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APPROACHES TO MAINTAINING THE RELIABILITY OF AUTOMOTIVE ENGINES UNDER HIGH-TEMPERATURE CLIMATE CONDITIONS

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Annotation: The main results of research work related to the development of theoretical and experimental methods for assessing the reliability of automobile engines operating in extreme hot climatic conditions based on the strength of internal combustion engines at the stage of their design and development are outlined. The most characteristic types and sources of engine failures, reliability criteria for engine elements are considered.
Keywords: Engine, reliability, design, various operating conditions, failures, strength, tension.

Introduction

One of the most important characteristics of modern internal combustion engines is their reliability, which makes it possible to quantify the change in engine quality over the time of its operation. Such an assessment greatly facilitates the development of comprehensive measures for the further improvement of existing and the creation of new engine designs, and contributes to an increase in the efficiency of their operation [1]. At the same time, the analysis of the nature and consequences of failures is one of the important stages in ensuring the reliability of the engine design, as well as a necessary means of assessing reliability at the initial stage of design, taking into account various operating conditions . Such an analysis allows you to establish the degree of influence of failures on the engine design and, if necessary, make appropriate changes to it, in addition, compile a list of possible failures for each part and identify the degree of their influence on the considered engine assembly or system. Figure 1 shows the main steps we propose to analyze the nature and consequences of failures for automobile engines operating in hot climatic operating conditions [2,3]. In practice, it is also necessary to consider the degree of influence of failures, that is, how seriously the nature of this failure affects the performance of the engine. This procedure, called the analysis of the nature, consequences and severity of failures, allows a more detailed analysis of the entire engine design by evaluating the impact of failure of each part, creates convenience, ease of understanding opinions between designers, helps to identify weaknesses in the designed design and identify areas for which additional or more careful analysis is required and this is of particular importance for extreme operating conditions [4]. In this regard, the requirements for the reliability of engines were distributed. It is known that the engine is a complex system and to ensure its trouble-free and durable operation, reliability indicators are predetermined for its individual systems, components and parts. This allows you to ensure the reliability of each element and, ultimately, the engine itself. Such an event for setting reliability indicators is called the distribution of reliability requirements by engine elements [5]. As a rule, such work is carried out before major decisions are made in the design or development of the engine structure.

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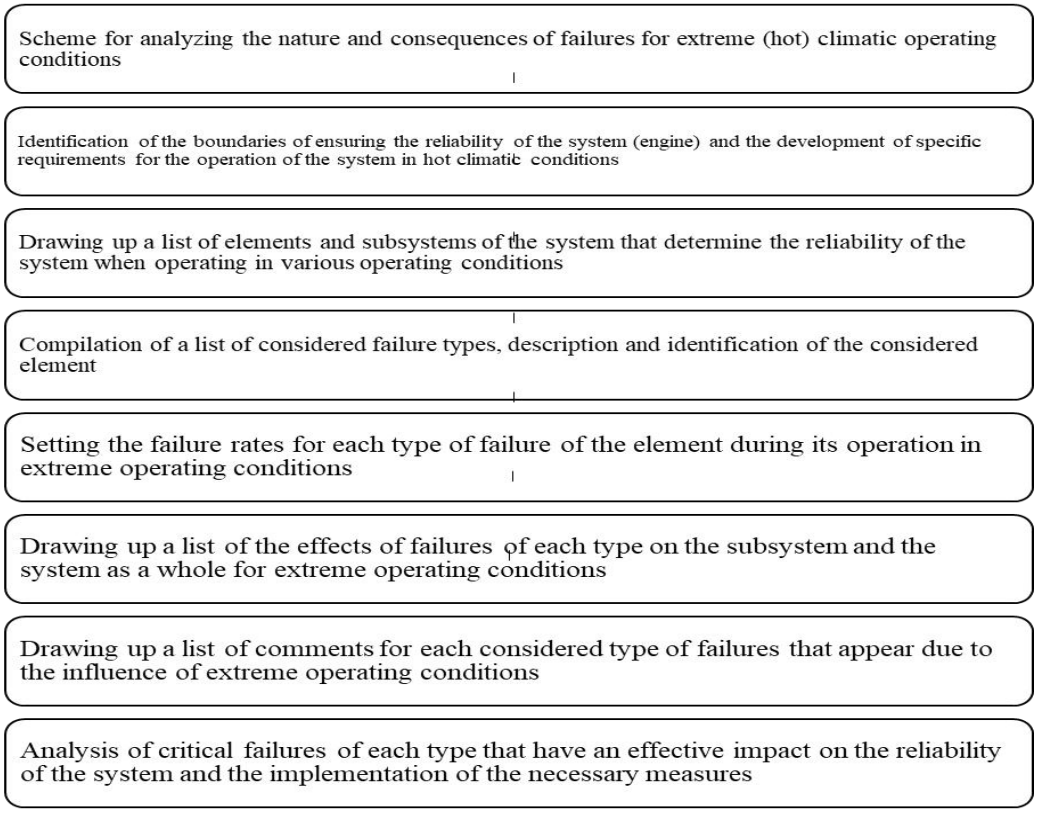

Figure 1. Scheme for analyzing the nature and consequences of engine failures as a system

Methods. When ensuring the reliability of an engine at the stage of its design, two methods are usually used: the method of similarly distributing reliability requirements by elements and the method of taking into account the factors affecting reliability [6].

The first method involves familiarizing the designer with similar systems, assemblies and engine parts. In this case, the designer uses data on failures of parts, assemblies and systems from similar engine designs obtained from various sources. The main disadvantage of the method is that a new engine and its elements are created based on the cost of designing and analyzing data on the reliability indicators of existing structures [7].

The second method is based on the consideration and analysis of the main factors that significantly affect the performance of the engine being created:

- environmental conditions. It takes into account such operating conditions as temperature, humidity, air dust content, vibration, etc. The method shows the sensitivity of the design to important environmental factors;
- modern technical level. The method takes into account the achieved level of excellence for a particular engine element or system;
- design complexity and resource. The complexity of the design is determined by the number of constituent elements and systems of the engine, and the resource is determined by the relative duration of its operating state during the entire period of operation;
— the severity of the system or component failure. The method takes into account how seriously the engine is affected by failures of its systems and components.

If methods are used separately, it is difficult to obtain the expected effect, since each of them has a drawback, therefore, in practice, it is necessary to combine both methods. This allows you to

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get better results by sharing data about both similar elements and information about new elements developed under the influence of other factors.

It is very important to develop stringent requirements and take into account harsh operating conditions. In connection with the high costs of developing engines operating in extremely difficult conditions (cold regions, hot climate zones and high mountains, etc.), the problem of ensuring their reliability is of particular importance.

Results and discussion

More than 90-95% of engine parts consist of mechanical elements, which allows us to accept: an engine failure occurs if the strength of the element or assembly material is less than the stress perceived by them.

Strength is the ability of a material, element or engine assembly to satisfactorily perform a given function without destruction when exposed to external loads and extreme environmental conditions.

Stress is the state of a part that occurs as a result of a load that tends to cause destruction of the material of an engine element or assembly. In this case, the load is understood as a mechanical load, as well as the influence of the environment, temperature, electric current, humidity, pollution, etc.

Due to the imperfection of technology or fluctuations in geometric dimensions, the strength is variable, which can be described by a certain distribution law. At the same time, the expected strength should be assessed taking into account all the main types of variability.

It is important to note that with a small spread of strength values, the reliability is higher than in the case of a distribution with the same average value, but with a larger dispersion. The following factors influence the increase in distribution dispersion: fatigue of a mechanical element, corrosion, wear, etc. For manifestation of the influence of these factors on the change in strength, a certain period of time is necessary, i.e., the distribution of strength is a function of time.

Stress, like strength, is variable, which is also affected by operating conditions, the quality of maintenance, the environment, etc. If an object (engine) is tested under controlled laboratory conditions, then the load on the engine elements can be taken constant, the voltages corresponding to it will also be constant . Therefore, the voltage is variable only in the conditions of actual operation of the engine.

When evaluating the distribution of stress and strength parameters of a mechanical part of an engine, by analyzing the relationship between stress and strength distributions, it is possible to calculate the probability of failure-free operation of a mechanical part. This method of calculation is considered in.

Figure 2 shows the dependence of the reliability of engine elements on the relationship between the parameters of stress distribution and strength.

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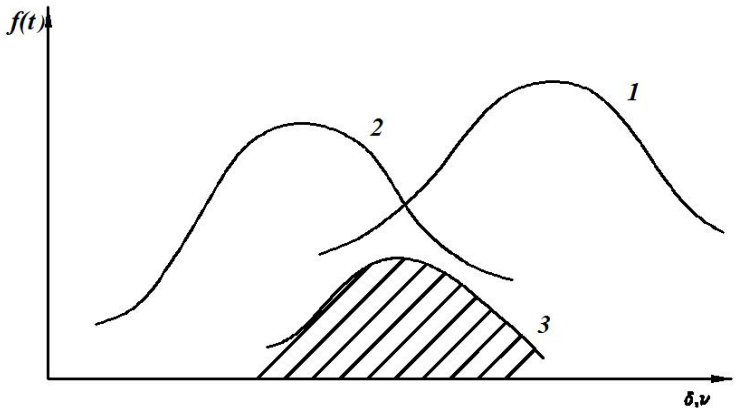

Figure 2. Dependence of reliability on the ratio between stress (δ) and strength distributions (ν):
1 - stress distribution, 2 - strength, 3 - area of reliable operation

Such a premise is applicable only in cases where there are no significant changes in the properties of engine elements during a given time interval. It is assumed that the manifestation of failure depends on the current voltage value, and not on the nature of the change in voltage parameters in the past.

Further development of the science of machine reliability should be based on the achievements of fundamental and applied sciences. This will make it possible to deeply study and analyze physical and chemical processes and phenomena, reveal their patterns and, ultimately, create machines with predetermined reliability indicators.

A detailed analysis and examples of optimizing the reliability of mechanical elements of various systems are given in.

Conclusion

The development of reliability models based on the relationship between strength and stress distributions is a promising approach to solving problems of ensuring the reliability of engine mechanical elements. But for its practical application it is necessary to solve the following problems:

creation of operational methods for obtaining real data on the operating conditions of engine elements, the absence of which makes it difficult to assess the typical stresses and environmental influences under which the element operates;

finding ways to obtain data on the variability of material properties over time;

further improvement of existing mathematical methods and probabilistic models for assessing reliability, which allows more accurate prediction of the reliability of engine elements.

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