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The Importance of Mathematical Modeling in the Area of Workplace Safety

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Abstract: *This article is devoted to the analysis of the results of the research work carried out in the framework of innovative research. The article presents the role of mobile applications in the life of a modern person and a variety of socio-economic issues in the field of labor protection. As well as the use of mathematical modeling methods to evaluate individual aspects of human interactions with the production environment and to study the dependencies between parameters in laboratory semi-industrial installations.*

Keywords: *Safety, noise, vibration, dust, gas, heat exchange, research, software, creation, labor protection.*

Mathematical modeling techniques have recently been applied to worker protection issues. With the help of this technique, you can identify ways to enhance various technological processes, examine working modes, and select the best ones based on safety considerations. It also makes it possible to test proposed theories about the structure and mechanism of processes and forecast trends in changes in the parameters of interest over time.

Workplace safety is characterized by a variety of problems that need to be solved and by the existence of fields connected to basic natural sciences. The classical theory of mass and heat transfer, which uses the equations from the theory of convective and radiant heat, to solve problems, is closely linked to the issues of thermal protection. (1). При организации защиты от вибрации и шума применяются методы классической механики, теории колебаний и акустики.

Aerodynamics or hydroaeromechanics are closely linked to the study of ventilation in industrial buildings.

The key to addressing the problems of electric shock protection lies in the principles of electrical engineering and electromagnetism.

The classical hydroaeromechanics, statistical, and molecular physics principles form the foundation for the development of the physical aspects of dust and gas capture (2). Finally, the advancements in the fields of medicine, psychology, and biology form the foundation of ergonomics.

Thus, the prospects for using first analytical, then experimental statistical modeling methods are predetermined by the specifics of labor protection measures, which are defined by a significant amount of experimental work at the stage of laboratory, industrial, and research.

In the first instance, the laws of energy and matter conservation are used to create the equations for dynamics and statics based on an analysis of the physicochemical nature of the processes taking place in an object. In the second instance, when the values of the output quantity are not in a single-valued relationship with the input effects and when knowledge of the mechanism of processes and the essence of the internal structure is lacking, the study of processes is carried out using statistical and probabilistic methods. Such a research plan is at its most logical when a general mathematical description is discovered using analytical techniques that enable, based on the physical nature of the process, to obtain an all-encompassing solution to the issue. The range of constant change, the range of variation in control parameters, the admissibility of variation zones to guarantee safety, etc. for a specific object are all established for that object using experimental-statistical methods.

The ultimate aim of mathematical modeling is to identify the functional relationships between the input and output parameters, the subjects of the models' decision-making, the forecasting of the process' output values over time, and the creation of suggestions (or systems) for its secure control.

The following guidelines can be outlined for the successful application of the methods mentioned above based on what has been said in studies in the area of labor protection:

1. The application of mathematical modeling techniques to examine the interdependencies between variables in laboratory, semi-industrial, and industrial installations and to evaluate specific elements of human interaction with the production environment
2. The mathematical description and optimization of intricately planned or already-in-use processes that are characterized by elements that negatively impact people.
3. Development of counting-deciding algorithm-based automated systems for the management of labor security and its control.

Specific groups of duties are present in each of these areas. Which is resolved by using the proper quantitative modeling techniques.

The method of a priori ranking of factors, or the rank correlation method (3), is used at the preliminary study stage of the object of study when it is necessary to select the most important factors from a large number of factors and views about their significance in the literature are conflicting. When variable qualitative features cannot serve as indicators, this technique is used. The process is influenced by a considerable number of variables (more than 5-7) at the following stage. The random balance method is used to complete the job of their reduction (3). The work (4) serves as an example of how the rank correlation technique can be used to determine the degree to which the energy characteristics of vibration—such as its intensity and speed as well as its type and length of exposure—have an impact on the illnesses it causes.

It becomes necessary to determine the distribution of random variables during the early stages of preliminary study on objects when the traits of individual parameters are examined. The proper selection of statistical processing techniques and the assessment of the properties of the investigated factors are influenced by knowledge of the distributional laws. This enables you to foresee the occurrence of risky circumstances and create strategies to stop the root causes of occupational morbidity and injuries.

In the area of labor protection research, locating the laws of distribution is frequently a task unto itself. Knowing these laws makes it easy to identify the equipment's safe ways of operation. For instance, Poisson's law describes how technological equipment failures that result in injuries are dispersed, and this distribution is used to evaluate the safety of the equipment. (5) The y (p) distribution closely approximates the distribution of incidents by severity (6).

Equations are the most practical way to describe different kinds of distributions. The equations of multiple non-linear regression provide a good description of the distribution of accidents by production as a whole by a distinct profession from these positions (7).

When performing work related to solving problems of the first direction, when the following are determined: the dependence of injuries and occupational diseases on technological, psychophysiological, organizational reasons and socio-hygienic working conditions (8); the nature of the influence of illumination, noise, dust and other factors on labor productivity (9); relationship between and operational reliability of equipment (10); the influence of technological factors on the vibration and noise activity of machines and mechanisms in normal operation and in the diagnosis of their malfunctions (11); coordinates of the installation of sensors for the state of the air (12); successfully used on the method of correlation analysis, which allows you to get paired between cause-and-effect factors.

The methods of multivariate analysis of variance and regression analyses are used to determine the overall assessment of the influence of causal factors on the working conditions of workers, along with an evaluation of the reliability of the data obtained in accordance with the pertinent statistical criteria. Here, the apparatus of applied statistics' probability theory is used to solve the problems of finding the levels of significance and computing the confidence limits for testing hypotheses (13). These techniques enable them to construct a model representing the simultaneous action of a complex of input factors using the static data from a passive experiment, to assess the impact of each factor individually, to analyze and understand the models in accordance with the physical nature of the process under study.

The difficulties associated with experimentally finding the likelihood of events are frequently resolved in the course of work on labor protection. Such an evaluation is typically done to determine the most logical design criteria for the components of future secure technology. Such works are founded on the HYPOTHESIS THEOREM (Bayes formula), the concept of total probability, and the theorems on addition and multiplication of probabilities (14).

Using the probabilistic method to solve modeling issues and create an analytical sketch of workplace safety conditions are some examples of its use (15). estimating the likelihood of industrial injuries (17) and evaluating the degree of development safety (16).

The statistical Monte Carlo method is preferred when evaluating the safety of equipment in industrial complexes with complex structures and varied operating conditions (18). (based on the law of large numbers and limit theorems).

The resolution of intricate multifactorial issues is a crucial component of the majority of laboratory and semi-industrial studies in the area of labor protection. This approach is based on experimental research with the potential for direct control over the control variables. Such tasks can be found, for instance, in ergonomics, gas and dust collection, and ventilation, where research is frequently done using full-scale installations or model installations that let one directly influence the control parameters.

Traditional research techniques are linked with a laborious experiment based on alternatingly varying each independent variable while maintaining the level of other independent variables.

The most efficient way to complete these duties is by planning and analyzing the experiment mathematically (15), which allows for a significant reduction in the number of experiments. Unfortunately, these techniques have not yet been widely adopted in the area of research on labor protection.

Finding the maximum or minimum values of the output parameters is frequently required when solving problems in the second direction. Utilizing optimization techniques, one can determine the ratio of the values of the output factors. Depending on the technique used, optimization can be done either directly by looking for an object's ideal conditions or on the basis of a mathematical model.

The following methods of determining the optimum are differentiated by the classification of optimization methods provided in work (10); analytical, mathematical, automatic, and automatic with self-adjusting models.

The automation of engineering work processes, whose goal is to lessen the labor burden of work in the pursuit of ideal design solutions, should also be included in these methods. These issues can occur when calculating ventilation systems, for instance, when it's necessary to account for the equipment's range and configuration, the lowest and highest permissible air velocities, the real resistance of tees and crosses, etc (11). The development of systems for automated optimal design and analysis of a set of heat exchangers (12) and the design of vibration protection systems are examples of work in this area (13).

The theory of systems of linear and nonlinear programming provides techniques for solving problems in this area. Processes are described by a system of algebraic equations of inequalities-restrictions, which are minimized by a nonlinear functional-objective function and communication equations (14).

The development of automated systems for managing labor protection and its control at the level of businesses, industries, and regions, based on the advanced technological capabilities of computers, has gained popularity in recent years. The third approach immediately contributed to the resolution of the issue of enhancing labor protection management techniques.

Local systems for automated control of the air basin have already been developed in the area of labor safety. Their organization's goals include issuing reference information to customers on the quantitative makeup of substances that pollute the atmosphere and controlling the gas emissions from chemical enterprises (15). (16). There are technological ways to create industry-specific automated systems for tracking, analyzing, and preventing workplace accidents (17).

When working in the third direction, it's important to decide on the samples, the frequency of data gathering, and the integration time in addition to establishing potential information flows. Static dynamics and spectrum analysis (18) techniques can be used to good effect in this.

The ergotic system, in which a person acts as a control link, can also be attributed here, in accordance with the study's goals. Forming a psychophysical image of the operator, coordinating information flows to him, and matching the features of the controlled process with the throughput and indicators of the human body are all steps in the construction of such a system. Correlation and component analyses are used in the search for a multifactorial operator model (9).

The technique of describing the operator's activity by transfer functions is used to align the operator's characteristics with the controlled process, making it possible to numerically analyze the psychophysiological traits of the operator using the gain factor, time constants, and pure delay (9).

The methods of static information theory are preferred for studying a human operator's information capabilities in an ergatic system because they allowed it to be determined that a person acts as a consumer of information and that their role is comparable to that of a channel with a finite capacity (13).

The process of resolving the class of issues under consideration involves the handling of static data, which necessitates the use of computers. There are created standard programs that can be used to carry out the required calculations per pm in accordance with the aforementioned methods of following and calculating in the software of computer centers.

As a result, the techniques of mathematical modeling can be successfully used at different stages of research in solving problems of labor protection, they will enable them to use more computer technology, and they will provide identification of research papers.

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