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The Impact of Working Conditions on the Workers in Foundry Production

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Abstract

This article examines the impact of working conditions on the health of foundry personnel. The study explores the effects of various production factors, such as dust, gas pollution, noise, vibration, and microclimate parameters, on workers in different areas of foundry workshops. The analysis also covers the state of occupational morbidity among personnel, taking into account the type of production (mass, batch, and small-batch). The findings reveal that the highest number of occupational diseases were detected in the cleaning, molding, melting and casting departments of foundries. The most affected professions include casting dressers, molders, smelters, melter-pourers, and repairmen. These results highlight the significant health risks associated with working conditions in these areas and underscore the need for improved safety measures and health monitoring in foundry environments.

Keywords

Foundry, Production factors, Occupational diseases.

Introduction

The working conditions of foundry workers are affected adversely by dust, gas contamination, noise, vibration, and microclimate parameters (Lazarenkov, 2021; Lazarenkov & Kot, 2021; Bugero et al., 2005). These factors cause an increase in general morbidity, the development of occupational diseases and an increase in industrial injuries (Aleshina & Novikova, 2024; Mitrohina & Makarova, 2014; Kosarev & Babanov, 2011; Lazarenkov, 2019a). Therefore, during the design of the technological process of manufacturing castings, it is necessary to take these factors into account.

Dust is released into the air of working areas during various processes, such as the preparation of molding and core mixtures, the manufacture of cores and molds, metal smelting, the knocking out of castings from poured molds, and the cutting and grinding of castings, etc. The composition of dust determines the nature of its effect on the human body (Chebotaryov & Semencova, 2021). The shape and size of dust particles are important, which can cause chronic tracheitis and bronchitis, as well as occupational diseases (silicosis). In foundries, sand mixers, core makers and molders are most often affected by silicosis as the dust concentration in their work areas can range from 2 to 12 mg/m^3 (Lazarenkov & Sadokha, 2022a). When

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knocking out castings from box-forms, cutting and grinding of castings, permissible dust concentrations can be exceeded by tens of times.

Harmful substances in the air of foundries are emitted during various technological processes, such as the manufacturing of cores and molds, metal melting and pouring, drying of pouring ladles, and others.

Carbon monoxide is the most common harmful substance that is formed during combustion of fuel in a cupola furnace, combustion of organic substances from the molding mixture and cores. Carbon monoxide at very high concentrations leads to loss of consciousness, convulsions and death due to oxygen deprivation. Most carbon monoxide is emitted at the workplaces of smelters and pourers, where concentrations exceed the permissible (20 mg / m^3) up to 2 times.

Nitrogen oxides are emitted during the operation of smelting furnaces, pouring liquid metal into molds and other technological operations. Nitrogen oxides cause vasodilation and reduce blood pressure, lead to pulmonary edema, affect the central nervous system, reduce a person's sense of smell, and cause dryness in the nose and throat. The nitrogen oxide content in the foundry usually does not exceed the permissible concentration.

When sand cores and molds are made from mixtures using organic binders, phenol, formaldehyde, and methanol are released into the air (Lazarenkov et al., 2022). Phenol is highly toxic. It is a nerve poison and has an irritating effect. In case of acute poisoning, symptoms such as weakness, agitation, headache, dizziness, increased salivation, and irritation of the mucous membranes of the upper respiratory tract are observed. Acute poisoning can occur as a result of phenol getting on the skin. Formaldehyde is generally toxic, irritating the skin and mucous membranes. It leads to spasms and swelling of the larynx, cough, shortness of breath, bronchitis, and pneumonia. When it comes into contact with the skin, dermatitis appears, and if ingested, it causes burns to the digestive tract, a burning sensation in the mouth and behind the breastbone, accompanied by nausea and vomiting with blood. It also affects the liver and kidneys. High concentration can lead to coma and damage to the heart muscle. Methanol (methyl alcohol) is a strong nerve and vascular poison, irritating the mucous membranes of the upper respiratory tract and eyes. After a few hours, headache, heaviness in the head and chest, difficulty breathing, general malaise and weakening of vision, shortness of breath, tachycardia appears. Then anxiety develops with complaints of difficulty breathing, tightness in the chest, fear of death, convulsions. Inhalation of methyl alcohol vapors can cause fainting, a feeling of intoxication, and irritation of the mucous membranes of the eyes and respiratory tract.

High temperatures in foundries can affect the cardiovascular and central nervous systems, as well as other systems and blood parameters. Long-term exposure to high temperatures without protective clothing can lead to a disruption of the salt balance, the development of vitamin deficiency, insufficient blood circulation in the heart, a decrease in the secretion of gastric and pancreatic juice, a weakening of attention, a slowdown in reactions and heat strokes. It has been established that, during the warm season, the air temperature in the workplaces of the melting and casting shops exceeds the permissible values by 6-10 °C or more. The intensity of thermal radiation near furnaces and during casting often exceeds the permissible value (140 W/m^2) by tens of times (Lazarenkov & Khoreva, 2017).

Noise is one of the most harmful production factors. It has a dual effect on workers: it affects the hearing apparatus, leading to the development of occupational diseases, sensorineural hearing loss—and impacts the functions of the central nervous system, digestive

system (ulcer defects), heart (myocardial infarction), and blood vessels (circulatory disorders). Hearing loss is most often found in molders, casting dressers, and metal grinders. Noise levels exceed permissible values in the workplaces of core, molding, melting and pouring, knocking out and grinding shops. The greatest excesses are found in core and jolt squeeze molding machines (by 9-16 dB), in knocking-out grates (by 14-22 dB), in dressing and cleaning equipment (by 16-24 dB) (Lazarenkov & Sadokha, 2022b).

Another significant factor is vibration. Long-term vibration exposure of a worker can lead to an occupational disease known as vibration disease. Local vibration causes spasms of the blood vessels of the hand and forearms, disrupting the blood supply to the limbs, affects nerve endings, muscle and bone tissue, leading to decreased sensitivity of the skin, thickening of muscle tendons, salt deposits in the joints of the hands and fingers, pain, deformations and decreased mobility of the joints. Personnel of manual molding tools, machines, and tools for cleaning and cutting castings are often exposed to local vibration. The level of local vibration can exceed permissible values by 3-7 dB (Lazarenkov & Khoreva, 2016).

However, scientific literature does not pay enough attention to studies of the influence of the working conditions of foundry workers on their occupational diseases. The purpose of this article is to study the degree of influence of industrial factors on the health of foundry workers.

Methodology

The morbidity analysis was carried out using data from occupational disease records and the results of annual medical examinations of foundry workers for the period from 2014 to 2023. Such a long period reduces the influence of random factors. In addition, over such a long period, diseases characteristic of a given production can be fully identified. Age, length of service on the shop floor and production conditions were also taken into account. The study of workplace working conditions was conducted in foundries with a total of approximately 3,100 employees. The sample volume is 83%.

Results and Discussion

It has been established that the foundry workers most often get sick from exposure to dust, vibration, noise. They get sick vibration diseases (61.3% from the total number of such diseases in mechanical engineering enterprises), sensorineural hearing loss (37.4% from the same indicator), silicosis (92.8%) and dust bronchitis (83.1%) most often. Table 1 shows the distribution of occupational diseases in steel and iron foundries and non-ferrous casting workshops. The high percentage of cases of silicosis and dust bronchitis are explained by the widespread use of manual tools and poor ventilation systems in workplaces. High concentrations of quartz dust (about 12-27 mg/m^3) are observed at the workplaces of core workers, molders, metal grinders, and casting cleaners. An analysis of the incidence of silicosis and dust bronchitis in cast iron and steel casting workshops shows that silicosis develops more frequently in steel casting workshops. Table 2 shows the distribution of occupational diseases in foundries with different types of production.

Table 1. Distribution of occupational diseases by foundries (by type of smelted metal)

Name of the occupational disease	Proportion of cases of illness in foundries, %		
	steel-casting foundry	iron foundry	non-ferrous foundry
cochlear neuritis	34.3	31.9	55.2
vibration white fingers	16.1	18.5	21.8
pulmonary silicosis	30.6	27.2	12.7
dust bronchitis	19.0	22.4	10.3

Table 2. Distribution of occupational diseases by foundries with different types of production

Name of the occupational disease	Proportion of cases of illness in foundries, % for type of production		
	mass production	batch production	small batch production
cochlear neuritis	36.9	34.0	31.8
vibration white fingers	18.8	19.4	23.3
pulmonary silicosis	25.7	28.9	29.0
dust bronchitis	18.6	17.7	15.9

Deviation of microclimate parameters from the norms leads to chronic colds, joint diseases, heat strokes, convulsions, stress conditions. The overall incidence of foundry personnel is 1.18 - 1.72 times higher than in the plant. The structure of morbidity is as follows: acute respiratory infections (on average 38.12 % of all cases), diseases of the musculoskeletal system (11.07 %), influenza (6.86 %), diseases of the respiratory system (4.3 %), hypertension (2.27 %), infections and diseases of the skin (2.1 %), heart disease (1.24 %), pneumonia (1.2 %), diseases of the nervous system (1.07 %) (Lazarenkov, 2019b).

The differences in morbidity in workshops with different types of production depend on the severity of labor and the impact of production factors on the personnel's body. These factors (and the intensity of their impact on the foundrymen’s body) depend on the degree of automation and mechanization of work, the duration of contact with harmful factors. The greatest disease of neuritis of the auditory organ occurs in casting dressers, molders, casting technician, metal grinders, repairers where the noise reaches 89 – 95 dB (Table 3).

Table 3. Distribution of occupational diseases by profession of workers in foundries with different types of production

Profession	Incident rate (cases per 1000 workers) in foundries for different types of production														
	mass production					batch production					small batch production				
	common diseases	vibration white fing.	neuritis	silicosis	dust bronchitis	common diseases	vibration white fing.	neuritis	silicosis	dust bronchitis	common diseases	vibration white fing.	neuritis	silicosis	dust bronchitis
casting dresser	7.19	2.27	1.68	1.54	1.70	7.08	2.44	1.33	1.68	1.63	5.15	1.89	0.71	1.28	1.27
melter – pour man	2.14		0.84	0.59	0.71	1.83		0.69	0.50	0.64	1.41		0.41	0.43	0.57
molder	2.90	0.44	1.26	0.58	0.62	2.53	0.40	1.11	0.46	0.56	1.66	0.35	0.73	0.28	0.30
coremaker	2.36	0.31	0.62	0.74	0.69	2.24	0.45	0.44	0.66	0.69	1.74	0.40	0.38	0.46	0.50
casting technician	3.01	0.52	0.87	0.74	0.88	3.41	0.75	0.93	0.80	0.93	2.26	0.56	0.53	0.51	0.66
metal grinder	5.28	0.76	1.12	1.54	1.86	5.54	0.85	1.23	1.70	1.76	4.84	1.03	0.99	1.36	1.46
repair man	4.64		1.04	1.83	1.77	2.98		0.89	0.98	1.11	1.73		0.58	0.52	0.63
sand mixer	1.45		0.31	0.52	0.62	1.19		0.26	0.44	0.49	0.60		0.13	0.25	0.22

Table 4 shows data on the average duration of the development of occupational diseases of foundry workers. The shortest periods of development of vibration disease, neuritis of the auditory organ, silicosis and dust bronchitis were recorded in the group of casting dressers. The hand-held cutting tool creates strong local vibration, high noise level and significant dust content. These factors noticeably affect the neurovascular apparatus of the hands, the hearing aid and the respiratory system of the dresser. The table shows the average duration of the disease. It was determined by the period from the beginning of work in these conditions to the registration of occupational diseases in healthcare organizations.

Table 4. Distribution of occupational diseases by duration of disease development in workers in foundries

profession	The average duration of the disease, years			
	vibration white fingers	cochlear neuritis	pulmonary silicosis	dust bronchitis
casting dresser	10.4	15.7	16.8	17.7
melter – pour man		22.8	21.2	20.6
molder	19.7	19.9	20.8	19.6
coremaker	18.3	20.4	19.6	20.8
casting technician		18.8	21.8	18.9
metal grinder	13.8	17.6	18.4	19.5
sand mixer		22.1	20.6	19.2
repair man		24.3	24.7	24.6

Conclusion

There are a number of production factors (such as, dust, gas pollution, noise, vibration, microclimate parameters) that negatively affect the health of personnel in the foundries. These factors can cause an increase in general morbidity, the development of occupational diseases and an increase in occupational injuries.

The problem of preserving the health of foundry workers must be solved, taking into account all the above-mentioned factors determining working conditions, by modernizing foundry equipment, expanding the scope of use of manipulators and robots when performing heavy and dangerous manual operations, and improving working conditions, especially at molding, smelting, and stump-cleaning sites.

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