METHODS OF ACCELERATING GAS EMISSION AFTER EXTENSIVE BLASTING IN OPEN-CUT MINES

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After borehole charges have been detonated in open-cut mines, a certain amount of poisonous gases remains in the spoil [1]; this gas is gradually emitted and contaminates the surrounding atmosphere, thus causing the mining and transport equipment to stand idle for considerable periods. Practical interest therefore attaches to the question of accelerating emission and dispersion of the gases from the spoil.

We studied two methods of accelerating and dispersing gases: spraying and injection of water into the spoil, and artificial ventilation of the latter. This paper gives the results of a determination of the efficiencies of these methods in the laboratory and in mines.

In open-cut mines in the Krivbass, dust suppression during operation of excavators in hot weather is usually effected by spraying the faces with water by hydromonitors installed on railway platforms or on dump cars. The consumption of water for spraying a face is 80-90 m$^3$ [2]. Furthermore, spraying is used for preventing agitation of dust on the spoil surface.

According to Drobot [3], spraying of the spoil has a marked effect on gas emission. He attributes this to the fact that spraying reduces the temperature of the gases in the solid mass as well as the natural draft, which in turn reduces the rate of evolution of CO; however, this assumption is not supported by specific data.

In addition to the beneficial effect on dust suppression, spraying may also impair the gas composition of the atmosphere around the spoil. We therefore carried out investigations both in the laboratory and in mines.

In the laboratory, experiments on the factors affecting gas emission from the spoil with different wetting procedures were carried out on different types of rock of the Krivbass. To the laboratory apparatus (Fig. 1a) was added a mixture of fractions smaller than 200 mm, corresponding to rocks or ores with Protodyakonov hardness coefficients $f = 6-8, 8-10, \text{ and } 10-12$, which was then covered with a lid; gas with an initial CO concentration of 0.2% was passed into working cylinder 4. The upper lid of the cylinder was then opened and spraying device 7, installed 0.5 m above the upper edge of the working cylinder, simultaneously put into operation. The device was connected to a water tank 1 by hose 2; it consisted of three tubes of diameter 10 mm in which several series of holes of diameter 3 mm were drilled. The tubes were located in such a way that the surface of the mixture in the cylinder was uniformly sprayed. The specific consumption of water was 40 liters/m$^3$ of pillar, the duration of spraying 3-5 min.

Gas sampling was effected at three points 5 of the laboratory apparatus at heights of 0.2, 1.0, and 1.7 m above the base of the cylinder. At these points we measured simultaneously the temperatures of the mixture of fractions, the air, and water with thermometer-probes 6, the mean value being 20-22°C.

During the investigations the rock mass was wetted by injecting water. For this purpose, immediately after the lid of the working cylinder was opened we drove needle-type tubes of diameter 15 mm up to a depth of 1 m into the mixture (see Fig. 1b). The needle-type tubes 3 were connected at one end to the water tank by a hose; at the other end were several holes of diameter 5 mm around the perimeter. Water was fed to the needle-type tubes and samples taken by the procedure described above. The water was fed at a pressure of 0.2 atm.


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The results of the investigation are given in Figs. 2 and 3. It can be seen from Fig. 2 that water spraying of a mixture of fractions corresponding to rock with $f = 8-10$ reduces the CO concentration in the working cylinder far more rapidly (curve 2) than under the same conditions in a dry mixture of fractions (curve 1). The marked reduction of the gas content in the initial period may be attributed to the fact that during spraying, water penetrates into the mixture of fractions and partially fills the pores so the gas located in the pores between the fragments is displaced. Such displacement is particularly intense during spraying. During spraying of chlorite-sericite schists with $f = 6-8$ or less (curve 3), gas emission is different than that in the above-mentioned rocks. It will be seen from Fig. 2 that curve 3 is located considerably above curves 1 and 2. This indicates that in weak rocks, spraying of the spoil markedly retards gas emission. It was noted that during spraying of schists ($f = 6-8$), a layer of water (1.5-2 cm) accumulated on the mixture surface and filtered very slowly into the mixture for 4 h. In the first 3.5 h the CO concentration at the points of the laboratory apparatus at heights of 0.2, 1.0, and 1.7 m increased somewhat (see Figs. 2 and 3) above the initial value, and then slowly fell. This might be due to the fact that in the first 4 h, on the surface of the rock there was formed a layer (skin) of water containing adhering and swollen dusty fractions; this not only prevents emission of the gases, but also displaces them into the underlying layers. This is promoted by some part of the water which penetrates within the spoil. It can be seen from Fig. 3d that the rate of gas emission from beneath the skin is greatly reduced. In this case the CO concentrations at heights of 0.2 and 1.0 m were practically the same 20 h after the beginning of the experiment. Marked retardation of gas emission in weak rocks during spraying is also confirmed by experiments in the TsGOK open-cut mine (Table 1).

It can be seen from Table 1 that, as in the laboratory experiments, spraying markedly reduces emission of CO; oxides of nitrogen are partially neutralized.

To determine the degree of swelling of Krivbass rocks which promotes skin formation, we performed laboratory experiments by the Rutkovskii method [4]. Several types of rock were studied. Their percentage increase in volume during wetting was determined by the formula [4]

$$W = \frac{V_{\text{max}} - V_0}{V_0} \%,$$

where $V_0$ is the initial volume of the rock sample and $V_{\text{max}}$ is the maximum volume of the rock sample after complete swelling.

The results are given in Table 2. It will be seen that the swelling of the rocks is due to the presence of clay particles. On the basis of the laboratory investigations and the data of Table 2, rocks containing 5% or more clay should not be wetted in the first few hours after blasting in order to accelerate gas emission.

Study of gas emission from the spoil during different methods of wetting reveals that, in contrast to spraying with injection of water via needle-type tubes at a pressure of 0.2 atm (see Fig. 2, curve 4), the process is initially retarded, then intensified. This may be explained by the fact that during injection of water to a depth of 1 m, it filters into the lower part of the working cylinder; at a height of 0.2 m from the base of the laboratory apparatus, initially gas emission is somewhat retarded because at the moment of injection the water prevents emission (see