

**“Assessment of the residual service life of wheeled motor units:
methods, problems and prospects”**

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Abstract. This article analyzes existing scientific approaches to assessing the residual life of wheel motor blocks, including statistical, diagnostic, modeling, and artificial intelligence-based methods. The advantages of each method are examined alongside their practical limitations. The author provides recommendations for implementing hybrid approaches, multi-parameter assessment systems, and the development of practical data bases tailored to the operational conditions in Uzbekistan. The article aims to improve the efficiency of technical maintenance, enable early fault detection, and ensure the operational reliability of motor blocks.

Keywords: wheel motor block, residual life, diagnostics, statistical methods, modeling, artificial intelligence, maintenance, vibration analysis, electromechanical system, technical reliability.

Introduction

Wheel motor units are an important part of railway transport, playing a large role in ensuring their reliability and durability, as well as maintenance costs, safety, and efficiency. This article analyzes existing approaches to assessing the residual life of wheel motor blocks, highlights problems, and provides scientific and practical recommendations.[1-5]

Literature review

There are many scientific developments on the assessment of the residual life of wheel motor units. They mainly rely on statistical, diagnostic, model-based, and artificial intelligence (AI) approaches. Statistical methods are based on old data, while diagnostic approaches rely on technical tools. Methods of physical-mathematical modeling allow for a deeper analysis of the functioning of components, but they increase complexity. Although AI technologies are promising, their effectiveness requires a large volume of high-quality data.

Analysis of problems and gaps. Analysis of the literature shows that, despite the numerous advantages of existing approaches used in assessing the residual life of traction motor blocks, in particular, the wheel motor block, there are also significant shortcomings and scientific and practical gaps associated with them. Below, these problems are analyzed in the context of each approach.

Limited applicability of statistical methods. Statistical approaches usually work on the basis of a large amount of historical data. However, in real practice, such data is not collected continuously and qualitatively. Particularly for components operating under load, such as wheel motor blocks, such parameters as production conditions, load modes, and service life are variable, and it is difficult to adapt them to a single statistical model. Also, statistical models often estimate only the average wear rate, which does not take into account the actual state of each individual motor unit.[6]

Practical limitations of diagnostic methods. Diagnostic approaches require high-precision technical tools, experienced specialists, and real-time monitoring systems. Such resources are not always available at production or service locations. The collection and analysis of vibration, thermographic, or electro technical diagnostic data requires valuable equipment, and in many cases, continuous monitoring systems. In addition, the interpretation of diagnostic signs can be different, which leads to an incorrect assessment. Therefore, the universality of these methods is low, and they lack standardized evaluation criteria.

The complexity of modeling-based approaches. Although mathematical and physical models are distinguished by their accuracy, they require the determination of a large number of parameters. For example, if such indicators as the thermal model of the electric motor, the distribution of the magnetic field, and the degree of mechanical wear and tear are not constantly monitored, the models deviate from real conditions. In addition, each model is adapted to a certain type of engine block, that is, it needs to be reconfigured to be applied to other types of devices. This complicates the widespread use of resource assessment.

Methods based on artificial intelligence are in the development stage. Although systems based on artificial intelligence and machine learning are very promising approaches, there are still several obstacles to their widespread adoption. Firstly, these systems require a large training database. In many cases, such information is not fully formed among the producers. Secondly, machine learning results are often based on the “black box” principle, meaning it's impossible to explain what conclusion the system drew. This reduces trust in AI systems among technical specialists.[2]

Lack of methodological approaches in local conditions. Many wheel motor blocks used in Uzbekistan are manufactured abroad, and there is no detailed technical resource documentation on their operational characteristics. In addition, technical regulations, methodological guidelines, or standardized diagnostic criteria

at the national level have not been sufficiently developed. This is a significant obstacle to the practical application of the results of scientific research.

Need for integrated approaches. In the current situation, each of the valuation approaches is used separately. But since real technical systems are complex, a combination of integrated approaches - that is, statistical, diagnostic, model, and AI methods - can give more results. Such complex systems provide not only a theoretically sound assessment, but also a reliable assessment in practice. Currently, there are few studies on such complex systems in the literature.[4]

Conclusion.

Based on the analysis of the above-mentioned literature and the analysis of existing problems, it has become obvious that the problem of assessing the residual life of a wheeled motor is currently relevant and requires a deep scientific and practical approach. Although the existing methods - statistical, diagnostic, physical modeling, and approaches based on artificial intelligence (AI) - each has its own advantages, all of them have certain limitations.

Although statistical approaches yield good results when sufficient historical data is available, they do not take into account the real-time situation. Diagnostic methods, while being highly accurate, depend on equipment and experienced specialists. Although modeling-based approaches provide an individual approach, they are difficult to use on a large scale. Although AI technologies are promising, their effectiveness requires a large amount of high-quality data.

Based on this, the following conclusions and recommendations can be made:

A multi-parameter evaluation system needs to be developed. Evaluation systems based not only on one or two parameters, but also on a complex of indicators (temperature, vibration, rotational speed, current, load, wear) are more effective.

Hybrid approaches, combining statistical and diagnostic methods, should be implemented. For example, real-time diagnostic data can be entered into the statistical model as an “adaptation”.

It is necessary to increase the number of studies aimed at the practical implementation of AI and digital twin technologies. For this, monitoring systems should be established in cooperation with manufacturers.

Methodological recommendations should be developed in accordance with local conditions. It is necessary to develop resource assessment criteria, taking into account the condition, operating modes, and service life of the wheeled motor blocks operated in Uzbekistan.

It is necessary to form a database of practical experience. Diagnostic results, service protocols, and failure statistics should be collected in a single system. This will be an important resource for further modeling and training of AI systems.

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