TECHNOSPHERE SAFETY

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Analysis and assessment of safety during operation of the shot blasting machine in the foundry

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Introduction. The article discusses the harmful factors of foundry production. The authors analyze and evaluate the workplace of the operator of the shot blasting chamber and offer technical solutions to improve working conditions and reduce the development of occupational diseases.
Problem Statement. The objective of this study is to assess the impact of noise and dust pollution on the production sites of the foundry.
Theoretical Part. In the course of the study, the most polluted areas were identified with the exceeding permissible values of the considered indicators of noise level and dust content. These are the areas of shake-out grids and casting cleaning. Measures to improve the situation were proposed, such as: organization of acoustics taking into account the characteristics of the production room (acoustic screens, soundproof partitions), a suitable sound absorption area of the premises, the improvement of sound absorption by upgrading the body of the shot blasting chamber.
Conclusions. The results of the analysis indicate a sufficiently high level of influence of harmful production factors on the operators of the shot blasting section of the foundry and the need to strengthen labor protection in this area.

Keywords: noise pollution, vibration, dust, foundry, production site, shot blasting equipment, acoustics.

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Introduction. The impact of negative factors on employees of foundry enterprises is considered. The air environment of the working area of foundry operators often does not comply with sanitary and hygienic standards. This is due to the complexity of technological processes and the presence of harmful factors. The greatest amount of dust, noise and vibration is produced by equipment that is used for products processing and grinding by the shot blasting method.

The process of shot blasting makes it possible to grind casting blanks of different shapes. However, this technological process is accompanied by the generation of a large amount of dust, which poses a threat to the workers' health. An integrated approach to reducing dust content and preventing occupational diseases can gradually solve the problem of creating safe working conditions [1].

Monitoring the permissible noise and vibration levels in production is a very complex and costly event. Increased noise and vibration are considered to be those environmental factors that are technically very difficult to bring into the compliance with regulatory values [2]. A large number of occupational diseases associated with hearing impairment manifest themselves in workers after a long time of work. The development of serious problems with the auditory nerve depends on technological processes in which the noise level exceeds the acceptable values. The greatest impact of increased noise is observed at the sites of molders, casting technicians, fettlers and casting cleaners for mass production, where the values of the pollution index reach 1.43–2.74 [3]. Table 1 provides the data.

Table 1

Value of the pollution index by noise factor in the areas of foundries with different noise patterns

№ п/п	Profession	Noise pollution index, Ksh	Number of jobs
1	Moulder	1.43	3
2	Casting technician	2.74	2
3	Fettler	2.46	3
4	Casting cleaner	2.67	1
5	Pouring man	0.79	4
6	Metals and alloys furnace-operator	0.79	4
7	Charge maker	0.22	1
8	Foundry machine engineer	0.45	1
9	Sand mixer	0.71	2

Problem Statement. The initial objective of this study was to analyze the experimental characteristics of noise pollution.

The results of noise level studies have shown that noise pollution significantly exceeds the established norms. The greatest exceedances of permissible sound levels are noted at the workplaces of core and molding jarring machines by 12-23 dB, at shake-out tables — by 17-26 dB, at cleaning equipment — by 16-27 dB [3-4].

According to the sanitary standards, there are the values of permissible sound pressure levels (Table. 2) [5].

The sound field in the working areas of foundries is heterogeneous. This is due to the different modes and operating time of the production equipment. The most dangerous is the periodic mode of operation with the maximum noise level in the area of medium and high frequencies.

Table 2

Permissible sound pressure levels, sound levels and equivalent sound levels in workplaces, industrial premises and on the territory of enterprises

Type of work activity	Sound pressure levels, dB, in octave bands with average geometric frequencies, Hz									Sound levels and equivalent sound levels, dBA
	31.5	63	125	250	500	1000	2000	4000	8000	
Performing all types of work at permanent workplaces in industrial premises and on the territory of enterprises	107	95	87	82	78	75	73	71	69	80

Foundries of mass production are distinguished by the fact that a lower level of automation and mechanization of processes allow you to choose the most rational and isolated position of the equipment. It follows from this that the main methods of protecting workers consist in the rational placement of equipment, the organization of proper acoustics of premises, the installation of sound-proof screens and the improvement of shot blasting equipment housings [6].

The second task of the study was the development of measures to minimize dust and ensure safe working conditions in the dustiest areas of the foundry — shot blasting ones.

Special measures for the use of continuous production technology remove dust immediately in the places where it appears, also prevent the formation and spread of dust mechanization and automation of processes, development, installation and configuration of remote control systems, sealing and isolation of equipment, supply and exhaust ventilation systems [7].

In the foundry, dusty air passes through the dust collector system and then enters the atmosphere. However, the effectiveness of such systems is not sufficient [4].

Theoretical Part. One of the main issues of the study is the question of the characteristics of the sources of emitted noise and dust at the cleaning sites with the highest level of noise pollution.

One of the main and most frequently used methods of surface treatment of metal workpieces is shot blasting. This method allows you to polish the casting most efficiently; it is carried out in a shot blasting chamber.

Figure 1 shows a diagram of the shot blasting section [7].

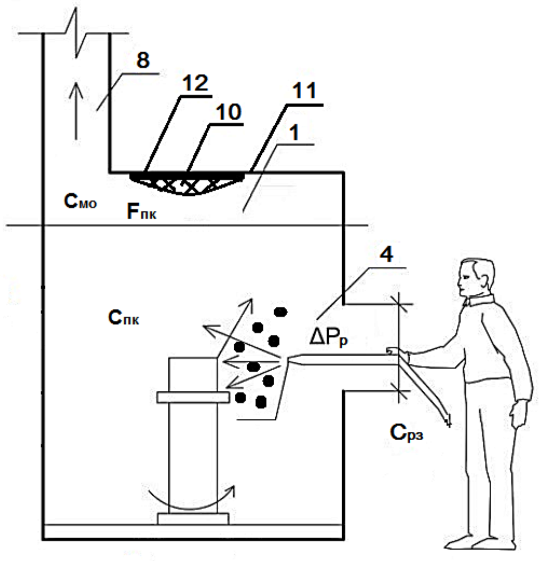

Fig. 1. The system of the shot blasting section of the foundry: 1 – shot blasting chamber; 2 – loading sector of the parts to be cleaned with a sealed door; 3 – control panel; 4 – shot blasting machine feed window; 5 – technological hole with a sealed lid for removing shot; 6 – compressed air line; 7 – air supply to the nozzle; 8 – air duct; 9 – conical air purification cyclone; 10 – VDM (vibration damping material); 11 – structural material; 12 – SAM (sound-absorbing material).Legend: Срз – concentration in the working area, Спк – concentration in the dust chamber, Смо – concentration in the local suction, Fпк – the area of the dust chamber, ΔPp – pressure drop during control

Shot blasting takes place in a chamber, which is a closed metal structure with a size of 2000x2000x2500 mm, its inner surface is made of 3 mm thick steel sheet and covered with 10 mm thick rubber. In the upper part, the chamber is connected by means of a pipe with a diameter of 630 mm to the local exhaust ventilation, which contains the cyclone TSN-11 [7].

Through the feed window, a shot with an average diameter of 2 mm falls on the surface of the product at a speed of 30 m/s. The principle of operation of a simple injection shot blasting machine is based on the operation of a hermetically sealed tank in which there is a shot under compressed air pressure. Under the influence of gravity and compressed air pressure, the shot is fed into the chamber. At the same time, noise of increased intensity is produced.

The amount of dust in the aspiration system to the dust collecting equipment was about 6 g/m^3, in the working area — about 9 mg/m^3 [7]. The degree of influence of dust on human health depends on its granulometric composition. Particles smaller than 10 microns remain in the lungs to a greater extent. Hazard class — 3, MPC = 0.5 mg/m^3. The level of air pollution in the working area forms a large number of factors that must be observed. This is a regular and high-quality repair and maintenance of equipment, the creation of effective modes of operation of aspiration systems and equipment for dust collection [8].

Dust after processing the surface of metal parts with shot turns into multicomponent, therefore, the development of effective measures for cleaning gas dust is required, in this regard, the study of elemental and dispersed compositions of dust particles is considered relevant. Granulometric analysis was used to estimate dust particles by size [3]. The particle distribution density and their size affect the properties of dustlike materials. The dust composition was determined using a Fritsch NanoTec laser particle analyzer, Analisette-22 model, using Fritsch Mas control software. Figure 2 provides the obtained data.

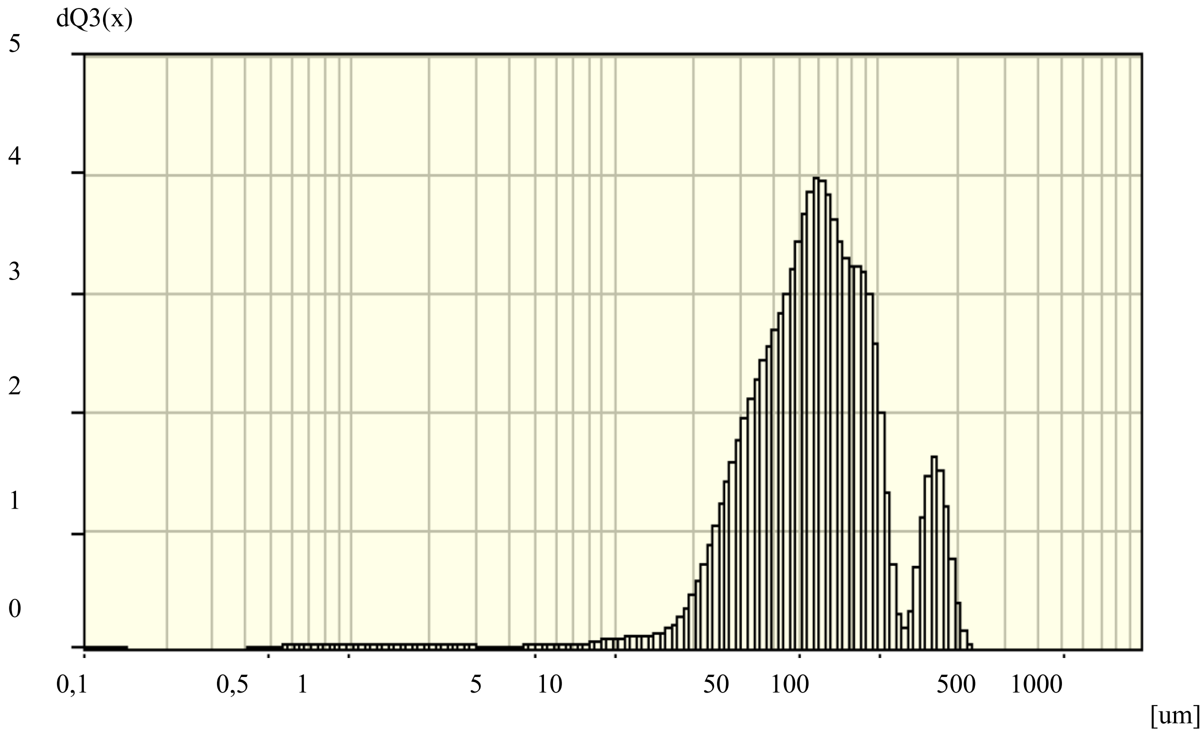

Fig. 2. Graphical results of the dispersed analysis of dust particles

The results are as follows: the dust contains about 90% of fine and medium-dispersed dust with a size of less than 100 microns. Particles of this kind are dangerous to human health; there is a risk of pneumoconiosis and silicosis.

The second stage of the experiment was aimed at detailing the dispersed composition of dust; it was carried out by X-ray spectral microanalysis [7].

X-ray phase analysis is the most promising method and is characterized by reliability and speed of obtaining results, based not on the comparison with available samples, but on the analysis of the crystal structure of the substance. The advantages of this type of analysis are non-infringement of the integrity of the part, assessment of phases in the mixture, tolerance to the volume of the object under study.

The data obtained by the X-ray spectral analysis show that dust has a shape that can be conditionally considered spherical. When settling, dust particles of this shape rotate and occupy a position at which they exert the greatest resistance to air. The shape of the sphere contributes to settling in inertial-type dust collectors and in the atmosphere. Particles smaller than 10 microns settle for a longer time, the presence of such particles in the air indicates the need to install a more efficient air purification system.

X-ray spectral analysis on the Bruker S8 Tiger wave X-ray fluorescence spectrometer at the Center for Collective Use of Scientific Equipment of VSU made it possible to obtain a more accurate number of elements in the sample. In order to refine the emission to standard concentrations equal to the maximum permissible concentrations of harmful substances in the air of the working area (MPCw.a.), it is proposed to supplement the existing dust collection system with a "wet" stage.

The main reason for the occurrence of strong noise is the peculiarities of the technological process in which aerodynamic noise occurs. To reduce noise of this kind, it is necessary to use techniques to improve the aerodynamic characteristics of the equipment.

The authors' proposal is to reduce the level of noise pollution by selecting soundproof and sound-absorbing parts of the body of shot blasting equipment.

The experimental studies of the absorption coefficients of a large number of cladding materials in the octave bands of the sound frequency spectrum, presented in [9], helped to choose the most effective combination of structural, sound-absorbing and vibration-damping materials. Methods of calculating the acoustic characteristics of materials and equipment helped to determine the optimal parameters of the components of production machines.

One of the authors' proposals is to maintain the thickness of the ferrous metal wall in the shot blasting chamber equal to 3 mm (Fig. 1, pos. 12), on which a layer of glued rubber with a thickness of 10 mm is applied (Fig. 1, pos. 10), which gives additional sound insulation of the walls of the chamber. On the inner surface of the chamber, it is necessary to apply sound-absorbing materials with a thickness of 30 mm, which are products that consist of superfine basalt fibers with a diameter of 1-3 microns, bonded together in the form of a canvas in a shell of glass fabric (Fig. 1, pos. 12). The sound absorption coefficient of the presented materials in the medium-high frequency range is from 0.5 to 0.9. Table 3 presents the sound insulation characteristics of the material made of superfine basalt fibers.

Table 3

Sound insulation characteristics of the material made of superfine basalt fibers

Material density – ρ = 15 kg/m^3. Material thickness – 30 mm. The size of the gap between the material and the insulating wall – 0 mm			
Frequency range, Hz	100–300	400–900	1200–1700
Normal sound absorption coefficient	0.05–0.15	0.22–0.75	0.85–0.93

The preliminary calculation of noise reduction at the operator's workplace when using the proposed measures showed that it was impossible to achieve the requirements of sanitary standards.

The results of experimental data on noise pollution do not meet the expected requirements. Carrying out a set of measures allowed reducing the noise level by 8-10 dB, which is not a safe value. To reduce the noise level more seriously, it is necessary to resort to installing a remote control system and sealing the equipment. [10].

The authors' proposal also consists in installing noise-proof structures and fencing in the areas with the most intense noise. This will help to form sound protection and significantly increase dissipation [11].

The recommended measures do not allow achieving the standard values of noise characteristics. Since making changes to the design of the shot blasting chamber is technically unrealizable, the use of personal protective equipment — a helmet with headphones is considered [12].

The authors offer comprehensive recommendations to reduce the level of dust and noise at the operator's workplace, which will consistently solve the problem of creating safe working conditions [12].

Conclusions. A comprehensive analysis of noise impact on foundry workers is described and the ways to optimize the working conditions of operators of shot blasting grinding plants are studied:

1. The unfavorable areas with the highest level of noise pollution have been identified — shake-out tables and shot blasting areas.

2. Granulometric analysis of the samples showed that dust with a size of less than 100 microns makes up 90% of its total volume.

3. It is established that in the shot blasting areas of the foundry, there is an excess of the normative values of the noise level by 4-18 dB.

4. A technical solution has been proposed to reduce the noise level for a standard shot blasting chamber — applying a two-layer coating on its inner surface consisting of a vibration damping material, which is a layer of glued rubber with a thickness of 10 mm and a sound-absorbing material made of super-thin basalt fibers made according to a flat scheme (cloth), which does not provide normative values of the noise level, but gives a significant decrease in it.

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V. Ya. Manokhin — scientific supervision, formulation of the basic concept, goals and objectives of the study; L. D. Drozdova — analysis of the research results, formulation of the conclusions; E. I. Golovina — performance of the experiment, analysis of the research results, formulation of the conclusions; D. A. Sokolov — preparation and formatting of the text of the article, work with literature.