Information System for Forecasting and Management of Occupational Risks

E V Klimova¹, A Yu Semeykin¹, E A Nosatova¹

¹Department of Life Safety, Belgorod State Technological University named after V.G. Shukhov, 46, Kostyukova str., Belgorod, 308012, Russia

E-mail: klimova.ev@bstu.ru

Abstract. The paper shows that the main reason for the occurrence of accidents at work is the human factor. The human factor should be attributed to the possibility of human mistaken or illogical decisions in specific situations, as well as incorrect actions caused by changes in the psychological and / or physiological state of a person due to the influence of factors in the working environment and the labour process, the lack or inadequacy of information support. The task of forecasting and reducing injuries and professional risks can be solved by using modern information technologies for statistical data processing and event prediction. For forecasting and management of professional risks at BSTU named after V.G. Shukhov information system has been developed. System allows to make the right decisions in real conditions taking into account various factors and to reduce the level of occupational injuries and accidents at industrial enterprises. This system is also used in training of managers, specialists and students in the field of occupational safety. The paper presents the structure and algorithm for analysing and predicting incidents and accidents using an information system.

Keywords: professional risk, information system, injuries, occupational safety.

1. Introduction
An analysis of the annual data on the level of industrial injuries shows that in Russia, on average, there is one fatal accident for every 20 – 22 injuries in the workplace. At the same time, in the countries of the European Union a similar ratio averages from 1:600 to 1:1900 [1, 2]. This is due to the shortcomings in the approaches to managing professional risks and occupational safety in Russia. In accordance with the Labor Code of the Russian Federation, professional risk is the probability of causing harm to health as a result of exposure to harmful and (or) dangerous production factors when the employee performs duties under an employment contract or in other cases established by the Labor Code of the Russian Federation and other federal laws [3]. Risk management is the collection and analysis of information on industrial safety, risk analysis (hazard analysis) and safety monitoring [4]. Accordingly, one of the methods in allowing a professional to reduce the risk is to collect statistical information about the problem situations in the workplace and conduct the initial analysis. The creation of an information system on the basis of a scientifically based method of recording, analyzing and forecasting occupational traumatism and occupational morbidity becomes an important stage for the prediction and management of occupational risk.
2. Relevance, scientific significance of the issue

The dynamics of changes in the indicators of industrial injuries shows a tendency to decrease, however, despite this, the level of injuries in the Russian Federation remains high, Figure 1. According to the data of the Ministry of Labor and Social Protection of the Russian Federation, the number of people injured in accidents at work is about 30,000 people per year; the number of fatalities reaches 1,200 – 1,400 people [2]. This fact makes the management of professional risks and the search for new technologies and methods of their reduction extremely urgent.

Analysis of the causes of injury to workers shows that the following reasons predominate [2, 5-8]:
– unsatisfactory organization of work process;
– violation of traffic rules;
– violation of the work schedule and labor discipline by the employee;
– violation of the technological process;
– shortcomings in the organization and training of workers in the field of occupational safety and health.

According to the Federal Environmental, Industrial and Nuclear Supervision Service of Russia, the main cause of accidents and accidents at hazardous production facilities (including fatal injuries associated with the impact of machinery and mechanisms) is a low production discipline on the part of engineering and technical workers, and also the quality of instruction on the safe methods of work; lack of control at the workplace by the person in charge of technical supervision [9].

Thus, the main reason for the majority of accidents and occupational injuries was and still is the so-called human factor, which should be understood as a number of factors, such as shortcomings in the vocational training and competence of the employee, the psychological state, the worker's motivation, and others [10]. These factors must to be taken into account when monitoring, assessing and predicting occupational risk indicators in the workplace.

Numerous researches of Russian and foreign scientists show that the level of professional risk depends on the set of probabilistic characteristics and the complex of connections between the working conditions, the labor process, the physiological and psychological state of a person, the availability and level of development of institutions for protection against risks (labor protection, social insurance, etc.). In addition, it is necessary to take into account that modern production is a complex of technical, social, economic and information systems. Thus, the task of assessing and
managing occupational risks and occupational safety is characterized by an unclear initial data and incomplete information for making management decisions in real time. This creates certain difficulties in making such decisions for managers and specialists of enterprises responsible for ensuring occupational safety. Therefore, in order to reduce occupational risk levels and the probability of injury at accidents, it is necessary to develop methods for assessing and forecasting occupational injuries and occupational hazards based on modern information technologies.

In Russia, expert decision support systems for the management of various technological processes in engineering are being developed [11]; in business processes [12]; in crisis and emergency situations [13, 14], etc. At the same time, there is no information on the development of expert decision support systems in the occupational safety management system for enterprises in various sectors of the economy [15].

In the works of many foreign researchers, studies are under way to develop algorithms for the forecasting and analysis of incidents and accidents in various industries (chemical, oil and gas, metallurgy, construction) [16-21]. The following technologies are used at the basis of foreign expert information systems:

– Fault Tree Analysis (FTA);
– Failure Mode and Effects Analysis (FMEA);
– Fuzzy Analytic Network Process;
– Bayesian Networks;
– Graphical Evaluation and Review Technique;
– Neural Networks.

All of the above listed methods of analyzing and forecasting incidents, erroneous actions of personnel, accidents and emergency situations make it possible to create integrated software products that are designed to facilitate occupational safety control and management processes in enterprises, hazardous production facilities, etc.

It should be noted that the results of well-known domestic and foreign studies are not fully brought to practical implementation in the form of expert labor safety management systems introduced at real enterprises.

3. Results and discussion

At the Department of Life Safety of BSTU named after V.G. Shukhov an automated professional risk management system has been developed, which is implemented as an web-based application that allows users to register as ordinary users to view injury data at enterprises, and managers or employees of enterprises to add new information about injuries. Registration of users and representatives of the enterprise is regulated by the site management, which monitors the reliability and quality of the data provided.

The scheme of the web-based application is presented in Figure 2.

The developed automated professional risk management system is a database that includes the following information:

– basic information about the enterprise (including information on the type of economic activity, the number of employees in the organization, the material and technical elements of working conditions, etc.);
– information about the personnel;
– factors of working conditions that correspond to hazardous and harmful production factors that are subject to hygienic evaluation on the basis of instrumental measurements of their levels, as well as expert evaluation of the conditions of the labor process;
– statistics of occupational injuries, which characterizes the dangers and threats in terms of the severity of the consequences of injuries to workers;
– measures for occupational safety, labor protection costs and their effectiveness.
Figure 2. The scheme of work of the automated information system through the Internet.

Block diagram of the algorithm for analyzing and forecasting occupational injuries is shown in Figure 3.

The main function of the developed information system is the ability to forecast the level of occupational risk (in terms of industrial injuries) for certain professions, industries and enterprises based on the analysis of events using fuzzy logic and logical-probabilistic modeling. The information system allows to produce:

– retrospective analysis of statistical indicators of injuries by quantitative statistical assessment of factors causing industrial injuries (based on information from investigation materials of real accidents);
– predictive analysis of the magnitude of injuries and occupational risks on the basis of fuzzy logic methods;
– quantification of traumatic factors based on the expert method;
– identification of problematic workplaces;
– selection of a management solution for managing the level of occupational risk (the basis for decision options for managers and specialists of enterprises responsible for ensuring occupational safety).

**Figure 3.** Block diagram of the algorithm for analyzing and forecasting occupational injuries using the professional risk management information system.
4. Conclusion
The paper shows that for the Russian Federation the problem of reducing the value of occupational risk is extremely topical. The analysis showed that the most promising method can be the use of information systems that predict the magnitude of the risk of injury to employees based on the processing of statistical data using predictive logic-probabilistic modeling based on fuzzy logic methods. In the Belgorod State Technological University named after V.G. Shukhov an information system for forecasting and managing professional risks has been developed, which is used to train and improve the skills of managers, specialists and students in the field of occupational safety and to solve the problem of reducing industrial injuries in industrial enterprises.

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