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Algorithms and Scientific Engineering Calculation Techniques For A Systematic Approach to Workplace Safety

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Abstract: In order to prepare occupational safety measures as effectively as possible and to make the greatest use of the resources available, it is suggested in the article that a management system be developed that, based on mathematical methodologies, offers information analysis, adoption, and implementation of management decisions.
Key words: working conditions, employment population, engineering calculation techniques

INTRODUCTION

Planning for workplace safety should be based on management theory, which takes a methodical approach to developing goals, criteria, techniques, and controls. We may discover the internal relationships of the process being studied and identify the primary management roles thanks to the systems approach technique.

It is essential to develop a management system that, based on mathematical techniques, offers information analysis, adoption, and execution of management choices in order to plan occupational safety measures as efficiently as possible and make the best use of the resources at hand.

When designing occupational safety measures, we should take into account the statistics of our Republic, which reveal that there were 18.13 million males and 17.89 million women overall at the beginning of 2023. There were 18.33 million people living in urban areas and 17.69 million in rural areas. 31.7% of the population is not of working age, 56.8% of the population is of working age, and 11.5% of the population is not of working age. In 2022, there were 932.2 thousand live births, of which 482.4 thousand were males and 449.8 thousand were girls. 458.8 thousand persons were born in rural regions, compared to 473.4 thousand in cities.

One child births made up 97.8% of all births, two children, 2.1%, and three or more, 0.1%.

Women giving birth were aged under 25 in 38.9% of cases, 25 to 39 in 60.1%, and 40 and above in 1% of cases.

10.7% of fathers were under 25, 83.4% were between 25 and 39, and 5.9% were over 40. According to the aforementioned figures, the employed population is made up of: (Diagram-1)

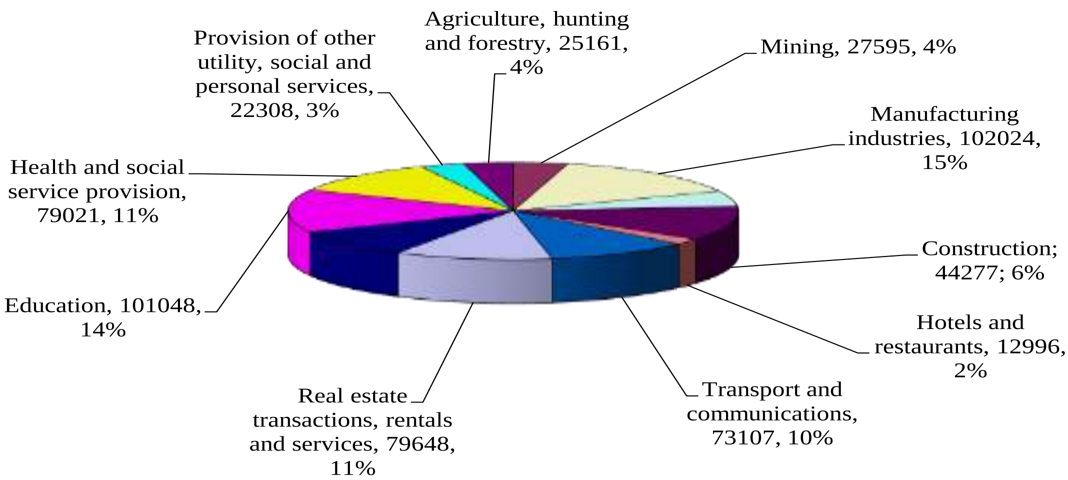

Diagram 1 Structure of the employed population

Achieving the best working conditions will be made possible by the implementation of occupational safety management systems at the level of a company, association, and industry. These systems will also increase the efficacy of the fight against occupational illnesses and general and general diseases.

An information processing tool, a control body, a control object, and a way to put control choices into action make up a control system in general.

The control system's goal is to modify the object's output parameters in line with predetermined standards or a control program. In this instance, input and output parameters are documented and utilized to identify the object, i.e., to create a mathematical model that is sufficiently appropriate to allow for the prediction of output variable values and the creation of essential control measures.

The control object is considered as a converter of a vector of input random functions of time $x(t)$ a vector of output random functions $y(t)$:

$$y(t) = A_t x(t), \tag{1}$$

here A_t – object description operator.

Each output variable $y_i(t)$ $(i=1, m)$ is caused by a collection of input variables $x_1(t),..., x_n(t)$, yet it is almost impossible to account for all of them. As a result, we must restrict our focus to a few influencing factors and label the remaining factors as uncontrolled noise.

Let's outline a few components of the management system for efforts to reduce morbidity via occupational safety.

The health of the workforce under study is the aim of control in this system.

This contingent is unified under the theory of qualitative homogeneity of the working circumstances variables impacting it and is distinguished by a specific length of service, age, gender, and professional structure.

The system's objective is to provide safe and healthy working environments while taking into consideration the characteristics of the workforce, the current socioeconomic and climatic circumstances, and the lowest feasible morbidity levels.

The production environment's attributes as well as the workforce's demographic and professional traits are considered input factors. Output variables are indices of morbidity that describe the employees' state of health.

The supply of a baseline level of morbidity, unrelated to the influence of production but dictated by climatic, sociological, and other elements uncontrolled in this system, should be the criterion for efficacy in the system under review.

Controlling influences are workplace safety procedures intended to reduce worker morbidity to the absolute minimum. These actions can safeguard employees, enhance working conditions, compensate for harm from unfavorable effects, and manage work and rest schedules.

In this arrangement, the labor protection services (safety and industrial sanitation) collaborate with the business administration as the management bodies. They assess the most recent data on working conditions and employee health, think through potential management solutions, create action plans, and oversee their execution.

Data on the state of the control object includes information on labor protection laws and regulations compliance, scheduled activities implementation, existing working conditions factor values, indicators of employee health status, and economic data.

Organizational, technological, and software information processing solutions enable you to create and compile indicators, carry out their in-depth research, and provide the best possible suggestions for management bodies.

Research, design, and technological solutions, measures of moral and financial incentives, individual and group protective equipment, pharmaceuticals and equipment, etc., required for the health indicators of employees, are the methods of putting control activities into action.

To implement the basic functions of managing labor safety measures, an automated data processing system should be created, where the following tasks should be solved:

- ✓ registration, control and accumulation of information;
- ✓ calculation of statistical indicators and printing of information tables;
- ✓ identification of the control object in order to determine the relationship between the parameters of working conditions and morbidity indicators;
- ✓ determination of the minimum possible morbidity levels and the corresponding optimal values of production factors that lie within realistically achievable limits;
- ✓ compilation of various options for preventive interventions and selection of the optimal option;
- ✓ assessment of projected morbidity levels;
- ✓ determination of the socio-economic effect of the system for optimal planning of preventive measures.

We shall take into consideration the progression of morbidity optimization phases using a functional calculation and graphic. An automated data processing system is used in this optimization.

The characteristics of the working environment and worker morbidity indicators serve as the input and output variables for the control object, respectively. These data are gathered and stored in the proper data archives. When the automated system is in the information management mode, such archives are created and used.

In the first situation, archives of information on working conditions and morbidity are updated and restocked at certain intervals. The values of production variables are evaluated, and morbidity rates are determined, if it becomes required to create reports or get operational data for a specific sample. In this situation, it becomes possible to quickly obtain the necessary information as well as compare working conditions and the prevalence of illness among various worker groups using general signs. This makes it easier to identify the most unfavorable production areas and facilitates the planning of targeted preventive measures.

Identification blocks for predicting optimization are added to the system while it is in control mode [9–11]. The basic base for the identification model is made up of working conditions parameters and morbidity indicators that have been statistically processed and grouped to enable for comparison examination. Here, quantifiable relationships are established utilizing factor and regression analysis methods:

where is the intensive indicator of the form of the disease;

- vector of working conditions parameters;

- the number of forms of diseases registered among the studied contingent of workers.

Models should be created based on the morbidity indicators [5] in order to completely define the management object as each of them characterizes certain features of the item.

Indicators of morbidity [4] were functions of characteristics governing working circumstances [2], with an optimal range for independent variables that can take on minimum values. As long as they are continuous, differentiable, and have global positive minima at these points and the corresponding optimal values of the arguments [4] are in a realistically achievable area constrained by technical and financial constraints, these values [6] can be defined as the lowest possible morbidity levels.

The smallest feasible incidence levels are defined by the boundary values of the actual region in the direction of the optimum in instances where the function minima do not fulfill the necessary requirements or the values of the relevant arguments are outside the really achievable region.

In order to estimate the minimal level of the morbidity indicator in accordance with the form, the following problem must be solved.

where is the vector of working conditions parameters, which represents the function's lower bound (precise minimum value);

On *X*, the minimization problem is solved, a set of values that are genuinely feasible. The vector makes the function smaller:

The indicators of the disease's form are minimized by each of the partial optimum vectors of working conditions parameters that were discovered after the issue of minimizing working conditions parameters was solved [7]. Finding the overall ideal vector of working conditions parameters, each of which components belongs to a private vector, is essential to reduce the total morbidity rate, which is equal to the sum of intense indicators for each individual nosological form:

Therefore, a combination of private optimum vectors that reduce certain types of illnesses can constitute the overall ideal working condition vector for the workforce under study.

When formulating preventative measures, the variables that make up the overall optimum vector should be considered. Classifiers created for distinct production facilities (shops, sections, professions, etc.) are needed for the automatic creation of individual plan choices. Each preventative measure must be classified using these classifiers, which must also include the cost of the measures as well as the precise attenuation of the detrimental elements of working circumstances that they combat [2]. With the aid of classifiers, several preventative plans are created with different activity compositions, costs overall, and effects on health[3] to obtain the determined ideal values of the working condition parameters:

The optimization problem is addressed for a specific efficiency criteria, taking into consideration technological and financial constraints, in order to ascertain the most reasonable form of the action plan. The criteria for the lowest level of the overall morbidity rate with low preventive costs in this problem are as follows:

We choose this period of time as the prediction period because we assume that after implementing a series of optimum solutions, the lowest feasible levels of morbidity will be reached. Using the identification model [1], after accurately estimating the values that the characteristics of working circumstances would have throughout time (without implementing optimal actions), we will ascertain the accurate prognosis of morbidity rates:

– prognostic value of the morbidity indicator according to the nosological form through the time of absence of measures; -prognostic values of working conditions factors without measures. (Diagram-2)

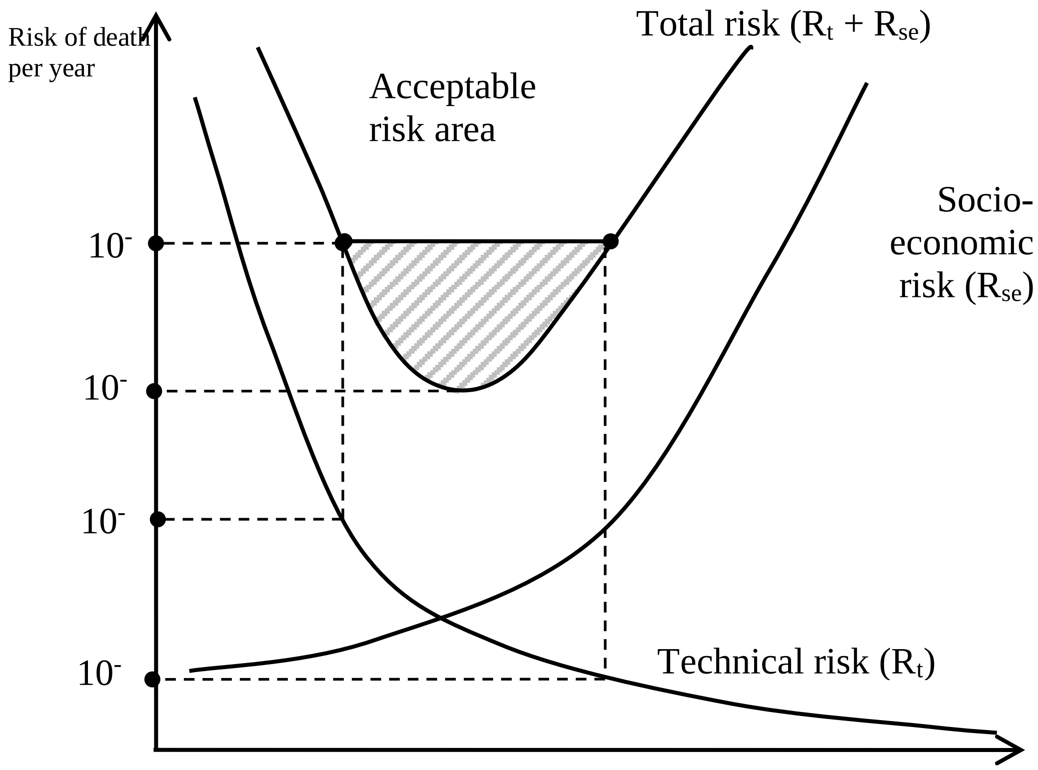

Diagram-2 Acceptable risk.

The socio-economic impact that can be obtained as a consequence of optimizing preventative actions can be calculated using prognostic values of morbidity indicators. We will calculate the size of this decline for various nosological forms, assuming that optimum treatments would reduce morbidity rates to the lowest achievable values:

We gain an overall decrease in morbidity as a result of optimizing preventative measures when we add up this reduction for all disease kinds detected for the item under study:

The number of employees who are no longer exposed to hazardous and challenging working circumstances should be used to gauge the social impact of health-improving initiatives because this directly impacts the decline in morbidity rates. As a result, it is possible to see the predicted decrease in the indicators for the number of sick individuals and the number of disease cases as being similar to one of the categories of societal effects discovered through optimization. The number of working days lost due to sickness will be reduced, and this will be regarded as a measure of the socioeconomic impact since it shows a decrease in lost productivity and, thus, a decrease in underproduction. It is feasible to determine the economic effectiveness of the best planning of actions intended to reduce the incidence of employees using this indicator and knowledge of the cost of one working day.

In the major workshops of the production association, the initial phase of an automated system for gathering and analyzing data regarding working conditions and worker disease has been placed into industrial operation. The stages of the aforementioned method for maximizing labor protection measures are implemented by this system: statistical processing of data on workers' working conditions and morbidity with temporary disability; printing of information tabs; modeling of quantitative relationships between working conditions factors and morbidity indicators. During the execution of the strategy for enhancing workplace safety measures, testing of next phases is anticipated.

Conclusion: 1. An automated control system's proper operation should serve as the foundation for the best planning of preventative actions aimed at lowering morbidity among employees.

2. Blocks for statistical information processing, modeling quantitative levels of morbidity related to production, categorization, and optimization of preventative actions must be included in the system for managing occupational safety measures intended to reduce morbidity.

3. Taking into account technological and financial constraints, optimization of actions aiming at lowering worker morbidity should be done using the criterion of maximal health-improving effect.

4. An automated control system that incorporates modeling and statistics processing steps.

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