Methodology for Determining Emissions of Pollutants into Atmospheric Air by Open-Pit Mining Works

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Abstract

In recent years, significant changes have occurred in the mining industry in the qualitative and quantitative indicators of technical means and materials used during the open mining of iron ore. Technical parks of loading and unloading and transport equipment have been updated, new types of explosives have appeared. Currently, there are no methods for calculating emissions of pollutants into atmospheric air from modern mining equipment.

In 1989, the "Methodology for calculating emissions of harmful substances from quarries taking into account the non-stationarity of their technological processes" was developed, which today no longer takes into account the above-mentioned factors and needs revision and additions.

"Methodology for determining emissions of pollutants into atmospheric air by open-pit mining works" was created on the basis of "Methodology for calculating emissions of harmful substances from pits taking into account the non-stationary nature of their technological processes" of 1989, as well as the data from industrial research and instrumental measurements of atmospheric air pollution during various technological processes in pits at dumps and tailings storages, which have been carried out in recent years.

Thus, the developed "Methodology for determining emissions of pollutants into the air by open-pit mining works" includes the data from the methodology of 1989, which are still relevant today, the data on technical characteristics and parameters of the equipment presently used by open-pit mining works, as well as the results of scientific research conducted by the Research Institute of Labour Safety and Ecology in the Mining and Metallurgical Industry of Kryvyi Rih National University.

The basis for development of the "Methodology for determination of emissions of pollutants into the atmospheric air by open-pit mining works" is the need to determine the amount of emissions of pollutants into the atmospheric air from modern technological processes and equipment of open-pit mining operations.

Keywords: *opencast mining, methodology, emissions, non-stationarity, technological processes*

Mining of iron ores by an open method, depending on the accepted system of discovery and development of a deposit, is associated with certain technological processes: drilling and blasting of the mining massif, loading, moving and unloading of the mining mass, as well as technological processes during work on tailings and sludge storages and during dump formation. Special mining transport equipment is used to carry out technological processes in quarries, dumps, tailings and sludge storages.

Drilling of shafts is carried out mainly by drilling machines of mechanical impact on the bottom of shafts. Machine tools for drilling holes are used as machines for mechanical impact, which pass the shafts with 160–320 mm diameter down to the depth of 35 m, as well as drilling rigs of imported production, such as Atlas Copco are used, which drill the shafts with the diameter of 110–270 mm.

Explosive rocks in pits are carried out by separate blocks with single-row or multi-row arrangement of shafts using various types of explosives. The amount of explosives detonated simultaneously in one mass explosion reaches more than 1,000 tons. When mass explosions are carried out, a significant amount of dust and harmful gases are formed, which are carried out of the pit space in the form of a dust and gas cloud and dispersed over considerable distances. At the same time, a part of the harmful gases remains in the blasted mining mass, which is released into the atmosphere during its excavation.

Excavation of mining rocks and loading into vehicles is carried out by excavators of ECG type, with a bucket capacity of 4; 4.6; 8; 10; 12.5 and15 m^3, as well as excavators of imported production, for example, TEREX, CATERPILLAR, HITACHI and Komatsu.

The movement of the mining mass from the mines to the reception points and the delivery of auxiliary loads in the pit is carried out by mining transport. Cyclic transport is mainly used in pits. Cyclic types of transport include rail and road ones. Diesel-powered dump trucks with a carrying capacity of 27–230 tons are used as vehicles. Trains with 6–12 dump trucks with a carrying capacity of 90–140 tons each with a

capacity of up to 150 m^3. Electric, diesel and diesel-electric locomotives are used as traction [1, 2].

Overburden and substandard minerals, which are mined in the pit during the development of the deposit, are removed to dumps. The process of dump formation is determined by the type of mining transport equipment that moves the rock into the dump, and is divided into bulldozer, excavator and conveyor dump formation. The dusty surfaces of the formed dumps are also powerful sources of dust emission.

During washing of enrichment waste (tailings), as well as during the construction of dams from tailings, separate areas of up to 30–100 hectares or more are formed, which remain dehydrated for several months a year. Dry beaches of tailings are the intensive sources of dust emission. The fractional composition of the upper layer of the beaches of the tailings ponds has a slight difference. Therefore, the intensity of dust blowing from the surface of dry beaches will mainly depend on the wind speed and the humidity of the tails.

In iron ore pits, the sources of release of harmful substances are mainly unorganized. In addition, almost all production processes in pits are characterized by cyclicity, so the sources of allocation are non-stationary in time.

When calculating dust emissions from dusty surfaces of dumps and dry beaches of tailings, climatic conditions such as material freezing, snow cover, and seasonal precipitation should be taken into account.

Emissions of polluting substances into the atmosphere are determined based on the application of the following methods:

- instrumental ones, which use the results of direct measurements of the concentrations of harmful substances in emissions, as well as their parameters (speed of movement, consumption, etc.). These include the method of sampling various pollutants, the method of timing the working time and downtime of equipment, etc.;
- calculations using the results of analytical and instrumental methods. These include the method of calculating the intensity of emission of pollutants, determining the parameters of the dust and gas cloud, the method of approximating functions, etc.

Technical indicators of technological processes (equipment productivity, material consumption, parameters of emission sources, etc.), as well as specific emissions of pollutants per unit of process indicator, are determined by the indicated methods.

By summing up the value of pollutant release from the source over time, their annual indicators are determined for a certain equipment or technological process.

For a qualitative and quantitative assessment of the impact of technological processes and mining transport equipment on atmospheric air pollution of pits and the convenience of calculating this impact, a classification of pollutant emission sources is necessary.

The sources of emissions are determined by each technological process. Depending on the goal, the source of emissions can be:

- a separate unit of equipment;
- the sum of emissions from all technological equipment involved in this process. In this case, the emission source model will represent a stylized (equivalent) emission source with averaged parameters (height, area, coordinates, etc.) and the sum of emissions from all similar emission sources.

The linear dimensions of the emission sources are determined by the features of the technological process and the dimensions of the mining transport equipment and its quantity.

The height of the sources located in the pit is determined taking into account the minimum height of the ground sources of unorganized emissions, which is equal to 2 m [1] or the height of the discharge source (drawing height, body height, etc.), and the height of the vane, where the wind speed is determined (10 m).

For a single drilling rig, a model of a planar unorganized source and a height, that takes into account the minimum height of the ground source and the height of the weather vane, is adopted.

Due to the rapidity of the rock blasting process (fractions of a second), the maximum one-time emission of pollutants during mass explosions, as a rule (for example, when setting standards for pollutant emissions), is not determined. At the same time, the actual amount of emissions in g/s may not have a physical meaning if the emission itself will last less than 1 s. But in cases where it is necessary to determine the impact of mass explosions on the border of the sanitary protection zone or on the border of the residential zone, it is necessary to calculate the dispersion of polluting substances during the mass explosion. For this purpose, equivalent maximum single emissions of pollutants are defined, reduced to a twenty-minute time interval, which values can be used as the input data for the scattering calculation program. For each block that is blown up, the equivalent pollutant emission reduced to a 20-minute interval is taken from a plane source with sides equal to the length and width of the block and a height equal to the depth of the shaft on the block, taking into account the minimum height of the ground source.

For a single excavator slaughter a plane source with dimensions equal to the maximum scooping radius of the excavator is accepted taking into account the height of the vane.

The linear dimensions of the planar source of emissions during the movement of motor vehicles on quarry or dump roads are accepted depending on the dimensions of the dump truck body and the number of dump trucks that are simultaneously in the pit or on the dump. The height of the source is taken taking into account the height of the dump truck and the height of the vane.

For railway transport operating in a quarry or on a dump, a plane source with linear dimensions of the train (locomotive and wagons) and heights taking into account the height of the dump truck and the height of the vane is accepted.

For a bulldozer, given that the main place of its work in a pit is an excavator pit, a planar type of source is adopted with parameters similar to those of an excavator pit with a source height that takes into account the minimum height of the ground source and the height of the vane.

Depending on the type of landfill (excavator or bulldozer), the source of pollutant emissions will be planar. The cyclicity of dust generation will be determined by the cyclical operation of the technological equipment.

In addition, dust is also released from the folded surface during the formation of a dump. The rise of dust depends on the type of mining mass, its granulometric composition, meteorological conditions, etc. The process of lifting dust from the surface of the dump over time has a cyclical nature, which depends on the above mentioned factors. The characteristic dimensions of the planar source of emissions in this case will be determined by the area of the sawing surface of the operating dumps, with the exception of the part where the technological processes are carried out.

In addition to the fixed stationary sources in the pit, there will also be mobile sources (internal combustion engines of mining transport vehicles – dump trucks, diesel locomotives and bulldozers).Emissions from mobile sources should also be taken into account when assessing the object's impact on the air environment (calculation of dispersion). For this purpose, mobile sources are presented in the form of conventional unorganized sources with defined spatial coordinates. For the pit, these mobile sources have the same coordinates as the corresponding ("Auto dumpcar", "Dumpcar", "Bulldozer") unorganized sources.

Specific emissions of pollutants from mobile sources are determined according to [2, 3] or by the characteristics of the equipment.

The purpose of the developed "Methodology for determination of emissions of pollutants into the atmospheric air by open-pit mining works" is the qualitative and quantitative assessment of emissions of pollutants into the atmospheric air during the conduct of open-pit mining works on the basis of their specific emissions. The "Methodology..." determines the emissions of pollutants into the atmospheric air from unorganized sources of emissions, taking into account the non-stationarity of the operation of technological equipment and the conduct of technological processes by open-pit mining works. The "Methodology..." is intended as a normative document for calculations and evaluation of emissions of pollutants into atmospheric air in pits, dumps and tailings.

The obtained results of calculations of emissions of pollutants into atmospheric air according to the "Methodology..." can be used:

- for compilation of statistical reports and for development of permission documents, provided for by the legislation of Ukraine;
- for development of project and pre-project documentation for enterprises with open ore mining;
- for planning the amount of damage to the environment and the measures for its protection.

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Metodyka wyznaczania emisji zanieczyszczeń do powietrza atmosferycznego z robót górnictwa odkrywkowego

W ostatnich latach w górnictwie zaszły istotne zmiany wskaźników jakościowych i ilościowych środków technicznych i materiałów stosowanych podczas odkrywkowego wydobycia rudy żelaza. Zaktualizowano parki techniczne załadunku i rozładunku oraz sprzętu transportowego, pojawiły się nowe rodzaje materiałów wybuchowych. Obecnie nie ma metod obliczania emisji zanieczyszczeń do powietrza atmosferycznego z nowoczesnych urządzeń górniczych. W 1989 r. opracowano „Metodykę obliczania emisji substancji szkodliwych z kamieniołomów z uwzględnieniem niestacjonarności ich procesów technologicznych", która obecnie nie uwzględnia już ww. czynników i wymaga rewizji i uzupełnień.

„Metodyka wyznaczania emisji zanieczyszczeń do powietrza atmosferycznego przez kopalnie odkrywkowe" powstała na podstawie „Metodyki obliczania emisji substancji szkodliwych z wyrobisk z uwzględnieniem niestacjonarności ich procesów technologicznych" z 1989 r. W ostatnich latach zostały przeprowadzone instrumentalne pomiary zanieczyszczeń powietrza atmosferycznego podczas różnych procesów technologicznych w wyrobiskach na hałdach i składowiskach odpadów. Opracowana „Metodyka wyznaczania emisji zanieczyszczeń do powietrza przez roboty odkrywkowe" zawiera aktualne do dziś dane z metodyki z 1989 roku, dane dotyczące charakterystyki technicznej i parametrów urządzeń stosowanych obecnie przez kopalnie odkrywkowe (z prac wydobywczych), a także wyniki badań naukowych prowadzonych przez Instytut Badawczy Bezpieczeństwa i Ekologii Pracy w Przemyśle Górniczo-Hutniczym Krzyworoskiego Uniwersytetu Narodowego. Podstawą opracowania „Metodyki wyznaczania emisji zanieczyszczeń do powietrza atmosferycznego przez zakłady odkrywkowe" jest potrzeba określenia wielkości emisji zanieczyszczeń do powietrza atmosferycznego z nowoczesnych procesów technologicznych i urządzeń kopalni odkrywkowej.

Słowa kluczowe: *górnictwo odkrywkowe, metodologia, emisje, niestacjonarność, procesy technologiczne*