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REDUCING THE EMISSION OF HARMFUL GASES INTO THE QUARRY ATMOSPHERE

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Annotation: This article highlights methods for reducing harmful gases released during thermal drilling and blasting operations in quarry conditions. It is noted that when using thermal drilling rigs powered by oxygen–kerosene fuel, explosive hydrogen mixtures may form at high temperatures. To counter this, methods such as injecting neutralizing agents with cooling water, installing neutralization devices after dust collection systems, and using water–fuel emulsions are recommended. According to the research results, the use of aqueous emulsions up to 12% does not affect drilling productivity and significantly reduces the toxicity of exhaust gases. In blasting operations, it is shown that the oxygen balance of explosives, the composition of the rock, and the blasting technology influence the amount of harmful gases produced. To reduce harmful gases, selecting explosives with an oxygen balance close to zero, enhancing ventilation, and adding neutralizing additives to stemming are recommended as promising approaches.
Keywords: Quarry atmosphere, thermal drilling, blasting operations, harmful gases, neutralization, water–fuel emulsion, carbon monoxide, nitrogen oxide, oxygen balance, ventilation.

Introduction: When drilling boreholes with thermal drilling rigs powered by oxygen–kerosene fuel, it is considered advisable to use low-temperature methods for cleaning quarry air from harmful gases. This is because at higher temperature ranges, the hydrogen released during drilling may form explosive mixtures. To combat this, the following methods are widely applied: injecting neutralizing agents together with cooling water, installing neutralization devices after the final stage of dust collection, using water–fuel emulsions, as well as applying combinations of these methods.

Reducing the intensity of gas emissions during borehole drilling

Gas emissions into the quarry atmosphere occur when drilling boreholes using thermal drilling rigs. To address this, a number of measures are applied, the main ones being: correct selection of combustible mixture components, the use of efficient fuel ignition methods, dilution of harmful gases, the application of gas neutralization methods, and others.

One of the most effective ways of combating harmful gases released into the quarry atmosphere when using thermal drilling rigs is gas neutralization. Among the promising methods is reducing the toxicity of gases emitted from boreholes by using fuel–water emulsions in thermal drilling. The essence of this method lies in burning a fuel–water emulsion in the burner flame instead of conventional technological fuel.

The emulsion is prepared in a liquid generator, into which technical water and fuel are supplied in a specified proportion. The reduction of toxic gases released into the quarry atmosphere when using water–fuel emulsions is presented in Table 7.1.

Table 7.1.

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Toxic gases and vapors	**Gas composition during emulsion drilling, %**	**Reduction of gas toxicity when drilling with a water–fuel mixture, %**			
		5	**7**	**8**	**10**
In an oxygen + fuel mixture					
Acrolein	0,0121	90	100	100	100
Carbon monoxide	12,8	25,2	49,6	60,5	50,6
Nitrogen dioxide	0,409	100	100	100	100
Diesel fuel + oxygen mixture					
Formaldehyde	0,0024	100	100	100	100
Acrolein	0,08	100	100	100	100
Carbon monoxide	21,72	37,3	55,5	69,4	71,6
Nitrogen dioxide	0,392	100	100	100	100

The use of emulsions containing up to 12% water in thermal drilling does not affect the operation of the burner or the productivity of the rig.

Reducing gas content in the quarry atmosphere during blasting operations. During blasting, toxic gases are formed as a result of the decomposition of explosives. The volume of any gases generated during blasting, as well as their total amount, is determined by the following expression:

W_2= 22,4 $\cdot n_m$, litr,

Here 22.4 — the volume of one gram-molecule at standard conditions, in liters; pmp_mpm — the number of gram-molecules of gas produced when 1 kg of explosive (PM) is detonated. When 1 kg of Ammonit No. 6 is detonated, 910 liters of gas are released.

Under conditions of negative oxygen balance, detonation of an explosive produces a large amount of carbon monoxide. In such cases, the chemical reaction may or may not lead to formation of solid carbon. Depending on temperature, the partitioning of oxygen between formation of CO_2, CO and H_2O can change.

The composition of the components in a reaction where solid carbon is not formed can be determined from the reaction that produces gaseous water:

$CO + H_2O \Leftrightarrow CO_2 + H_2 + g$.

When the temperature rises, the reaction shifts to the left, and when it decreases, it shifts to the right.

During the explosion process, a large amount of nitrogen is released, and at high temperatures it dissociates (decomposes) to form nitrogen oxide. This phenomenon mainly occurs with explosives that have a positive oxygen balance.

Nitrogen oxide may also be released directly during the decomposition of ammonium nitrate:

$2NH_4NO_3 = 2NO + N_2 + 4H_2O$.

When the volume of oxygen in the quarry atmosphere is sufficient, nitrogen oxide is converted into nitrogen dioxide or transformed into nitrous anhydride:

$2NO + O_2 = 2NO_2 + q$,

$4NO + O_2 = 2NO_2O_3$.

The amount of harmful gases produced also depends on the chemical composition of the blasted rock and the blasting technology used.

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According to research carried out on determining the gas content of explosives in ore quarries, when hard magnetite hornfels (f = 16–18) were blasted with TNT, the maximum amount of carbon monoxide formed was 70 L/kg of explosive. When shales were blasted with grammonite 79/21, the minimum amount of carbon monoxide was recorded (9.4 L/kg of explosive). However, in the first case the formation of nitrogen dioxide was minimal, while in the second case it was observed at its maximum.

When large amounts of explosives are detonated, a complex of various measures is applied to reduce the gas content of quarry air. The main ones include: using explosives with an oxygen balance equal to or close to zero; applying blasting technologies that reduce gas generation; intensifying quarry ventilation, and so on.

For example, replacing TNT with grammonite 79/21 has resulted in more than a fourfold reduction in the formation of the toxic gas carbon monoxide.

When blasting with large volumes of explosives, adding neutralizing additives to the composition of the explosive and the stemming (plug) is considered a key and promising approach to reducing the release of harmful gases into the quarry atmosphere. It is advisable to use solutions as both internal and external stemming.

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