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Engineering environmental protection at an industrial facility

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Abstract. The aim of this study is to study engineering safety at an industrial facility. The subject of the study is dangerous and harmful factors of production, which include dust and harmful gases. The objectives of the study is assessing the dispersed composition of dust, which determines the microclimate of the working area on the example of a foundry. The presence of fine dust in the air space of the workshop leads to occupational diseases, such as pneumoconiosis (silicosis), bronchitis, dermatitis, conjunctivitis. The dust dispersion assessment took into account the relationship between the particle size and the speed of movement under the action of gravitational or centrifugal forces. The granulometric composition of the provided powder sample was determined by laser diffraction, implemented on the Fritsch NanoTec "ANALISETTE 22" laser particle analyzer. Data analysis shows that almost all phases of the technological process determine the microclimate of the internal environment and in the inter-hull zone during emission dispersion. The degree of exposure depends on the dispersion and chemical composition of the dust, in particular, in the air, the dust is oxidized to form a SiO2 film. In addition, there are other harmful substances in the workshop air that can be deposited on dust particles, which makes dust more dangerous and in this case it is necessary to take into account more stringent values of maximum permissible concentrations (MPC). An increase in the SiO2 content tightens the requirements for the cleanliness of the air in the working area. In the work, on the basis of theoretical and experimental data, the most dangerous areas with the formation of industrial dust from the standpoint of environmental risk were identified, the dust dispersion was assessed, the dust collection system was finalized, and a wet cleaning system was installed. **Keywords:** working area, industrial safety, dispersion, dust, concentration, granulometric analysis.

1 Introduction

At various stages of the technological process, high concentrations of dust and harmful gases are released. When melting metal and processing castings, suspended and gaseous contaminants are released [1]. The environmental situation in the casting processing shop is determined by the technological processes occurring during the metalworking of components [2, 3].

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Protection of atmospheric air from dust is currently carried out by a cyclone with subsequent flare emission into the inter-hull zone. In the foundry, shot blasting of castings is carried out in a special sealed chamber. The operator is protected from dust by a respirator.

2 Main Part

In the working area of foundries, in addition to dust, there are also carbon oxides, sulfur dioxide, nitrogen and its oxides, aerosols, hydrocarbon vapors, etc. [4, 5]. The foundry of machine-building production is located in urban development. The degree of environmental safety is determined by the microclimate in the zone of the shot blasting plant and the inter-hull zone of the plant (when emissions are dispersed) [6, 7].

If there are several unidirectional contaminants in the air of the workshop, their accounting is estimated by the formula (1):

$$\frac{К}{MPC} = \frac{К1}{MPC1} + \cdots + \frac{Кn}{MPCn} \leq 1 \qquad (1)$$

The objective of this work is to ensure safe levels of exposure to the operators of the shot blasting section of the foundry, as well as in the wind zone.

The actual efficiency of dust collectors operating in the workshop is insufficient, since there is a multiple excess of the maximum permissible concentration of substances in the working area. The dust collection system can be supplemented with a second "wet" stage in order to refine the discharge into the inter-hull zone to the level of the MPC of the working area [8].

Devices for cleaning emissions are proposed, the main task of which is to increase the ability of dust collection by ensuring effective coagulation of dust particles in a humidified gas-air stream, allows air to be cleaned of dust.

In the works an assessment of the category of environmental hazard of the enterprise Ceop is proposed in four classes [8-9]. Ceop is the coefficient of environmental hazard of the enterprise is determined by the formula

$$K_{EOP}=\sum_{i=1}^{n}\left(\frac{M_i}{C_{MPCi}}\right)a_i \qquad (2)$$

where Mi is the mass of the pollutant, t/year; SPDKi = Si / MPCr.z. is the concentration of the pollutant in fractions of MPCr.z., ai is the coefficient taking into account the hazard class of the i-th substance: ai = 1,7 — 1^{st} hazard class; a2 = 1,3 — 2^{nd} hazard class; a3 = 1,0 - 3^{rd} hazard class; a4 = 0,9 — 4^{th} hazard class. Ceop >106 — correspond to the enterprises of the 1st category, the most actively polluting the atmosphere. 106>Ceop>104 — 2nd category, 104>Ceop 103 — 3rd category, Ceop <103 — 4th category.

To analyze the assessment of the enterprise category, the parameter P is calculated based on the required air consumption TPV, m^3/s, and the parameter R for each i-th substance and each source j according to the formulas:

$$TPV_{ji}=10^3M_{ji}/GLR_i \qquad (3)$$

$$R_u=\frac{D_j}{Hi+Di} * \frac{Cij}{MPCi}*10^3 \qquad (4)$$

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where Mji is the mass of the substance emitted by the source in one second, g/s; MPCi is the maximum permissible concentration of the substance, mg/m3; Dj is the diameter of the mouth of the source. If the mouth of the source is not round, then its largest size is taken as Dj, m. Nj is the height of the source above ground level, m; C ji is the concentration of the substance at the mouth of the source, g/m^3.

For Dj>0.5 Nj, the expression Dj/(Nj + Dj) is assumed to be equal to one.

The value of the parameter Pi, m3 / s, for each substance is determined by the following formula:

$$P_i=\sum_{j=1}^{n} \mathrm{T}PV_{ji}\, R_{ji} \tag{5}$$

where n is the number of sources in an enterprise that emits substances of the same name.

In particular, it is proposed to assess the category of an enterprise as an air pollutant on the basis of the environmental risk coefficient Cer:

$$\text{KEPu}=\sum_{j=1}^{n} 10^6 \frac{MjiDjCji}{MPC_{ji}^2(Hi+Di)}=\sum_{j=1}^{n} 10^6 \frac{Dj}{Hi+Di}\left(\frac{Cj}{MPC_{ji}}\right)^2 q_j \tag{6}$$

Data analysis shows that almost all phases of the technological process determine the microclimate of the internal environment and in the inter-body zone during emission dispersion [10].

The danger of dust exposure to human health depends on the dispersed composition, which is determined by the quantitative ratio of dust fractions of various sizes in it [11-13].

The main part. For dust analysis, the method of granulometric analysis was used, the principle of which is based on the relationship between the size and speed of movement under the action of gravitational or centrifugal forces. The determination of the granulometric composition of the provided powder sample was carried out by laser diffraction, implemented on the Fritsch NanoTec “ANALISETTE 22” laser particle analyzer (Fig. 1, 2) with the Fritsch Mas control control software package, in accordance with the requirements of ISO 13 320-2009 at the “Prof. Yu. M. Borisov Center for Collective Use”.

Fig. 1. General view of the Analysette-22 NanoTec laser analyzer (Fritsch, Germany).

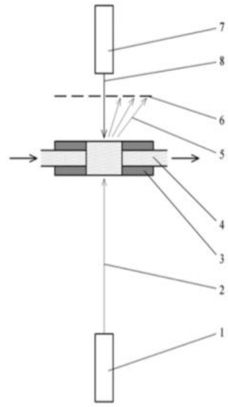

Fig. 2. Optical part of the Analysette-22 NanoTec laser particle analyzer:1 — front laser; 2 — front laser beam; 3 — measuring cell; 4 — dispersed medium containing the sample; 5 — laser radiation scattered by the sample; 6 — detector; 7 — rear laser; 8 — rear laser beam.

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To study particles in the analyzer, the principle of diffraction of laser radiation on dispersed samples is used, and then the Fraunhofer model is used for analysis. This model is used only for samples with particles larger than 0.1 microns (100 nm).

Justification of the results obtained. According to the results of the analysis, the granulometric composition of the samples presented was determined. The results are summarized in Table 1 and shown in Figure 3.

Table 1. Granulometric composition of the sample, percentage of particles of a certain size.

Value, %	Particles size, microns	Value, %	Particles size, microns	Value, %	Particles size, microns
%	<= 0.050 microns	0.9%	<=1.000 microns	1.5%	<=2.000 microns
1.9%	<=3.000 microns	2.0%	<=4.000 microns	2.2%	<=5.000 microns
2.9%	<=10.000 microns	5.3%	<=20.000 microns	39.9%	<=50.000 microns
86.2%	<=100.000 microns	99.6%	<=200.000 microns		

86.2% of the sample was obtained less than 100 microns, 13.8% are heavy particles larger than 100 microns. Particles of this size are dangerous to human health, as they cause pneumoconiosis, and in the presence of a SiO2 film, silicosis [14-15].

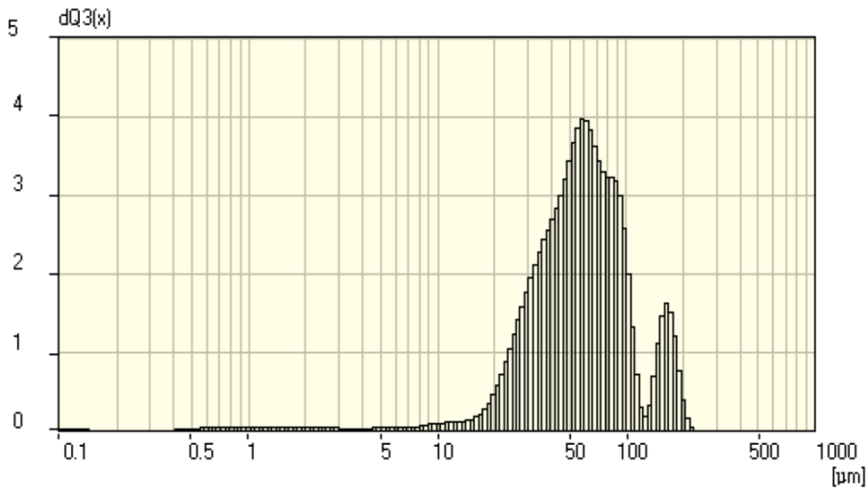

Fig. 3. Graphical results of measurement of dispersed analysis of dust particles.

Due to the fact that the amount of fine dust less than 100 microns is 86.2%, the dust collection system has been supplemented with a second wet stage in order to further purify the release into the interbody zone to the level of MPCr.z.

3 Results

1. The study of the structure of the dust formed on the shot blasting sites during the dispersed (granulometric) analysis showed that when crushing 86.2% of the dust released has a fraction size of less than 100 microns, i.e. refers to medium and fine dust having a settling rate of less than 7 cm/s.

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2. Based on calculations of the environmental risk coefficient, it has been established that the foundry is a third category air pollutant.
3. The air condition in the foundry is characterized by an excess of the actual concentrations of harmful substances over the maximum permissible concentration of the working area by 7-12 times.

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