EVALUATION OF OCCUPATIONAL RISK FOR HEALTH IN MULTI-FACTOR INTENSIVE INFLUENCE

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***Aim*. Practical realization of conceptual model of occupational risk evaluation and methods of analysis of structure and extent of occupational risk. *Materials and Methods*. Evaluation of occupational risk for health completed on an example of labor of hot forging die press operators. In a conceptual model the main information blocks are "Hygienic Evaluation of the Working Conditions and of Workload" (for prior evaluation of occupational risk) and "Evaluation of Health Condition" (for posterior evaluation of occupational risk). The task of the first block was evaluation of exposure doses of such factors as thermal stress of the environment, local and total vibration, noise, and also evaluation of the extent of the workload by parameters of severity and tension of the working process. The health condition was evaluated by four blocks: parameters of the functional condition of an organism, presence of occupational diseases, diseased conditions with temporary disability, and evidence of accelerated ageing by parameters of biological age. *Results and Conclusions*. Results are presented on the basis of in-depth analysis of intensive influence of industrial factors in accordance with domestic and ISO standards. Etiogenous analysis of occupational risk for the main stress factors and integral evaluation by the index of occupational diseases were conducted. The index takes into account categories of risk and severity of occupational diseases with respective partial indices for the leading unfavorable industrial factors. This enabled adequate evaluation of damage to health induced by occupational industrial factors of different intensity. Comparison of hygienic and medico-biological parameters of evaluation of occupational risk on the basis of etiogenous analysis showed the probability for quantitative evaluation of multi-factor intensive influences and for development of effective prophylactic measures on their basis.**

Keywords: *multi-factor intensive impact, model, occupational risk, etiogenous analysis, damage to health, effective prophylaxis.*

According to F.F. Erisman, "the aim of hygiene … is to find means to mitigate all unfavorable for a human organism natural and social influences". The quality and direction of development of hygienic science are closely connected with search of these means which in turn are practical results of realization of informative and effective modern methodologies.

In the previous century study of the influence of environmental factors on a human organism was mainly reduced to determination of the maximum permissible exposure limits harmless for an organism. After that, up to the present moment the predominating approach consists in evaluation of the extent of risk from exposure to the environmental influences [1-15].

The term "occupational hazard" was first mentioned in 1959 in Recommendations of the International Labor Organization (ILO). In the hygienic literature this term was presented by International Standards Organization (ISO) in 1971 in evaluation of loss of hearing from noise. Russian scientists, on the basis of their own experience and concepts of ILO, WHO, ISO, formulated principles and axioms of the occupational medicine and industrial ecology concerning po-

tential dangers and hazards for health and their quantitative measure – risk [1-7,10-13].

Existence of potential hazard and danger in particular conditions determines the priority, methodology and scope of hygienic problems. Therefore, one of central directions of the modern hygienic science is evaluation of the occupational risk to health of individuals working in unfavorable conditions, with subsequent development and introduction of the effective preventive complex, and one of the cardinal tasks of the occupational medicine and industrial ecology is declared to be development of methods of the quantitative evaluation of measure of risk for health and its prevention [13,16].

Materials and Methods

In accordance with the theory of the occupational health risk elaborated in Research Institute of Occupational Medicine of RAMS, to solve the task of the integral evaluation of the multi-factor intensive impact of adverse working conditions, a conceptual model was elaborated for evaluation of the occupational health risk with the aim of scientific substantiation of preventive measures on an example of labor of hot forging die press operators [1-3,5,14,17,18].

In this model the main information blocks are "Hygienic Evaluation of the Working Conditions and of Workload" (for prior evaluation of occupational risk) and "Evaluation of Health Condition" (for posterior evaluation of occupational risk).

The task of the first block was evaluation of exposure doses of such factors as thermal stress of the environment, local and total vibration, noise, and also evaluation of the extent of the workload by parameters of severity and tension of the working process. The main normative document used for prior evaluation of the risk for overrange of normative standards was "Guidance on Hygienic Evaluation of Working Environment and Labor Process Factors. Criteria and Classification of Working Conditions" (P 2.2.2006-05). Additionally, there was evaluated risk for development of occupational diseases due to chronic thermal exposure, influence of local and general vibrations and of noise, according to the effective ISO standards.

Posterior estimation was made using the recommended medico-biological parameters given in "Guidance on Evaluation of Occupational Risk for Health of Workers. Organizational and Methodological Basics, Principles and Evaluation Criteria" (P 2.2.1766-03). The health condition was evaluated by four blocks: parameters of the functional condition of an organism, presence of occupational diseases, diseased conditions with temporary disability, and evidence of accelerated ageing by parameters of biological age. This approach permits to evaluate real (posterior) occupational risk and an associated medico-social damage.

Results and Discussion

Structure and extent of the occupational risk were analyzed on the basis of in-depth analysis of multi-factor intensive influence of a complex of harmful industrial factors. Evaluation of the working conditions by overrange of maximal permissible concentration (MPC) and maximal permissible levels (MPL), and by classes of working conditions in accordance with Guidance P 2.2.2006-05 showed that the most unfavorable factors are heating microclimate and local vibration. Thus, according to environmental thermal load index, the permissible temperature at the workplaces was exceeded on average by 15°C (with extreme value 29.1°C) which was evaluated as dangerous (extreme) impact of 4^{th} class of hazard. In a similar way intensity of IR radiation was evaluated which was 15 times the MPL, and at some workplaces – 20 times MPL.

The levels of local vibrations are characterized as extreme factors, since the maximal value 124 dB at which the hand tools are not permitted to be used, was exceeded in all measurements. Maximal levels exceeded MPL by up to 21dB, which equals 40 doses. Low frequency of vibration and significant physical loads create conditions for spread of vibrations to the upper shoulder girdle with a high probability of damage to the osteoarticular apparatus from the wrist up to the cervical section of the spine. The measured parameters of the total vibration significantly exceeded MPL for technological equipment (25 times the dose) and practically reached MPL for transport vibration, and in some measurements exceeded even this limit. Total vibration is evaluated as 3^{d} degree 3^{d} class of working conditions (3.3 d.).

The noise exceeding the equivalent level of MPL by up to 30 dB A is evaluated as 3^{d} de-

gree of hazard (3.3d.); however, measured levels exceeded maximal permissible dose on average 1000-fold, and maximal exposure during the working shift reached the values 538 Pa^2h, mainly due to the impulsed character of noise.

It was interesting to analyze the actual multi-factor load of the industrial environment on organisms of workers to evaluate the extents of risk of health damage according to criteria of ISO international standards. For analysis not only physical, but also clinico-physiological criteria of health damage were used. In particular, the extreme character of the thermal load of the environment is evidenced by high values of WBGT-index which significantly exceed the criterion parameter (39^oC) by 13°C and induce thermal stress that threaten with heat stroke. Local vibration transmitted to the arms and exceeding MPL 40-fold, significantly exceeds even the limit of danger (10 m/s^2 according to some foreign standards) and creates a high probability of vibration-induced disorders – 10% in 1.5 year and 30% in 3 years. Total vibration parameters are also significant and correspond to the criterion "fatigue-reduced working capacity". Noise exposure reaching the average equivalent level 104 dB A, can cause loss of hearing at voice frequencies above 30 dB in 10% of workers with the occupational experience 12 years that in many countries is considered to be the criterion of the occupational loss of hearing, and according to Russian criteria corresponds to the 3^d degree cochlear neuritis. Hygienic evaluation of the working environment by the domestic norms is close to evaluation by international standards. Here, the latter additionally provide a prior estimation of the risk for damage to health.

It was principally important to analyze the structure and extent of the occupational risk for health of die press operators by clinico-physiological parameters for the main adverse industrial factors.

Below there are given results of evaluation of structure of the occupational risk for hot forging die press operators taking into account the category of severity of disorders, and also the share of occupational exposures in causes of diseases and the extent of their determinancy for analysis of the componential contribution of factors and for adequate prophylaxis. In general, thermal stress and local vibration were evaluated by class 4 as dangerous (extremal) factors, and noise and total vibration – to the 3^d degree of hazard [17]. Parameters of the concentrations characterizing the air environment of the working zone were basically close to MPC. It is important to emphasize a high extent of the working load by parameters of severity and tension of the working process (extremely high turnover of weight – 39 tons per shift associated with a high risk of traumas and burns, etc.), that was evaluated 3.3. by extent of hazard.

In the structure of the industrial risk the main industrial stress factors were determined with their corresponding clinico-physiological manifestations. Etiological approach permits to identify predominating signs of damage or syndromes, with determination of their frequency and extent of evidence according to accepted criteria of the occupational pathology. It should be specially emphasized that dramatic increase in the biological age practically by 11.8 years relative to the due age, undoubtedly evidences the leading pathogenetic role of chronic overheating in hard physical labor. The modern effective labor legislation considers the labor of die press operators to be associated with adverse industrial conditions with the 10 year earlier retirement which practically coincides with the results of authors' study of the ageing acceleration rate [19,20]. This showed the necessity of in-depth evaluation of the clinical data as consequences of the high extent of chronic overheating from exposure to the extreme levels of radiant heat. A characteristic example is alterations in the coagulation and anticoagulation systems of blood evaluated as the 1^{st} stage of DIC (disseminated intravascular coagulation) syndrome which, under action of extreme stimuli (burns, traumas) may lead not only to formation of hemostatic thrombus, but also to disseminated intravascular coagulation of blood and to intravascular aggregation of platelets [21].

Hard work combined with thermal stress is associated with significant alterations of biochemical parameters that reflect both tension of the energetic processes (increase in energy expenditure) with predomination of

lipid metabolism, and also with microtraumas of muscle tissue. These factors underlie the detected significant pathological alterations in the cardio-pulmonary system, in GIT and in other systems.

Local vibration, basically, a combination of vibration and physical load, causes evident signs of vibration pathology and overwork manifested by a complex of parameters and first of all by acceleration of ageing of the bone tissue – up to 10.6 years. Here, the osteoarticular disorders are multiple of control from 3.6 to 4.6 and closely approach the magnitude 5 which is the criterion of the determinism of the sign [22,23].

The evident connection of occupational loss of hearing with intense noise needs no proof. Cochlear neurites with a significant reduction in hearing in 30.3% of examined individuals are referred to the 1st category of risk and the 3d degree of severity in the system of evaluation of occupational diseases by categories of risk and severity developed by Research Institute of Occupational Medicine of RAMS. The evaluation of the structure of the occupational risk given above permits to refer these factors to extremal impacts of high intensity [17].

Usually, in evaluation of multi-factor intensive influences hygienists pay attention either to the prevalence rate, or to severity of diseases. But for improvement of prophylactic measures and for protection of individuals working in unfavorable environmental conditions it is required to evaluate real exposure to the acting factors and potential medico-social damage and to predict the extent of risk of the occupational disease and the category of its severity. Evaluation of occupational diseases by their risk and severity including a single numeric index integrating both parameters permits to simultaneously evaluate different nosological forms of diseases under intensive multi-factor influences. This will help to solve the problem of integral evaluation of multi-factor influences not only by criteria of hygienic degrees of hazard and danger, but also by occupational disease index – a single numeric parameter that takes into account category of frequency and severity of occupational diseases.

Etiogenous analysis of the occupational risk for die press operators by the main industrial stress factors included integral estimation by the index of occupational hazards that takes into account categories of risk and severity of diseases with their respective partial indices for the leading unfavorable factors of the industrial environment. Thus, thermal stress in hard physical work that causes clinical manifestations of chronic overheating in more than half of the long-working workers, gives index 0.5. Impact of vibrations especially of local shock vibrations transmitted to arms, shows signs of vibration disease even in workers with short working period (in 30-80% of cases) to the extent of "thermoamputation" (here, alterations in the osteoarticular apparatus were 4.6 times that in the control group), and makes a total index 0.61. Intensive impulsive noise resulting in loss of hearing in 30% of individuals with a long working period, gave index 0.33. Thus, the total strong vibroacoustic impact gives the total index 0.94, and chronic overheating in hard physical work is 0.5, which makes the total index of occupational diseases 1.44 that exceeds the criterion value for extreme impact 1.0.

Comparison of hygienic and medico-biological parameters of evaluation of occupational risks on an example of workers engaged in hot forging, on the basis of analysis of causes showed the probability for quantitative evaluation of complex contribution in multi-factor intensive impacts and for elaboration of effective prophylactic measures on their basis.

Conclusions

The developed conceptual model of evaluation of the occupational risk permits complex evaluation of occupational risk of health damage of any professional group with different combinations of industrial environmental factors and working load with different extent of their evidence for subsequent use in substantiation of prophylactic measures.

Authors have no conflict of interest to declare.

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