Principles of organization of technological service systems to ensure their reliability

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Abstract. The article analyzes technological systems, which are the production basis of organizations that provide services and produce goods, and service subsystems. In order to study the principles and methods of organizing services to ensure the reliability of the technological system, it is necessary to consider four types of technological systems in the agro-industrial complex: technological systems of plant growing, livestock and other agricultural and processing companies; technological systems of plant-growing processes, animal husbandry, processing of vegetable and animal raw materials; technological systems of production units; and technological systems of production units of enterprises. The systematic approach and the monographic method were used; a systematic analysis of the service system was carried out. It was established that the reliability of a technological system can be improved by organizing technical services and relying on the following principles: creation of a parallel system; organization of a reliability management system; the entry of reliability management into the quality management system, risk management and the general structure of enterprise management; analysis of the types and consequences of failures of the technological system; formation of redundancy; state reliability management; optimization of the structure of the subsystem of technical service by modeling their functions and developing tools for providing technical services.

1. Introduction

Technological systems are the production basis for organizations that provide services and produce goods. The concept "technological system" is defined as "a set of interconnected means of technological equipment, production items and performers in technological processes or operations under the regulated production conditions” [1]. The subject of the service industry is a service that is characterized by intangibility, since most services are actions and works that are inseparable from their sources; services are heterogeneous by quality, short-lived and cannot be registered as property objects.

A system is an emergent set of elements united by the system-forming factors, possessing general systemic properties of stability, reliability and efficiency. These properties allow the system to
compete in fairly complex conditions of the changeable external environment, to maintain its structure and hierarchy throughout the entire life cycle.

The structure of a system is the mutual relationship of its subsystems and elements, determined by functional and parametric connections. Subsystems share some functional or structural characteristics of the technological system of a higher level. An element of the technological system is its part conventionally taken as indivisible at this stage of research. The system hierarchy includes four levels of technological systems: operations, processes, production divisions and organizations as a whole. In addition to a structure and a hierarchy, the system is characterized by organization and technology, composition of fixed assets, parameters and conditions.

An organization is an internal structure, methods and ways of achieving goals.

Technology is a sequence of operations performed during the operation of a system.

System parameters can be input and output, the latter characterize the efficiency, reliability, stability, quality of a system.

The reliability is "a property to keep values of all parameters characterizing the ability to perform required functions in the specified conditions." It is a complex indicator that, depending on the industry and the situation, may include reliability, durability, maintainability and preservation (the property of a system to continuously maintain an operable state until the end of its life cycle), adaptability to the restoration of an operable state and preservation after storage or forced long-term downtime [2]. Service systems allow you to maintain operability, reduce the failure rate, restore operability and save it during the periods of non-use, for example, during quarantine.

The efficiency depends on organization, methods and principles of ensuring the operable state of the serviced technological system.

The goal of the research is to study the principles and methods for ensuring the reliability of the technological system.

2. Materials and methods

The research methods are monographic, system, and functional types of analysis of systems. A number of research institutes, including the Institute of Mechanical Engineering of the Russian Academy of Sciences, and industry research institutes, were involved in improving the reliability of technological systems. An operating state of the system is "the state of the technological system, in which the value of at least one parameter of productivity of the technological system does not correspond to the requirements established in the normative-technical and (or) design and technological documents", when the inoperative state of the corresponding parameters do not meet the established requirements [1]. Failures of technological systems are divided into functional, with a complete loss of the ability to work, and parametric, in which the system continues to function, but the efficiency and quality are partially reduced. There are failures of service parameters (parametric), quality, productivity, and cost. In case of cost failures, the organization becomes uncompetitive, and cannot sell its products or services at a profit, its financial stability decreases to an unstable state. Failures can be caused both by internal and external factors.

3. Results and discussion

An analysis of the technological systems showed that its service should be aimed at increasing reliability as a complex property, characterized by the probability that there will be no failures of quality of manufactured products. The utilization rate of the technological system, the probability of performing work and the productivity retention factor will be within acceptable limits. The probability of producing the i-th product is determined by formula

\[ P_{y_i}(t) = P\{V_i(t) \geq V_0\} \]  

where \( V_i(t) \) is actual and set volumes of products \( i \) of required quality produced for period \( t \) [1].
The utilization factor characterizes the relative proportion of time during which the vehicle is in a working state, taking into account all types of downtime.

Therefore, the service organization should be aimed at reducing non-productive downtime caused by functional and parametric failures of the technological system.

For example, a grain processing enterprise is a technological system of the service industry serving the agro-industrial complex. In turn, it has its own service system for ensuring operational reliability - a reliability management system (Fig. 1).

![Figure 1. The structure of the grain processing equipment reliability management subsystem](image)

The production system is a source of requests for maintenance and repairs. Requirements, or requests, for service enter the service subsystem, if it is busy with service, then the requests wait in the queue. At the service stations, they are satisfied and the serviced requests leave the maintenance and repair system.

The parallel system principle provides for the creation of a parallel subsystem to ensure the operability of the technological system.

![Figure 2. The main functions of a RMS manager](image)
The first principle is organization of a specialized subsystem that is engaged in restoring the operability of the technological system: the reliability management system (RMS). In accordance with the state standard, RMS is developed for restoring the operability of the technological system. Its main task is to manage the reliability and quality of the enterprise. Therefore, it should be part of the management structure. The direct management of RMS is carried out by a company manager [3]. These responsibilities can be assigned to the head of the quality department (Fig. 2).

The second principle is the organization of service of the technological system. It provides for the entry of reliability management into the quality management system, risk management and the general structure of enterprise management (Table 1).

Table 1. Strategic, tactical and operational decisions of risk management of a technological system [4]

|                | Strategic | Tactic            | Operational                     |
|----------------|-----------|-------------------|---------------------------------|
| Top manager. Representative of the owner. Manager | Identification of objectives, means, risks, participants, and creation of a basis for making tactic and operative decisions | Identification of means ensuring implementation of objectives and management of tactic goals within the strategic level | Implementation of decisions taken at the tactic level, and operative risk management |

The third principle is an analysis of the types and consequences of failures of a technological system, due to the application of the national risk management standard. The principle gives recommendations to achieve the set goals. Failure Modes and Effects Analysis (FMEA) is a method of systematic system analysis to identify potential failures, their causes and consequences, as well as the impact of failures on the system (the system as a whole or its components and processes) [5].

The principle of redundancy is a special case of using a parallel system for a system element. It involves the creation of redundancy due to a loaded and cold reserve and additional connections. These can be such backup methods as duplication, diagnostic methods, information backup.

The principle of strategic management is a planned preventive system (by the operating time - motorcycle hours, consumption of a certain amount of fuel or performance of a certain volume of works in conditional reference hectares), by the state (the list and frequency of maintenance is determined by the state of machines), by the event, and for imported machinery and equipment - "service for reliability" [6, p. 8].

Optimization of the organization structure of the technical service subsystem is based on the model of its functions and the mathematical apparatus of the theory of probability and the theory of Markov processes. It is necessary to develop tools for technical service on a different basis [7, p. 3807-3815]. Optimization of the technical service subsystem by the autonomous, centralized, and combined (hybrid) methods.

The principle of forming the information redundancy of a technological system is based on predictive modeling and mathematical modeling [8, p. 715-719].

4. Conclusion
The reliability of a technological system can be achieved by providing technical services and relying on the following principles:
- creation of a parallel system (creation of a parallel subsystem to ensure the operability of the technological system);
- organization of a specialized subsystem that is engaged in restoring the operability of a technological system: a reliability management system (due to the application of the National Standard of the Russian Federation);
- the entry of reliability management into the quality management system, risk management and the general structure of enterprise management;
– analysis of the types and consequences of failures of the technological system (due to the application of the national standard for risk management);
– redundancy is a special case of a parallel system, formation of redundancy due to a loaded and cold reserve and additional connections (duplication, diagnostic methods, informational, etc.);
– formation of information redundancy on the basis of predictive modeling and mathematical modeling;
– strategic management: planned and preventive systems, states, events, reliability;
– optimization of the technical service subsystem by modeling its functions;
– development of tools for providing technical services and using them.

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