ECONOMIC ASSESSMENT OF THE WORKING SEQUENCE
OF DIFFERING COAL RESERVES

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The operation of collieries involves not only the planning of time-tables for mining-out the various seams, but also the solution of problems related to economic assessment of the advisability of working individual sectors with unfavorable conditions. Investigations have shown that the recommended procedure [1] does not tell us the optimal and most economic approach for working such sectors in the take.

By the recommendations in [1] we obtain information only on the advisability of abandonment of coal reserves with unfavorable working conditions; no information is given on the economic consequences of postponing such operations to later years or of reducing their participation in the annual output of the mine.

Developing Astakhov's recommendations [1], the Institute of Mining, Siberian Branch, Academy of Sciences of the USSR, has devised a method of assessing the economic consequences of the mining-out sequence of reserves with differing working conditions; this tells us not only the advisability of mining-out "poor" reserves, but also the optimum times and volumes of such operations.

Bearing in mind that the economic consequences depend on the proportion \( \eta_t \) of "poor" reserves in the overall minable reserves of the mine \( Q_t \), and on the initial participation of "poor" reserves in the annual output \( A \) of the mine, the new method recommends two alternative solutions to the problem, with \( \omega \leq \eta_t \) and with \( \omega > \eta_t \), where \( \eta_t = q_s/Q_t \) and \( \omega = A_s/A \). \( q_s \) are the coal reserves with "poor" working conditions, in tons, and \( A_s \) is the intended annual output of these reserves, in tons.

Alternative I, \( \omega \leq \eta_t \) (Fig. 1).

Mining-out of the reserves \( q_s \) at a rate \( \omega < \eta_t \) in comparison with uniform "extraction" (\( \omega = \eta_t \)) in \( T_\Sigma \) years will ensure an over-all saving on current outlay by the \( (t + T_\Sigma) \)-th year

\[
\sum_{k=1}^{T_\Sigma} S_k = C_x A \left( \lambda - 1.0 \right) (\eta_t - \omega) T_m \frac{(1.0 - \eta_t)}{(1.0 - \omega)}. \tag{1}
\]

However, beginning from the \( (t + T_\Sigma + 1) \)-th year, the working of "poor" reserves will be effected at a rate \( \omega' = 1.0 \), which will lead to overspending on current outlay (loss), of which the over-all amount at the completion of mining-out of such reserves of the mine, i.e., by the \( (t + T_m) \)-th year will be equal to the saving shown by (1):

\[
\sum_{k=1}^{T_m} V_k = C_x A \left( \lambda - 1.0 \right) (1.0 - \eta_t) T_m \frac{(\eta_t - \omega)}{(1.0 - \omega)} \tag{2},
\]

where \( \lambda = C_s/C_x \), \( C_s \) is the mean approximate cost of mining-out 1 ton of \( q_s \) reserves, in rubles, \( C_x \) is the mean approximate cost of mining-out 1 ton of the other reserves \( (Q_t - q_s) \) in rubles, and \( T_m \) is the service life of the mine in years.

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Fig. 1. Economic scheme of working reserves with \( \omega < \eta_t \) in the initial period of operation of the mine.

\[
T_m = \frac{Q_t}{A(1.0 + \rho)};
\]

where \( \rho \) is the coefficient of coal losses above the planned figure for the take of the mine (the ratio of the annual liquidation of workable reserves to the annual output of the mine).

On the basis of recommendations in [1-3] for comparing current losses for different periods, we reduce saving (1) and loss (2) to a single time scale, to the \((t + T)\)-th year in the future:

\[
\left( \sum_{k=1}^{t_p} S_k \right)_T = C_x A (\lambda - 1.0) (\eta_t - \omega) P^{T - \tau_z} \left( \frac{P^{T \rho} - 1.0}{P - 1.0} \right) ;
\]

\[
\left( \sum_{k=t_p + 1}^{T_m} Y_k \right)_T = C_x A (\lambda - 1.0) (1.0 - \eta_t) P^{T - \tau_z} \left( \frac{P^{T \rho} m - \tau_z - 1.0}{P - 1.0} \right) ,
\]

where \( P = [1.0 + E_H (1.0 - \gamma)] \), \( E_H \) is the standard efficiency of new investment, \((1.0 - \gamma)\) is that part of the annual capital saving which is the source of the expansion in production, expressed as a fraction, and \( \tau_z \) is the duration of simultaneous working of "poor" and "good" reserves, in years.

With \( \omega \leq \eta_t \), \( \tau_z = T_m \frac{(1.0 - \gamma)}{(1.0 - \omega)} \) when \( \omega > \eta_t \), \( \tau_z = T_m \frac{\eta_t}{\omega} \) (see alternative III).

Comparison of (3) and (4) reveals that on the scale of the \((t + T)\)-th year the saving is greater than the loss by the following amount

\[
\left( \sum_{k=1}^{t_p} S_k \right)_T - \left( \sum_{k=t_p + 1}^{T_m} Y_k \right)_T = C_x A (\lambda - 1.0) \frac{P^{T - \tau_z}}{P - 1.0} \times \left[ 1.0 - \eta_t + P^{T \rho} \left[ \eta_t - \omega + \omega - 1.0 \right] \right] .
\]

Analysis of (5) reveals that the maximum saving under these conditions \((\omega \leq \eta_t)\) may be obtained by: a) increasing the absolute value of the difference \((\eta_t - \omega)\) and b) reducing the period of working out the "poor" reserves, the period \((T_m - \tau_z)\).

Method a. Let \( \epsilon \) be the new rate of working the reserves \( q_s \) (\( \epsilon \) being less than \( \omega \)); the condition for achieving the maximum saving is then written as \( \epsilon = 0 \), which means no mining-out of the \( q_s \) reserves for a period \( \tau_z \). In addition to the saving obtained by reducing the operational losses on coal "extraction," we will then observe a saving (or over-expenditure) on the outlay in undertakings involved in processing or consuming coal \( \Delta V \text{ rubles/ton}. \) Furthermore, working of the \( q_s \) reserves at a rate \( \epsilon < \omega \) may sometimes be accompanied by losses of investment used in the \( t \)-th year for preparing these reserves. In a general case, method a is economically advantageous (on the scale of the \((t + T)\)-th year) if,