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COMPREHENSIVE ASSESSMENT OF THE IMPACT OF AIR NOISE AND DUST ON FOUNDRY OPERATORS

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Abstract*: The main goal of the work is a comprehensive assessment of the impact of noise and dust in the foundry. Based on the results of the analysis, the main disadvantage areas with exceeding the permissible noise and dust level are presented – areas of knockout grates and casting cleaning areas.*
Recommendations are proposed for the selection of technical measures, including the rational placement of equipment, their mode of operation, the installation of acoustic screens and sound-insulating partitions near unprotected workplaces, as well as a rational selection of the equivalent sound absorption area of the workshop premises, which will create safe production conditions. Ways of improving the working conditions of operators of sand and shot blasting installations by reducing noise at their workplaces are considered: increasing sound absorption in the body of the shot blasting chamber and installing noise-protective shielding structures to fence off areas with the most intense noise.

Keywords: *noise, vibration, dust, foundry, shot blasting section, noise-reducing shielding structures, sound absorption*

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1. INTRODUCTION

The article is devoted to a comprehensive assessment of the impact of dust, noise and vibration on the operating personnel of the foundry. The complexity of technological processes, the presence of harmful factors in the working area of the operators of the foundry affect the quality of the air environment of the foundry, which usually does not meet sanitary and hygienic standards. Special equipment located in the foundry additionally releases a large amount of heat into the air of the working areas, the surplus of which can also lead to changes in climatic conditions inside the production premises of the foundries.

Improving the quality of production products, increasing their reliability and durability to a greater extent depend on the cleanliness of the surfaces. Processing by shot blasting reels and chambers is the most common method in industrial sphere. This equipment belongs to the group of the most environmentally unfriendly: a large amount of emitted dust, the presence of shot supplied under pressure, which are accompanied by high levels of noise and an increase in vibration activity. Increased noise and vibration are considered those environmental criteria for which it is technically most difficult to achieve their compliance with regulatory values. The harmful effects of noise and vibration on the human body are manifested in various forms, for example, noise (neuritis of the auditory nerve) and vibration diseases, increased fatigue, decreased productivity and the quality of work. And at present, noise and vibration diseases in foundry occupy the second and third places in the list of occupational diseases [1].

In the shops of mass foundry production, the largest number of occupational diseases associated with exposure to excessive noise from the equipment on workers are of a longer duration.

The highest incidence rate of auditory neuritis in foundries is found among the professions such as cutters, molders, shapers, smelters, and cast cleaners working with shot blasting equipment.

2. NOISE ASSESSMENT IN FOUNDRY AREAS

The objective of this study is to analyze the experimental characteristics of noise in the working area of the foundry when performing various operations.

The research results showed that the noise parameters of the main types of foundries exceed the permissible noise standards at workplaces. At the same time, the greatest excess of the permissible sound levels [2] is noted at work places (by sound pressure levels) at rod and molding shaking machines by 12-23 dB, at knock-out grates by 17-26 dB, at cutting and cleaning equipment by 16-27 dB [3].

The noise spectra from the main casting machines are broadband, and at the same time the sound field in the working areas of the shop is non-uniform due to the fact that the main noise sources have different powers and different patterns of the spectrum. Equipment with shock operating mode emits intermittent noise with the maximum sound power level in the medium and high frequencies, which are most sensitive and dangerous to humans.

Index for the noise factor Ksh obtained by calculation based on empirical data for various sections of the foundries. As can be seen from the table, the greatest impact, increased noise, is observed in the areas of molders, cutters and cast cleaners 1,43-2,67 [3].

A specific feature of batch production foundries is that, despite a large number of technological processes, a lower level of automation and mechanization of these processes allows choosing a more rational and, as a rule, isolated arrangement of equipment that creates increased noise levels. It should be noted that in these workshops the operation of the equipment occurs cyclically and, accordingly, the equivalent noise levels will have lower values. This is especially evident when foundry production in a stepped mode. Knock-out grates work in the third shift, when only the knock-out of castings from the mold takes place. Therefore, the development of recommendations for reducing noise in the foundry through a reasonable choice of technical measures, including the rational placement of equipment, the mode of their operation, the installation of acoustic screens and sound-insulating partitions at unprotected workplaces, as well as the rational selection of the equivalent sound absorption area of the workshop room by increasing the area of the sound-absorbing the wall cladding of the workshop and the use of piece sound absorbers [4].

3. REDUCING NOISE FROM MAJOR SOURCES

One of the main objectives of this study was to identify the main sources of radiated noise and dust in the cutting-cleaning areas with the highest pollution index by the noise factor Ksh, in particular in the shot blasting chamber.

The most common surface processing for metal parts is sandblasting or shot blasting. This technological operation allows high-quality grinding of the casting, it is carried out in a shot blasting chamber.

An integrated approach to reduce the level of noise and dust emitted during the shot-blasting process, including: determining the main sources emitting noise, assessing the sound field in the chamber, accounting the sound insulation of the chamber walls, choosing materials that reduce noise and installing noise-protective structures allows you to consistently solve the issue of creating safe production conditions [5].

Figure 1 shows a diagram of the drone-blown area.

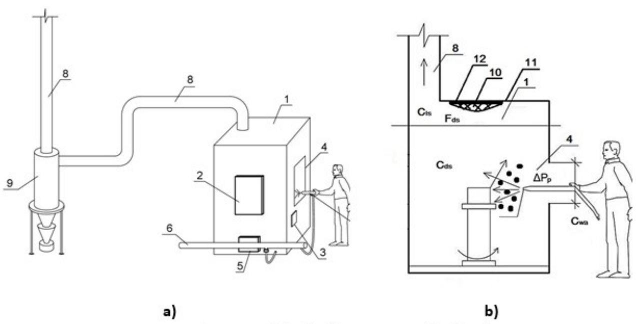

Fig. 1: The system of the shotblasting section of the foundry: a – shot blasting chamber scheme; b – section of the shot blasting chamber; 1 - shot blasting chamber; 2 - boot sector of the parts to be cleaned with a sealed door; 3 - control panel; 4 - shot blasting machine supply window; 5 - technological hole with a sealed cover for shot removal; 6 - compressed air line; 7 - air supply to the nozzle; 8 - air duct; 9 - conical cyclone for air purification 10 - VDM (vibration damping material); 11 - construction material; 12 - ZPM (sound-absorbing material)
Legend: $C_w a$ - concentration in the working area, C_{dc} - concentration in the dust chamber, C_{ls} - concentration in the local suction, F_{dc} is the area of the dust chamber, ΔP_p is the pressure drop during control

The shot blasting process operates in a one-shift mode with insignificant technological breaks. Shot-blasting of castings is carried out in chambers, which are a closed metal structure measuring 2000 x 2000 x 2500 mm, the inner lining of the chamber is made of steel sheet 3 mm thick and covered with rubber 10 mm thick. In the upper part, the chamber is connected via a 630 mm diameter branch pipe to the local exhaust ventilation, which contains a TsN-11 cyclone for dust removal [6].

As studies have shown, shot with an average diameter of up to 2 mm is directed by a compressed air flow at a speed of 30 m/s through the feed window to the surface of the product. The principle of operation of a simple injection shot blasting machine is based on the operation of a hermetically sealed tank, in which shot is located under the pressure of compressed air. Under the action of gravity and compressed air pressure, the shot is fed into the chamber. In this case, noise emission of increased intensity occurs.

The main effect on the formation of the sound field in the shot blasting chamber is provided by the noise emission of the jet supplied under pressure of compressed air, that is, aerodynamic noise. To reduce aerodynamic noise, various sound-absorbing elements with curved channels are used. Reducing aerodynamic noise is also possible by improving the aerodynamic characteristics of vehicles.

The authors have proposed technical measures to reduce noise levels due to the optimal selection of sound-insulating and sound-absorbing elements of the blast machine housings, which make it possible to reduce the noise levels inside the plant and to reduce the noise outside the shot blasting machine body.

Experimental studies of the absorption coefficients of a large number of facing materials in the octave bands of the audio frequency spectrum, presented in [7], made it possible to choose the most effective combination of structural, sound-absorbing and vibration-damping materials. The method of engineering calculation of the acoustic characteristics of foundry equipment made it possible to create a computer-aided design system for shot and sandblasting installations, minimized in noise level by selecting the optimal combination of wall thickness and grades of facing material.

The authors proposed to keep the thickness of the structural material equal to 3 mm in the shot blasting chamber, and leave the existing layer of glued rubber 10 mm thick as additional sound insulation of the chamber walls. What is more, the rubber layer will be useful for vibration damping. Additionally, on the inner surface of the chamber, it was proposed to apply a sound-absorbing material 30 mm thick, which are products made from a loose layer of canvases of super-thin basalt fibers in a glass fabric sheath. The sound absorption coefficient of such materials in the mid-high frequency range ranges from 0.5 to 0.9.

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

As a result of the above measures, the noise level at the workplace of the operator of shot blasting processing outside the chamber can be reduced by no more than 8-10 dB in the normalized frequency range.

To minimize the noise level, correct technological measures are required for the introduction of remote control and work on the sealing and isolation of equipment, which makes it possible to reduce noise pollution immediately at the source of its formation [8].

The authors also propose to install noise-protective shielding structures and shield areas with the most intense noise, which will increase dissipation and form sound protection for a more favorable acoustic field in the foundry, and in particular at the workplace of the operator of the blast chamber. [9].

The recommended measures do not allow achieving the required standard values of the existing noise characteristics. Since making changes to the design of the blasting chamber is technically unfeasible, the use of personal protective equipment - a helmet with headphones is considered [11].

4. REDUCING DUSTINESS IN THE FOUNDRY SHOT BLASTING AREA

The second task of the study was to ensure the reduction of dustiness and create a safe environment for the operators of the shot blasting section of the foundry, since a large content of dust was found precisely in the shot blasting section of the foundry.

The shot-blasting process allows for high-quality grinding of casting products of various shapes, however, this technological process is accompanied by the generation of a large amount of dust, which poses a threat to the health of workers. An integrated approach to reduce dust content and prevent occupational diseases allows consistently solving the problem of creating safe production conditions [5].

Special technological measures for the introduction of continuous production technology remove dust immediately from the places of its formation, and also prevent the formation and spread of dust; mechanization and automation of processes; introduction of remote control; work on sealing and insulation of equipment; creation of devices for local ventilation suction, exhaust or supply and exhaust ventilation [8].

In the foundry, polluted air is filtered using a variety of dust collectors and then released into the atmosphere. However, the effectiveness is not sufficient [1].

At the same time, the concentration of dust in the aspiration system before the dust collecting equipment, as shown by measurements, is 5.6 gm3, in the operator's working area - 8.7 mg/m^3 [6]. The degree of air pollution in the working area of production depends on many factors, for example: the quality and consistency of maintenance, effective operating modes of aspiration systems, the state of dust collection equipment [10].

Dust after processing the surface of metal parts with shot is converted into a multicomponent, therefore, to search for highly effective means of cleaning gas dust, the study of the elemental and dispersed composition of dust particles is considered relevant. Granulometric analysis was used to evaluate dust particles by size [3]. Particle size and particle density affect the properties of pulverized materials. The particle size distribution of the dust was determined on a Fritsch Analisette-22 NanoTec laser particle analyzer using the Fritsch Mas control software.

It was found that a significant amount of fine and medium-dispersed dust with a particle size of less than 100 microns, which amounted to about 90%, Particles, whose size is less than 100 microns, pose the greatest threat to human health, since, lingering in the lungs, provoke the onset of pneumoconiosis, and in the presence of a SiO2 film - silicosis.

The second stage of the experiment was aimed at detailing the dispersed composition of dust and determining the elemental composition, which were carried out using X-ray spectral microanalysis [6].

X-ray phase analysis is characterized by high reliability and expressiveness, it is direct (that is, it is based not on indirect comparison with any samples, but on the determination of the crystal structure of a substance). It is insensitive to the volume of the investigated product, can be carried out without disturbing the sample or part, and estimate the number of phases in the mixture. All of the above refers to the advantages of this type of analysis.

The dust, studied by means of X-ray spectral microanalysis, caught in the shot-blasting section and the section for removing molds, had a shape that allows it to be conventionally considered spherical. As a rule, when settling, dust particles rotate, occupying the position that provides the greatest resistance to air. The spherical shape promotes settling in the atmosphere and inertial dust collectors. Particles less than 10 microns in size settle for a rather long time, their presence indicates the need for highly efficient air purification systems.

X-ray spectral analysis on a wave X-ray fluorescence spectrometer "Bruker S8 Tiger" at the Center for Collective Use of Voronezh State University made it possible to obtain a more accurate percentage of elements in the sample. For the purpose of additional treatment of the emission to standard concentrations equal to MPCr.z., it is proposed to supplement the existing dust collection system with a "wet" stage.

5. CONCLUSION

The article presents an analysis of the effect of noise on foundry operators and considers ways to improve the working conditions of operators of sand and shot blasting plants by reducing noise at their workplaces, which is an important socio--economic, environmental, scientific and technical problem. The results are presented in the following key findings:

1. Unfavorable areas for exceeding the permissible noise level were identified - areas of knock-out gratings and areas for cleaning casting.
2. It was found that the noise levels at the workplaces of operators of sand and shot blasting chambers exceed the standard values by 4-18 dB. The greatest excess of actual noise levels over the normative ones is observed at the workplaces of operators of shot blasting machines.
3. Disperse (granulometric) analysis of dust generated in shot blasting areas showed that a fraction of less than 100 microns in size accounts for 90%.
4. The authors offer recommendations for reducing noise and dust at the operator's workplace.

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