Also noteworthy is the scheme for extraction of coal by coal saws beneath a flexible midroof in strips along the strike without leaving coal pillars between them.

The hydraulic method with use of a high-pressure water jet is not only more economical but is also the most nearly universal method and can be used in all collieries of the Prokop'evsk-Kiselevsk region for manless extraction, regardless of the complexity of the bedding and the presence of faults.

Thus with regards to the development of working of seams of the Prokop'evsk-Kiselevsk seams of the Kuzbass, it would be most advantageous if all the collieries went over to the hydraulic extraction of coal. This would double the output per man in the colliery, regardless of the complication of the geological conditions as the mining operations are transferred to deeper horizons.

The operational coal losses can be reduced by the more effective working of faulted sectors of the seams by the use of a high-pressure water jet together with a flexible midroof as an artificial roof.

Investigations by the Gidrougol' Production Union have shown that primarily it would be most advantageous to convert the 20 collieries with the most complex geological conditions, combining these collieries into 6 hydraulic mines with a capital expenditure of 894 million rubles (Table 2).

Conversion of 20 collieries from the conventional extraction procedure to hydraulic extraction would increase the output per man from 40-60 to 22-300 tons/month and reduce the cost of the coal from 8-24 to 6-7 rubles per ton.

Furthermore, the implementation of these proposals would give a saving of 240 million rubles per annum in the Prokop'evsk-Kiselevsk region.

MODELING THE ECONOMIC INDICES OF KUZBASS PITS

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In the development of models of the economic indices of coal mines, difficulties arise owing to the complexity of the structures of mining enterprises, the indeterminacy of the conditions of operation, and the complexity of the internal links determining the output parameters (the volume of extraction, the output per man-shift, the cost of extraction, the profit, and the capital outlay). In developing models for coal mines, use has been made of statistical methods, in particular, regression and factorial analysis and elements of the theory of pattern recognition [1-3]. There is promise in developing discrete-continuous models including a stage of separation of the initial group of pits into homogeneous classes with subsequent development of statistical models for each class of pits with similar conditions of operation.

Models of economic indices, obtained on the basis of statistical treatment of the results of operation of pits of an entire region (e.g., the Kuzbass), can be useful in long-term prediction and in the mine planning stage. However, in predicting the individual indices of a particular pit these models may lead to large errors.
Clearly, for short- and medium-term prediction and development of optimal control actions it is necessary to develop models separately for each pit on the basis of information on the previous history of operation of the particular enterprise. However, here we encounter the following difficulties: statistical series determining the dynamics of geological conditions and economic indices, as a rule, can be obtained only over a short period of observations; the statistical information is inaccurate, especially with respect to the input parameters. Therefore the possibility of using traditional methods to model the technical and economic indicators (TEI) of a particular pit is very limited.

One promising method of constructing models of complex stochastic objects is the method of group arguments [5] designed for solving a wide range of interpolation problems. It is based on the principle of "mass selection" or "heuristic self-organization," which can sharply increase the accuracy of a mathematical model for a brief period of observation with maximum possible reduction in the subjective a priori information on the part of the author of the model. This method, which extends the possibilities of regression analysis and the theory of statistical decisions, is based on the principle of external supplementation and multiple decision structures.

Gritsko and Shtele [4] were the first to point out the necessity of using the principles of self-organization (by the method of group arguments) to develop models of control and prediction in applications to coal mines.

Without dwelling in detail on the algorithms of the method of group arguments, which can be found in [5, 6], let us describe some results of modeling of economic indices of Kuzbass pits.

As an example, let us take the results of a synthesis of models of economic indices of the Taenzhaya mine of the Kuzbassugol Production Union with the aid of a multiple differential prediction algorithm [7].

We assume that the object is represented by a system of differential equations with lagging arguments:

\[
\frac{dV_i}{dt} = f_i(V_{1(0)}; V_{1(-1)}, \ldots, V_{1(-\tau)}, \ldots, V_{n(0)}; V_{n(-1)}, \ldots, V_{n(-\tau)}; \\
\mu_i(0); \mu_i(-1), \ldots, \mu_i(-\tau), \ldots, \mu_m(0); \mu_m(-1), \ldots, \mu_m(-\tau)),
\]

where the \(V_i\) are the parameters of state of the system \((i = 1, \bar{n})\), the \(\mu_j\) are the controlled and uncontrolled actions on the system \((j = 1, m)\), and \(\tau\) is the length of the previous history taken into consideration. For our problem, \(V_1\) is the cost of the extraction in rubles per ton, \(V_2\) is the productivity in tons per man-month, \(V_3\) is the output in thousands of tons per year, \(\mu_1\) is the relative water amount, \(\mu_2\) is the total thickness of the simultaneously worked seams, \(\mu_3\) is the reserves ready for extraction, \(\mu_4\) is the total active fund, \(\mu_5\) is the total passive fund, \(\mu_6\) is the total number of workers, and \(\mu_7\) is the annual expenditure of electrical energy.

The algorithm involves correlational selection of the most influential indices and replacement of the derivatives in (1) by finite differences; the \(f_i(.)\) are expressed in the form of a polynomial of optimal complexity. The coefficients of the polynomials are determined with the aid of the heuristic self-organizing method of group arguments. The desired complete description is replaced by a set of "partial descriptions," each of which depends on only two arguments.

As support function we use polynomials of degree no higher than the second relative to two arguments. The "partial descriptions" which have passed the threshold values of the self-selection criterion are the arguments for the "partial descriptions" of the next stage. The accuracy of each partial description is estimated by means of the rms error in the checking sequence.

As the initial information we used a matrix of the conditions of operation and the output parameters for the Taenzhaya pit in 1963. We used two versions of the calculations, for the data in 1963-1974 and in 1963-1977.

The first version of the calculations was made with the aim of verifying the predictive possibilities of the models for known information in 1975-1977. In the first version of the calculations the operator of "partial descriptions" was linear, but in the second, quadratic. In both versions the duration of the previous history was taken to be equal to three.