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STUDY OF THE INFLUENCE OF VARIOUS TECHNOLOGICAL FACTORS ON THE RELIABILITY OF MACHINES AND EQUIPMENT OPERATING IN EMERGENCY SITUATIONS AND EXTREME CONDITIONS

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A B S T R A C T

The article presents the results of research on the influence of various technological factors on the reliability of machines and equipment operated in emergency situations and extreme conditions. The regularities obtained are discussed.

Keywords: machines; equipment; technological factors; extreme conditions; reliability; emergency; working efficiency.

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The results of studies on the influence of various technological factors on the reliability of machines and equipment operated in emergency situations and extreme conditions show that various processes occur on the working surfaces of their parts, which in many cases are not interconnected [1].

For example, as a result of wear on the surfaces of machine parts and equipment, they lose their original performance, and their technical characteristics deteriorate sharply. Research conducted during operation can evaluate the relationship between individual technological factors and the performance of machines and equipment, you can get information about the main reasons for changing their technical characteristics, about the duration of work before repair, about reliability indicators, etc.

The results of numerous studies on determining the service life of machines and equipment depending on the wear of the surface layer of their main parts show that they belong to the category of random processes. Wear laws are random functions, since it is impossible to determine in advance which implementation of a given function will take place under existing operating conditions. It is only possible to establish the probability of wear occurring at a given rate.

According to [2], there are two main ways to identify distribution laws: the study of physical phenomena that lead to failures, and the statistical study of failures using the method of mathematical statistics.

The first method is based on the development of a special area of knowledge of failure physics. In this direction, of interest are attempts to interpret the distribution laws used in reliability theory based on the construction of failure models. The second method is empirical; it is often used due to the lack of other possibilities.

When studying sudden failures of units and connections of machines and equipment operating in extreme conditions, it can be assumed that each failure is the result of random factors. When studying the failure-free operation of machines and mechanisms, the normal, exponential, logarithmically normal, gamma and Weibull distributions, etc. are used.

Using the techniques described in [2], it is possible to determine the failure rate, the probability density function of the uptime of machines and equipment operating in emergency situations and extreme conditions, the failure rate $\lambda(t)$, the mean time to failure T, the variance of the failure time D.

The number of failed equipment $n(\Delta t)$ in the total number of equipment $N(0)$ Δt is called the failure rate $\hat{a}(t)$, provided that the failed equipment is not restored or replaced by new ones.

The statistical estimate of the failure rate $\hat{a}(t)$ of the equipment can be written by the formula

$$\hat{a}(t) = \frac{n(\Delta t)}{N(0)\Delta t}. \quad (1)$$

If Δt is approached indefinitely to zero, passing to the limit, then after appropriate transformations we obtain

$$a(t) = q(t), \quad (2)$$

where $a(t)$ – failure rate.

Dependence (2) shows that the frequency of equipment failures determines the rate of decrease in the probability of equipment failure-free operation over time. The probability density of random equipment operation time to failure is written by the formula

$$a(t)=f(t), \quad (3)$$

where $f(t)$ is the probability density function of the uptime of machines and equipment.

The failure rate $\lambda(t)$ is often used to assess the reliability of non-recoverable machines and equipment and is determined by the expression

$$\lambda(t) = \frac{a(t)}{P(t)}. \quad (4)$$

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T as the mathematical expectation of the average operating time is written by the formula

$$T = \int_0^{\infty} P(t)dt. \quad (5)$$

The statistical evaluation of the mean time to failure $\hat{T}$ is the arithmetic average of individual time to failure of the same type of machines or equipment:

$$\hat{T} = \frac{1}{N_0}\sum_{j=1}^{N_0}\tau_j, \quad (6)$$

where N_0 – number of equipment tested; τ_j - is the operating time of the j-th equipment before the first failure.

The dispersion of the failure time $\hat{D}$ is determined by the formulas:
for $N_0 > 30$

$$\hat{D}[\xi] = \frac{1}{N_0}\sum_{j=1}^{N_0}\left(\tau_j - \hat{T}\right)^2; \quad (7)$$

for $N_0 < 30$

$$\hat{D}[\xi] = \frac{1}{N_0 - 1}\sum_{j=1}^{N_0}\left(\tau_j - \hat{T}\right)^2. \quad (8)$$

The nature and size of the worn surfaces of parts are of primary importance in case of loss of working capacity. Knowing the rate, nature of wear and distribution, it is possible to identify the influence of parts and connections on the performance of machines and equipment and the operating time with the necessary technological parameters. At established speeds and shapes of worn surfaces of the main parts of machines and equipment, it is possible to determine the main parameters of their performance and allowable wear [3].

When determining the loss of the working capacity reserve due to the destruction of the surfaces of parts of machines and equipment operating in emergency situations and extreme conditions, it is possible to make calculations to identify the shape of worn surfaces and establish the effect of wear on performance.

Research [4, 5] shows that the course of wear in time during the period of normal wear obeys a linear law with some deviations that are not regular. Thus, the wear of parts of machines and equipment produced by the same enterprise can be represented in time as a random function.

By applying various methods and as a result of accurate measurements, it is possible to establish the amount of wear on the surfaces of parts over time for each specific case. For example, after a period of running-in, the course of cylinder wear in time is characterized by a linear law and ends after 5-7 months of pump operation. During steady-state wear, the wear rate is constant, and from its value it is possible to determine the average amount of wear and the shape of the worn surface of the cylinders. The analysis of worn surfaces shows that the greatest wear occurs at a distance of 80-120 mm from the end of the cylinder.

The results of experimental studies show that due to wear, the radial clearances in the parts of rolling bearings increase, the radial components of the tension force displace the inner ring in the radial and axial directions. The same movement occurs if there is only lateral runout of the outer ring track. The specified displacement can increase and decrease due to errors in the surfaces mating with the bearing. The difference in the size of the balls for each revolution of the shaft due to the difference in speeds also affects the performance of the bearing units [6].

The analyzes carried out make it possible to predict a decrease in the performance of machines and equipment from thermal deformations and wear. An analysis of the nature of thermal deformations and wear makes it possible at the stage of designing machines and equipment to find opportunities for improving the designs of the main units and critical parts. An increase in the wear resistance of parts leads to an increase in the working capacity of almost all machines and mechanisms. The wear resistance of the surfaces of parts should be increased taking into account the intensity of work and the workload of individual units and connections of machines and equipment.

When predicting reliability, the loss of operability of machines and mechanisms due to the wear of individual parts and mates as a whole is essential.

The use of various methods to control the wear of parts and restore their performance is a progressive way. With this method, individual nodes and interfaces are not regulated, regulation is carried out only for the main parameters, machines and equipment that determine performance.

It should be noted that it is impossible to influence the influence of various processes only by such methods, since each process has its own characteristics and physical nature and affects the reliability of machines and equipment in different ways. Therefore, the regulation of the performance of machines and equipment must be carried out taking into account the time of their changes.

One of the main tasks of mechanical engineering is the creation of such machines and equipment designed for operation in severe emergency situations and extreme conditions that can ensure the preservation of their high initial technical performance, regardless of the influence of the external environment and other related processes.

Vibration is the dominant factor negatively affecting the reliability of machines and equipment operating in severe emergencies and extreme conditions. Various methods are used to reduce the harmful effects of vibrations on machines and equipment. Usually, a damper is often used or the creation of new oscillations that are inverse in phase to existing ones. However, the recommended methods do not completely eliminate vibration, but only slightly reduce it. When using machines and mechanisms in severe emergency situations and extreme conditions due to frequent changes in working conditions, the nature, direction and magnitude of vibrations become unstable, which also negatively affects their elimination.

The main requirement for vibration control is that the vibration intensity should be minimal under any operating conditions of machines and mechanisms, which is practically impossible.

An analysis of the mechanism of the occurrence of vibrations shows that their formation is significantly influenced by factors of various nature: both constant, and regularly changing and random. Therefore, to regulate and evaluate vibrations, it can be effective to use various methods of mathematical statistics.

Gaps or other types of defects arising from the wear of the surfaces of parts of individual machines and equipment can be eliminated if mechanisms are provided for bringing

the contact surfaces together. Such control methods are used in rolling and sliding bearings, in worm and gear drives, in various types and types of threaded connections.

Intensive wear of the surfaces of parts is typical for machines and equipment operating in severe emergencies and extreme conditions. Wear worsens technical characteristics, especially the reliability parameters of machines and mechanisms operating under excess loads and in adverse atmospheric environments. Distortions of geometric shapes and uneven wear of high-precision working surfaces of critical parts also affect the quality of work performed, productivity, and operational reliability of machines and equipment.

To compensate for the surface wear of critical parts of machines and equipment operating in severe emergencies and extreme conditions, various methods can be used, such as auto-compensation, automatic clearance adjustment, a self-regulation system, active control methods, the principle of bringing worn surfaces together with the application of constantly acting forces, a system feedback, balancing principle, extreme regulation system, etc.

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Исследование влияния различных технологических факторов на надёжность машин и оборудований, эксплуатируемых в чрезвычайных ситуациях и экстремальных условиях

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Реферат

В статье приводятся результаты исследований по влиянию различных технологических факторов на надёжность машин и оборудований, эксплуатируемых в чрезвычайных ситуациях и экстремальных условиях. Обсуждаются полученные закономерности.

Ключевые слова: машины; оборудование; технологические факторы; экстремальные условия; надежность; аварийная ситуация; работоспособность.

Fövqəladə hallar şəraitində və ekstremal vəziyyətlərdə istismar olunan maşın və avadanlıqların etibarlılığına müxtəlif texnoloji amillərin təsirinin tədqiqi

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Xülasə

Məqalədə müxtəlif texnoloji amillərin fövqəladə hallar şəraitində və ekstremal vəziyyətlərdə istismar olunan maşın və avadanlıqların etibarlılığına təsiri ilə bağlı tədqiqatların nəticələri təqdim olunur. Əldə edilən qanunauyğunluqlar müzakirə olunur.

Açar sözlər: maşınlar; avadanlıq; texnoloji faktorlar; ekstremal şərait; etibarlılıq; qəza halları; işləmək qabiliyyəti.