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METHOD OF EVALUATING THE SAFETY OF THE TECHNICAL SYSTEM AT A METALLURGICAL PLANT

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Using a generalized index of operational factors to evaluate the safety of engineering systems at metallurgical plants during different periods of normal operation makes it possible to improve the safety of the plant by allowing timely and objective analysis of the condition of a given system and the implementation of operational measures designed to reduce the risk of accidents.

Changes in the technical and economic conditions at metallurgical plants create the prerequisites for the development of new technologies and new types of equipment, which in turn requires the solution of new, more complicated technical and managerial problems to ensure that the production process remains safe. The founding document in regard to safety is the Federal Law "Industrial Safety of Hazardous Production Facilities," which establishes general criteria and requirements for ensuring safe production practices at metallurgical plants.

Occurring simultaneously with the above-noted changes has been a change in the structure of production at metallurgical plants, the net effect being the consolidation of equipment into complex technical systems. In accordance with GOST 27.002-89 [1], potentially hazardous objects must meet safety requirements both during service and when the object is not working. New approaches therefore are needed to evaluating the safety of engineering systems, their safety being one of the prerequisites for stable and hazard-free operation of the metallurgical plant.

We will examine one method that makes it possible to evaluate the safety of an engineering system by means of factors that are characteristic of production processes [2].

Ensuring the safety of engineering systems is a complex, multifaceted task that includes technical, organizational, and informational aspects. The main requirement for choosing the above-mentioned factors is the use of a systems approach based on a comprehensive evaluation of various planning indices. Knowing these indices makes it possible to determine the effect of the factors on the safety of engineering systems. In essence, these factors are situational in nature and arise in the course of man–machine interface (see Fig. 1). The factors determine the relationships between the indices, which are evaluated based on objective conditions that characterize the given production process: the technology, the condition of the equipment, the supervision and organization of work, the professional skills and training of the workers, and the information system that is in place.

Determinacy, manageability, mobility, and interconnectedness are all qualities that are intrinsic to these factors, which makes it possible to follow the dynamics of their development and find ways to control them in order to eliminate adverse impacts on the safety of the given engineering system. Each factor is characterized by a certain set of indices that in

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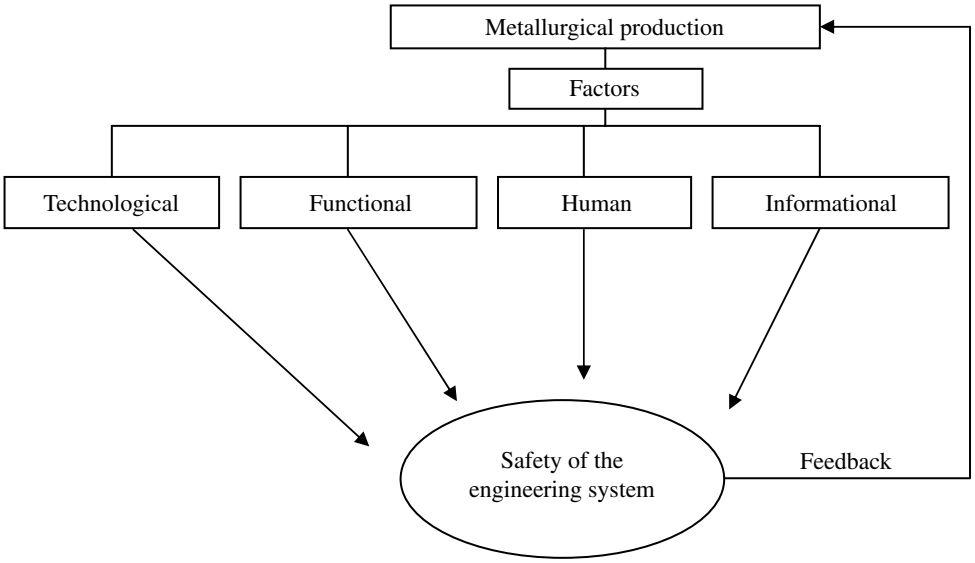

Fig. 1. Structure of the effect of different factors on the safety of an engineering system at a metallurgical plant.

aggregate determine its potential. At the same time, each index of a factor can interact with another factor or one of its indices.

In evaluating the safety of an engineering system, it is necessary to determine and study the indices of a factor that have a significant effect on it, i.e., indices that are related to the condition of the equipment, job organization, and the qualifications of the plant's employees.

The indices of factors affect one another, i.e., the final indices have an effect on the indices that characterize individual aspects of production operations at the plant. Thus, the most important considerations in determining the indices of the various factors are using a systems approach, correlating different indices with one another, and analyzing the interrelationships, interdependencies, and functional dependencies [3].

Engineering systems at metallurgical plants must satisfy certain safety requirements over the duration of their service life. The service life of any engineering system is characterized by three periods. The first period (from 0 to t_i) is the period during which adjustments are made to the system before it is put into regular operation. The second period (t_{i+n}) is the normal period of operation of the system, while the third period (after t_{i+n}) is the aging period.

Before introduction of the system (t_i), its safety H_i is rated at 100%. During the period of normal operation (t_{i+n}), the system's safety declines due to factors related to the operation of the metallurgical plant. Thus, during this period the safety of the system will satisfy the condition: $H_{i+n} \le 100\%$. When the system reaches its limiting state, its safety will be: $0 \le H_{i+n}$. Thus, the safety of the system during its normal period of operation can be described by the expression

$$0 \le H_{i+n} \le 100\%. \tag{1}$$

The safety of an engineering system at a metallurgical plant (H_{i+n}) can be evaluated by means of a generalized index (K_{of}) of operational factors at the plant. The index K_{of} is the average value of all the indices for the above-mentioned factors associated with the plant that affect the safety of the given engineering system during the period of time t_{i+n}. The index is found from the formula

$$K_{\text{of}} = \frac{K_1 + K_2 + K_3 + K_4}{4}, \tag{2}$$

where K_1, K_2, K_3, and K_4 are the technological, functional, human, and informational indices of each factor. Thus, the safety of the engineering system (H_{i+n}) during the normal period of operation (t_{i+n}) can be expressed by the formula

$$H_{i+n} = H_i \times K_{\text{of}} \quad \text{or} \quad H_{i+n} = K_{\text{of}} \times 100\%. \tag{3}$$

Equation (3) makes it possible to evaluate the safety of the system based on each index (K_1, ..., K_4), and this evaluation can be done for the system as a whole or its individual sections. Also, if necessary, the evaluation method described here makes it possible to introduce new indices and factors or, conversely, to eliminate existing ones – depending on the problem being addressed.

Thus, evaluating the safety of engineering systems at a metallurgical plant during different periods of normal operation by using a generalized index of operational factors makes it possible to improve the safety rating of systems by allowing timely and objective evaluation of a system's condition and taking steps to reduce the risk of accidents during production operations.

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