q / (K_1 + K_2 + K_3),$$

where K_1, K_2, K_3 are the factors which are chosen regarding how critical that kind of deviations is for the company business. They are normalized (0–1); O_t is time deviation; O_c is cost (budget) deviation; O_q – quality deviation. The indices O_t, O_c, O_k are calculated on the basis of special scales, allowing to classify the deviations from the point of view of the seriousness of their consequences for the enterprises of rocket-and-space industry and are defined on the basis of the corporate standard.

To estimate the project management efficiency KPI system (Key Performance Indicators) (the system of key productivity indices) has been chosen. The choice has been defined due to the following reasons: KPI is the method of estimation which is carried out by the use of unbalanced quantity indices, the results of business processes performance and their comparison with strategic, tactical and operational target reference points to get the deviation value (difference) between the target and the actual index. In other words, KPI is a system of estimation of management productivity. At the enterprises of rocket-and-space industry the given system allows to consider both the quantitative indices (the quantity of technologically necessary works, the project duration) and qualitative indices (competence level, hi-technology level, the result value, etc.).

The estimation of project management consists of competences estimation of the project team participants (structural-role; professional; communicative) and estimation based on the indices of the purposes of management achievement (on the basis of system KPI).

To get quantitative characteristics of project management the author has chosen the characteristics, allowing to estimate both the purposes achievement of the project at each of its phases and the level of competences and the overall performance efficiency of the project team.

The integral estimate of the project result and management at each phase of the project life cycle will allow to consider interferences of the technology of getting a product and management technologies that will give the opportunity to carry out their optimization.

On the basis of the received values the author offers to carry out the analysis of interdependence and interrelation of the characteristics in the network of the given project.

Application of the given technique is limited by the presence of some conditions: quality competences selection, quality of the purpose indicators definition, complexity of definition of the project contextual restrictions, a great number of expert estimates (experts of high qualification in different areas are required).

Thus, the author proves the application of the following tools:

– estimation of deviations in terms, budget, quality;

– estimation methods of the project management efficiency (on the basis of KPI method);

– competences estimation компетенций of the project team participants;

– estimation criteria for of contextual restrictions influence;

– estimation criteria for of the delayed effects breaking;

– the Integral estimate of the project performance;

– the given tools allow to estimate the project performance from various positions and to get a uniform integral index considering the interference of all the parameters influencing the project performance. Application of the given tools will allow to receive the full-scaled picture of the project performance, which make it possible to find out weak points and to make well-founded management decisions in due time, and to avoid similar situations in the further projects that in turn will raise the maturity level of project management at the enterprise.

On the basis of peculiarities of rocket-and-space industry enterprises the revealed problems of the estimation of project management performance and factors systematization the following requirements and principles have been defined (see the table).

The formulated principles specify in the necessity to work out special tools for the project performance estimation at the rocket-and-space industry enterprises.

For the decision of the designated problems on the basis of the systematic factors and the proposed requirements the author has developed the system model of the project management estimation.

To construct the model on the basis of the specified concept of the project management estimation by result and management, the structural elements of estimation defined by the author, are decomposedinto smaller components (see the figure).

The result of the project is estimated with a traditional method according to three restrictions: terms, budget, quality. These indices most precisely reflect a technical aspect of the project and allow to estimate the efficiency of the chosen industrial technology for product manufacturing. Thus, to get a total integral estimate by result and management it is necessary to be conducted at three stages, each of which corresponds to its submodel.

1. Block 1. Integral estimate of the project performance at each phase of the project life cycle .

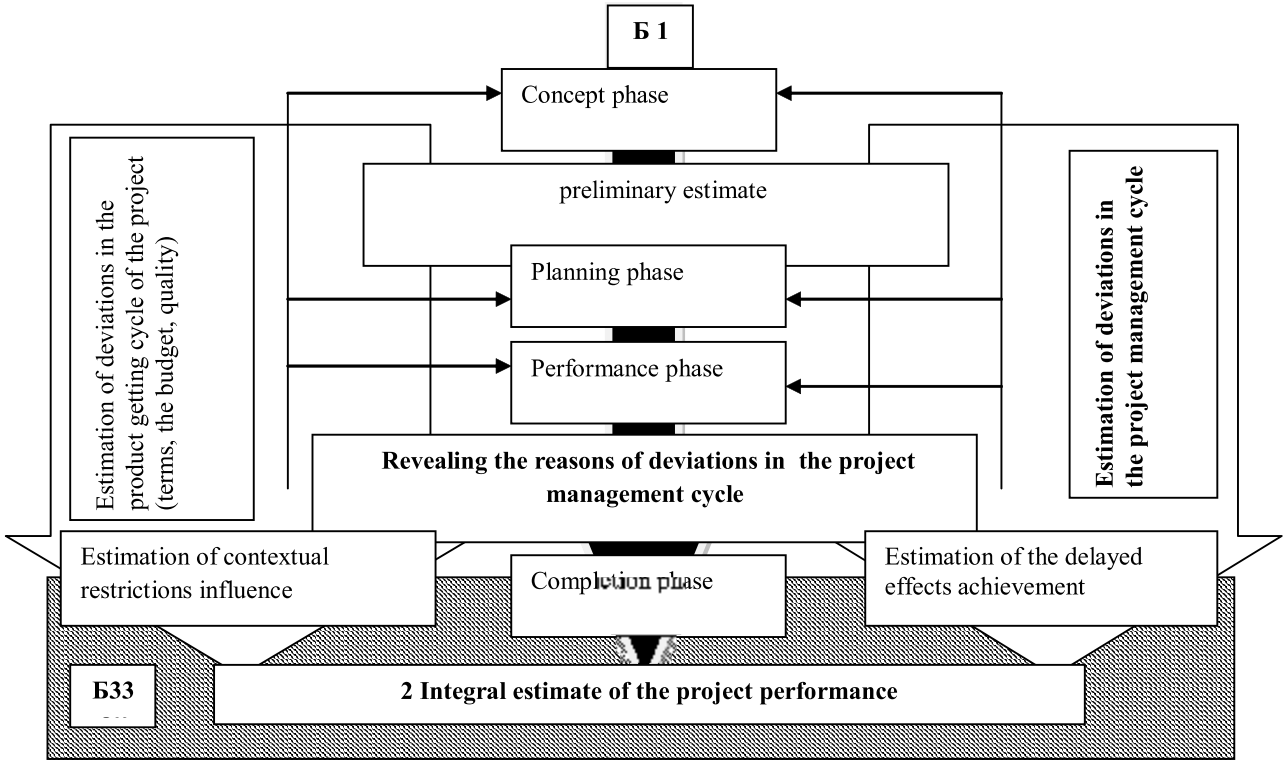
2. Block 2. Integral estimate of the project performance after its completion (official closing of the project).

3. Block 3. Integral estimate of the project performance in the case of the delayed effects subject to contextual restrictions.

The offered model gives the possibility to realize sensitivity analysis, that is to find out the most important entrance parameters of the model and definition of the system of indices of the project performance estimation corresponding to it. Thus the people concerned, making the estimation, are given

not the only point estimate but the full-scaled picture reflecting estimation indices of all structural components of the model, concerning both technology of the project result achieving (product) and the project management (an overall performance efficiency of the project team) taking into account contextual restrictions at each phase of the project life cycle.

Application of the given method will allow to correlate the project result and the project management efficiency at



Structural model of Integral estimate of the project performance

Principles of estimation of project performance at rocket-and-space industry enterprises

Peculiarities of project performance at rocket-and-space industry enterprises	Requirements to the project management systems at rocket-and-space industry enterprises	Requirements to the estimation of the project performance	Estimation principles
Uniqueness of produced products. The innovative cycle peculiarities: space vehicle creation consists in constant perfection of the "know-how"	To differentiate the processes of product getting and project management. Project management demands special knowledge and skills	The project performance estimation should be conducted both concerning product creation and the project management process	The principle of results decomposition of based on the product creation cycle and the project management cycle
Necessity of adaptation to market conditions, high level of competition	Project life cycle structurization	The project performance estimation should be conducted at each phase of the project life cycle, providing the possibility of the intermediate result estimation	Principle of each phase of the project life cycle estimation
Necessity to raise the enterprise and project management efficiency. Possibility of the project overrun out of the framework of one enterprise	To consider the project team to be the core element of the project organizational structure and the responsibility centre while project management estimation	The estimation should allow to establish borders of responsibility of the project team for the result	The principle of the project team responsibility
High risk of a product loss during manufacturing, its implementation and in the course of its use. Extreme service conditions	To estimate the delayed effects of the project (connection with strategy) and contextual restrictions (the problem complexity and the result importance, environmental resistance)	The estimation should allow to consider the influence of contextual restrictions and the achievement of delayed effects	The interrelation principle

each phase of the Project life cycle and after its termination. Besides, the offered model of estimation will expand the base to conduct the comparative analysis of projects that will allow to raise maturity level of project management at the enterprise and to stimulate a particular project team according to the level of the project result achievement of of and its management efficiency in a real-life environment.

The author denotes the following subjects for whom the offered model is: project management team members of; the internal auditor centre of the enterprise (probably a design committee or a control centre of projects); top management representatives to make strategic decisions (especially for standard projects) and the analysis of maturity of level of project management at the enterprise; design while distributing bonus fund the participants of the project team according to the estimation of the project performance; the expert centre of the enterprise for the analysis of use (working out) of the intellectual property objects in the course of the project performance.

Thus, using developed technique of integral estimate of the project performance allows to carry out the multiple aspect analysis of the project performance taking into account specificity of enterprises. The integral estimate is conducted both concerning the project result, and the project management which allows to expand the possibilities the project approach at the rocket-and-space industry enterprises.

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IMPROVING OF METHODS TO FINANCE INNOVATION ACTIVITIES AT DEFENCE ENTERPRISES AND INDUSTRIAL COMPLEX IN THE FORM OF BONDED DEBT

The article gives the results of problems examination that are connected with estimating the volume of corporate bonded debts. A review of the basic methods to estimate the volume of corporate bonded debts was carried out. There were offered methods of financing innovation activities at defence enterprises and industrial complex in the form of bonded dept including determination of its basic parameters.

Keywords: methods and forms of financing, corporate bonded debt.

According to Conception of Long-term Social and Economic Development of Russian Federation which was accepted by the government up to 2020, it is supposed to form a large group of enterprises which will be active in innovations including enterprises in defence and industrial complex. By 2020 their portion should rise up to 40–50 % (in 2007 their proportion was 13 %). At the same time, the weight of innovative production in the total volume of industrial production should increase up to 25–35 % by 2020 (in 2007 their proportion was 5.5 %).

To solve this problem different methods and forms of financing innovative activities should be widely used with involving private capital. One of the important forms of financing innovation activity is corporate bonded debt. The main peculiarity of this form is that it can be placed among unlimited number of creditors in the same market conditions. Nowadays in Russian Federation more than 95 % of all the issues of corporate bonded debt are the public form of loan (Kraev A. O., Konkov I. N., Maleev P. U. Market of debt securities. 2002).

On the whole, every corporate public bonded debt is defined by several indicators: volume of debt, income paid off, period of capital formation, period of income payment, availability or non-lack of integral option, availability or lack of guaranteeing or other additional rights. This variety of indicators can beget new kinds of bonds. Existing world practice shows that nowadays there are more than 1 500 kinds of bonded debts.

Main indicators among these bonds are the following four: volume, income, period of capital formation, period of income paid off. The rest two indicators are subsidiary and are used in connection with main figures. So, the integral option "put" or "call" according to the period of validity may increase or shorten the period of capital formation. The convert option influences yield of bond because it is supposed to exchange the debt of the joint-stock company to the share in its shareholders' equity. A the same time, availability of guaranteeing which is given to the enterprise by third person in the form of deposit, guarantee or bail directly influence the volume of borrowing and its yield.

Taking the managerial decision about using bonded debt for investing innovation activities raises the problem of estimating the conditions of borrowing. It influences selection of methods to finance the innovation activity which is carried out in the form of bonded debt. "Volume" is the most important indicator to influence the selection of form to finance innovation activity in the form of bonded debt.

To estimate possible volume of bonded debt companies can use several groups of methods. The first group is "normative methods". The volume of bonded debt is determined by amount of shareholders' equity or by the scale of guaranteeing which is given to the company by the third person (deposit, guarantee or bail). The second group determines the volume of borrowing on basis of taking into account joint calculation of enterprise property. The

company's property in fact is the guarantee of paying the debt capital back to the creditor. The third group takes into consideration the company's cash flows. "Cash flow" just as property is guarantee of paying the debt capital back to the creditor. In the forth group there are analogous methods which use multipliers to calculate property and cash-flows of the two companies. At the same time, the first company plans to get loan capital and the second one is an analogous company which already has a loan capital. Here according to the comparison of these companies the volume of loan capital is calculated. The fifth group calculates the volume of bonded debt according to the cost of investment project of the definite company. Practically it is a recommendation for the minimum size of loan capital. The sixth group of methods takes into consideration operating and financial leverage. Their extreme size leads to limiting issue of bonded debt.

To study practices of estimating possible volume of public bonded debt of the company the authors have analyzed issue of the bonds in six industries within the period of 2005–2007. These industries were the leaders of using the bond form of financing in Russian Federation according to the volume of debt capital and number of bond issue. All in all 185 bonded debts of mechanical engineering, power industry, ferrous metallurgy, transport and telecommunications and food industry companies have been analyzed.

While analyzing there revealed two distinct groups of borrowers on the bonded debt market which require different methods of estimating the volume of public bonded debt. The first group consists of the companies that are direct borrowers. They get public loan capital to satisfy their needs. Companies of defence and industrial complex belong to the first group. The second group consists of the companies that are quasi-borrowers. They are subsidiaries which are intermediaries between the creditors and the associated company. Their main aim is to get a loan capital but not the operational activity. According to the data from analyzed industries the share of quasi-borrowers was from 11 to 25 % from total quantity of borrowers in different years.

Analyzing evaluation methods showed that Russian industrial companies used three groups of methods: methods which take into consideration joint calculation of enterprise property, methods which consider cash flow and normative methods. It is important to mention that only direct borrowers used methods which regard property and cash flow of the company in forecasting. Normative methods are used by quasi-borrowers and partially direct borrowers. Methods which constitute 6–29 % of joint calculation of enterprise property make from 16 to 29 % of total number of used methods. Methods which consider cash-flow make from 39 to 47 %, and normative methods make from 25 to 34 %.

The most effective methods to evaluate precisely the volume of corporate bonded debt are normative methods. The volume of the guarantees given to the company indicates the volume of corporate bonded debt. The other methods of evaluation give lower level of accuracy. First of all, it is connected with accuracy in evaluation of property and cash flow of the company.

As a rule, borrowers evaluate of the company property to be deposit with a considerable discount. At the same time the amount of a discount is different to each creditor. As the result, mortgage value of the property is underestimated in the company which affects potential borrowing abilities of the company. At the same time, creditors calculate the volume of cash flow of the companies according to previous periods with their following extrapolation in the future period. As the result, if earnings of the company in the previous periods were low, it influences potential abilities to get loan capital. Even so, there is a possibility that forecast itself can not be realized.

It confirms the following analysis of the industries. By using the evaluation methods according to joint calculation of enterprise property among direct borrowers 42 % of bonded debts were not supported by property. By using evaluation methods according to cash-flow calculation the same situation among direct borrowers was up to 48 % of situations.

The period of 2005–2007 was relatively stable for the Russian Federation. Gross Domestic Product was constantly growing during this time and there were free financial recourses in the national financial market. Therefore, unendowed bonded debts were placed in the market without troubles. In conditions of the economical crisis such bonded debts can not be placed in the Russian national financial market. Besides, in the period of 2008–2009 there were defaults on unendowed bonded debts.

Therefore, there is a problem to objectively evaluate borrowing abilities in relevance to bonded debt. On the other hand, there is a problem in preventing mistakes in managerial decisions concerning using corporate bonded debts to finance innovation activities. There are main reasons for creation a new methodology of evaluating the potential volume of corporate bonded debts.

At the heart of the new methodology of evaluation the volume of public corporate bonded debts there is a combination of two frequently used methods of estimation (method of taking into account joint calculation of enterprise property and method which takes into consideration company's cash flows). It is important to mention that there is a common principle for both these methods. According to this principle there is a guarantee to the creditor for paying back loan proceeds.

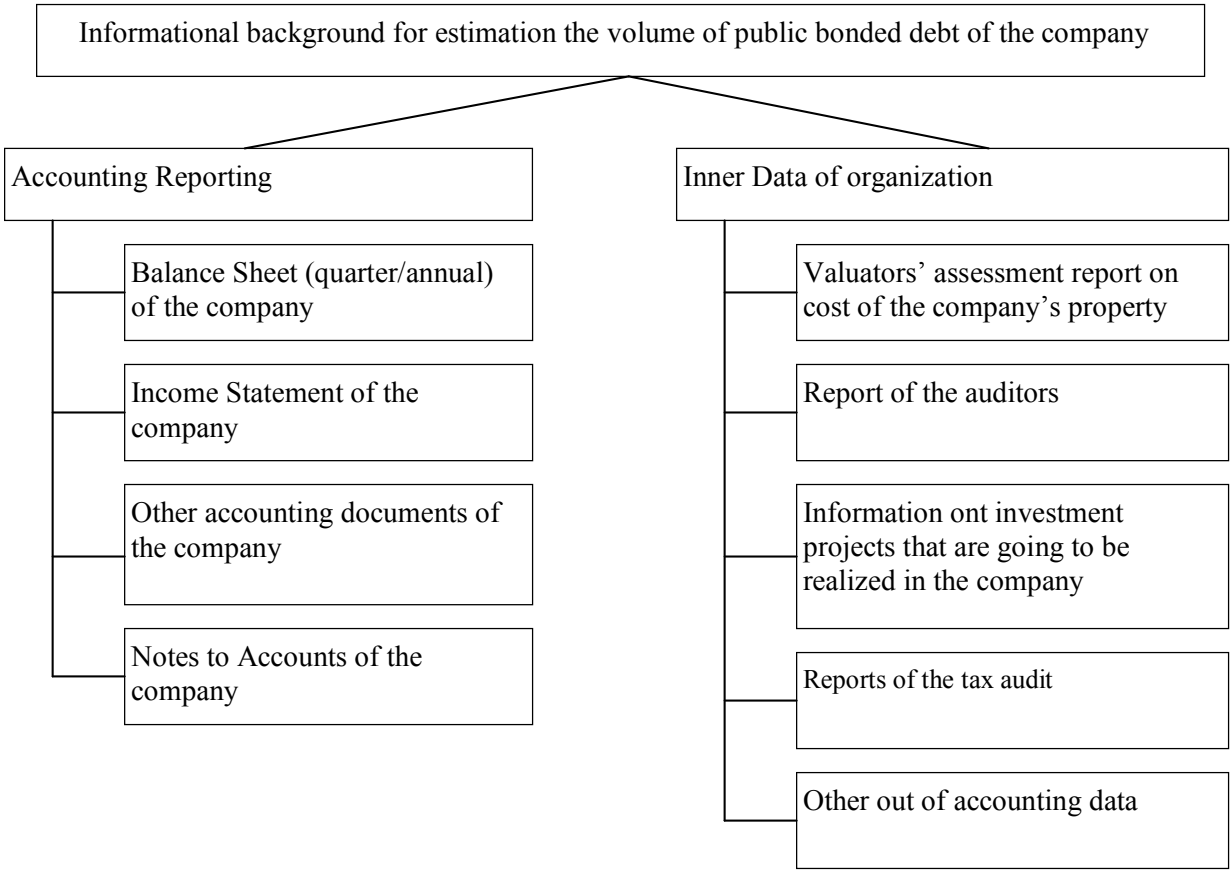
In the offered technology of evaluating the volume of public corporate bonded debts the existing weaknesses of the evaluating methods were minimized. This technology considers assets of the company in aggregate (with the correction coefficients) and average annual income during several years. At the same time, obtained figures are clarified according to the values which are on off-balance accounts. Later on, according to final findings evaluation of the volume of public corporate bonded debts which can get in market conditions is done. Versatile calculation of guaranteeing property potential of the company can raise the accuracy of the volume of public corporate bonded debts evaluation which can attract in market conditions.

To use the offered methodology of evaluation the definite informational background is needed. The basis of such informational background is two groups of informational sources including accounting reporting of the company and out of accounting data (see the figure). These informational sources can provide necessary data for evaluation according to joint calculation of property and its cash flow.

Testing was carried out to demonstrate effectiveness of the offered evaluation methodology. Testing itself has two stages. At the first stage the volume of public bonded debt was forecasting according to the offered methodology. At the second stage getting evaluation data was compared with actual values of the volume of public bonded debt of the analyzed companies in six industries in the period of 2005–2007. Thereupon, it was determined whether there was a shortage or reserve of possibilities of the volume of public bonded debt attracting in market conditions.

As the result of the comparison the following conclusions were made out. First, during the evaluation of the volume of public bonded debt according to this methodology repayment to creditors was from 69 to 86 % in bonded issues. In the companies of defence and industrial complex this figure was higher. It was 95 %. Secondly, quality of guaranteeing allows getting additional financial activities more than 100 % from the really obtained activities according to joint calculation of property and cash-flow of the company. In the companies of defence and industrial complex this indicator was 98 %.

This methodology of estimation of the volume of public bonded debt allows companies of defence and industrial complex to estimate precisely its borrowing abilities. It influences taking the right managerial decision when choosing methods of financing innovation activities of the companies of defence and industrial complex in the form of bonded debt.



Structure of informational background to forecast the volume of public bonded debt according to joint calculation of property and cash-flow of the company

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FEATURES OF OPERATIONAL COSTS DECOMPOSITION BY CARRYING OUT OF SHIP-REPAIR WORKS

Types of costs decomposition at the ship-repair enterprises are offered, considering individual character of works and allowing improving qualitative characteristics of cost management.

Keywords: operating costs.

The management of an industrial enterprise on the toughly competitive market and amid the general stagnation of Russian economy demands the revision of approaches to business dealing.

The most important task for the moment is the increase of cost management efficiency. The specified problem gets a special topicality for the domestic ship-repair facilities, because the influence of the world financial crisis has extremely negatively affected the quantity and volumes of services rendered by them.

Russian ship-owners due to the pressure for money have no possibility to carry out full-fledged repair of ships; they postpone it for the vast future, or carry out it abroad. Therefore modern practice of the ship-repair enterprises management should be built on daily work with the expenses, aimed at their optimization that will provide stability of market positions and rise of profitability level.

The efficiency of functioning of the cost control system depends on qualitative and quantitative characteristics of cost information. The method of cost calculation and accounting actually applied at the ship-repair enterprises does not allow to solve the specified problems in complex. Therefore, by working out and improving the cost management system of the ship-repair enterprises, the definition of the cost decomposition method meeting the above-stated requirements is of great importance.

For cost calculation of ship-repair work the following sharing of production costs is proposed which, in our opinion, will considerably expand the possibilities of information processing for management targets: material, operational, shop and administrative expenses (tab. 1).

Thus, material costs are understood as the costs of raw materials, materials, semi-finished products, components, etc. i. e. all that makes the material basis of manufactured products. Material costs arising by renewal or manufacturing of assemblies and details are to be calculated by the processes which are planned and carried out according to repair sheets. If in the frames of ship repair work, the assembly was not restored, but replaced, the given expenses are charged not to the process, but to the order as a whole.

Operational expenses are understood as the cost of the basic technological operations which must be executed for the work (process) completion in full volume. The given expenses include:

– wages with taxes of the personnel directly participating in the process;

– expenses for the electric power and the fuel consumed by the equipment;

– equipment depreciation;

– auxiliary materials which can be charged directly to the given process;

– expenses for providing of processes with materials and their storage.

Shop overheads include:

– wages of shop administrative and support personnel;

– expenses for lighting, heating and water supply of the shop;

– expenses for depreciation of industrial premises and the equipment not belonging to the machinery, directly participating in the processes;

– transport expenses ensuring the shop functioning.

The structure of administrative expenses consists of:

– wages of administrative and maintenance staff of the enterprise;

– expenses for lighting, heating and water supply of non-production-related premises;

– expenses for depreciation of non-production-related premises and the equipment, not included into the process and shop equipment;

– transport expenses ensuring the enterprise functioning;

– commercial expenses.

Shop expenses are allocated on processes and administrative costs directly on fulfilled orders by cost drivers.

A cost driver is the basic indicator of the cost level: for the rent it is the area of the premise occupied by the given employee; for the cost of consumed electric power it is

Table 1

Process-focused cost classification of ship-repair enterprises

Tasks	Material costs	Operational costs	Shop overheads	Administrative expenses
Cost price calculation	Direct costs		Indirect costs	
	Operational costs		Recurring costs	
	Main costs		Overhead costs	
Planning	Variable costs		Conditionally variable costs	Fixed costs
Control	Relevant costs		Partially relevant costs	

consumed electric capacity of the personal equipment of the worker (adjusted for operating time), etc. For estimation of transferable cost, the value of the cost driver unit is defined first: of one square meter, kilowatt-hour, etc. The required transferable sum is defined by multiplication of the driver unit cost by the quantity of the driver consumed by given resource. For shop expenses it is reasonable to use as drivers the expenses value of one basic worker per hour of his work and per hour of operation of the main machinery (fig. 1).

By process costing it is advisable to apply the cost decomposition by job specialization. Such breakdown is necessary for accumulation of statistical base by formation of the norms of resources consumption to realize production processes. In the system of standards with the aim of its simplification, the factors considering the characteristics of workplaces are developed. For example, the rate of work done by one welder during the fulfillment of similar works in the shop and directly on the repaired vessel can vary considerably because of different volumes of preparatory work or weather conditions complicating the work fulfillment.

Decomposition of expenses by executors and workplaces is necessary for control of labor productivity level and material consumption by each worker.

Thus, the offered defragmentation of processes will give the possibility for convenient costs distribution by cost centers – production shops.

Besides, it is reasonable to use such kind of decomposition, characteristic for job method of cost accounting, like repair work types and orders. The short substantiation of cost decomposition is given in table 2.

The presented cost decomposition has following advantages:

– first, such decomposition draws a parallel between the expenses for manufacture and principal activity types in the process of manufacture, regularizes the allocation of responsibility centers;

– secondly, the allocation in separate group of process costs simplifies the control over the productivity of workers;

– thirdly, material and process costs have the expressed variable character, therefore such sharing allows to use in the cost management the break-even analysis and direct-costing method;

– fourthly, such cost sharing allows applying the process-focused approach to the definition of the production cost.

Process as it has been described earlier, is understood as a circuit of interconnected operations (works) on manufacturing of ready-made goods or on rendering of services on the basis of resources consumption.

Taking into account job specialization one allocates production processes which if necessary are split into subprocesses. Subprocesses are understood as process stages, the process components characterized by the availability of a certain intermediate result and representing a circuit of works and operations.

In order to separate basic subprocesses from technology of ship-repair works, it is necessary to define, what criterion is to be used for cost decomposition. For process-focused costing the basic criterion of optimal decomposition is such splitting of technology of ship-repair works by which the separated parts – subprocesses would have the least degree of cost variability per time unit of process for different work types and objects of repair. In this case the repair sheets which are cost calculations in the ship-repair enterprises, calculated on the basis of the addition of the cost of the number of processes included in these sheets, adequately reflect the cost of each order, regardless the type of repaired vessel and repair work type.

Characteristic feature of the ship-repair facility is the big nomenclature of works. However they can be grouped into such work sets which are identical for any type of a repaired vessel and kind of repair. The differences between each specific repair order consist only in selection of these sets of processes, and the use of each specific process. So, for example, the replacement of the set for the ships under projects 866 and P-14A is equal to the cost of an hour of works, both for interim overhaul, and for current repair.

So, the works meeting the specified requirements can be grouped inside of one process, in this case the requirements of the decomposition criterion formulated earlier, will be observed even in case of various disproportionate changes of the price of one hour of operation of each unit involved into the process.

At the ship-repair facilities of Krasnoyarsk region which are carrying out the majority of ship-repair works themselves, it is reasonable to allocate following processes:

Table 2

The Substantiation of cost decomposition

Decomposition type	Decomposition purpose
By orders	The control of use of cost limit by each object of repair
By types of repairs works	For reception of the statistical information necessary for short-term and intermediate-term costs planning
By processes	Simplification of monitoring tasks, short-term and intermediate-term costs planning, fixing of production costs to the cost centers (shops)
By subprocesses	Increase of degree of costs controllability due to decrease of percentage of indirect (distributed) expenses. Harmonization and perfection of business processes of the enterprise to achieve more effective usage of the enterprise resources. The control of completion percentage for works planned in repair sheets, the possibility of comparison of actual expenses on each point of the repair sheet with the standards
By job specialization	For working out and specification of cost standards of processes
By workplaces	Application of the correction factors increasing standard labor inputs of the process depending on work conditions, the control of usage efficiency of the equipment
By executors	The control of working hours efficiency for each executor. Responsibility personification on effective use of resources

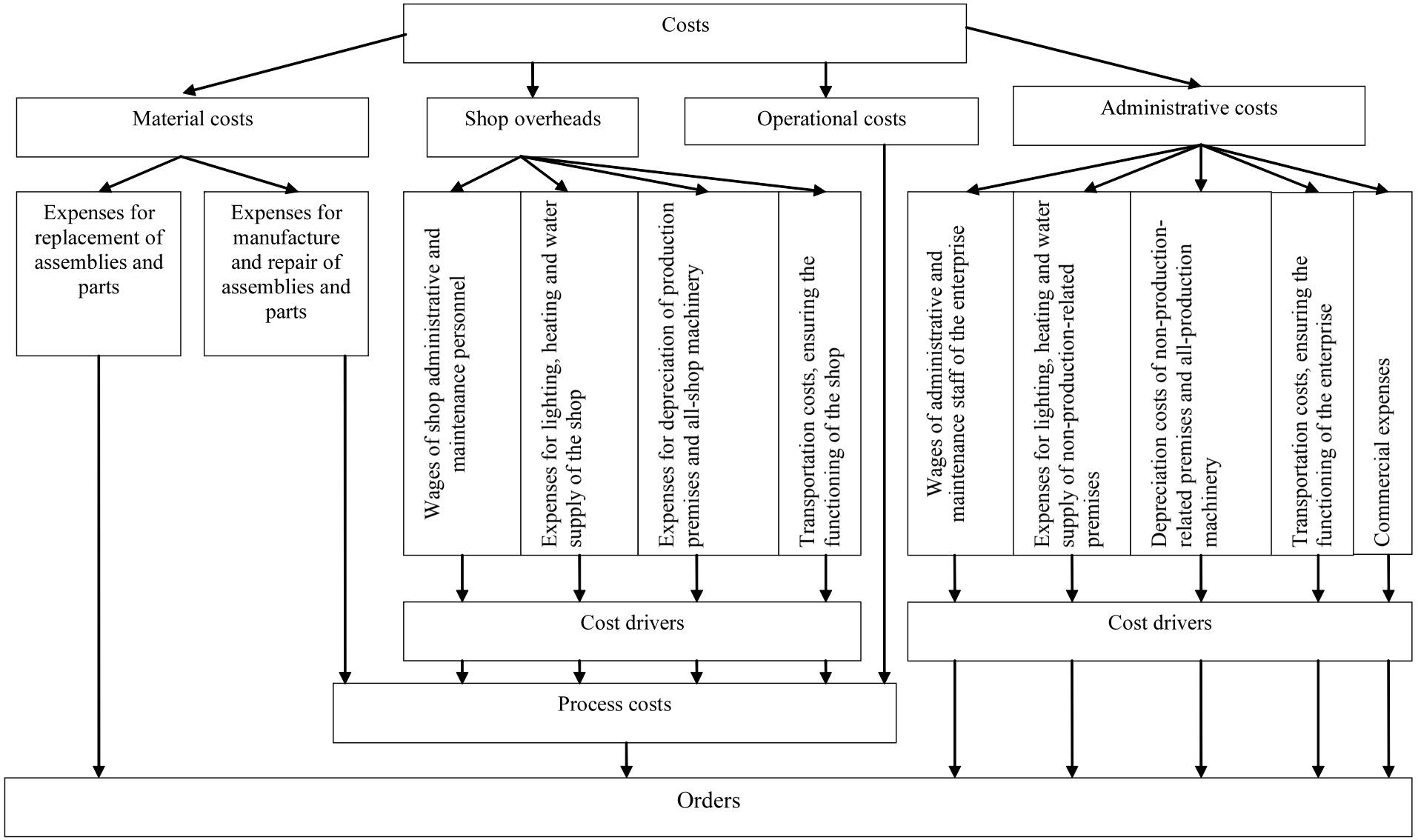

Fig. 1. Diagram of process-focused costs allocation of the shop-repair enterprise

– repair of the ship hull and deck erections;
– repair of engines;
– repair of ship auxiliary mechanisms;
– repair of electrical and radio equipment;
– repair of ship systems;
– the interior outfitting;
– gleaning, painting, insulation works.

It allows providing the route of ship-repair works. The task of monitoring of the level and structure of costs becomes simpler. For each of the specified processes one can deduce by statistical way the factors of ratio of different material inputs to labor input. So, for example, in the process cost structure of the interior outfitting, cleaning, painting, insulation works, prevail the expenses for remuneration for labor. The most material-intensive are repair of the ship hull and deck erections and repair of engines. In the first of the specified processes the expenses for metal products dominate, in the second – for spare parts for the equipment.

In case of application of the offered process cost management system the structure of ship-repair works looks as follows (fig. 2).

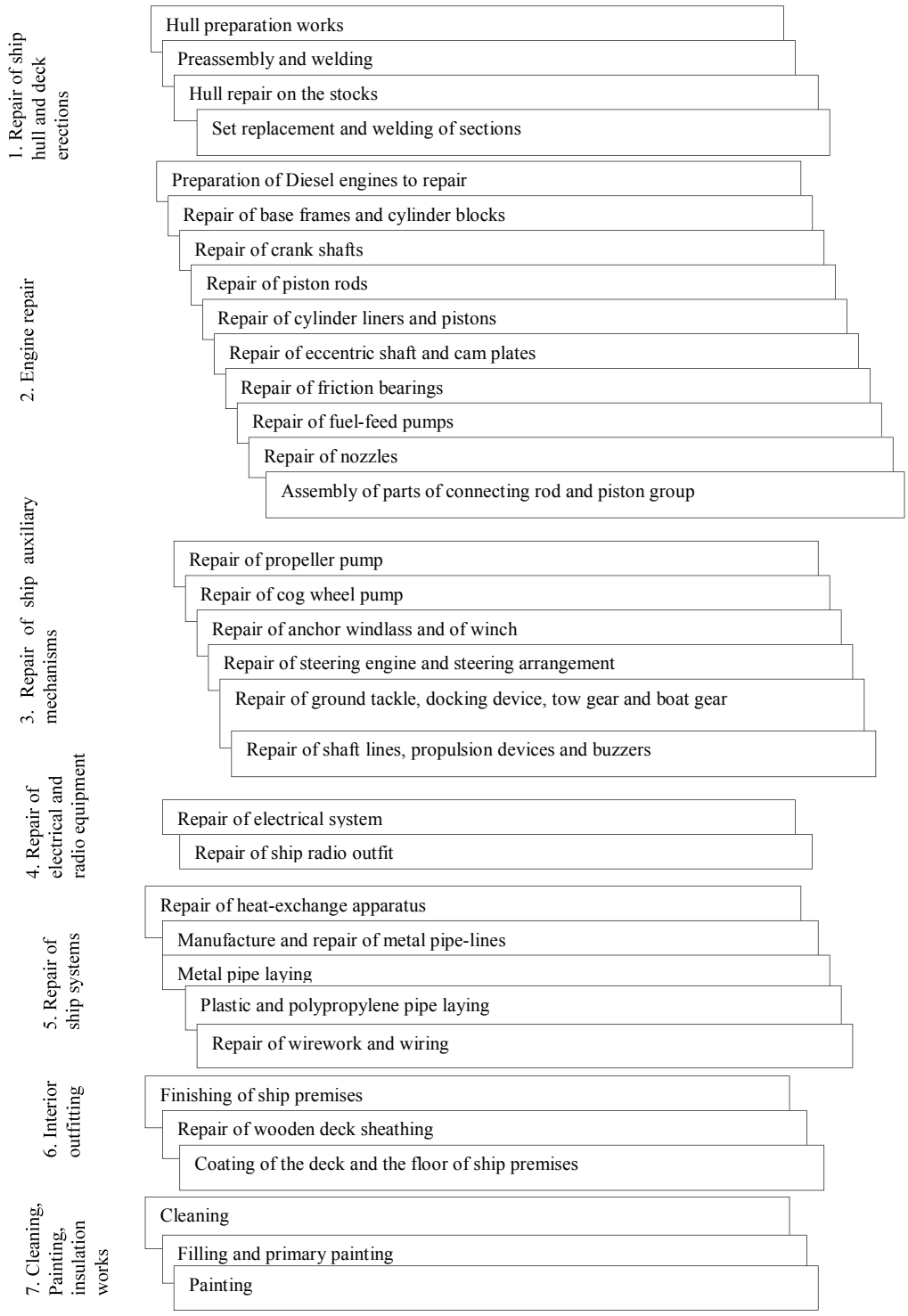

Fig. 2. The structure of ship-repair works

The offered cost decomposition gives the possibility to realize the process-focused approach to cost controlling, it makes possible the analytical processing by orders, by types of repair, by production processes, by subprocesses, by job specialization, by workplaces and executors.

Today implementation of the process organization of management in different forms takes place at Public Corporation "Novorossiysk ship-repair factory", Federal State Unitary Enterprise "Admiralteyskiye verfy", Public Corporation SRK "Sevmorsudoremont". The employees of all above-stated enterprises noted positive administrative effect, but it is necessary to say that management techniques used at these factories, are focused, mainly, on optimization of processes, improvement of their quality. The cost management is considered as auxiliary, derivative function. Within the offered process-focused approach, conversely the main objective is first of all the production cost management, and the process decomposition is the basis of this system allowing achieving more effectively of assigned administrative tasks.

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PRINCIPLES AND METHODS OF CONSTRUCTION AND FUNCTIONING OF SERVICE ENTERPRISE'S MANAGEMENT SYSTEM IN MARKET CONDITIONS

Principles of construction and functioning of management system by the enterprise of service sphere in conditions of the market, are considered. The model of relationships between causes and effects, reflecting influence the administrative actions on business-processes, that maintenances the appeal of firm's services is presented. The technique of estimation of quality of management system by the service firm is resulted.

Keywords: management system, services, quality, principles.

Development of integration processes in the economy and interconnections between the territories implies a high level of services and trade as a link economic mechanism. The prospects of growth of volumes of services make this sector very attractive for investment and the application of entrepreneurial activity. Obviously, the businesses which whose services are consistent with international quality standards and have high value to consumers, the benefits of its acquisition will reach this market and build on it the positions.

Analysis of the problems of improving the system of enterprise management services showed that, firstly, the needs of formation and development of quality management on aggregate characteristics are currently neglected. Secondly, existing approaches to understanding the quality of company management is not fully focused on particular services. As a result, enterprise management services often fail to ensure the receipt of the required result – services that meets the requirements of consumers in all components. In the end, when the current high level of competition in the consumer market, reduce business risk or lose the main competitive advantage – the quality of services offered. Third, when evaluating and designing management systems company does not take into account the effect of quality management on service quality which makes following conversion of resources in the process of outlet to receive services demanded by consumers, as at present, as well as strategically.

It should be noted that much attention in research and publications are focused on such areas of knowledge, as an efficient and competitive management, quality control, while the quality of the management system note only a few scientists. At the same time, considering the dependence of the quality of the nature of management processes, it may be noted that not all areas were adequately covered in the research.

Analysis of existing approaches to improve the management showed that they did not fully take into account the need for quality control as a condition for improving services, reducing the possibility of designing an integrated management system in the context of three dimensions: efficiency, competitiveness and quality. Developed methodical, organizational and economic approaches in order to improve the enterprise management services that improve quality, must take into account the specific characteristics of the management object and provide better services and more fully satisfy the demand.

To solve the above-mentioned problems should be developed theoretical and methodological position to improve governance, to reflect better the characteristics of service industries and the need to improve the quality of services offered on the market. This led to the relevance of research performed, the object of which were service industries, operating in market conditions. Subject of study – management relations arising in the functioning and development of service industries.

The existing conditions of service are aiming to improve the quality of management in improving the business management system that is essential to increase the quality of the services market to the changing needs of clients. Achieving

these characteristics of quality control depends on how they are integrated into the service industries and set out in the work rules. Improving the management of enterprise services and the development of its quality is ensured implementation of the principles of management, revealing its specifics.

Generalization of existing management principles [1; 2], as well as an efficient, competitive management in the service economy in contemporary conditions allowed the author to highlight the most relevant in today's economy characteristics of quality, based on the necessity of building management.

Taking into account the specifics of the service industries, the nature of the influence of various factors on the quality of services (tab. 1), further analysis has allowed the author to formulate specific guidelines relevant to a concept of quality business management services and to ensure a given quality of service:

1. Principle of balance improved governance. Approval of changes in enterprise management services to the parameters of quality, efficiency and competitiveness.

2. The principle of synchronicity of change. Alignment speed external and internal changes, willingness to change. Involves predicting changes in the market of consumer services, identify opportunities, conduct timely adjustments, including the rejection of uneconomic activities, overcoming the stereotypes of thinking.

3. The principle of recognition and enrichment of the means in accordance with changing customer needs. Includes the need to integrate the features and components of the service, as a result of the activities and management, their interaction in the design of technology management, as well as the fullest use of communications with the customer service (since the delivery of services and consumption are related and often occur simultaneously).

The presented guidelines are in addition to the existing rules of construction and operation of the system of enterprise management services, which opens up new opportunities for improved technology management on the proposed features of its quality, providing accounting and impact on quality of service factors.

Model of causality, reflecting the impact of managerial influence on business processes to ensure the attractiveness of services business.

The nature, direction and strength of the impact of managerial influence on the creation of bases for the implementation of market strategy and achieving business goals. Part of the strategy is not implemented because management can not properly form the existing capacity for implementation of strategic objectives. This applies in particular to improve the quality of services.

Providing management system to improve the quality of services is mediated through effects on internal business processes. Improving the management of its quality characteristics affect the financial results through the chain of cause and effect relationships (fig. 1).

Special importance managerial transformation acquires in achieving compliance with the market strategy of the enterprise.

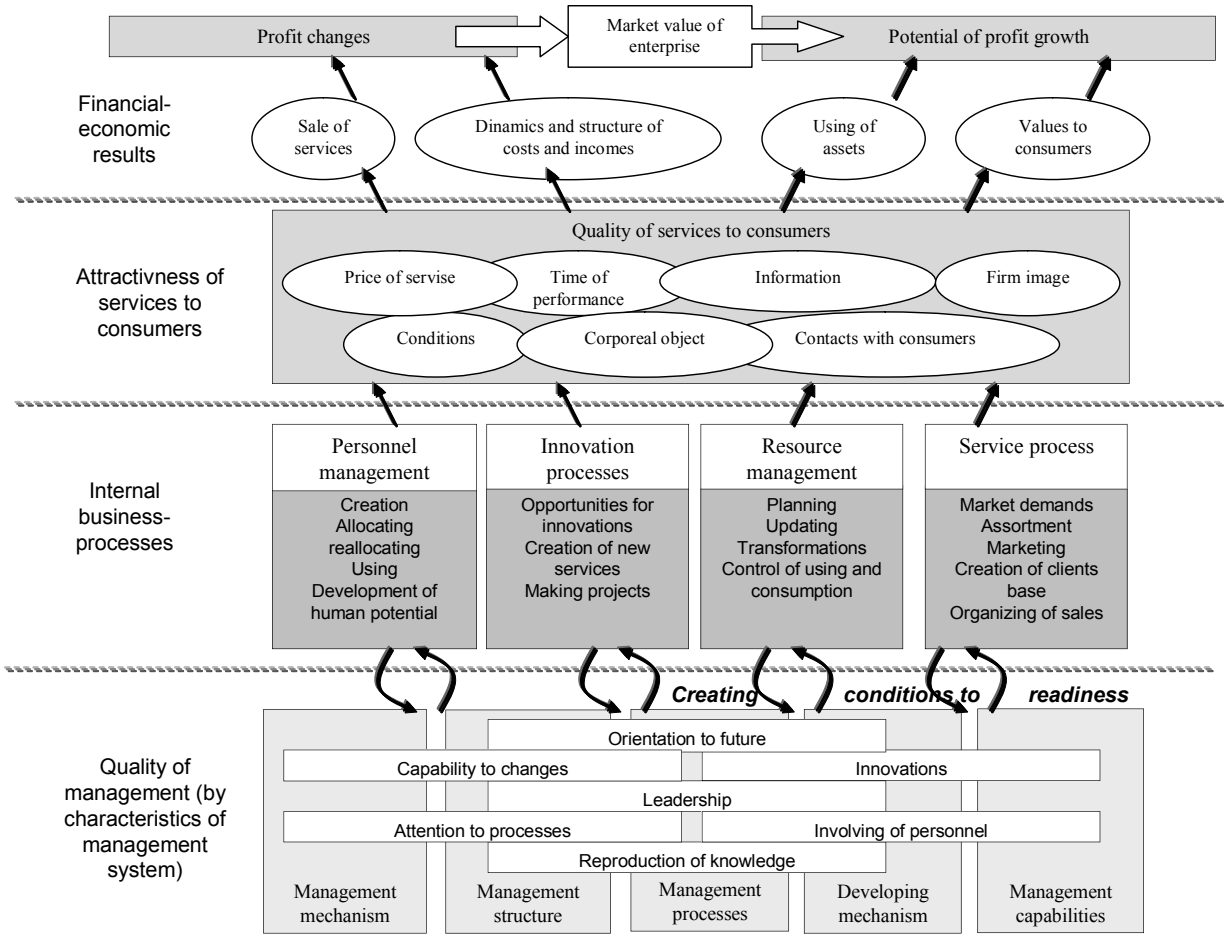

Fig. 1. The model of causality, reflecting the impact of managerial influence on business processes to ensure the attractiveness of services business

In the same time, improved management is primarily for the organization of potential, but not market value. Internal processes, such as personnel management, resourcing, organizing the sale of services needed to transform the potential value of improving the quality of governance in the quality of services, increase sales (URL: http: // www.bscol.com.). To do this they should be directed to the use-value proposal to the client or financial improvement.

Services offer which meets consumer requirements for all components in this case – a condition when the quality of management makes the quality of services. Continuous line of actions and offer opportunities of use-value customers is a decisive factor in implementation the strategy into practice.

Aims to improve the quality of services and quality control related to each other cause effect relationship. Financial results can be obtained only if satisfied with the target group of customers. The proposal describes the use-value customers, how to increase sales and win the loyalty of target customers. Internal processes create and provide a customer this proposal. Finally, the control system has an impact on internal processes and factors of service quality, integrating all the components, as part of market strategy.

Thus, the presented model is a complementary tool in designing programs to achieve the required level of services quality to consumers. Building management system, which has the characteristics of quality, creates the necessary preconditions for successful implementation of strategic changes in the organization of services that transform it into a state in which it will be ready for the strategy.

Forming of enterprise management services' quality should be based on special diagnosis of the management system's state, its impact on factors of service quality, hence the need to develop an appropriate assessment methodology (fig. 2).

The quality assessment of enterprise management services should be conducted in two ways:

– assessing the existence and degree of quality management's characteristics display – focus on the future leadership, innovation, staff involvement, attention to processes, reproduction of knowledge, ability to change;

– assessing the result for consumers by component services – the material component, the price, the time and conditions for the provision, information support, the company's image and direct services.

To do this, the author proposes to compile the relevant matrix:

1. Matrix analysis of the quality control characteristics: the rows specified elements of the system management, and the columns – the characteristics of quality control.

2. Matrix analysis of the ability to provide the result for consumers: the rows specified elements of the system management, and the columns – components of the service as a result of management.

In the fields of matrixes formed by the total score on these two indicators in the figure, each of which is 0.5 points.

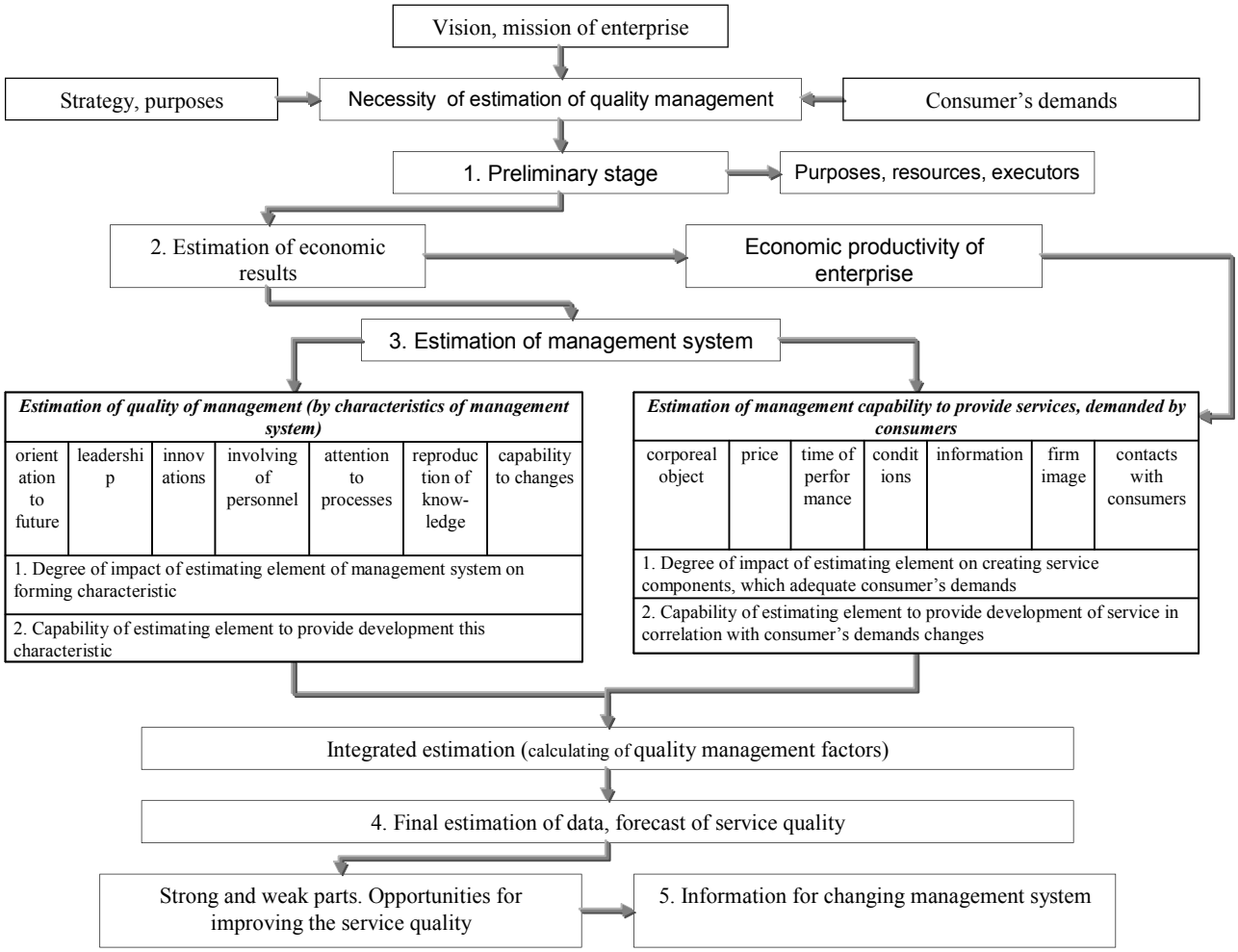

Fig. 2. Stages of the methodology for assessing the quality of enterprise management services

The number of investigated elements as control system is defined by the objectives of the assessment.

In rows is calculated the total number of points, which scored a particular control element in assessing the properties of (*Es*) and the results of management (*Er*).

On the basis of expert evaluations carried out the calculation of coefficients of control quality.

1. The coefficients of management quality (*MQc*):

1.1. As elements of management

$$MQ_i = \frac{Es_i}{7},$$

where *Es* – the total number of points, which scored a particular control element in the evaluation of quality characteristics.

1.2. In general, for control system

$$\overline{MQ} = \frac{\sum_{i=1}^{n} MQ_i}{n}.$$

The coefficients indicate to what extent the control elements have the quality characteristics.

2. Management ability coefficients in order to obtain results in line with market requirements (*MQr*).

2.1. According to elements of management

$$MQr_i = \frac{Er_i}{7},$$

where *Er* – the total number of points, which scored a particular control element in assessing the management ability to ensure the desired result.

2.2. In general for control system

$$\overline{MQr} = \frac{\sum_{i=1}^{n} MQr_i}{n}.$$

Coefficients represent how the effect of control system leads to results – for their services.

3. Coefficient of quality control forms an overall assessment of the elements and in general to control systems.

3.1. According to elements of management

$$MQQ_i = \frac{MQc_i + MQr_i}{2}.$$

3.2. In general for the control system:

$$MQQ = \frac{\overline{MQc} + \overline{MQr}}{2}.$$

Changing of structure and dynamics of the coefficient of quality control shows positive (increasing to 1) or negative vibrations in the internal processes of the enterprise.

Thus, the presented method integrates the existing methods of diagnosis, reflecting the sequence of study, the relationship stages, importance of each of them. This allows to monitor assessing individual processes and projects, identify problems in management, leading to a change in service quality and economic results of enterprises. As a result of forming information of high significance for the development and monitoring of project execution and strategy development firm in the market, measuring the goals to improve governance. We can conclude that this variant of this technique may become part of the main analytical tools of business [3] used in selecting and designing management techniques. Presented performance indicators can be used to identify the needs of strategic changes in management services, as well as for internal audit management, including the functional area.

Application of activity and enterprise management services provided by teaching the provisions in the quality of management, operation and development management system in accordance with the principles and characteristics of quality management form the impact such a way that affects the quality of service and improve the economic and financial performance on the market.

Application of a comprehensive assessment of the enterprise service indicators for assessing the quality of management makes it possible to improve the accuracy and efficiency of goal-setting, strategic planning and monitoring to improve the management system.

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THE MECHANISM OF STIMULATION OF DEVELOPMENT OF BIOTECHNOLOGIES IN FOREIGN COUNTRIES

The biotechnology is one of scientifically-practical priorities of the XXI century. The key role in stimulation of development of biotechnology in foreign countries is taken up by the state which solves this problem by means of a complex of measures both administrative, and economic influence.

Keywords: tools, biotechnology, biofuel, nonconventional power.

Nowadays the world's economy suffers a constant increase of a hi-tech influence and in connection with this, the problem of investigation of various mechanisms of scientifically-technological development which correspond to modern ideas of scientific and technical progress arise. Thus, the mechanism of scientifically-technological development is understood as the system of mutual relations between the state, scientific and technical sphere and market which provides constant development and updating of technological armament of manufacture [1].

The EU countries are among the leaders in manufacture of the energy which is based on nonconventional renewed energy source (NRES). The most impressing successes are reached in development of a wind power, the sun and biomass. In the present time about 70 % of energy developed in the world by the wind energetic units is given by the EU-27 countries. The share of the countries in the world's energy production by the wind energetic units is presented in table 1.

In the total capacity of the established solar collectors, the European Union strongly keeps the second place conceding to China. The use of biomass in a power economy of EU extends. In 2005–2008 in Austria, Great Britain, Finland, Sweden the large thermal power stations working on a biomass, including the agricultural, household and various industrial wastes containing organic chemistry started to work. The interest of investors to the development of the sea wave's energy and inflow grows. In 2002–2008 in Great Britain, Ireland, Spain the wave power stations were constructed and started to operate.

There are various conditions for development of nonconventional power in the countries of the European Union. These distinctions are caused by the following factors:

1. Geographical and natural (a rain, a direction of water streams, solar intensity, presence of fossil power resources, etc.).
2. Economic (an oil and gas price, a size of the subvention for traditional sources based' power manufacture, a system of economic regulation of nature protection, etc.).
3. Political and social (the international obligations and programs, influence of "Green" parties in the state bodies and local authorities, the administrative initiative and responsibility, public opinion, etc.).
4. Technological.

The combinations of these factors influence the way and prospects of development of nonconventional power in the abovementioned countries. For example, Great Britain, the Netherlands and Romania, which possess oil and gas in the territory, are less anxious to develop the nonconventional power, than the majority of the EU countries. The countries of Southern Europe have more favorable possibilities for a solar energy use, than countries of Northern Europe. It is not a surprise that Greece surpasses Sweden in total capacity of the established solar collectors. And Sweden has higher a hydro energy potential. This is reflected in the structure of the electric power manufacture based on renewed sources. If almost 80 % of "pure" energy in Greece are made on the basis of solar energy, in Sweden about 90 % of cumulative manufacture of the electric power based on renewed sources devoted to hydroelectric power station.

Favorable geographical and environmental conditions are important, but not the only condition of the successful development of renewed power. So, the best conditions for wind energy units in Europe the Great Britain, Ireland, France and Estonia possess. As a result of favorable geographical and an environmental conditions the wind energy units in Ireland can produce twice more electric power, than the same

Table 1

The share of the countries in the world's energy production by the wind energetic units, %

Countries	Share
Germany	32
USA	19
Spain	17
Denmark	7
India	6
Italy	3
Great Britain	2
Netherlands	2
Portugal	2
Australia	1
Sweden	1
Other countries	8

units established in Germany. However, thanks to the state support effective methods the general capacity of the wind energy units in Germany (more than 19,000 MW) 10 times surpasses the capacities of all wind energy units of Great Britain, Ireland, France and Estonia all together.

In conditions of globalization of economic and an aggravation of the problems connected with the climate change, the role of the international obligations as motivator of development of alternative energy sources has increased. In 1997 as the initiators of the Kiotsky report, the EU countries have declared their readiness to decrease 8 % of emissions of "hotbed" gases by 2008–2012, including Germany and Denmark – 21 % less, Australia – 13 % less, Great Britain – 12.5 % less. The performances of these international obligations of the EU countries connect with the development of NRES and the increase of their share in the power balance. According to the instructions of the EU and a national programs on stimulation of a renewed energy sources by 2010 it is declared to increase a share of "pure" energy in the general current consumption of the EU countries 8.1 % more, including Denmark – 20.3 %; Greece – 11.5 %; Sweden – 10.9 %; Great Britain – 8.3 %; Austria – 8,1 %; Germany – 8 % [2].

The important role in development of nonconventional power a technology factor is played. The development of nonconventional energy sources is based on the uses of progressive technologies and the equipment, providing long terms operation, modern control systems, diagnostics and the safety control. Having a high innovative potential and the advanced power machine-building base Germany (firms Tacke, RePower, Enercon), Denmark (Bonus Energy, Vestas Wind Sistems), Spain (Gamesa) not only provide wind energy units for their own countries, but also provide such complexes to Britain, Italy, France and other countries.

To this far incomplete list of the factors, defining the modern level and prospects of development of NRES, it is necessary to add the adverse political climate, the thought up strategy of development and the effective mechanism of stimulation of development of nonconventional power.

The key role in stimulation of development of nonconventional power in the EU countries is taken up by the state which solves this problem by means of a series of administrative measures, and economic influence.

The basic methods of economic influence are:

– coordination of the design documentation and delivery of licenses for building of operation objects;

– carrying out the tenders for realization of projects in the sphere of nonconventional power;

– obligatory quotation of manufacture (consumption) of the electric power based on the renewed sources and penal sanctions for defaults of the established obligations;

– information and ethical support of the renewed power;

– assistance to the administrative structures of different levels to carrying out the advertising companies, exhibitions and presentations of power saving technologies.

The mechanism of economic influence includes the following tools:

– extra charges to tariffs for the NRES energy;

– free manufacturers of "pure" energy from the power taxes;

– quotas and "green" certificates;

– crants from special fund;

– cuarantors on research and development in the field of nonconventional power;

– the accelerated amortization of the equipment;

– participation in financing the objects of nonconventional power use (with participation of the state, private business, local authorities, the population);

– state research and development financings in sphere of nonconventional power (grants).

In the majority of the countries the preference is given to one of the listed above tools, though some countries (for example, Australia, Belgium) uses wider scale of stimulus. In table 2 the countries using concrete tools of economic influence are presented.

Let's have a more detailed view on the stimulation tools of development of nonconventional power in the EU countries.

1. Austria.

The system of NRES encouragement in Austria is the most difficult. Except the basic specified tools this system includes various kinds of direct subsidizing, soft loans, tax discounts. Thus in each of its nine regions Austria operates nine various decisions, regulating tariffs for NRES. There are considerable regional distinctions in tariffs for the NRES (a solar energy – 32 to 1, a biomass energy – 8 to 1). Authoritative European experts estimate the Austrian system of NRES stimulation as chaotic, considering as more rational the simple systems with smaller quantity of regulators. Thus, as a rule, refer to experience of Spain and Denmark [2].

2. Spain.

One of the most considerable achievements of Spain in wind power use we can name the conditions, withdrawn to builders: along with the investments into the wind energy objects they have to carry out obligatory additional investments into the development of infrastructure or the social sphere of the corresponding region. Thus, arising additional financial expenses as the Spanish practice shows

Table 2

The tools of economic influence on the development of nonconventional power in the EU countries

Stimulation tools	Countries which use such tool
Extra charges to tariffs	Australia, Germany, Greece, Denmark, Spain, Luxembourg, Portugal, Finland, France, Sweden
Free from power taxes Quotas and "green" certificates	Netherlands, Slovakia, France, Czech Republic, Sweden
Grants from special fund, based on the reception of taxes, connected with the traditional source electric power	Austria, Bulgaria, Great Britain, Hungary, Netherlands
Grants for the research and development in the field of nonconventional power	Great Britain, Germany, Denmark, Spain, Finland

are not burdensome for investors. At the same time this sphere of investment allows to lower the resistance of local population and the regional ecological organizations to building of the wind energy units.

3. Denmark.

The successes of Denmark in the development of nonconventional power are connected with the use of rational forms of the private-state partnership and attraction of broad masses of the population to realization of projects on development of renewed energy sources. The share form of financing of investment projects of nonconventional power units was extended in this country (with participation of the state, private business, local authorities and the population). Such form of partnership allows not only integrating interests of federal and local authorities, businessmen and the population, but also it is rational to distribute incomes and possible risks between participants of the concrete investment project. The long-term experience of use of the given form of partnership of the state, business and the population is saved up in Denmark in the work of more than 3,000 energy units which joint proprietors are 150 thousand citizens.

Last years the share form of financing of investment projects in the sphere of nonconventional power takes its root into Spain, and the Spanish experience of additional obligations of investors in the development of social sphere and infrastructure is recognized in Germany.

4. The Netherlands.

In the Netherlands the stimulation of a renewed power is based on a tax tools use. Thus the state leans on Keyn's concept of demand stimulation, releasing the consumers of the energy received from all kinds of renewed sources from the taxes (since 2002 this privilege is cancelled for hydro electric power station). Notice down that the tax regulators are the subject to private changes; therefore initiatives of investors in development of NRES restrain absence of long-term guarantees and essential risks. The Dutch model of stimulation of NRES which kernel are taxes, has not received a recognition in the EU countries though many tools of a tax policy are widely used in the European countries, carrying out an auxiliary role in the national systems of stimulation of nonconventional power.

5. Great Britain.

The original system of stimulation of the nonconventional power, based on a quota system and certificates, takes a root into Great Britain in the last decade. Its essence is that the state establishes the minimum quota of consumption (manufacture) of the electric power from renewed sources in the total amount of power consumption (manufacture) to the companies. In 2006–2007, for example, this quota made 6.7 % [3]. The so-called green certificates representing the record in the electronic register, confirming the fact of consumption (manufacture) of certain quantity of energy on the basis of renewed sources of this or that company is thus put into circulation. The companies which have not coped with officially established quotas of consumption (manufacture) of "pure" energy, can enlist their performance by purchase of "green" certificates from the organizations having "a superfluous" share of consumption (manufacture) of "pure" energy. And the companies which have exceeded officially established quotas, can sell these "surpluses" for market prices. Thus, the market of "green" certificates regulated by the state is created. Logic addition of this scheme of formation of the market with "pure" energy are the penal sanctions applied to the companies, not carrying out the established quotas of consumption (manufacture) of the electric power developed on the basis of renewed sources.

The tested model of stimulation of the alternative power approved in Great Britain, combining methods of direct state regulation with market mechanisms, since 2003 takes root in a power economy of Sweden, and last years the recognition is obtained in Austria, Belgium, and Italy.

6. Germany.

Along with wind energy in the EU countries the solar power engineering has started to develop. Germany is the leader in the sun energy use among all European countries, there the half of all solar electric power industry of the European Union is established. The reasons of success of German solar power engineering are caused by a considerable state support of this branch. So, the federal Program of 100,000 solar roofs is realized in Germany and provides the financial grants to investors at a rate of 0.51 billion euro, it is the largest financing program in sphere of solar power in the world. The state gives financial support to building of houses of a new design in which the heating system is based not on use of mineral fuel, but on application of the solar collectors established on roofs of houses and a reformative solar energy in the thermal.

The similar programs of investment stimulation of development of solar energy use in housing sector are accepted in Spain, Luxembourg, Portugal. The state grants allow private investors to cut half expenses on installation of solar panels and approximately twice to reduce production costs of energy on the basis of a sunlight.

In the majority of EU countries the basic stimulation tool for the solar power development as well as wind energy is tariffs and extra charges. The flexible scale of extra charges for generating companies of various capacity, patterns of ownership operates. In Germany, for example, only small installations receive indemnification (capacity no more than 5 MB), in Portugal the more powerful units are supported, however the compensatory surcharges for 1 kW·h of the electric power is twice less, than for small installations. In Luxembourg the private generating companies for 1 kW· hour of the electric power developed by photo-electric elements receive twice bigger indemnification in comparison with the municipal manufacturers. Among the general methods of state regulation of the solar power engineering market in the EU countries the regressive extra charges are used. In Germany, for example, extra charges for the electric power units based on the sunlight annually decrease 5 %, in comparison with the previous year, in Luxembourg – almost 10 % [3].

The European experience shows that there is no only system of stimulation of nonconventional power in EU yet. Each country searches its own rational schemes and effective tools of stimulation. At the same time it is possible to ascertain that two models of motivation of development of NRES: compensatory and quoting operate in the EU. According to the first model the country's state influences manufacture and deliveries of "pure" energy, guaranteeing the generating

companies the long-term fixed prices for the electric power based on NRES. Thus, minimization of negative influence of market condition on dynamics of power consumption and risks for investors is supposed. The second model, unlike the first, assumes a combination of methods of direct administrative regulation (quoting) with market mechanisms ("green" certificates trade for market prices).

In the last years the manufacture and biofuel gets more and more wide use in many countries of the world. So, the considerable part of the collected corn in the USA goes on manufacture of the ethanol used as car fuel. Last year the gain of the corn in the country has reached 10.5 billion, almost 1/5 of which has been processed in 5 billion gallons of ethanol on 112 american factories. If all american ethanol manufacturing factories which are reconstructed or on the stage of building start to operate in the near future by 2008, as the experts of "Business Week" magazine estimated, almost the half of the total amount of gained corn in the USA will serve as a raw material for ethanol reception (2007. № 38(9134). P. 4).

The interest to biofuel manufacture increases not only in the United States, but also the EU countries. So, Secretaries of State for Energy – the members of the European Union have proposed to increase this indicator by 10 % till 2012. However, the majority of the EU countries have not even executed yet the earlier stated agreement to replace the use of fuel into biofuel by 2 % till 2005. Only Sweden and Germany have reached this purpose. As experts point out, one of the reasons of it is the high price on biofuel manufacture, despite the various agricultural grants allocated to farmers in the EU countries. So, as British economists calculated, 1 liter of diesel made from rapeseed costs 0.3 euros higher than the usual oil fuel.

Germany, it is the most active from all EU countries in the problem of biofuel energy use and the replacement of usual fuel into its eco friendly non-polluting analogue. Since 2008, Great Britain plans to undertake the similar measures, and to impose the penalty of 15 penny for the l liter of fuel to the enterprises which will not fulfill the requirement.

The increase of biofuel manufacture will bring the great changes into agricultural sphere, and will influence the development of farming. So it can increase the cost of corn, as it was caused by the increase of ethanol demand made from it, it has already led to a rise of soya-beans and other grain crops prices and a foodstuff. Then such rise can influence the price for meat and soft drinks. The american manufacturers of chicken meat notice that their expenses have already increased by 1.5 bln. dollars a year.

So in the conclusion it is necessary to mention the development of biotechnology should be recognized by a state policy: adequate forms of organizational, financial and information support, both federal and regional, legislative maintenance, stimulation of business and the private-state partnership.

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