INTERACTIVE METHOD OF SOLUTION OF THE SPACE PROBLEM OF PLANNING THE VOLUME OF MINING OPERATIONS IN STRIP MINING OF COAL, WITH IMPLEMENTATION ALGORITHM

A. S. Tanaino and A. A. Botvinnik

In planning the volume of mining operations at currently operating quarries, an "inverse" method of problem solving has traditionally been employed [1, 2]. In this method, the planned migration of the technological work sites (coal faces, benches, decks, etc.) are first constructed either graphically or on a computer, and the volume of mining operations then calculated in the contours thus created. The required (planned) volume of mining operations is established by iterative migration of the corresponding contours. As a rule, such a method of solution is time-consuming, particularly if computers are not used. One consequence is that evaluations of plans for mining operations are generally not sufficiently exhaustive.

In the present study a direct method of problem solving is described. The distinguishing feature of the method is that the required (projected) volume of mining operations is specified at all possible work sites (coal or strip benches, layers of spoil dumps, etc.). Moreover, face contours corresponding to this volume of mining operations and maintained to within the technological constraints are created automatically, having been determined by the existing spatial position of the mine workings and the predicted geological conditions. The results that are obtained are presented in graphical form and are amenable to graphical correction, if needed in subsequent iteration of the calculations.

Evaluation of Method. A solution of the "direct" problem is extremely attractive, though it produces a number of difficulties due to the nature of the production process, specifically:

- the work sites and their relative position in space change dynamically;
- the diversity of geometric models of the work sites together with the variability of the local geological conditions often make it necessary to change the parameters of the work sites (e.g., there may be previously undetected tectonic elements, certain technological regulations may not have been observed, etc.), making it impossible to create an algorithmic decision capable to handling the diversity of situations;
- virtually every repeatedly planned migration of mining operation entails not only taking account of the existing set of circumstances. It also entails the need to perform calculations for a prediction plan possessing varying degrees of exhaustiveness (e.g., to take account of possible natural changes in the occurrence of the coal beds and in the qualitative characteristics of these occurrences, etc.) as well as the need to take account of technological constraints, for example, in planning the volume of operations at a bench section it is necessary to enter the admissible gradient and radius of curvature of the path along the entire bench, including its potential migration into the interior of the massif, etc.

The next distinctive feature of the problem-solving process is due to its very statement. That is, in this solution the projected volume of output may be achieved at any work site, independently of its relative position with respect to the elevation of the working zone. Consequently, the solution of the problem may yield the projected contour, containing a specified volume (of coal or overburden) at a selected work site. If this is not the site in the working zone space with the highest elevation, it will be necessary to check that the technological constraints regarding observance of the dimensions of the work areas, safety berms, etc. in the direction of the front of operations being performed everywhere above the arrayed benches are being maintained.

In other words, it is necessary to quantitatively estimate the consequence of a plan for achieving specified volumes at a selected work site, i.e., everywhere at elevations higher than the arrayed benches that occur in the zone of influence of operations at a given work site. It is also necessary to determine the volumes that must be achieved until or, if possible, at the same time as operations that are being performed at the initial work site.
Evidently, estimation of the consequences of a projected decision entails a host of possible corrective actions in deciding on a specified volume and localization of the region within which this volume is to be achieved. It is, however, virtually impossible to achieve formalization of the possible corrective actions. It is clear that a rational division of functions between those involved in automation of calculations and those which are the responsibility of the decision maker will make it necessary to create an interactive decision-solving system. The language of the dialogue must be based on graphical images, i.e., standard images of the engineering representation of graphical documentation. The latter requirement for the solution of the problem is achieved through a special organization of the information database and of methods of database access.

Structure of data objects. The present study was carried out as a development of a computer-aided design and planning system for strip mining of coal deposits (CADPOCD) [3, 4], as well as ideas that underlie the study of geological information science [5]. In [3, 4] the general elements of the composition and structure of an object-oriented database were presented.

Let us introduce the necessary definitions of the data objects that are used in planning the volume of mining operations. [The term, "edge," should be understood as referring to either the bench crest or bench toe. — Trans.]

\( \langle \text{work site} \rangle := \langle \text{coal bench} \rangle \mid \langle \text{strip bench} \rangle \mid \langle \text{layer of spoil dump} \rangle; \)
\( \langle \text{coal / strip bench} \rangle := \langle \text{name} \rangle \langle \text{crest} \rangle \langle \text{toe} \rangle \langle \text{type of qualifier} \rangle; \)
\( \langle \text{name} \rangle = \) alphabet or numerical designator of coal seam, bench, layer, etc.;
\( \langle \text{crest / toe} \rangle := \langle \text{type of qualifier} \rangle \{x_i, y_i, z_i\}_{i=1}^k; \)
\( \{x, y, z\} = \) spatial coordinates of points of edge lines (in the coordinate system adopted at the enterprise), selected independently of the direction of circumvention. In general, each edge is considered as a set of analogously circumscribed lines that are "sewn" together at their endpoints. The question whether the edge is continuous is ignored.

\( \langle \text{plan for calculation of reserves} \rangle := \langle \text{name of seam} \rangle \langle \text{geological blocks} \rangle \langle \text{characteristics of blocks} \rangle; \)
\( \langle \text{geological blocks} \rangle := \langle \text{number of block} \rangle \{x, y\}, \) where \( x \) and \( y \) are coordinates of the points of the vertices of the contour of the block ordered with respect to an arbitrary circumvention;
\( \langle \text{number of block} \rangle = \) a number
\( \langle \text{characteristics of blocks} \rangle := \{Q_i\}, \) where \( Q \) is an ordered set of quantitative data that characterize a geological estimation block (mean thickness of seam and clean band, category of seams, angle of dip, etc.).

\( \langle \text{bedded ore intersection} \rangle := \langle \text{name of seam} \rangle \langle \text{number of borehole} \rangle \{x, y, z\} \langle P_i \rangle; \)
\( \langle \text{name of seam} \rangle = \) a number
\( \langle P_i \rangle = \) set of data describing the bedded ore intersection, e.g., depth of ore intersection of borehole top and floor, thickness of coal and rock layer, ash content of layers, etc.;
\( \{x, y, z\} = \) coordinates of mouth of borehole.

\( \langle \text{geological sketches} \rangle := \langle \text{name of seam} \rangle \{x, y, z\} \{Z_i\}; \)
\( \{x, y, z\} = \) spatial coordinates of positioning of geological sketch to floor of coal seam or coal bench;
\( \{Z_i\} = \) ordered set of measurements across differentiated layers or test intervals.

\( \langle \text{parameters of process flow diagram} \rangle := \langle \text{search word} \rangle \{\Pi_i\}; \)
\( \langle \text{search word} \rangle := \langle \text{code} \rangle, \) i.e., for distinguishing the type of technology which is being employed (in the present case, pipeline or by means of transshipment of overburden in the worked space);
\( \{\Pi_i\} := \) ordered list of geometric parameters (angles of slope, dimensions of work areas, safety berms, etc.).

\( \langle \text{longitudinal profile of work site} \rangle := \langle \text{name} \rangle \{x_1, y_1, z_1, x_2, y_2, z_2\} \{x_i, y_i, z_i\} \{P_i\}; \)
\( \{x_1, y_1, z_1, x_2, y_2, z_2\} = \) spatial coordinates of start and end of toe of bench;
\( \{x_i, y_i, z_i\} = \) spatial coordinates of points along the edge line with equal step in the direction of the front (in the present case, with step equal to the distance between the mine survey profiles);
\( \{P_i\} = \) characteristics of profile, e.g., slopes between stakes, length of horizontal distance piece between stations.

\( \langle \text{plan of mine survey profile lines} \rangle := \langle \text{number} \rangle \{x, y, \alpha\} \langle \text{number} \rangle \{x, y, \alpha\} \ldots \langle \text{number} \rangle \{x, y, \alpha\}; \)

573