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RESULTS OF THE STUDY OF A MIXED EFFECT OF WORKPLACE HAZARDS ON THE STATE OF HEALTH IN MECHANICAL ENGINEERING WORKERS

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Abstract. *The necessity of studying qualitative and quantitative characteristics of a complex of workplace factors of modern mechanical engineering is substantiated. A potential possibility of a mixed effect of chemical and physical hazards on the workers' organism is found out. Higher levels of MTD, which can be caused by reduced adaptive abilities of the workers' organism, serve as the criterion for an unfavorable influence of a complex of workplace hazards (chemical pollutants, noise, vibration, electromagnetic fields, hard and strenuous work).*
Key words*: Chemical pollutants, noise, vibration, mixed effect, morbidity with temporary disability.*

Introduction. One of the main places among many factors, which affect human health and form environment, is taken by work space hazards, including unfavorable microclimate conditions, electromagnetic radiation and chemical pollutants [1]. Very widespread from the viewpoint of technological process maintenance at modern industrial plants that manufacture or use various chemicals is the equipment, which generates electromagnetic fields with different voltages. The above makes possible a mixed effect of electromagnetic fields and various chemical compounds, often potentially dangerous for the human health, on the organism of workers. At the same time the modern technological process of production is characterized by use of a wide spectrum of physical means of influence, higher or low temperatures, laser radiation, etc. [2,3].

The above facts cause formation of a complex of unfavourable work space factors with the subsequent mixed effect of chemical and physical hazards on the

organism of workers and, as result, necessitate revealing of human adaptation mechanisms for this kind of unfavourable influence.

Materials and methods. The state of work space at machine shops and foundries with assessment of working conditions of their workers and morbidity with temporary disability (MTD) in some occupational groups was studied at engineering plants of the Kharkiv Region. Work environment was studied in nine shops, where machine parts underwent chemical and mechanical treatment. The studies were carried out with standard methods and use of modern laboratory equipment [4]. At permanent and temporary work places some meteorological factors were measured, namely: air temperature, relative humidity, air flow speed, thermal radiation intensity; in some cases – temperature of heated surfaces of technological equipment and its protective covers, content of dust and harmful chemicals in air, intensity of noise and its frequency characteristics, levels of whole-body and local vibration, levels of electromagnetic fields. All in all, about 4,500 measurements of harmful work space factors were taken. Timekeeping observations of labour hours were conducted and job descriptions of workers from the main occupational groups were made.

Results. The researches, conducted in order to study working conditions at work places of engineering plants, revealed that work environment at the above shops did not satisfy sanitary and hygienic requirements by many factors. Thus, the microclimate at foundries was assessed as warming. The microclimate at all machine shops was assessed as warming in the warm season and cooling in the cold one; this thing can affect the workers' organism and provoke failures in the adaptive mechanisms of their organism.

Besides, infrared radiation at foundries in the working area of the people, who work with molten metal or shake out hot casts, exceeded permissible values several times. The temperature of heated surfaces of the main technological equipment at foundries exceeded permissible values 1.5–2 times. Dust content in the air of the working area at foundries exceeded its maximum permissible concentrations (MPC)

for relevant kinds of dust at all work places. The most dangerous dust is that one, which contains 98 or more per cent of free silicon dioxide; this is produced in processes of sand making, forming, manufacturing of cores, shaking out and cleaning of casting blocks.

The highest concentrations of dust (20.4–58.8mg/m^3) were registered at work places of moulders, casting technicians, coremakers and fettlers. Other work places revealed lower concentrations (6.1 –17.7mg/m^3). At machine shops, the content of dust in the working area air exceeded its permissible regulatory values too; at some places of work its concentrations were as high as 11 mg/m^3 (MPC = 6 mg/m^3).

Studies of the content of harmful chemicals in the working area air of foundries proved that at all their shops the values of carbon monoxide, sulphurous anhydride, manganese and nitrogen oxides and other substances were mainly within their permissible ranges, except for phenol and formaldehyde. The above substances were revealed at core areas in all work places of female coremakers. Phenol was detected in concentrations, which exceeded the permissible ones (0.1 mg/m^3) 2–5.2 times; the permissible concentrations of formaldehyde (0.05 mg/m^3) were exceeded 2–6.2 times. At a precision casting foundry, work places of pattern makers revealed only hydrocarbons with concentrations of 800–900 mg/m^3, which exceeded MPC 2–3 times.

In the overwhelming majority of work places at machine shops, where oil and emulsion metalworking lubricants (MWL) were used, their working area air contained only small amounts of carbon monoxide, hydrocarbons and sulfur dioxide gas or did not have them at all.

Measurements of noise and vibration, taken at foundries during the work of fettling and cleaning equipment, demonstrate that parameters of these factors exceeded permissible values for noise by 13–35 dB and vibration by 20–23 dB (pneumatic hammers) or by 4–10 dB (grinding machines). The whole-body vibration on the floor of work places of casting technicians exceeded maximum permissible levels (MPL) by 11–13 dB.

Studies of noise at machine shops showed that by sound volume it exceeded MPL at all four shops on all examined work places of machine operators. By its character, the noise was mainly medium-high-frequency with prevalence of high frequencies and excess of sound volumes by 6–14 dB.

At work places with the equipment, which generated electromagnetic fields, the latter were measured, but no measurement exceeded regulatory values by either electric or magnetic components, though the above values were close to their upper permissible limits.

The conducted timekeeping studies of the work and job descriptions of 52 workers of the main occupations demonstrate a significant load with their primary and auxiliary work. A high percentage of forced breaks was observed in the majority of occupational groups, it resulting from breakdowns in the technological production cycle. The primary work of all examined occupations is connected with the influence of

workplace hazards on the workers' organism, namely: unfavourable meteorological conditions, a high dust content in the working area air, contamination of the working area air with combustion residues of organic chemicals and resins, as well as occupational noises, local and whole-body vibrations, hard physical and strenuous work.

The study of morbidity with temporary disability of workers at foundries and machine shops showed that the level of morbidity in the foundry workers was significantly higher. This difference can be explained, first of all, by a broader spectrum and a considerable excess of safe levels for the majority of hazards, as it was registered in foundry engineering, and, as a result, a higher intensity of their effect. The comparison of morbidity rates in cases for these two cohorts of workers demonstrated that the above difference caused, first of all, a higher morbidity of foundry workers with respiratory diseases (respectively, 87.0 and 30.97 cases), diseases of the nervous system and sense organs (2.53 and 1.0 cases), diseases of the alimentary organs (3.07 and 1.8 cases), diseases of the skin and hypodermic tissue (2.87 and 1.73 cases), diseases of the urogenital system (1.8 and 0.9 cases), diseases

of the musculoskeletal system and connective tissue (6.03 and 3.5 cases), as well as more poisonings and injuries (5.08 and 4.2 cases).

The supposition about a higher hazard level of the work environment at foundries is also confirmed by the fact that in foundry workers the average duration of one case of disease from a whole range of nosologic units turned out to be higher. It concerns, first of all, infectious diseases (20.3 and 11.8 days, respectively), diseases of the nervous system and sense organs (10.8 and 7.9 days), diseases of the respiratory organs (6.2 and 5.9 days), diseases of the skin and hypodermic tissue (11.7 and 10.3 days), diseases of the musculoskeletal system and connective tissue (13.7 and 11.8 days), poisonings and injuries (28.4 and 16.5 days). Besides, the connection with their service record in foundry workers was more significant than that of machine shop workers. In the both groups of shops the occupations, which were subjected to a higher influence of workplace hazards, had higher morbidity values too.

The study of the relationship between the rate of MTD in workers of some occupations at foundries and their working conditions by the results of correlation, regression and dispersion analyses made it possible to reveal close links between these indices.

Thus, the overall multiple correlation coefficient in the obtained multiple regression equation, which characterizes relations between microclimate, dust, noise, carbon monoxide and morbidity, was 0.91, the index of multiple determination being 0.82. The latter demonstrates that, beginning from morbidity at the rate of 34.85 cases in 100 workers per year, its increase by 82 % is caused by the effect of the above workplace factors. By values of the separate indices of multiple determination it was revealed that microclimate caused 34.4 % of morbidity, carbon monoxide 26.5 % and noise 19.9 %. All these coefficients and indices were statistically significant. As for the index for dust, it was negative for the general rate of morbidity, very low (0.4 %) and statistically insignificant.

The pairwise correlation analysis revealed direct relations of the rate of morbidity with working conditions in such aspects as microclimate, carbon monoxide

and noise. Pairwise correlation coefficients for these factors were, respectively, 0.70 ($p < 0.01$), 0.71 ($p < 0.05$) and 0.46 ($p < 0.05$). The pairwise correlation coefficient for dust was 0.44 and approached the statistical significance of the probability factor, which was 2.03.

Thus at foundries, beginning from the rate of 34.85 cases in 100 workers per year, the increase of MTD by 82 % was largely caused by the influence of workplace hazards, including microclimate, carbon monoxide as an indicator of combustion residues of organic substances, and noise.

The preliminary pairwise correlation analysis (calculations of pairwise correlation coefficients) of the relations between the rate of MTD in cases for 100 workers per year with indices of their working conditions made it possible to find out that only three of the five hazards, which were taken into consideration at machine shops (hard and strenuous work, effects of MWL, dust and noise), were more or less connected with the rate of morbidity; these were noise, hard work and use of MWL. The overall coefficient of multiple correlation between the general rate of MTD and the three hazards (hard work, MWL and noise), which were taken into consideration, is 0.87. The influence of all these three hazards on morbidity proved to be statistically significant ($p < 0.05$), as it is based on the fact that the sample volume at machine shops included about one thousand workers.

Conclusions.

1. Working conditions at foundries of machine shops are characterized by the influence exerted on the workers by a complex of workplace hazards; first of all, these include unfavourable microclimate, dust, harmful chemicals (products of destruction of organic compounds and polymers), noise, local and whole-body vibrations, hard and sometimes strenuous work, as well as electromagnetic radiation for workers of some occupations.

2. The levels of the majority of work space hazards on permanent work places exceed hygienic regulations or are at the level of the upper border of permissible standards.

3. By results of the conducted observations it has been found out that within 65–87 % of the time of their working shift the workers are at their permanent work places and under the influence of work space hazards with such a possible result as a failure of the adaptive mechanisms in the workers' organism.

4. When compared with machine shops, work at foundries causes a higher morbidity with temporary disability by all indices: persons, cases and days of disability, average duration of one case of disease. This difference results from more considerable values for diseases of the respiratory organs, nervous system and sense organs, alimentary organs, skin and hypodermic tissue, musculoskeletal system and connective tissue, etc.

5. The general rate of MTD of foundry workers is substantially caused by the effect of work space hazards, first of all microclimate, carbon monoxide and noise. Beginning from the rate of 34.85 cases in 100 workers per year, its further increase by 82 % is caused by the influence of the above workplace factors, including the following effects: microclimate – 34.4 %, carbon monoxide – 28.5 % and noise – 19.9 %.

6. The general rate of MTD of machine shop workers is substantially caused by the effect of work space hazards, first of all hard work, noise and MWL. Beginning from the rate of morbidity of 26.82 cases in 100 workers per year, its further increase by 76 % is caused by the influence of the above factors, where hard work increases morbidity by 33 %, use of MTD by 17 % and noise by 26 %.

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