Coal producers waste water purification

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Abstract
The short description of low-cost technology of purification of open-pit waste waters through the artificial filtering massifs made of mining waste is presented in the paper. Results of research on establishment of dependences of decrease in oil products concentration on length of filtration path are given.
Key words: ARTIFICIAL FILTERING MASSIF, OPEN-PIT WASTE WATERS, SUSPENDED MATERIALS, OIL PRODUCTS

Features of geological structure of the Kuznetsk coal basin stipulate the application of a low-cost open technique of coal mining, which is more advantageous both from the economic standpoint, and by safety criteria of mining. However, open mining affects significantly the water resources of region. Intensive pollution of reservoirs and water courses, exhaustion of the underground water-bearing layers, violation of a hydrographic network, etc. belong to the main disadvantages of an open technique of coal mining. Besides, the volume of the water coming into the mining producers exceeds significantly the needed quantity. According to the data of annual reports of ecology and natural resources department, 348.277 million m^3 of water were taken away during production of soft coal, brown coal and lignum fossil from waters of Kemerovo region in 2013 (mostly from underground water objects (96,5%) when draining of mine openings). At the same time, only 87.018 million m^3 of water (25%) has been used within a year.

Waste water disposal is mainly carried out into surface water bodies. In 2013, 303.983 million m^3 of waste waters were spewed out, and 267.623 million m^3 of them were spewed out into surface water bodies. According to the category of quality, the waste waters spewed out into surface water bodies are polluted by 82.6% and only 9,3% of waters are treated to standard quality.

The solution of problem of waste water purification is associated with great difficulties when open mining of mineral deposits. Due to the continuous toughening of requirements to quality of waste water discharge, their purification in holding ponds and clarification ponds does not provide achievement of threshold level value indicators; what is more, these waste treatment facilities occupy the considerable areas. It should be noted that usually there are some catchment basins distant from each other; furthermore, they change the location in process of mining. For example, JSC Kuzbassrazrezugol coal company has 32 sites of water use considering the fact that the structure of company includes 7 sections.

The formation of overburden rocks (large volumes of solid waste of minerals production) is another negative factor of open mining. Dumping place of overburden rocks harms significantly to natural environment: the earth capacity reaches 35-40 hectares of earth for 1 million t of the mined coal.

The noted negative phenomena cause need of integrated approach to development of measurements for reduction of harmful effect of open coal mining on the environment (Figure 1).
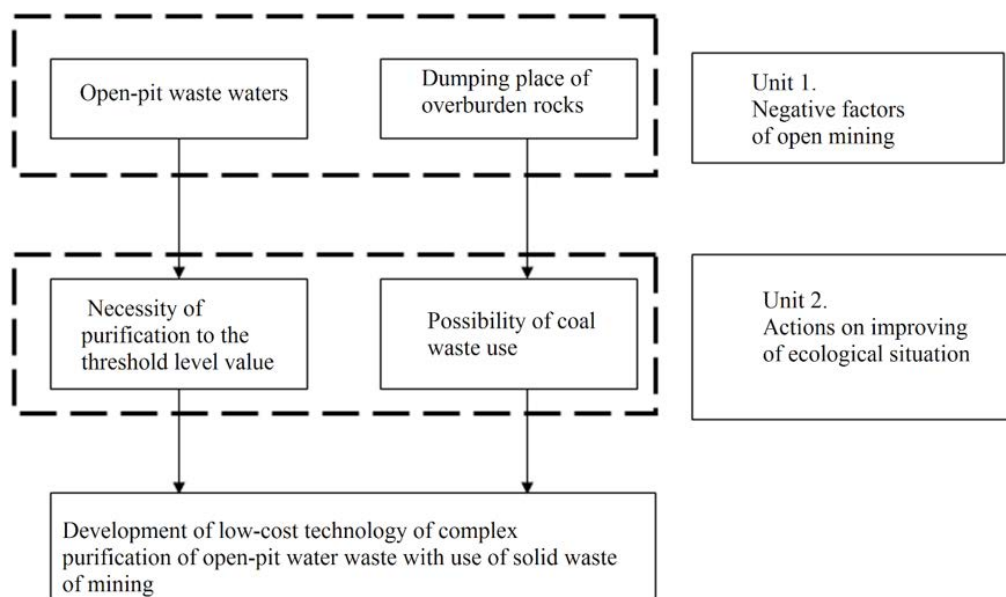

Figure 1. Structure of integrated approach

Since 80th years of the XX century, technology of purification of open-pit waste waters through the artificial filtering massifs (AFM) made of mining waste has been developed at the Kuzbass state technical university [1]. Many scientists have studied filtering water through the porous media [2-7], but the obtained dependences and regularities are not used for purification of open-pit waste waters. Researches [8, 9] are devoted to purification of industrial wastes of the enterprises developing placer mines. Open-pit waste waters and their purification have the distinctive features.

The massif is overburden rocks dump, for which geometrical parameters (length, width, height) are calculated considering throughput capacity and purification of all the inflow water to requirements of water discharge. Design of massif and technology of its erection are protected by the patent [10]. In general terms, construction of AFM with water-resistant abutments is shown in Figure 2. The water-resistant abutments, which are discharged from low permeability rocks (for example, mudstones), serve for increase of a level of water flows purification. It is achieved by means of purified water lifting in the high granular layers of the filter.

This technology has obtained universal implementation in Siberia, the Far East, etc. Currently, design institutes of Kuzbass use a method of AFM calculation in case of project implementation of perspective sections ("Ananyinsky", "Kuprinsky", "Koksovy" etc.). As an example, the layout of the artificial filtering massif in relation to conditions of section "Kaygursky" is shown in Figure 3.
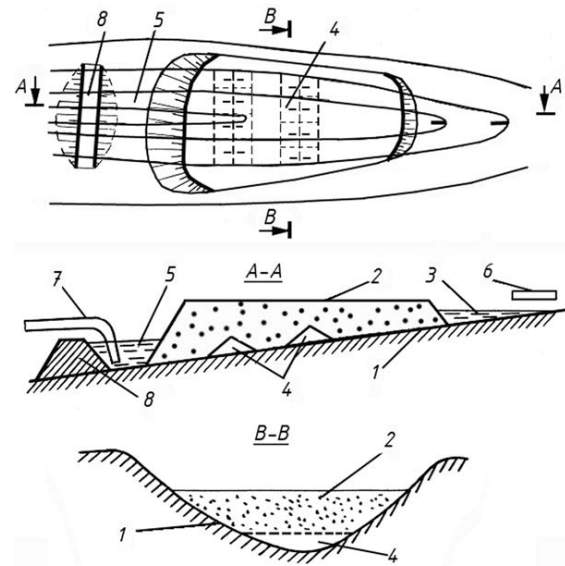
Figure 2. Construction of AFM with water-resistant abutments: 1 – filter bottom; 2 – AFM body; 3 - receiving drainage for polluted water; 4 - water-resistant abutments; 5 – pool of purified water; 6 - admitting pipe; 7 – pipeline of purified water; 8 -retaining weir
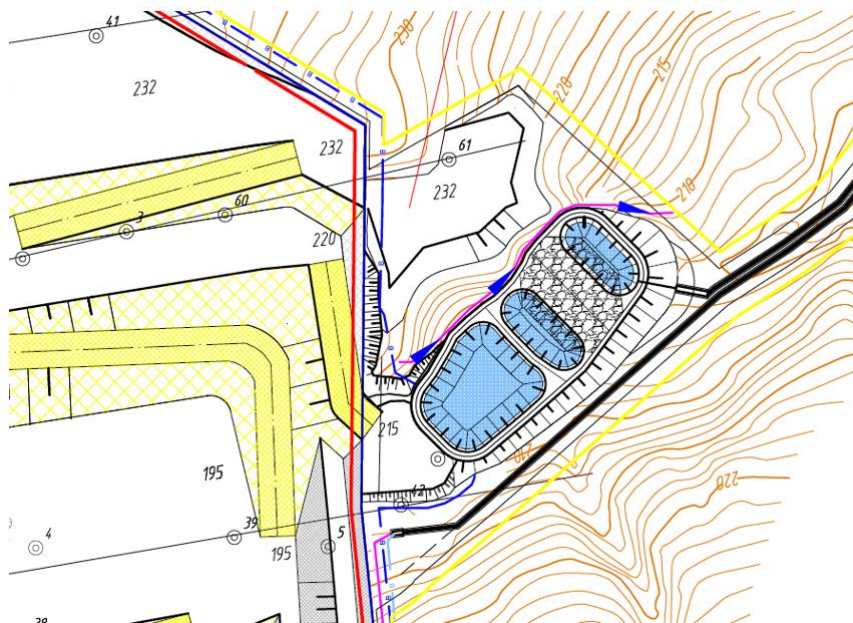
Figure 3. Layout of the artificial filtering massif in the section "Kaygursky"

Purification of open-pit water flows from basic contaminating impurity (suspended material) [11] is high-priority direction of technology while purification from other impurities has not been considered. However, due to results of authors' experimental studies, it was established that reduction of almost all contaminating impurity concentration [12] is achieved when filtering the polluted open-pit water through coarse massifs of overburden rocks.

Some results of researches on establishment of dependences of oil products concentration reduction on length of filtering path are given in this paper.

The researches consist in sampling of open-pit waters before filtering, the laboratory analysis of oil products composition and calculation of parameters of oil products particle settling in AFM.

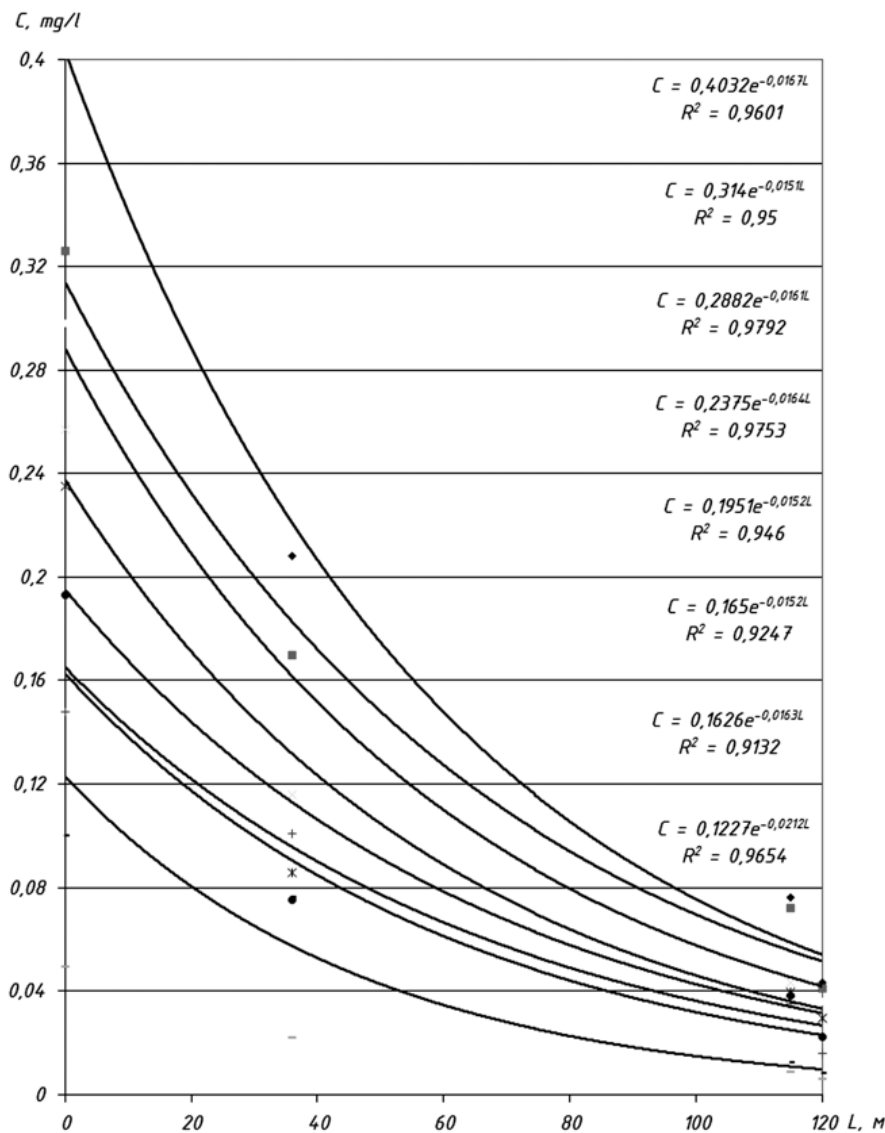Conditions for researches in section "Tomusinsky" were the following:

The filtering massif discharged from coarse half-rock rocks with approximate lithologic composition of rock: sandstone - 65%, siltstone - 29%, mudstone and carbon-bearing mudstone - 6%. Length of filtering

path is 120 m. Slope of the artificial filtering massif base is 1.5 ° on average. In total, 8 series of experiments have been conducted. Results are shown in Table 1. Graphical interpretation of data of Table 1 is shown in Figure 4.

Table 1. Research results on setting of dependences of impoverishment of oil products in pit waste waters on the path

No experiment	Concentration of oil products C, mg/l, in case of filtering distance L, m			
	$L = 0.1$ m (input of the filtering massif)	$L = 36$ m	$L = 115$ m	$L = 120$ m (output of the filtering massif)
1	0,415	0,208	0,076	0,043
2	0,326	0,17	0,072	0,041
3	0,298	0,152	0,054	0,036
4	0,257	0,116	0,043	0,029
5	0,235	0,0855	0,0395	0,0295
6	0,193	0,075	0,038	0,022
7	0,148	0,101	0,035	0,016
8	0,1	0,076	0,012	0,008

Curve equations shown in figure:

$$C = 0.4032 e^{-0.0167L}, \quad R^2 = 0.9601$$
$$C = 0.314 e^{-0.0151L}, \quad R^2 = 0.95$$
$$C = 0.2882 e^{-0.0161L}, \quad R^2 = 0.9792$$
$$C = 0.2375 e^{-0.0164L}, \quad R^2 = 0.9753$$
$$C = 0.1951 e^{-0.0152L}, \quad R^2 = 0.946$$
$$C = 0.165 e^{-0.0152L}, \quad R^2 = 0.9247$$
$$C = 0.1626 e^{-0.0163L}, \quad R^2 = 0.9132$$
$$C = 0.1227 e^{-0.0212L}, \quad R^2 = 0.9654$$

Figure 4. Dependence of oil products concentration on length of filtering path

The analysis of dependences provided in graphics has showed that the change of oil products concentration C from filtering path L with high accuracy (R^2 is not lower than 0.91) is approximated by expression

$$C = C_0 \cdot e^{-0,016L}$$

where C_0 – initial concentration of oil products in the waste waters discharged for purification, L – filtering path, m.

Thus, the obtained formula allows forecasting of water purification quality for section "Tomusinsky" in case of different initial concentration of oil products and length of filtering path.

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