OPTIMIZATION OF PREPAREDNESS FOR EXTRACTION OF BALANCE-INDUSTRIAL MINERAL RESERVES

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Abstract

Investigational provision of extractive power-shovels industrially-balance supplies with the different degree of preparedness to the booty and quarry overall depends on a time domain between loosening of array of ferrous quartzite's. Time domain between loosening of array of ferrous quartzite's in coalfaces and a time domain between the mass loosening can be anything. It is well-proven that effective work of quarry in the case when time domains between the mass loosening of array of balance-industrial supplies and loosening of array of ferrous quartzite's in coalfaces gather. Reasonably, that an optimal time domain between the mass loosening of balance-industrial supplies in iron-ore careers is in limits from two to three weeks.

Forming each of single streams of iron-ore mass it takes place under act of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass. Therefore, taking into account influence of losses of balance-industrial supplies and the obstruction of content of quality indexes of minerals in the stream of iron-ore mass execute calculations of signs of content of quality indexes of minerals in the single streams of iron-ore mass. Base the decision of these task expressions of balance of amount of iron-ore mass and amount of content of quality indexes of the iron related to magnetite at working off areas of deposits of hard minerals.

The offered methodology of setting of norms of the balance-industrial supplies prepared to the booty is approved on the careers of Krivbass and methodology of setting of norms of preparedness of the balance-industrial supplies prepared to the booty, developed for operating mining industry enterprises modernized and adjusted to the use on the stage of planning. Setting of norms of balance-industrial supplies of hard minerals consists in determination of optimal correlation of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in a stream iron-ore mass, characterize that a parameter for the case of working off contacts longitudinal lift.

In relation to work of one extractive unit in a i-y change have changeable indexes of booty, losses of balance-industrial supplies, obstruction of content of quality indexes of minerals and content of quality indexes of the iron related to magnetite, what deposits set for areas, used in a i-y change. Thus examine change abilities of indexes of technological process as casual functions during the fixed period (change, ten-day period, month, quarter and other), that mean that during work of separate mining unit and all ore mining enterprise) amount and content of quality indexes of the obtained and lost balance-industrial supplies, amount of breeds of obstruction and content of quality indexes for them averaging out useful component examine as casual processes and for their description the mathematical vehicle of theory of casual functions (is used cross-correlation functions).

Entry. Productive work of every extractive unit at the booty of ferrous quartzites arrive at an open method, if certain accordance sticks to between the different project technological types of mountain works. Planning of development of mountain works in the process of exploitation of balance-industrial supplies of areas of array of hard minerals of deposit is the important stage in the decision of questions of technology of mountain production that provides plenitude of mastering of balance supplies of bowels of the earth [1].

At the annual planning of development of mountain works go into detail and specify perspective plans, and also decide concrete technological questions: establishment of volumes of pre-production mining and threaded works taking into account norms on the degree of preparedness of the prepared and ready to the booty balance-industrial supplies exposed, and also task on the volume of commodity products; set experience works that is sent to the improvement of booty of balance-industrial supplies from the bowels of the earth; determine the rational amount of simultaneously working extractive units with the aim of providing of necessary amount and quality of commodity products; set the optimal loading, fold the calendar graphic arts of booty of balance-industrial supplies of ferrous quartzites on every extractive unit and determine terms their redemption.

Provision of every extractive power-shovel the industrially-balance supplies prepared to the booty with the different degree of preparedness to the booty, and quarry on the whole, depends on a time domain between loosening of array of ferrous quartzites. Effective work of quarry will be in that case, when time domains between the mass loosening of array of balance-industrial supplies and loosening of array of ferrous quartzites in coalfaces gather, then, when time of mass explosion coincides in all extractive coalfaces. An optimal time domain between the mass loosening of array of balance-industrial supplies in iron-ore careers is in limits from two to three weeks [2,3].

An aim of work is development of methodology of setting of norms of ready of the booty of balance-industrial supplies.

For the achievement of the aim such tasks are untied:

– it is an analysis of present methods of setting of norms of ready to boot of balance-industrial supplies;

– it is an improvement of existent methodologies of setting of norms of the balance-industrial supplies prepared to the booty;

– it is establishment of norms of the balance-industrial supplies prepared to the booty.

An idea of work is an analysis and determination of methods of calculation of optimal of the balance-industrial supplies prepared to the booty for development of economy of ore-mining enterprises and indexes of plenitude of the use of resources of bowels of the earth at present labour and material sources.

A research object is the balance-industrial supplies of ferrous quartzites prepared to the booty.

The article of research is methodology of setting of norms of ready to the booty of balance-industrial supplies.

Initial positions of optimization of preparedness are to the booty of balance-industrial supplies. Methodology of optimization preparedness to the booty of balance-industrial supplies and system of content of quality indexes of minerals in the stream of iron-ore mass at the open method of booty in comparing to underground, at general methodical approach, has substantial differences [4,5]. Firstly extractive unit at the underground method of booty keeps balance reserves that determine the parameters of the accepted system of development, and optimization of preparedness to the booty of balance-industrial supplies is optimization of number of extractive units. Secondly on careers ready to the booty, the prepared and exposed industrially-balance supplies change in wide limits at the same number of extractive power-shovels. There is a task to optimization of not only number of extractive power-shovels but also their provision of the industrially-balance supplies prepared to the booty and in addition, at an open method in the process of averaging out of content of quality indexes of minerals in the stream of iron-ore mass of value has direction of mining on extractive ledges.

If at the underground method of booty, optimizing the system characterize a presence two independent changeable are numbers of extractive units on an ore-mining enterprise and capacity of composition of averaging out of content of quality indexes of minerals in iron-ore mass, then at the open method of booty of balance-industrial supplies to these two add changeable two is a provision of the industrially-balance supplies prepared to the booty

and direction of mining. Optimization at four and mathematical vehicle let to untie such task. However for realization number of independent changeable expediently and it maybe to shorten. Create the industrially-balance changeable is difficult and bulky, but will be carried out, so as the worked out methodology supplies prepared to the booty on a career with the aim of providing of the productivity of extractive power-shovels. Determine necessary front of works of one extractive power-shovel under right technological planning of enterprises, that is why size balance-industrial supplies that provide one extractive power-shovel prepared to the booty, determine coming from his productivity and normative front of extractive works. If the examine the provision of quarry the industrial supplies prepared to the booty as dependent changeable, conditioned by the number of extractive units, in connection with it independent changeable during optimization will shorten to three: number of extractive units; direction of booty of balance-industrial supplies; a volume of composition of averaging out of content of quality indexes of minerals is in iron-ore mass.

Optimization of balance-industrial supplies after the degree of preparedness to the booty together with the system of averaging out content of quality indexes of minerals in the stream of iron-ore mass carry out separately for every category of balance-industrial supplies and for all categories simultaneously.

In first case, during separate optimization, for the every category of balance-industrial supplies estimate the economical consequences of their changeability: from one side, charges on realization of mountain works for creation of ready to the booty, prepared and exposed balance-industrial supplies, from other is a loss from changeability. To define an economic effect from changeability of the prepared and exposed balance-industrial supplies will execute through the estimation of their influence on the size of the balance-industrial supplies prepared to the booty, on the number of extractive units. Between industrial supplies ready to the booty, prepared and exposed on a career there are dependences that is set in relation to the terms of booty balance-industrial supplies from an iron-ore deposit, bed, ore body or areas of array of minerals. During separate optimization of every category of balance-industrial supplies together with the system of averaging out of content of quality

indexes of minerals in the stream of iron-ore mass will set the objective functions of optimization for ready to the booty of $E_г$, prepared E_n and exposed E_p of balance-industrial supplies. Thus in general case determine every objective function as a function of changeability three independent changeable: numbers of mining units of N; straight to the booty of hard minerals φ; to the volume of composition of averaging out of content of quality indexes of minerals in iron-ore mass of V.

$$E_г = F_г(N, \varphi, V) \tag{1}$$

$$E_п = F_п(N, \varphi, V) \tag{2}$$

$$E_p = F_p(N, \varphi, V). \tag{3}$$

Optimizations each of objective functions (1)–(3) specifies on existence of local optimum, that is answered by the optimal value of capacity of composition of averaging out of content of quality indexes of minerals in iron-ore mass and means that in this case(for one system of averaging out of content of quality indexes of minerals in iron-ore mass) it is impossible simply to define the volume of composition of averaging out of content of quality indexes of minerals in iron-ore mass [7,8]. On a career simultaneously all categories of balance-industrial supplies (ready to the booty, preparation and exposed) function from the methodical point of view expedient determination of function total economic effect.

$$E = E_г + E_n + E_p = F(N, \varphi, V) \tag{4}$$

At most the function of total economic effect allows simply setting optimal values of independent changeable:

а) Numbers of extractive units, straight to the booty of balance industrial supplies and volume of composition of averaging out of content of quality indexes of minerals in iron-ore mass;

б) Optimal values of dependent changeable – ready to the booty, prepared and exposed balance-industrial supplies.
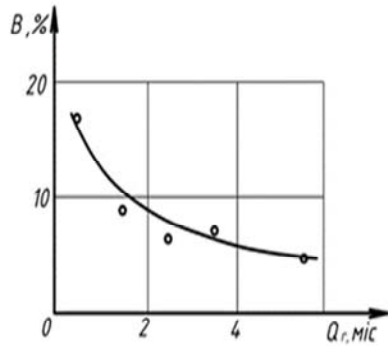
Dependences are between the industrial supplies losses of balance-industrial supplies and obstruction of content of quality indexes of minerals prepared to the booty. In accordance with the worked out methodology of norm of balance-industrial supplies after the degree of preparedness to the booty, the norms of the industrial supplies prepared to the booty on the careers of Krivbass determine from the count losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass at a booty. An account shows that the losses of balance-industrial supplies result in an increase, and obstruction of content of quality indexes of minerals – to reduction of normative size of the balance-industrial supplies prepared to the booty. In this connection during optimization of quality indexes of booty of balance-industrial supplies from the bowels of the earth take into account their influence on normative preparedness to the booty of balance-industrial supplies, that is only one of consequences of connection losses of balance-industrial supplies, obstruction of content of quality indexes of minerals in the stream of iron-ore mass and preparedness to the booty of balance-industrial supplies of minerals [8,9]. For consideration of this question the conducted analysis of indexes of mining of balance-industrial supplies is from the bowels of the earth and state of preparedness to the booty of balance-industrial supplies of hard minerals. Statistical processing of current data of ore-mining enterprises of Krivbass, used for establishment of dependence of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass at a booty from the provision of the industrially-balance supplies prepared to the booty and obstruction quality indexes of minerals in the stream of iron-ore mass on the mines of Krivbass (fig. 1 and fig. 2).

By the nature of these dependences next conclusions are done:
a) dependence of obstruction of content of quality indexes of minerals in iron-ore mass from value of the balance-industrial supplies prepared to the booty near to hyperbolical and testifies that on the mines of Krivbass at the insufficient provision of the industrially-balance supplies of obstruction of content of quality indexes of minerals prepared to the booty at iron-ore mass grows;
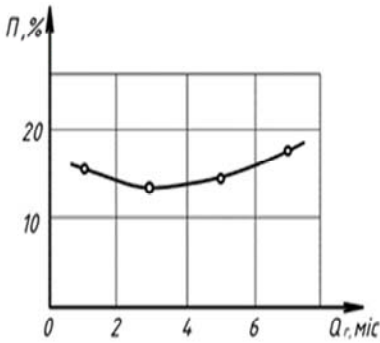
Fig. 1. Dependence of losses of balance-industrial supplies at a booty (*П*) from the provision of the industrial supplies ($Q_Г$) prepared to the booty on the mines of Krivbass
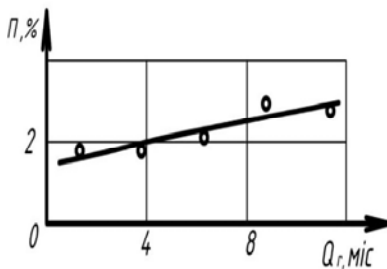
Fig. 2. Dependence of obstruction of content of quality indexes of minerals in iron-ore mass at a booty (*B*) from the provision of the industrial supplies prepared to the booty on the mines of Krivbass

б) at providing the industrially-balance supplies prepared to the booty in iron-ore mass changes near to the normative level of obstruction content of quality indexes of useful minerals and doesn't depend from the provision of mine the industrially-balance supplies prepared to the booty. Explain character of the set conformity to law that in the conditions of deficit of the balance-industrial supplies prepared to the booty of ore-mining enterprise, in order to avoid blowing off plan tasks from the booty of balance-industrial supplies enterprise, in order to avoid blowing off plan tasks from the booty of balance-industrial supplies, increases the amount of breeds of obstruction of content of quality indexes of minerals, bring over that to the booty of unstandardized supplies.

в) Dependence of losses of balance-industrial supplies on the industrial supplies prepared to the booty does not have specific character (a cross-correlation relation presents 0,4–0,5) clearly. In area of deficit of the industrial supplies prepared to the booty the average of losses of balance-industrial supplies grows, and at the surplus provision of the industrial supplies of hard minerals of loss of balance-industrial supplies prepared to the booty also have a tendency to the increase.

An analogical analysis is conducted from actual data of work of iron-ore quarries of Krivbass. The set dependences of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass from the provision of the industrial supplies prepared to the booty are brought around to fig. 3 and on fig. 4.

Fig. 3. Dependence of losses of balance-industrial supplies at a booty (Π) from the provision of the industrial balance supplies (Q_Γ) prepared to the booty on the careers of Krivbass
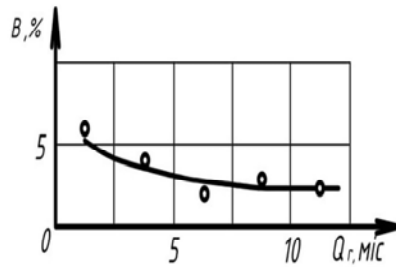
Fig. 4. Dependence of obstruction of content of quality indexes of minerals in iron-ore mass at booty (B) from the provision of the industrial balance supplies (Q_Γ) prepared to the booty on the careers of Krivbass.

Character of these dependences shows that they have the same conformities to law, as well as dependences that is set for ore-mining enterprises with the underground method of booty, namely the obstruction of content of quality indexes of minerals in iron-ore mass at the booty of balance-industrial supplies increases at the deficit of the industrial supplies loss of balance-industrial supplies prepared to the booty grow at the surplus provision of the industrial supplies prepared to the booty.

The set dependences specify on the existent ore, technological, organizational and other terms of mining from iron-ore deposits, beds, ore bodies or areas. These dependences take place, when ore-mining enterprises work in the conditions of surplus or deficit of the industrial supplies prepared to the booty. The set dependences show that passing of ore-mining enterprises to work with normative preparedness of balance-industrial supplies to the booty will allow on iron-ore careers to bring down the obstruction of content of quality

indexes of minerals in the stream of ore mass approximately on 1,5–2 and on mines to bring down the losses of balance-industrial supplies on 2.

Got results testify that setting of norms of balance-industrial supplies after the degree of preparedness to the booty and realization of norms in a production is an effective measure in area of guard of bowels of the earth, that will allow to decrease the losses of balance-industrial supplies and obstructions to content of quality indexes of minerals in iron-ore mass.

Influence of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals is in iron-ore mass on the process of averaging out. Development of ore body or areas of array of hard minerals of deposit is accompanied by the losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass by barren layers and containing breeds. Losses of balance-industrial supplies and obstructions of content of quality indexes of minerals in flow of iron-ore mass influences on homogeneity of content of qualities indexes of constituents of iron-ore mass. Under act of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass oscillation of content of quality indexes of useful components grows in the obtained iron-ore mass. The calculation of indexes of homogeneity of content of quality composition of iron-ore mass during exploitation and planning on a ore-mining enterprise takes into account influence of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals is on the process of averaging out of content of quality indexes of minerals. There is question, as homogeneity of content of quality indexes of useful shock-tench in the stream of iron-ore mass related to the losses of balance-industrial supplies and obstruction of content of quality indexes of minerals. Homogeneity of quality composition of total ore mining stream of iron-ore mass depends on homogeneity of single streams that come from the coalfaces of separate extractive units. In turn, forming each of single streams of iron-ore mass it takes place under act of losses of balance-industrial supplies and obstruction of content of quality indexes of useful minerals in the

stream of iron-ore mass. Therefore taking into account influence of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass will execute the calculations of signs of content of quality indexes of minerals is in the single streams of iron-ore mass. Base the decision of this task expressions of balance of amount of iron-ore mass and amount of content of quality indexes of the iron related to magnetite at working off the areas of deposit of hard minerals with the industrially-balance supplies of $Б$ [7,12]

$$Д = Б - П + В,$$
(5)

$$Дa = Бc - Пc_П + Вb,$$
(6)

where $Д$, $П$ is accordingly amount of the obtained and lost balance-industrial supplies, thousands of т; $В$ is an amount of breeds of obstruction content of quality indexes of minerals, thousands of т; a, c, $c_П$, b is content of quality indexes of useful component accordingly in obtained, in an array, in the lost balance-industrial supplies and in the breeds of obstruction of content of quality indexes of minerals.

Formulas (5) and (6) just for any area of minerals develop that, that is why will use them for the estimation of amount of content of quality indexes of the iron related to magnetite and to content of quality indexes of minerals in the stream of iron-ore mass, by obtained mining unit in a fixed period of time (hour, change, daytime). For example, in relation to work of one extractive unit in a i-y change expressions (5) and (6) have changeable indexes of booty, losses of balance-industrial supplies, obstruction of content of quality indexes of minerals and content of quality indexes of the iron related to magnetite, that is set for the areas of bed exhaust in a i-y change. Thus change abilities of indexes of $Д_i$, $П_i$, $В_i$, C_i et al examine as casual functions during a corresponding period (twenty-four hours, ten-day period, month, quarter and other), that mean, that during work of separate extractive unit or all ore-mining enterprises amount and content of quality indexes of obtained and the lost balance-industrial supplies, amount of breeds of obstruction and content of quality indexes for them averaging useful component examine as casual processes and for their description the mathematical vehicle of theory of casual functions is

used. In the quality indexes of descriptions of casual processes, losses of balance-industrial supplies and obstruction of content of quality indexes of minerals determine accordingly the cross-correlation functions of $r_{ДД}$, $r_{ПП}$, $r_{ВВ}$. If in a formula (6) to put the value of $Б$, that certainly from equality (5), then expression is for balance of amount of content of quality indexes of the iron related to magnetite, at working off the area of bed will be

$$Д_i a_i = Д_i c_i + П_i c_i + B_i b_i - B_i c_i - П_i c_{Пi}, \qquad (7)$$

For determination of correlative functions of right and left parts of equality (7) determine the presence of cross-correlation of accidental functions, that is included in expression of balance of amount of content of quality indexes of the iron related to magnetite. Task decides taking into account cross-correlation all accidental functions of $Д_i$, $П_i$, B_i, C_i and. Thus limited to consideration of characteristic case of booty of balance-industrial supplies from a deposit at that casual functions of $Д_i$, $П_i$, B_i mutually correlates, and all other casual functions, that is included in expression (7) – does not correlate. For these terms, taking into account, that X and X' values of casual function, that attributing to the different moments of time of t and t' (to the different crossing of casual function) we have

$$\begin{aligned}
r_{ДД}r_{aa'} &= \overline{ДД}'r_{aa'} + \overline{aa}'r_{ДД'} = r_{ДД}r_{cc'} + \overline{ДД}'r_{cc'} + \overline{cc}'r_{ДД'} + r_{ПП}r_{cc'} + \overline{ПП}'r_{cc'} + \\
&+ \overline{cc}'r_{ПП} + r_{ВВ}r_{cc'} + \overline{ВВ}'r_{cc'} + \overline{cc}'r_{ВВ} + r_{ПП}r_{c_П c_П'} + \overline{ПП}'r_{c_П c_П'} + \overline{c}_П\overline{c}_П r_{ПП} + \\
&+ r_{ВВ}r_{bb'} + \overline{ВВ}'r_{bb'} + \overline{b}\,\overline{b}'r_{ВВ} + 2r_{Дc,Пc} - 2r_{Дc,Вc} - 2r_{Дc,Пc_П} + 2r_{Дc,Вb} - 2r_{Пc,Вc} - \\
&- 2r_{Пc,Пc_П} + 2r_{Пc,Вb} + 2r_{Вc,Пc_П} - 2r_{Вc,Вb} - 2r_{Пc_П,Вb},
\end{aligned} \qquad (8)$$

where $r_{xy,zu}$ is a mutual covariance function of product of $X\times Y$ and $Z\times U$ casual functions of X, Y, Z, U; $M[x] = \overline{x}$ it is a mathematical hope of casual function of X.

Determine mutual covariance functions that is included in expression (8) as

$$\begin{aligned}
r_{Дc,Пc} &= \mathrm{M}\left[ДcПc \right] - \mathrm{M}\left[Дc \right]\mathrm{M}\left[Пc \right] = \\
&\overline{ДП}\,\overline{c}^2 - \overline{Дc}\,\overline{П}c = ДП\,\sigma_c^2 r_{ДП}(\sigma_c^2 + c^2),
\end{aligned} \qquad (9)$$

where $r_{ДП}$ is a mutual covariance function of casual functions of $Д_i$ and $П_i$.

Determine like $r_{Дc,Пc} = \overline{ДB}\sigma_c^2 + (\sigma_c^2 + \bar{c}^2)r_{ДB}$; $r_{Дc,Пc_П} = \overline{c}\overline{c}_П r_{ДП}$;

$$r_{Дc,Bb} = \bar{c}\bar{b}\,r_{ДB}\,;\; r_{Пc,Bc} = \overline{ПB}\sigma_c^2 + (\sigma_c^2 + \bar{c}^2)r_{ПB}\,;\; r_{Пc,Пc_П} = \overline{c}\overline{c}_П \sigma_П^2\,;$$

$$r_{Пc,Bb} = \bar{c}\bar{b}\,r_{ПB}\,;\; r_{Bc,Пc_П} = \overline{c}\overline{c}_П r_{BП}\,;\; r_{Bc,Bb} = \bar{c}\bar{b}\,\sigma_B^2\,;\; r_{Пc_П,Bb} = \bar{c}_П\bar{b}\,\overline{r}_{ПB}\,.$$

Putting the value of covariance functions in expression (8) and uniting him relatively $r_{aa'}$, determine

$$r_{aa'} = \frac{1}{r_{ДД'} + \overline{ДД'}}[(r_{cc'} + \overline{c}\overline{c}')(r_{ДД'} + r_{ПП'} + r_{BB'}) + r_{cc'}(\overline{ДД'} + \overline{ПП'} + \overline{B}\overline{B'}) +$$
$$+ r_{c_П c_П}(r_{ПП'} + \overline{ПП'}) + r_{bb'}(r_{BB'} + \overline{B}\overline{B'}) + (\overline{c}\overline{c}' - 2\overline{c}\overline{c}_П)r_{ПП'} + (\overline{b}\overline{b}' - 2\overline{c}\overline{b})r_{BB'} -\quad (10)$$
$$\overline{a}\overline{a}'r_{ДД'} + 2r_{ДП}(\sigma_C^2 + \bar{c}^2 - \overline{c}\overline{c}_П) - 2r_{ДB}(\sigma_C^2 + \bar{c}^2 - \overline{c}\overline{b}) -$$
$$- 2r_{ПB}(\sigma_C^2 + \bar{c}^2 - \overline{c}\overline{b} - \overline{c}\overline{c}_П + \overline{c}_П\overline{b}) + 2\sigma_C^2(\overline{ДП} - \overline{ДB} - \overline{ПB})].$$

Expression (10) shows, copulas between quality signs, characterize the processes of averaging-out of content of quality indexes of minerals that in iron-ore mass, losses of balance-industrial supplies and obstructions of content of quality indexes of minerals during work of separate extractive unit. In case at $t=t'$ formula (10) will use for determination to dispersion of content of quality indexes of averaging out useful component in the obtained balance-industrial supplies.

$$\sigma_a^2 = \frac{1}{\sigma_Д^2 + \overline{Д}^2}[(\sigma_c^2 + \bar{c}^2)(\sigma_Д^2 + \sigma_П^2 + \sigma_B^2) + \sigma_c^2(\overline{Д}^2 + \overline{П}^2 + \overline{B}^2) +$$
$$+ \sigma_{c_П}^2(\sigma_П^2 + \overline{П}^2) + \sigma_b^2(\sigma_B^2 + \overline{B}^2) + (\bar{c}^2 - 2\overline{c}\overline{c}_П)\sigma_П^2 + (\bar{b}^2 - 2\overline{c}\overline{b})\sigma_B^2 -$$
$$\overline{a}^2\sigma_Д^2 + 2K_{ДП}(\sigma_c^2 + \bar{c}^2 - \overline{c}\overline{c}_П) - 2K_{ДB}(\sigma_c^2 + \bar{c}^2 - \overline{c}\overline{b}) -\quad (11)$$
$$- 2K_{ПB}(\sigma_C^2 + \bar{c}^2 - \overline{c}\overline{b} - \overline{c}\overline{c}_П, + \overline{c}_П\overline{b}) + 2\sigma_C^2(\overline{ДП} - \overline{ДB} - \overline{ПB})].$$

where $K_{ДП}$, $K_{ДB}$, $K_{ПB}$ is cross-correlation moments of sizes of $Д$ and $П$, $Д$ and B, $П$ and B. Will consider cases at the booty of balance-industrial supplies.

1. The obstruction of content of quality indexes of minerals passes gobs. For determination of f covariance function in a formula (10) assume that $\bar{b} = \bar{b}' = 0$, $r_{bb'} = 0$.

$$r_{aa'} = \frac{1}{r_{\mathcal{ДД'}} + \overline{\mathcal{ДД'}}}[(r_{cc'} + \overline{c}\overline{c}')(r_{\mathcal{ДД'}} + r_{\mathcal{ПП'}} + r_{\mathcal{ВВ'}}) + r_{cc'}(\overline{\mathcal{ДД'}} + \overline{\mathcal{ПП'}} + \overline{\mathcal{ВВ'}}) +$$
$$+ r_{c_{\Pi}c'_{\Pi}}(r_{\mathcal{ПП'}} + \overline{\mathcal{ПП'}}) + r_{\mathcal{ПП'}}(\overline{c}\overline{c}' - 2\overline{c}\overline{c}_{\Pi}) - \overline{a}\overline{a}'r_{\mathcal{ДД'}} + 2r_{\mathcal{ДП}}(\sigma_C^{\,2} + \overline{c}^2 - \overline{c}\overline{c}_{\Pi}) - \quad (12)$$
$$- 2r_{\mathcal{ДВ}}(\sigma_C^{\,2} + \overline{c}^2) - 2r_{\mathcal{ПВ}}(\sigma_C^{\,2} + \overline{c}^2 - \overline{c}\overline{c}_{\Pi}) + 2\sigma_C^{\,2}(\overline{\mathcal{ДП}} - \overline{\mathcal{ДВ}} - \overline{\mathcal{ПВ}})].$$

For the calculations of dispersion of content of quality indexes of useful component at the obstruction of content of quality indexes of minerals assume gobs, that $\overline{b} = 0$ and $\sigma_b = 0$. Will have

$$\sigma_a^{\,2} = \frac{1}{\sigma_{\mathcal{Д}}^{\,2} + \overline{\mathcal{Д}}^2}[(\sigma_c^{\,2} + \overline{c}^2)(\sigma_{\mathcal{Д}}^{\,2} + \sigma_{\Pi}^{\,2} + \sigma_B^{\,2}) + \sigma_c^{\,2}(\overline{\mathcal{Д}}^2 + \overline{\Pi}^2 + \overline{B}^2) +$$
$$+ \sigma_{c_{\Pi}}^{\,2}(\sigma_{\Pi}^{\,2} + \overline{\Pi}^2) + \sigma_{\Pi}^{\,2}(\overline{c}^2 - 2\overline{c}\overline{c}_{\Pi}) - \overline{a}^2\sigma_{\mathcal{Д}}^{\,2} + 2K_{\mathcal{ДП}}(\sigma_C^{\,2} + \overline{c}^2 - \overline{c}\overline{c}_{\Pi}) - \quad (13)$$
$$- 2K_{\mathcal{ДВ}}(\sigma_C^{\,2} + \overline{c}^2) - 2K_{\mathcal{ПВ}}(\sigma_C^{\,2} + \overline{c}^2 - \overline{c}\overline{c}_{\Pi}) + 2\sigma_C^{\,2}(\overline{\mathcal{ДП}} - \overline{\mathcal{ДВ}} - \overline{\mathcal{ПВ}})].$$

2. The obstruction of content of quality indexes of minerals is absent. For the calculation of covariance function of content of quality indexes of useful component at this case in a formula (12) will accept, that $\overline{B} = \overline{B}' = 0$, $r_{BB'} = 0$. Will get on such conditions

$$r_{aa'} = \frac{1}{r_{\mathcal{ДД'}} + \overline{\mathcal{ДД'}}}[(r_{cc'} + \overline{c}\overline{c}')(r_{\mathcal{ДД'}} + r_{\mathcal{ПП'}}) + r_{cc'}(\overline{\mathcal{ДД'}} + \overline{\mathcal{ПП'}}) + r_{c_{\Pi}c'_{\Pi}}(r_{\mathcal{ПП'}} + \overline{\mathcal{ПП'}}) + \quad (14)$$
$$+ r_{\mathcal{ПП'}}(\overline{c}\overline{c}' - 2\overline{c}\overline{c}_{\Pi}) - \overline{a}\overline{a}'r_{\mathcal{ДД'}} + 2r_{\mathcal{ДП}}(\sigma_C^{\,2} + \overline{c}^2 - \overline{c}\overline{c}_{\Pi}) + 2\sigma_C^{\,2}\overline{\mathcal{ДП'}}].$$

For the calculation of dispersion in a formula (13) assume, that $\overline{B} = 0$, $\sigma_B = 0$, $K_{\mathcal{ДВ}} = 0$, $K_{\mathcal{ПВ}} = 0$. A formula (13) substantially will simplify and she will assume an air

$$\sigma_a^{\,2} = \frac{1}{\sigma_{\mathcal{Д}}^{\,2} + \overline{\mathcal{Д}}^2}[(\sigma_c^{\,2} + \overline{c}^2)(\sigma_{\mathcal{Д}}^{\,2} + \sigma_{\Pi}^{\,2}) + \sigma_c^{\,2}(\overline{\mathcal{Д}}^2 + \overline{\Pi}^2) + \sigma_{c_{\Pi}}^{\,2}(\sigma_{\Pi}^{\,2} + \overline{\Pi}^2) + \quad (15)$$
$$+ \sigma_{\Pi}^{\,2}(\overline{c}^2 - 2\overline{c}\overline{c}_{\Pi}) - \overline{a}^2\sigma_{\mathcal{Д}}^{\,2} + 2K_{\mathcal{ДП}}(\sigma_C^{\,2} + \overline{c}^2 - \overline{c}\overline{c}_{\Pi}) + 2\sigma_C^{\,2}\overline{\mathcal{ДП'}}].$$

3. The losses of balance-industrial supplies at a booty are absent. It means that in the formula (10) of value of all indexes, balance-industrial supplies related to the losses from the array of hard minerals, id est $\overline{\Pi}$, $\overline{c}_{\Pi}$, $r_{\mathcal{ПП'}}$, accept such that equal a zero. Have thus

$$r_{aa'} = \frac{1}{r_{ДД'} + \overline{ДД'}}[(r_{cc'} + \overline{c}\,\overline{c}')(r_{ДД'} + r_{BB'}) + r_{cc'}(\overline{ДД'} + \overline{BB'}) + r_{bb'}(r_{BB'} + \overline{BB'}) +$$
$$+ r_{BB'}(\overline{b}\,\overline{b}' - 2\overline{c}\,\overline{b}) - \overline{a}\,\overline{a}'r_{ДД'} - 2r_{ДB}(\sigma_C^2 + \overline{c}^2 - \overline{c}\,\overline{b}) - 2\sigma_C^2\,\overline{ДB}]. \tag{16}$$

Dispersion for this case will get from expression (11), taking on all values of indexes of losses of balance-industrial supplies, that equal a zero.

$$\sigma_a^2 = \frac{1}{\sigma_Д^2 + \overline{Д}^2}[(\sigma_c^2 + \overline{c}^2)(\sigma_Д^2 + \sigma_B^2) + \sigma_c^2(\overline{Д}^2 + \overline{B}^2) + \sigma_b^2(\sigma_B^2 + \overline{B}^2) +$$
$$+ \sigma_B^2(\overline{b}^2 - 2\overline{c}\,\overline{b}) - \overline{a}^2\sigma_Д^2 - 2K_{ДB}(\sigma_C^2 + \overline{c}^2 - \overline{c}\,\overline{b}) - 2\sigma_C^2\,\overline{ДB}]. \tag{17}$$

4. The losses of balance-industrial supplies are absent and the obstruction of content of quality indexes of minerals in the stream of iron-ore mass passes gobs. In this case in a formula (16) accept $\overline{b} = \overline{b}' = 0$, $b = b' = 0$, $r_{bb} = 0$ and expression for the calculations of covariance function assumes

$$r_{aa'} = \frac{1}{r_{ДД'} + \overline{Д}^2}[(r_{cc'} + \overline{c}\,\overline{c}')(r_{ДД'} + r_{BB'}) + r_{cc'}(\overline{ДД'} + \overline{B}\,\overline{B}') -$$
$$- \overline{a}\,\overline{a}'r_{ДД'} - 2r_{ДB}(\sigma_C^2 + \overline{c}^2) - 2\sigma_C^2\,\overline{ДB}]. \tag{18}$$

Like from a formula (17) will get expression for the calculations of dispersion of content of quality indexes of useful component

$$\sigma_a^2 = \frac{1}{\sigma_Д^2 + \overline{Д}^2}[(\sigma_c^2 + \overline{c}^2)(\sigma_Д^2 + \sigma_B^2) +$$
$$+ \sigma_c^2(\overline{Д}^2 + \overline{B}^2) - \overline{a}^2\sigma_Д^2 - 2K_{ДB}(\sigma_c^2 + \overline{c}^2)]. \tag{19}$$

In default of losses of balance-industrial supplies and obstruction of content of quality indexes of useful minerals, as follows from formulas (18) and (19), a covariance function and dispersion of content of quality indexes of averaging-out useful component in the obtained balance-industrial supplies depend only on content of quality indexes of useful component in the bowels of the earth.

$$r_{aa'} = \frac{1}{r_{ДД'} + \overline{Д}^2}\left(r_{cc'}r_{ДД'} + \overline{c}\,\overline{c}\,'r_{ДД'} + \overline{ДД}r'_{cc'} - \overline{a}\,\overline{a}\,'r_{ДД'}\right), \qquad (20)$$

$$\sigma_a^{\,2} = \frac{1}{\sigma_Д^{\,2} + \overline{Д}^2}\left(\sigma_c^{\,2}\sigma_Д^{\,2} + \sigma_Д^{\,2}\overline{c}^2 + \sigma_C^{\,2}\overline{Д}^2 - \overline{a}^2\sigma_Д^{\,2}\right), \qquad (21)$$

what confirms the justice of the set dependences.

Analyzing formulas (5)–(19) taking into account the terms of booty of balance-industrial supplies will execute the estimation of influence of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass on homogeneity of quality composition of single stream of iron-ore mass that comes from the coalface (or coalfaces) of separate extractive unit. Changeable in these formulas determine from geological survey data and materials of exploitation of deposit, bed, ore body or areas of array of hard minerals. Difficulties are presented by determination of functions of $r_{BB'}$, $r_{bb'}$, $r_{ПП'}$, $r_{cПc'}$ at the booty of balance-industrial supplies underground method.

Determination of influence of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals on the processes of booty of balance-industrial supplies and averaging of content of quality indexes of minerals in the stream of iron-ore mass results in necessity expansion and deepening of scientific bases about essence of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals. Examine the obstruction of content of quality indexes of minerals as a process of bringing in the booty of gobs and unstandardized balanced supplies. Point description of process of obstruction of content of quality indexes of minerals with the use of mathematical vehicle to the theory of casual functions that allows in number to estimate influence of obstruction on the process of content of quality indexes of minerals in iron-ore mass.

Like will consider and will describe the losses of balance-industrial supplies as process of losses. In connection with it actual tasks of study of processes of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals are in the stream of iron-ore mass, exposure of conformities to law of their formation and flowing in time at the different systems and methods

of booty of balance-industrial supplies from the areas of array of hard minerals of deposit. The processes of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in general case are uneven, in identical time domains in a booty attract the different keel-bone of breeds of obstruction with different content of quality indexes of useful component, and also lose the different amount of balance-industrial supplies with different content of quality indexes, that influences on the process of averaging of content of quality indexes of minerals in the stream of iron ore mass, increasing oscillation of content of quality composition of averaging of the obtained balance-industrial supplies. For the increase of homogeneity of content of quality, composition of averaging of balance-industrial supplies it is necessary so to plan a booty that the processes of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass flowed in time evenly.

Estimating influence of obstruction of content of quality indexes of minerals in the stream of iron-ore mass on averaging of content of quality indexes of minerals in iron-ore mass assume, that between the average of obstruction averaging and standard deviation there is dependence determine that on results the analysis of current data of ore-mining enterprises of Krivbass during a few years. As evidently from a diagram, what is shown on fig. 5, approximate dependence a line.
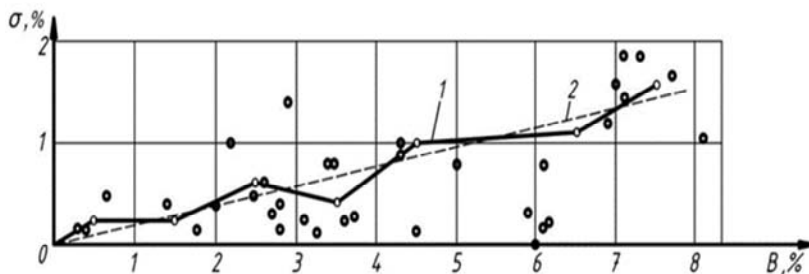
Fig. 5. Dependence of standard deviation of size of obstruction of content of quality indexes of minerals in the stream of iron-ore mass from her mean value: 1 is an empiric curve; 2 is equalization of regression

The results of cross-correlation analysis testify to the presence of connection between sizes: the coefficient of correlation equals 0,7; the error of coefficient of correlation presents 0,04 and testifies to authenticity of the got results and equalization of regression

$$\sigma_B = 0,2\overline{B}. \tag{22}$$

Dependence (22) simplifies the calculations of size and estimation of influence of obstruction of content of quality indexes of minerals on the process of average of content of quality dates of minerals in iron-ore mass, so as an exceptional necessity of realization of experimental works. Explain the presence of such conformity to law that an average is related to the scope of vibrations of obstruction of content of quality indexes of minerals in the stream of iron-ore mass. An increase or reduction of average of obstruction of content of quality dates of minerals in the stream of iron-ore mass is related to the increase or reduction to the range of changeability of obstruction of content of quality indexes of minerals in the stream of iron-ore mass with a size middle quadratic rejection.

Optimization of correlation of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals is in the stream of iron-ore mass. Setting of norms of balance-industrial supplies of hard minerals consists in determination of optimal correlation of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass, that for the case of working contacts longitudinal characterize a parameter [7–10]. On the set technology of mountain works and processing of content of quality indexes of the iron related to magnetite in the stream of iron-ore mass optimal estimation of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass, that certainly by the method of variants of working off contacts or analytical method by being of extremum of technical-economic model of prognostication of the system "a quarry is an ore mining and processing factory". Method of variants universal, but is labour intensive and does not allow exactly to expect optimal correlation, that is why will take advantage of analytical method of optimization singing-relation of losses of balance-industrial supplies and

obstruction content of quality indexes of minerals in the stream of iron-ore mass by determination of a maximum of mathematical technical-economic model of income. Will analyses influence of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass on an income that gets an ore mining and processing combine because of the activity, determine as a difference of cost of concentrate and complete charges on its production.

$$\Pi_P = Q_K \text{ц}_K - 3_K. \tag{23}$$

The amount of the obtained balance-industrial supplies and concentrate withdrawn from them is bound by dependence [9]

$$Q_K = Д\gamma_K, \tag{24}$$

where $\gamma_к$ is an exit of concentrate, part of units.

Coming from balance of balance-industrial supplies and content of quality indexes of the iron related to magnetite at enriching and taking into account the mechanical losses of concentrate determine the exit of concentrate from expression

$$\gamma_K = \frac{a - a_X}{(a - a_K)(1 - \pi_K)}, \tag{25}$$

where and is AV content of quality indexes of the iron related to magnetite in the obtained balance-industrial supplies in a plan period; $a_к$, a_x is AV content of the quality dates iron related to magnetite, accordingly in a concentrate and milltailingss in a planning period; $\pi_к$ are mechanical losses of concentrate in enumeration on a concentrate, parts of units.

Complete charges on the production of concentrate fold from charges on industrially-balance supplies and transporting of the obtained iron-ore mass, on the exception of content of quality indexes of the iron related to magnetite, and charges, on the booty of opening breeds. In addition, an enterprise must bring in paying for the bowels of the earth and make amends for injury to the state through industrially-balance supplies with the use of earth under a quarry (mountain taking), dumps of opening breeds, and industrial

ground. An ore-mining enterprise gets an additional income from realization of breeds of opening and milltailingss of content of quality indexes of iron related to magnetite after processing. Thus possible cases:

а) Losses of balance-industrial supplies and obstructions of content of quality indexes of minerals in the stream of iron-ore mass influences on the size of additional income;

б) Losses of balance-industrial supplies and obstructions of content of quality indexes of minerals in the stream of iron-ore mass does not influence on the size of additional income.

Meet the second case more often at the robot of ore-mining enterprises that is part of the first and will consider him at development of technical-economic model of combine. The size of income that gets ore-mining enterprise depends on that, or lose industrially-balance supplies in an array or loosen and take out in a dump. At working off the high-dipping balance-industrial supplies of deposit, bed, ore body or areas of array of hard minerals lose only loosening balance-industrial supplies. At deposits, beds, ore bodies or areas lose balance-industrial supplies both in the loosening state (contacts of hanging side of bed) and in an array (contacts of laying side). For simplification of researches we are work out models for every type of balance-industrial supplies lose that. Taking into account previously mentioned and different character of influence of conditionally changeable and conditionally-permanent charges on the income of enterprise, for a case, when lose loosening balance-industrial supplies, expression (23) will write down as [9]

$$
\begin{aligned}
\Pi_P = \ & Д\gamma_К \left(ц_К - з'_{ТК} \right) - Q_В з'_В - 3''_В - Дз'_{ДТР} - 3''_{ДТР} - Дз'_{ПР} - \\
& - 3''_П - Бт_Б - Бт_{ГО} - Q_В \left(1 - u_В \right) m_В - Д \left(1 - \gamma_К \right)\left(1 - u_Х \right) m_Х - \\
& - T_{ПП} + Q_В u_В \left[\gamma_{ТВ} \left(ц_{ТВ} - з'_{ТТВ} \right) - \left(з'_{ТПВ} - з'_{ТВ} \right) - з'_{ПВ} - \\
& - з'_{ТХВ} \left(1 - \gamma_{ТВ} \right) - \left(1 - \gamma_{ТВ} \right) m_{ХВ} \right] - 3''_{ТВ} + \\
& + Дu_Х \left(1 - \gamma_К \right)\left[\gamma_{ТХ} \left(ц_{ТХ} - з'_{ТТХ} \right) - \left(з'_{ТХП} - з'_{ТХ} \right) - з'_{ПХ} - \\
& - з'_{ТХХ} \left(1 - \gamma_{ТХ} \right) - \left(1 - \gamma_{ТХ} \right) m_{ХХ} \right] - 3''_{ТХ} ,
\end{aligned}
\tag{26}
$$

where $\gamma_к$, γ_{TB}, γ_{TX} is an exit of concentrate, commodity products accordingly from the breeds of opening of balance-industrial supplies and milltailingss of content of quality indexes of the iron related to magnetite, part of units; u_B, u_X is a coefficient of the use (processing) of

breeds of opening and tails of enrichment content of quality indexes of the iron related to magnetite, part of units; $ц_К$, $ц_{ТВ}$, $ц_{ТХ}$ is a cost of 1 т concentrate, commodity products, that is got from the breeds of opening and milltailingss of content of quality indexes of the iron, related to magnetite, hrn.; $з'_{ТК}$ are conditionally-changeable charges on to the transportation concentrate from an ore mining and processing factory to the point, a consumer, hrn./of т, bears expenses from that; $з'$ In are conditionally-changeable charges on a production $з'_{ДВ}$ and transporting in mine dump $з'_{ТВ}$, taken on 1 т of breeds of opening, hrn.; $з'_{ДПР}$ and $з'_{ПР}$ are charges accordingly on the booty of balance-industrial supplies and transporting to the ore mining and processing factory and primary exception of content of quality indexes of the iron, related to magnetite in the stream of iron-ore mass and on a production and transporting in the dump of breeds of opening, thousand a hrn.; $Т_Б$, $Т_{ГВ}$ is paying accordingly for the bowels of the earth and earth of the mountain taking (on 1 т of balance-industrial supplies), hrn.; $Т_В$ is paying for earth under the dumps of opening breeds, what relate to 1 т of the geological opening, hrn.; $Т_{ХХ}$ is paying for earth under tailing dump, take that to 1 т milltailingss of content of quality indexes of the iron, related to magnetite, hrn.; $Т_{ПП}$ is paying for earth under industrial site, thousand a hrn.; $з'_{ТТВ}$, $з'_{ТТХ}$ are conditionally-changeable charges on transporting of 1 т of commodity products, that is got from the breeds of opening and tails of content of quality indexes of the iron related to magnetite, from the places of their processing to the railway, hrn.; $з'_{ТВП}$, $з'_{ПВ}$ are conditionally-changeable charges on transporting from a quarry to the place of processing and exception of 1 т breeds of opening, hrn.; $з'_{ТХП}$, $з'_{ПХ}$ are conditionally-changeable charges on transporting from an ore mining and processing factory to places of processing of milltailingss and on the exception of 1 т milltailingss of content of quality indexes of the iron, related to magnetite, hrn.; $з'_{ТХВ}$, $з'_{ТХХ}$ are conditionally-changeable charges on transporting of 1 т tails (wastes) of processing of breeds of opening and milltailingss of content of quality indexes of the iron related to magnetite from the places of processing , hrn.; $Т_{ХВ}$, $Т_{ХХ}$ is paying for the use of earth under tailing dumps wastes of processing of breeds of opening and milltailingss of content of quality indexes of the iron related to magnetite, that is taken on 1 т, hrn.; $з''_{ТВ}$, $з''_{ТХ}$ is a sum of

conditionally-permanent charges on the exception of breeds of opening and milltailingss, thousand hrywnas.

Expression (26) after transformation and introduction of conditional denotations will write down as

$$\Pi_P = \text{Д}[\gamma_{\text{К}} A_1 - A_2 + \Pi p_{\text{X}}] - Q_{\text{B}}(A_3 - \Pi p_B) - \text{Б} A_4 - 3''_{\text{К}} - T_{\text{ПП}}, \quad (27)$$

Where
$$A_1 = u_K - 3'_{TK}, \quad (28)$$

$$A_2 = 3'_{\text{ДТР}} + 3'_{\text{ПР}} + (1 - \gamma_{\text{К}})(1 - u_{\text{X}})m_{\text{X}}, \quad (29)$$

$$A_3 = 3'_B (1 - u_B)m_B, \quad (30)$$

$$A_4 = m_{\text{Б}} + m_{\text{ГО}}, \quad (31)$$

Πp_B is an income from realization of opening breeds; take that to their 1 т, hrn.

$$\Pi p_{\text{B}} = u_{\text{B}}[\gamma_{\text{ТВ}}(u_{\text{ТВ}} - 3'_{\text{ТТВ}}) - (3'_{\text{ТПВ}} - 3'_{\text{ТВ}}) - 3'_{\text{ПВ}} - (1 - \gamma_{\text{ТВ}})(3'_{\text{ТВХ}} - m_{\text{ХВ}})] - 3''_{\text{ВВ}}; \quad (32)$$

Πp_X is an additional income from realization of milltailingss of content of quality indexes of the iron, related to magnetite, take that to 1 т of iron-ore mass, hrn.

$$\Pi p_{\text{X}} = u_{\text{X}}(1 - \gamma_{\text{К}})[\gamma_{\text{ТХ}}(u_{\text{ТХ}} - 3'_{\text{ТХХ}}) - (3'_{\text{ТХП}} - 3'_{\text{ТХ}}) - 3'_{\text{ПХ}} - (1 - \gamma_{\text{ТХ}})(3'_{\text{ТХХ}} - m_{\text{Х}})] - 3''_{\text{ТХ}}; \quad (33)$$

$3''_K$ is a sum of conditionally-permanent charges at the production of concentrate, hrn.;

$$3_{\text{К}}'' = 3_{\text{В}}'' + 3''_{\text{ДТР}} + 3_{\text{П}}''. \quad (34)$$

Optimization of balance-industrial supplies of hard minerals mathematically and logically legitimate only at complete them contoured, at Б=of const, and the known quantitative, quality and technological descriptions. Because of it will write down expression (27) as a function of Б; П; В. In that case, when lose balance-industrial supplies in the loosening state, the amount of breeds of

opening that must be extracted at working off balance-industrial supplies determines as

$$Q_B = БК_{ВГ} + П - В. \qquad (35)$$

If we lose balance-industrial supplies in an array

$$Q_B = БК_{ВГ}. \qquad (36)$$

Putting expressions (23), (34), (35) in (27) and taking into account the different exit of concentrate in accordance with (25), will get two cases, when lose balance-industrial supplies:

а) in the iron-ore mass removed from an array

$$Пр_0 = Б[\gamma_Б A_1 - A_2 - K_{ВГ}(A_3 - Пр_В) - A_4 + Пр_Х] - $$
$$- П[\gamma_П A_1 - A_2 + A_3 - Пр_В - Пр_Х] + В[\gamma_В A_1 - A_2 + \qquad ; \quad (37)$$
$$+ A_3 - Пр_В + Пр_Х] + З_К" - Т_{ПП}$$

б) in the array of hard minerals

$$Пр_М = Б[\gamma_Б A_1 - A_2 - K_{вг}(A_3 - Пр_В) - A_4 + Пр_Х] - \qquad (38)$$
$$- П[\gamma_П A_1 - A_2 + Пр_Х] + В[\gamma_В A_1 - A_2 + Пр_Х] - З_К" - Т_{ПП}.$$

In careers is both connected at working off contacts losses balance-industrial supplies and obstruction to content quality indexes minerals in a stream iron-ore mass and independent from each other (flying away of pieces of iron-ore mass and breeds, cleaning out of ballast). The last are caused by technological reasons and are the proportionally liquidated balance-industrial supplies. At working off contacts determine dependence between the careening bone of losses of balance-industrial supplies and obstructive content of quality indexes of minerals of breeds the chart of working off contacts. Charts of working off working over off contacts brought to the chart longitudinal with flat hay-crops after correlation amounts of balance-industrial supplies, lose that obstructive content of quality indexes of minerals of breeds.

Thus, amount of balance-industrial supplies lose that and obstructive content of quality indexes of minerals of breeds in a career determine as

$$\Pi = \Pi_\Delta + \Pi_T = V_\Delta \rho_\Pi k^2 + \pi_T Б = Б_\Delta k^2 + \pi_T Б, \qquad (39)$$

$$B = B_\Delta + B_T = V_\Delta \rho_B (1-k)^2 + \beta_T Б = B_\Delta (1-k)^2 + \beta_T Б, \quad (40)$$

where Π_Δ, B_Δ is an amount accordingly balance-industrial supplies, lose that breeds of obstruction of content of quality indexes of minerals in "triangles" at working off near contact zones, thousands of т; Π_T, B is an amount of balance-industrial supplies and breeds of obstruction of content of quality indexes of minerals, lose that at cleaning out of working grounds of ledges (trough technological reasons), thousands of т; V_Δ is a volume of near-contact zone, thousand $м^3$; ρ_Π, ρ_B is a middle closeness accordingly balance-industrial supplies lose that content of quality indexes of minerals of breeds $т/м^3$.

Determination of maximum for expressions (37) and (38), will put for them (39) and (40) and, taking into account, that $Б=of\ const$, will find derivatives for k at working off a contact longitudinal split with flat hay-crops, will equate the last with a zero and will untie the got expressions relatively k. Value of k at working off a contact longitudinal split with flat hay-crops, at that objective functions (37) and (38) have at most, determine from expressions

$$k_{1_0} = \frac{A_2 - A_3 + \Pi p_{\text{в}} - \Pi p_{\text{х}} - A_1 \gamma_B}{A_1 \left(\dfrac{\rho_\Pi}{\rho_B} \gamma_\Pi - \gamma_B \right) - \left(A_2 - \Pi p_{\text{х}} \right) \left(\dfrac{\rho_\Pi}{\rho_B} - 1 \right)}, \qquad (41)$$

$$k_{1_{\text{м}}} = \frac{A_2 - \Pi p_{\text{х}} - A_1 \gamma_B}{A_1 \left(\dfrac{\rho_\Pi}{\rho_B} \gamma_\Pi - \gamma_B \right) - \left(A_2 - \Pi p_{\text{х}} \right) \left(\dfrac{\rho_\Pi}{\rho_B} - 1 \right)}. \qquad (42)$$

Value of symbols in expressions (41) and (42) answers denotation in formulas (28)–(33), and γ_Π and γ_B determine from expression (25). After formulas (41) and (42) determine to the normative determination parameter for the case of working off the contacts of spilt and correlation of amount and volume of balance-industrial supplies, lose that and breeds of obstruction of content of quality indexes of minerals at working off contacts with different content of quality indexes of the iron related to magnetite, in balance-industrial supplies, lose that and obstruction content of quality indexes of

minerals breeds in the case when ore mining and processing a factory can do all obtained balance-industrial supplies that is got at correlation of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass, corresponding normative value parameter for case acquisition contact longitudinal splits.

Calculations of normative values of parameter for the case of working off contacts longitudinal splits from expressions (41) and (42) simplify in comparing to the method of variants and continuous perfection of methodology of setting of norms of balance-industrial supplies of hard minerals. Determine AV content of quality indexes of the iron related to magnetite, in balance-industrial supplies infinitely thin layer on the hay-crop of ledge at working off a contact longitudinal split with flat hay-crops determine

$$a_r = \frac{I_\Pi \, drl \, \rho_\Pi c_\Pi + I_B \, drl \, \rho_B b}{I_\Pi \, drl \, \rho_\Pi + I_B \, drl \, \rho_B}. \tag{43}$$

Determine I_Π and I_B through the height of ledge and parameter at working off a contact longitudinal split with flat hay-crops, will get

$$a_r = \frac{k\left(\dfrac{\rho_\Pi}{\rho_B} c_\Pi - b\right) + b}{k\left(\dfrac{\rho_\Pi}{\rho_B} - 1\right) + 1}. \tag{44}$$

From expression (44) determine the value of k, at that balance-industrial supplies infinitely thin layer on the hay-crop of ledge have the known content of quality indexes of the iron related to magnetite

$$k = \frac{a_r - b}{\dfrac{\rho_\Pi}{\rho_B}\left(c_\Pi - a_r\right) + a_r - b}. \tag{45}$$

Determine a_r, at that an ore mining and processing combine will get an income as a result of working off balance-industrial supplies, content of quality indexes useful to the component "bracks" and will

designate $a_б$, for that $a_б$ will equate expression (45) in turn with expressions (41) and (42). Untiing got to equality, will find:

$$a_{б_0} = \frac{A_1\left(b\gamma_{П} - c_{П}\gamma_{B}\right) + \left(A_2 - A_3 + Пр_{B} - Пр_{X}\right)\left(c_{П} - b\right)}{A_1\left(\gamma_{П} - \gamma_{B}\right)}; \quad (46)$$

b) for the case of losses of balance-industrial supplies in an array

$$a_{б_М} = \frac{A_1\left(b\gamma_{П} - c_{П}\gamma_{B}\right) + \left(A_2 - Пр_{X}\right)\left(c_{П} - b\right)}{A_1\left(\gamma_{П} - \gamma_{B}\right)}. \quad (47)$$

Putting in expressions (46) (47) exit of content of quality indexes of the iron, related to magnetite in a concentrate from balance-industrial supplies lose and obstruction content of quality indexes of minerals of breeds (25), in that a will accept according to such, that equals $c_{П}$ and b, and executing transformation, will get the value of "brack" contents of quality indexes:

a) for the case of losses of balance-industrial supplies in loosening iron-ore mass

$$a_{б_0} = a_{X} + \frac{A_2 - A_3 + Пр_{B} - Пр_{X}}{A_1}\left(a_{K} - a_{X}\right)\left(1 + \pi_{K}\right); \quad (48)$$

б) for the case of losses of balance-industrial supplies in an array

$$a_{б_М} = a_{X} + \frac{A_2 - Пр_{X}}{A_1}\left(a_{K} - a_{X}\right)\left(1 + \pi_{K}\right). \quad (49)$$

Value of symbols in expressions (44)–(49) answers expressions (28)–(33). Official [1,3–5] and driven to technical literature [2,6,8,9] methodologies of setting of norms of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals do not take into account a loss, that inflicts to the national economy an enterprise from an exception from earth and use of breeds of opening

and milltailingss of content of quality indexes of the iron related to magnetite, that it is taken into account by the worked out methodology. Without harm from the exception of earth from and use of breeds of opening and milltailingss of content of quality indexes of the iron related to magnetite expressions for brack contents of quality indexes simplification and accept:

a) for the case of losses of balance-industrial supplies in loosening iron-ore mass

$$a_{\delta_0} = a_X + \frac{з'_{ДТР} + з'_{ПР} - з_В'}{ц_К - з'_{ТК}} (a_К - a_X)(1 + \pi_К); \qquad (50)$$

b) for the case of losses of balance-industrial supplies in an array

$$a_{\delta_М} = a_X + \frac{з'_{ДТР} + з'_{ПР}}{ц_К - з'_{ТК}} (a_К - a_X)(1 + \pi_К). \qquad (51)$$

Analysis of formulas (46)–(51) certifies that content of "brack" of quality indexes useful to the component takes into account the economy of enterprise and technology of exception of content of quality indexes of the iron related to magnetite in the stream of iron-ore mass only. Normative value of parameter of $k=k_Н$ determine from expression (44), that after the substitution of $a_r=a_\delta$ will write down as

$$k_Н = \frac{a_\delta - b}{\dfrac{\rho_П}{\rho_В}(c_П - a_\delta) + a_\delta - b}. \qquad (52)$$

Determine normative correlation of amount of losses of balance-industrial supplies and obstruction content of quality indexes of minerals of breeds after a substitution in expression (52) as

$$\omega_н = \frac{B}{П} = \frac{\rho_П}{\rho_В} \left(\frac{c_П - a_\delta}{a_\delta - b} \right)^2. \qquad (53)$$

During work of ore-mining enterprises there are cases, when a production capacity of ore mining and processing factory is on the exception of content of quality indexes of the iron, related to magnetite in the stream of iron-ore mass less than, than production capacity of quarry is on the booty of balance-industrial supplies of hard minerals. Such case is considered in-process [2] and "limitation of the second kind" is adopted. We are work out methodology of setting of norms of balance-industrial supplies of hard minerals at "limitation of the second kind" in relation to terms, when the use of opening breed and milltailingss of content of quality indexes of the iron related to magnetite.

For the receipt of decision determine influence of loss from the exception of earth from. At "limitation of the second kind" a permanent size is an amount of the obtained balance-industrial supplies of $Д=Д_ф=const$, where $Д_ф$ is a production capacity of ore mining and processing factory on the exception of content of quality indexes of the iron related to magnetite in the stream of iron-ore mass. An amount of balance-industrial supplies of hard minerals, pay off that, is a size changeable.

Thus, at "limitation of the second type" of task of setting of norms of balance-industrial supplies of hard minerals it is set forth so: to find such amount of balance-industrial supplies of hard minerals, pay off that and norms of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass, at that a combine will get a maximal income, and the amount of the shipped iron-ore mass equals the production capacity of ore mining and processing factory on the exception of content of quality indexes of the iron related to.

So as at "limitation of the second kind" balance-industrial supplies of hard minerals not certainly, then, decide a task the method of progressive approximations, or analytically, at that the amount of contacts is proportional to the amount of balance-industrial supplies of hard minerals, pay off that. Legitimacy of this assumption is confirmed by experience of quarries of Krivbass and setting of norms of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass: the relative (actual and normative) losses of balance-industrial supplies and

obstructions of content of quality indexes of minerals have insignificant vibrations in years.

Doing foregoing assumption, determine the optimal value of parameter for the case of working off contacts longitudinal splits $k=k_{\text{Пo}}$ for "limitation of the second kind" in the case when lose balance-industrial supplies in loosening iron-ore mass. For reduction of record in expression (37) will designate

$$A_Б = \gamma_Б A_1 - A_2 - K_{\text{ВГ}}(A_З - \Pi p_В) - A_4 + \Pi p_X, \tag{54}$$

$$A_П = \gamma_П A_1 - A_2 + A_3 - \Pi p_В + \Pi p_X, \tag{55}$$

$$A_B = \gamma_B A_1 - A_2 + A_3 - \Pi p_В + \Pi p_X; \tag{56}$$

Then will write down as

$$\Pi p_0 = Б A_Б - \Pi A_П + B A_B - 3_K'' - T_{\text{ПП}}. \tag{57}$$

Putting in (57) expressions (39),(40) and

$$Б = Д + \Pi - B, \tag{58}$$

Determine a value at most the got expression on condition of *Б=of const*. Value to the parameter for the case of working off contacts longitudinal splits $k=k_{\text{П}}$, at that this expression has at most, determine as

$$k_{\text{П}} = \frac{\sqrt{\dfrac{\rho_П(A_Б - A_П)}{\rho_B(A_Б - A_B)} - \left[\dfrac{\rho_П(A_Б - A_П)}{\rho_B(A_Б - A_B)} - 1\right] \times \dfrac{\pi_m(A_Б - A_П) - \beta_m(A_Б - A_B)}{\beta_\Delta(A_Б - A_B)} - 1}}{\dfrac{\rho_П(A_Б - A_П)}{\rho_B(A_Б - A_B)} - 1} \tag{59}$$

Taking into account the exit of concentrate (25) from the stream of iron-ore mass of balance-industrial supplies of hard minerals, pay off that and lose and obstructive content of quality indexes of minerals of breeds will have

$$A_Б - A_П = \frac{(c - c_П)A_1 - [(A_3 - Пp_В)(K_{ВГ} + 1) + A_4](a_К - a_Х)(1 + \pi_К)}{(a_К - a_Х)(1 + \pi_К)}. \quad (60)$$

$$A_Б - A_В = \frac{(c - b)A_1 - [(A_3 - Пp_В)(K_{ВГ} + 1) + A_4](a_К - a_Х)(1 + \pi_К)}{(a_К - a_Х)(1 + \pi_К)}. \quad (61)$$

If lose industrially-balance supplies in the bowels of the earth, in expression (59) will accept [got taking into account expression (38)]

$$A_Б - A_П = \frac{(c - c_П)A_1 - [K_{ВГ}(A_3 - Пp_В) + A_4](a_К - a_Х)(1 + \pi_К)}{(a_К - a_Х)(1 + \pi_К)}. \quad (62)$$

$$A_Б - A_В = \frac{(c - b)A_1 - [K_{ВГ}(A_3 - Пp_В) + A_4](a_К - a_Х)(1 + \pi_К)}{(a_К - a_Х)(1 + \pi_К)}. \quad (63)$$

The amount of balance-industrial supplies pay off that determines from expression (58), after a substitution for him expressions (39), (40) $k = k_{II}$ and $Д = Д_ф$.

$$Б = \frac{Д_ф}{1 - \pi_Δ k_{II}^2 + \beta_Δ(1 - k_{II})^2 - \pi_Т + \beta_Т}, \quad (64)$$

where $Д_ф$ is a production capacity of ore mining and processing factory from the exception of content of quality indexes of the iron, related to magnetite in the stream of iron-ore mass, thousand t; $\beta_Δ$, $\pi_Δ$ it is a relation of amount of balance-industrial supplies and breeds of obstruction of content of quality indexes of minerals in near contact zones to the balance-industrial supplies of hard minerals, pay off that, part of unit

$$\pi_Δ = V_Δ \rho_Б / \widetilde{Б}, \quad (65)$$

$$\beta_Δ = V_Δ \rho_В / \widetilde{Б}, \quad (66)$$

$\widetilde{Б}$ is an amount of balance-industrial supplies of hard minerals, pay off that, in the initial (before optimization) variant of working off, thousand т; $V_Δ$ is a volume of near contact zones in the initial variant

of working off balance-industrial supplies, thousands of м^3; $\rho_Б$, ρ_B is a middle closeness of balance-industrial supplies and breeds of obstruction of content of quality indexes of minerals, т/м^3; π_T, β_T is relative losses of balance-industrial supplies and bringing in of unstandard supplies on technological reasons, parts of units.

Analyzing principles of setting of norms will notice that at "limitation of the first kind" ($Б=const$, $Д=var$) determine the losses of balance-industrial supplies and obstructions of content of quality indexes of minerals during work with that an enterprise gets a maximal income as a result of working off the balance-industrial supplies of hard minerals, and at "limitation of the second kind" ($Д=const$, $Б=var$) the requirement of receipt of maximal income a mining ore enterprise is kept, but on condition of exception of content of quality indexes of the iron related to magnetite in the stream of iron-ore. Calculations, optimal value of parameter for the case of working off contacts longitudinal splits of the second kind" always more than first. A sum of income at "limitation of the second kind" will be both less and more than at "limitation of the first kind", but income, that it is got on 1 т of balance-industrial supplies pay off that, always less than, than at "limitation of the first kind".

Thus, at "limitation of the second kind" at most will get an income due to the increase of losses of balance-industrial supplies and reduction of obstruction to content of quality indexes of minerals, id est due to unusing of balance-industrial supplies. As researches of setting of norms of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals showed for the terms of iron-ore quarries of Krivbass in the case when sum of income at "limitation of the second kind" less than, than at "limitation of the first and at certain correlation of production capacities of quarry and ore mining and processing factory, there is possibility to get a greater income, than at "limitation of the second kind" and this is "limitation of the third kind" [2,6,10,12], what responds to the condition, that the amount of content of quality indexes of minerals in the stream of iron-ore mass that is got at working off the maximal amount of balance-industrial supplies of hard minerals with the certain size of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass equals the production capacity of ore mining and processing factory on the exception of content of quality indexes of the

iron related to. At "limitation of the third kind" the optimal losses of balance-industrial supplies and obstructions of content of quality indexes of minerals in the stream of iron-ore mass determine from the mining-and-geological and technological terms of booty of balance-industrial supplies of hard minerals and exception of content of quality indexes of the iron related to magnetite.

Optimal value of parameter for the case of working off contacts longitudinal splits $k=k_{III}$ at "limitation of the third kind" determine if in expression (23) will put (39), (40) and will untie relatively for the case of working off contacts longitudinal splits k

$$k_{III} = \frac{\sqrt{\dfrac{\rho_{\Pi}}{\rho_{B}} - \left(\dfrac{\rho_{\Pi}}{\rho_{B}} - 1\right)\dfrac{Б\left(1 - \pi_{\text{T}} - \beta_{\text{T}}\right) - Д_{\Phi}}{V_{\Delta}\rho_{B}} - 1}}{\dfrac{\rho_{\Pi}}{\rho_{B}} - 1} \qquad (67)$$

The got results testify that setting of norms of balance-industrial supplies after the degree of preparedness to the booty and realization of norms in a production is an effective measure in area of guard of bowels of the earth, that will allow to decrease the losses of balance-industrial supplies and obstructions of content of quality indexes of minerals in iron-ore mass.

Implications

1. Optimization of balance-industrial supplies after the degree of preparedness to the booty together with the system of averaging out of content of quality indexes of minerals in the stream of iron-ore mass carry out separately for every category of balance-industrial supplies of hard minerals and for all categories simultaneously. The relative (actual and normative) losses of balance-industrial supplies and obstructions of content of quality indexes of minerals have insignificant vibrations in years.

2. Worked out methodology of setting of norms of balance-industrial supplies after the degree of preparedness to the booty, norms of the industrial supplies prepared to the booty on the careers of Krivbass determine taking into account the losses of balance-industrial supplies and obstruction of content of quality indexes of

minerals in the stream of iron-ore mass at a booty. Methodology of setting of norms of preparedness of the balance-industrial supplies prepared to the booty is modernized and adjusted to the use on the stage of planning. Indexes and coefficients characterize correlation of separate constituents of balance-industrial supplies, type of transporting of iron-ore mass and unevenness of extractive works.

3. The set dependences specify on the existent mining, technological, organizational and other terms of mining from ore bodies or areas of iron-ore deposits and show that passing of ore mining enterprises to work with normative preparedness of balance-industrial supplies to the booty will allow on iron-ore careers to bring down the obstruction of content of quality indexes of minerals in the stream of iron-ore mass on 1,5–2.%.

4. Correlation of amount and volume of balance-industrial supplies, lose that and breeds of obstruction of content of quality indexes of minerals at working off contacts with different content of quality indexes of the iron related to magnetite, in balance-industrial supplies, lose that and obstructive content of quality indexes of minerals breeds in the case when an ore mining and processing factory can do all obtained balance-industrial supplies that is got at correlation of losses of balance-industrial supplies and obstruction of content of quality indexes of minerals in the stream of iron-ore mass, corresponding to the normative value of parameter for the case of working off contacts longitudinal splits.

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