Türkiye 16. Madencilik Kongresi / *16.h Mining Congress of Turkey,* 1999, ISBN 975-395-310-0

CRITERION OF OPTIMAL DEVELOPMENT OF MINING WORKS AT THE QUARRY

B.Rakishev, B.Gurjevsky
Kazak National Technical University, Almaty, Kazakstan

Zh. Imashev
JSC Karagailinskoe rudoupravlenie, vil. Karagaily, Kazakstan

ABSTRACT: Always projection and perspective planning of development direction of the working zone at the quarry space has been and is one of the most responsible and complicated problems. It must satisfy to the demanded level of minerals effective extraction and it is solved by the method of variants. From considered set the preferable variant is chosen by the results of technical-economic estimation and comparison of BCR, NRV, IRR, etc.

The necessity of the pointed economic criterions application is unquestionable. But the probabilistic nature of used economic indices (prime cost, prices, assignments, etc.), high complication and labour-intensity of the multivariant calculations induce to limit the area of search. 'This striving can be realized by the way of elaboration of the working zone development strategy and determination of its base variant on the basis of use of the less labour - intensive, but representative enough technological criterions. Majority of the present methods of search are founded at minimization of the current (K_T) or average from exploitation beginning (K_{CH}) coefficients of strip (or mining mass).

DISCUSSION AND NEW OBSERVATIONS

By estimation of the offered to crediting finished projects of the industrial objects (mining enterprises) most frequently the economic criterions are applied: Benefit / Cost Ratio (BCR); Net Present Value (NPV); Internal Rate of Return (IRR). With this, the main economic indices of the enterprise work are adduced to the same moment of estimation. It predetermines their close intercommunication and interconditionality. For example, for the enterprise, working at the unprofitable-break-even level, the internal rate of return is equal to such rate of discount, which is enough in order the net present value of the project should be equal to zero, and benefit / cost ratio - to "one". The project, characterizing with the positive meaning of NPV, if discounting has been realized with taking into account of imputing value of capital (stake on profit, which could be received by investing of the alternative projects), has the internal rate of return above the minimum coefficient of cover of expenditure and the benefit / ratio more than "one" at the same time.

It is universally recognized that NPV is the general undiscrepant criterion, allowing to realize reliable ordering of the project variants in accordance with the problem of maximization of receipts from imputing capital. The criterion of BCR has the particular nature, because it gives the indirect estimation of the projecting conclusion. Its meaning more than "one " points out at the usefulness of conclusion. Nevertheless this criterion can be reliable instrument of economic estimation of the variants of mining works current state by choosing of direction of their development in the quarry field.

Thus, the necessity of application of the called economic criterions is unquestionable by the project estimation as a whole and by choosing of regime and calendar plan of mining works under conditions of the complex deposit exploitation in regime of resources economy.

By projecting of mineral homogeneous beds exploitation broadly and rightfully such criterions are used as the coefficients of the strip, which characterize ratio of barren rocks volume to the volume of mineral, extracted during the appointed period of the quarry's work; or the coefficients of mining mass, as the ratio of its total volume to the volume of ore, extracted during the same period [Hohryakov, 1992]. Thus, choice of the rational direction of mining works development, in particular the direction of the quarry deepening, is realized with use of the criterions:

$$K_T \rightarrow \min; \qquad (1)$$

or the more general one

$$K_{CH} \rightarrow \min, \qquad (2)$$

where correspondingly, K_T M KCH are the current and average from the exploitation beginning coefficients of the strip.

The methods, using the criterions (1,2), issue from the principle: the necessary quantity of ore (Pj) by passing of working zone from (j-1)-th to j-th position can be extracted at the expense of increase of the quarry depth. With this, in process of mining-geometrical analysis its bottom is assumed (at the geological cuts and plans) either as the point or as the excavations of minimum necessary dimensions. However, side by side with this, there is another way of ore obtaining in the same or more volume at the expense of maximum admissible use of the ore body area.

At any stage of exploitation it is always expedient to estimate the possibility of adding on the volumes of ore Pj without carrying out of deepening works. By equality of min Kc_H the heightened expenses are more probable at the first variant in result of additional expenditures for mining mass lifting from the increased depth, for removal of barren rocks grown share from the "superfluous" deep horizons. Increase of the more expensive cutting works by preparing of these horizons and raising of mining works concentration lead also to the growth of unproductive expenditures.

For broadening of the sphere of the criterions (1, 2) applicability at the example of the deep-bedding steeply-falling iron-ore deposit the appropriatenesses of K_T and KCH change as far as the quarry's working zone development had been investigated (Mustafina, Gurjevsky, et al, 1977). For this purpose the subsidiary technological index - the quasi-contour coefficient of mining mass - had be considered. It maybe either the linear one as the ratio of the length of the working board slope line ly to the total length of the ore zones plots I my along this line (correspondingly, Ky - for the left and Ky - for the right boards of zone), or the square one - Ksj, being defined by ratio of the corresponded areas of mining mass and ore (fig.1). The first criterion is used by choosing of mining works development direction in plane of the i-th geological cut, and the second one - by solution of the volume problem.

In result of investigations it had been determined that between Kc_H, K_T and quasi-contour coefficients of the strip (mining mass) there is the direct dependence. By the working zone development Kc_H changes depending on K_T. In one's turn, K_T is the function of the quasi-contour coefficients change as far as boards moving apart from the arbitrary point M (look figure 1), i.e.:

$$K_{cnj} = \psi (K_{Tj}), \qquad (3)$$

$$K_{Tj} = \Phi (K_{ij}', K_{ij}''). \qquad (4)$$

The character of the quasi-contour coefficients meanings change depends on the initial position of the boards, angles of their slope ((p) and change of concrete mining-geological situation at the area of their moving. Thus, analysis of the functions of the quasi-contour coefficients change allows to estimate one or another position of the working zone. The dimensions of its bottom are determined as the difference between abscissas of points of intersection of the right and the left boards lines with the researched horizon.

The equality:

$$K_{ij}' = K_{ij}'' \qquad (5)$$

is the necessary condition of rationality of the working zone position. Among great number of its positions, answering this indication, the

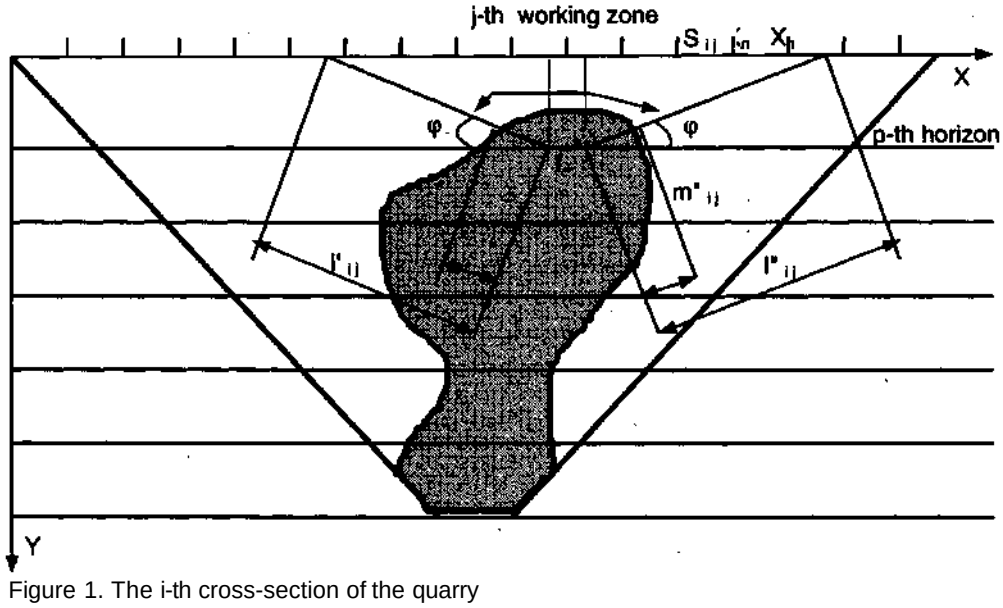

Figure 1. The i-th cross-section of the quarry

optimal one is that, which satisfies the criterion (2), i.e.

$$\min K_{CHij} = K_{ij}' = K_{ij}'' \qquad (6)$$

The typical graphs of changes of $K_{T)}$ K_{CH} and quasi-contour coefficients meanings for the upper ore horizons of considered type of the deposits are adduced at the fig.2. The method of their position determination, satisfying expression (6), is reflected here too.

As is obvious from the graphs, the methods, based on search of the rational position of the working zone with the minimum dimensions of its bottom, don't allow to receive the lowest meanings of K_{CH} and K_T. Besides that, even satisfaction of the criterion (1) doesn't provide minimization of the more general criterion (2). It happens only by satisfaction of the condition (6). Therefore, in this case the condition K_T -» min can't be the criterion of the optimumness of the working space development.

The results of subsequent analysis of the working zone development from the foregoing positions as far as mining works lowering are adduced at the fig.3. It is clear from the graph that the quarry by depth maybe break up into a row of zones, where the different principles of the working space optimal position determination work depending on correlations of minimal and equal meanings of the quasi-contour coefficients of the strip (K^n) and the receiving by this meanings of KKT and K_m.

The first zone is characterized by following correlation of these coefficients:

$$K_{CH} \geq \min K_{n,n} > K_T \qquad (7)$$

Here for search of the optimal position of the working zone the foregoing method may be used.

In the second zone, as in the fourth one, the correlation between the coefficients changes:

$$K_{CH} \leq \min K_{n,n} \geq K_T \qquad (8)$$

The conditions of optimization in this zone are:

$$K_{CH} \rightarrow \min;\ K_T \rightarrow \min;\ \min K_{CH} \leq K_{n,n} \qquad (9)$$

There are no any possibilities of the meanings K_{CH} and K_T improvement at the expense of $K_{„,n}$ changes (by q> = const) here. The methods (1,2) maybe used for finding of the rational directions of the mining works

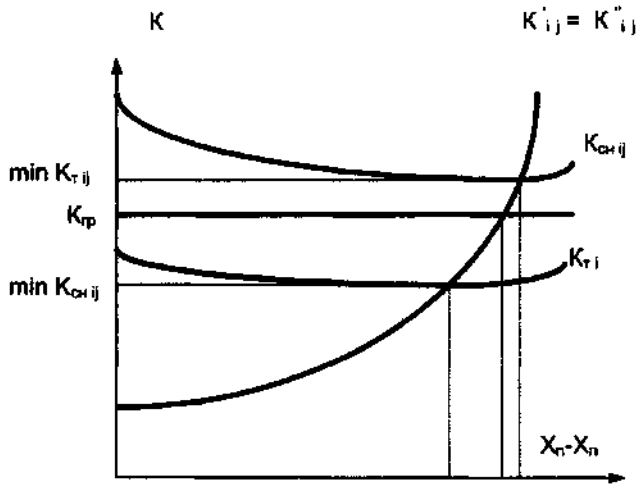

Figure 2. The graphs of changes of the strip coefficients depending on the dimensions of the working zone bottom at the researched horizon

development with the minimal dimensions of the quarry bottom.

In the third zone the correlation is:

$$K_{CH} < \min K_{n,n} \leq K_T \qquad (10)$$

Therefore, there is a possibility of the criterion (1) use by way of improvement of exploitation indices at the expense of K_T meaning lowering by principle:

$$\min K_T \leq K_{n,n} \qquad (11)$$

By realization of this condition K_{CH} meaning is reduced somewhat too.

The considered technological indices maybe used as the estimation enterions of the variants of the mining works development at the quarries, exploitating the beds of homogeneous mineral. By exploitation of the complex deposit, when several type-kinds of ores can be at the working zone and certain part of some varieties of stripping rocks is of consumers' interest, such coefficients are unacceptable (Rakishev, Gurjevsky et al, 1998). They don't take into account the differences in expenses for extraction and processing of various minerals, and also the obtaining of several kinds of commodity output of unequal value. In this case the generalized economic criterion is preferable.

The last one maybe constructed, if the total expenses, connected with exploitation of some volume of mining mass, be designated as 3, and total returns (profits), which may be expected from its realization, - as fl. Their ratio 3/fl characterizes degree of putting expenses use. Let's call this correlation as the coefficient of expenseness (Z), i.e.

$$Z = З/Д \qquad (12)$$

As is obvious, the new criterion corresponds to the current meaning of inverse quantity of BCR (benefit/ ratio). The less meaning of this ratio the expedient inclusion of the considered plot into the working zone.

The coefficient of expenseness for" the j-th working zone at the considered horizon according to the definition and by analogy with (5) is determined by expression:

$$Z_{pj} = Z_{j1} = Z_{j2} = \ldots = Z_{jn} \qquad (13)$$

where Z_{Pj} is the coefficient of expenseness at the p-th horizon for the j-th position of the working zone; Zy is the same one at the j-th contour of bottom for the i-th section.

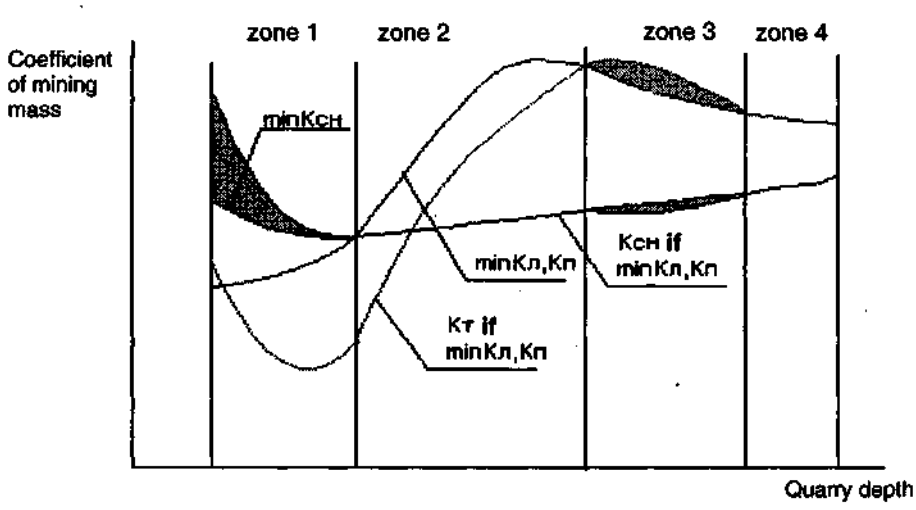

Figure 3. Correlation of the technological criterions by stages of the quarry exploitation

Dependence (13) shows that by adopted form, dimensions of the working zone in the j-th position at the considered horizon the equality sections, normal to the contour of the quarry current bottom.

Among the number of possible positions of the quarry working zone the optimal one should be that., by which the minimal meaning of the coefficient of expensiveness (Z_{vj}) is provided, determined for the total volume of this space, and it is equal to Z_{pj}, satisfying the condition (13), i.e.

$$\min Z_{vj} = Z_{pj} \qquad (14)$$

The proposed method reduces essentially labour-intensity of the works for choosing of the base variant of the quarry working zone development direction.

CONCLUSION

1. By determination of the rational direction of the mining works development at the quarry, exploitating the homogenous beds of mineral, together with the economic criterions such technological ones maybe used as K_T -> min, KCH-> min.

2. Depending on the correlation between the meanings of the coefficients K^, K_T and K_{nn} at the quarry space by depth the areas of the more preferable application of the one from the pointed in p.1 criterions maybe determined.

3. Under conditions of the complex deposits exploitation the minimum of the coefficient of expenseness, which expresses the volume of expenses, putting at the profit unit, and corresponds to the meaning of the BCR inverse quantity, is the working criterion of the estimation of the mining works development optimumness.

REFERENCES

Hohryakov V.S., 1992. The quarries projecting. - M.: Nedra, 360 p.

Rakishev B.R., Gurjevsky B.A., Imashev Zh.R., 1998. To the quarries projection in the regime of the resources preservation. Environmental Issues and Waste Management in Energy and Mineral Production, p.p. 45-48. Rotterdam: Balkema

Mustafina A.M., Gurjevsky B.A., et al., 1977. Rapid Building and development of the deep quarries. Alma-Ata.: Nauka, 255 p.