ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

Volume 8
Issue 2
2023

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UDC 629.4.023.11

ANALYSIS OF EXISTING METHODS AND APPROACHES TO THE ASSESSMENT OF RESIDUAL RESOURCES OF TRACTION ROLLING STOCK

YUSUFOV ABDULAZIZ

Doctoral student of Tashkent State Transport University
E-mail: abdulazizyusufovv@bk.ru, phone.: (+99894) 308-88-08
Orcid: 0000-0001-8310-8225

Abstract:

Objective. The article presents an analysis of existing methods and approaches to assessing the residual life of elements of load-bearing structures of traction rolling stock. In this work, methods for assessing reliability indicators and reliability during the use of torsion action content are presented. The analysis of the characteristics characterizing the reliability of technical objects is presented. To confirm the validity of the forces acting on the motion, algebraic formulas are given.

Methods. Based on existing methods and approaches, statistical, quasi-static, dynamic, variable, multiple and low-cycle effects of loads were analyzed in detail. The Weibull equation, the Mazing principle.

Results. Structures of railway traction rolling stock during operation take on loads (static, quasi-static, dynamic, variable, multiple and low-cycle) that affect the design of the support at different levels and periods of use. At the same time, it causes both elastic and plastic deformations.

Conclusion. At the same time, it is necessary to achieve a uniform distribution of deformations and loads in the structure as a result of a gradual change and displacement of the mechanical properties of the metal structure material. Consideration of the deformed state of the traction rolling stock structure in the kinetic sense and analysis of the boundary states based on the criteria of cracks or permissible impact on the structure allows us to determine the appropriate limiting forces, the number of cycles and time characterizing the bearing capacity.

Keywors: residual resource, reliability, bearing capacity, statistical load, quasi-static load, dynamic load, variable, multiple and low cyclic loads, Weibull equation, Masing principle.

Introduction. The practical significance of the problem of the residual life of traction rolling stock in railway transport is even greater. Although at the current pace of scientific and technological progress, the moral wear of railway rolling stock machines is going faster than before, the real resource in many industries has not reached economically acceptable values. One of the biggest problems we face is that replacing obsolete railway equipment with new ones is not economically justified. The reason is that, although most of the machines used in railway transport are obsolete, their initial resource has not yet been completely exhausted [1,2,3,4,5]. Currently, the problem of determining the optimal variant of energy and labor costs spent on replenishing the fleet of locomotives and their repair, the solution of which contributes to the fulfillment of the tasks facing rail transport, is urgent.

Methods. To date, two directions of assessing the reliability of traction rolling stock have been formed. The first of them is operational reliability, the basic principles and methods of which are formulated by S. V. Serensen, V. P. Kogaev, R. M. Schneiderovich, R. V. Kugel, B. S. Kuznetsova, A.M. Scientists such as Sheinina have studied. The analysis of work in this direction shows that the procedure for determining reliability indicators in the presence of information about the nodes of traction rolling stock is reduced, so to speak, to the appropriate methods. However, research methods and operational reliability also have some disadvantages, the main one of which is that the duration of information payment takes a lot of time.

The second direction is the determination of reliability indicators in the design of the structure. In this direction, it should be noted that Academician E. A. Chudakov's method of calculating structures for strength in the form of reserve coefficients does not allow us to proceed to estimating the resource of parts, as for the intuitive forecasting method, which is advisable if the developed parts are compared with similar parts that have proven themselves well in the work [6,7,8].

According to GOST R 27.002-2009 (reliability in technology. Terms and definitions) reliability refers to the availability property and the reliability and maintenance properties that affect it. Reliability is a complex [9,10,11] that performs specified functions, preserves specified operational indicators, maintains its operational indicators within certain limits for a specified period of time or during the required working time.

Reliability indicators can be partially determined using stands at manufacturing plants and during various tests at repair facilities, but the most complete information about operational reliability can be obtained using archived data in repair depots. Information is collected on traction rolling stock, while not only malfunctions and malfunctions, various impacts (maintenance, current and major repairs) are recorded, but also the operating conditions of the rolling stock, for example; the transported cargo, the length of traffic, the percentage of traffic on various roads, etc.

Based on the results of observations, typical malfunctions of elements are identified, the causes of their occurrence are identified, details that limit their reliability are identified, parameters and types of resource allocation laws of these parts are determined, spare parts standards are evaluated, etc. [12,13,14].

Results. Improving the reliability of machines, equipment and devices is one of the priority areas of technology and technology development for the coming decade. The most important property characterizing the reliability, service life and resource intensity of technical objects. The theory of reliability allows us to assess the influence of factors on the average resource and resource allocation, to assess the residual resource in combination with methods and means of technical diagnostics.

Technical resource is a value that characterizes the reserve of useful operation of an object. According to GOST 27.002-89, a resource is the total uptime of an object from the beginning of its operation or restoration after repair to the transition to the limit state [15].

Units of measurement of residual resources are selected for each industry separately in relation to each class of machines, aggregates and structures. The best and universal unit from the point of view of theory and general methodology is a unit of time.

Firstly, the operating time of a technical facility as a whole includes not only the time of its useful work, but also the total working time and breaks. At the same time, in these gaps, the object is exposed to environmental influences and loads arising during operation. Thus, the aging process, when the properties of materials change, proportionally leads to a decrease in the total resource [16,17].

Secondly, the resource is closely related to the service life, which is defined as the calendar duration of the object's operation before the transition to the limit state and is measured in units of time. The service life of the object before decommissioning (planned, standard service life) is largely due to the pace of scientific and technological progress in this area.

Thirdly, when predicting the duration of the functioning of an object in the tasks of forecasting the residual resource of its functioning for a certain period of time, this is a random process, the argument of which is time. Thus, at runtime it is to determine the value of the random time function here [18].

Structures of railway traction rolling stock during operation take on loads (static, quasi-static, dynamic, variable, multiple and low-cycle) that affect the design of the support at different levels and periods of use. At the same time, it causes both elastic and plastic deformations. Loads (impacts) are characterized by the degree of propagation in space, the speed of their movement and other estimated parameters. To check the operability of the design of the traction rolling stock, the impact class and its characteristics are established, which should be reflected in the model. The belonging of an effect to a certain class is determined by its most important properties, depending on which the following classification is considered [19].

- Statistical (or quasi-static) effects that do not lead to a significant acceleration in the design.

Static loads refer to the effect of time on the development of fatigue failure of the structure or to single or less frequently repeated loads. Such loads (usually to a lesser extent), which can lead to a breakdown or breakdown of the structure due to fatigue, affect most traction moving parts. To do this, the calculation of the load-bearing capacity of traction moving parts should be based on statistical or repetitive statistical load-bearing capacity and endurance.

The load capacity of traction moving components affected by static load should be considered because of their effect on plastic deformation and movement, since in some cases the limiting state of the part should correspond to the presence of plastic deformations in it.

$$n = \frac{Q_{\text{пред}}}{Q_T} \cdot \frac{Q_T}{Q_{\text{раб}}} = \frac{Q_{\text{пред}}}{Q_{\text{раб}}} \cdot n_T \qquad (1)$$

In this place;

$Q_{\text{пред}}$ — the maximum load corresponding to the maximum permissible movement, load-bearing capacity or fatigue, depending on the criterion by which

In this expression, the coefficient $Q_{\text{пред}} / Q_{\text{раб}}$ shows how much the margin of safety differs from the usually calculated yield strength when calculating static load-bearing capacity.

- ➢ A dynamic effect that cause significant accelerations due to the variability of vibrations close to the main tone.
- ➢ O impact variables that change their values or positions at different points. In many cases, exposure variables are not constant. Then they can be characterized by discrete quantities, and they are considered as short-term processes over a period of time during which the effect exists.

Then these data can be characterized by discrete quantities, and during the period of time during which the effect exists, they are considered as short-term processes. If these loads exceed a certain level, irreversible changes will begin to occur in the metal structure element, which will lead to cracking. The crack, developing gradually, eventually leads to the rapid destruction of the elements of the traction rolling stock. This phenomenon is called metal fatigue.

The physicomechanical nature of the fatigue elimination process is studied by various methods (X-ray, microscopic, hardness and microhardness measurement, polarization-optical method in silver chloride, electric, etc.).

This is very convenient for solving cyclic problems, since this implies the similarity of single and cyclic deformation curves, and, consequently, the solution of the cyclic problem can be obtained on the basis of static solutions.

the static load-bearing capacity is determined;

Q_T — appropriate load to reach the current limit at the sharpest points of the structure;

n_T — safety margin when calculating the current strength.

In some cases, it is convenient to use the equation proposed by Weibull to describe fatigue curves.

$$(N_{\text{Б}} + B)(\sigma - \sigma_{-1})^q = K \qquad (2)$$

In this place;

σ_{-1}— the ultimate strength of the design sample, i.e. the highest value of the maximum cycle stress that it can withstand without breakage,

$N_{\text{Б}}$— it is called a test base (usually 10 million cycles for steel samples, 50-100 million cycles for light alloy samples).

The margin of safety in the calculation of static load-bearing capacity can be determined as follows:

- ➢ And the short-term effects that affect the structure over time are much less than the lifetime of the structure. The service life of a structure is a process with an interval of several iterations, which is affected by the load.

The generalized Masing principle is defined for a cyclic deformation curve as follows.

$$\frac{\overline{S}}{S_T^{(K)}} = f\left(\frac{\overline{E}}{S_T^{(K)}}\right) \qquad (3)$$

In this place;

$\mathrm{S}_{\mathrm{T}}^{(\mathrm{K})}$ – depending on the number of cycles, the coefficients are determined;

$\overline{\mathrm{E}}$ – accumulated fatigue in the structure.

Prolonged exposure to its element during the time corresponding to the service life of the structure. It is a continuous or continuous process with relatively small changes in load times during the same type of work cycles. At the same time, changes in the load value are determined by the characteristics of the locomotive equipment and its purpose (shunting, luggage).

Parts of various machines used in many machines, especially traction rolling stock, diesel engines, reactors, work for a long time under load at high temperatures. Some features of plastic deformation under these conditions lead to breakage or failure of its components. Deformations caused by compression can reach the limit values at which the machine will fail in time. As a result, the metal gradually weakens due to elastic stresses at the connection points of the structure, and the possibility of reuse of a certain service life by reducing the limiting stresses over time leads to a slow increase in deformations over time under the influence of constant loads.

In general, in order to determine the maximum load on distortion, it is necessary to determine the dependence of this load on deformations, calculate the final accumulation. It is necessary to determine the maximum number of cycles (time) for the specified time (number of cycles) and determine the endurance reserve.

$$n_N = \frac{N_{\text{пр}}Q}{N_{\text{раб}}} \quad \text{and} \quad n_t = \frac{t_{\text{пр}}Q}{t_{\text{раб}}} \qquad (4)$$

Special effects resulting from very rare effects. With the help of modern engineering programs, it is necessary to determine the probability of their occurrence [20].

Conclusion. During long-term operation of structural elements under alternating stresses (millions), the limiting state is determined mainly by changes in the state of the metal, which gradually accumulate in it as a result of deformation (fatigue process). If the structures operate at high temperatures, time becomes one of the factors leading to the occurrence of boundary conditions. At the same time, it is necessary to achieve a uniform distribution of deformations and loads in the structure as a result of a gradual change and displacement of the mechanical properties of the metal structure material. Consideration of the deformed state of the traction rolling stock structure in the kinetic sense and analysis of the boundary states based on the criteria of cracks or permissible impact on the structure allows us to determine the appropriate limiting forces, the number of cycles and time characterizing the bearing capacity.

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