ALGORITHMS FOR FORECASTING THE LIFE OF MODERN TECHNOLOGICAL MACHINES

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Annotation: This scientific article is devoted to the development and implementation of algorithms for forecasting the life of modern technological machines. The study analyzed the dynamics of wear and damage that occur during the operation of machines under mechanical, thermal and vibration loads. The possibilities of accurately assessing the duration of operation by integrating real-time monitoring systems, sensor data, historical performance statistics and the results of physical and mathematical modeling are highlighted. Using algorithmic approaches developed on the basis of artificial intelligence, big data analysis and digital twin technology, mechanisms for obtaining accurate forecasts of the life of machines, optimizing maintenance processes and minimizing production stops are shown. Also, the possibilities of increasing the economic efficiency of production, optimizing spare parts management, and improving constructive solutions at the design stage are scientifically revealed.

Keywords: Service life, technological machines, forecasting algorithms, wear dynamics, physical and mathematical modeling, artificial intelligence, digital twin, big data analysis, maintenance, production efficiency.

The service life of technological machines directly depends not only on their structural perfection, but also on the conditions of their use, the quality of maintenance, and the load regimes in the production process. The issue of accurately predicting the service life of machines in industrial systems is of strategic importance in ensuring the stability, continuity, and economic efficiency of production. Algorithmic approaches, that is, forecasting systems based on special mathematical and computational models, play a central role in this. Modern technological machines are combined with a high level of mechanization, automation, and digitalization, and the possibilities of continuous monitoring of their operating parameters have expanded. Therefore, the analysis of real-time data, historical performance statistics and the integration of physical and mechanical modeling results are key factors in the forecasting of the operational duration.

Mechanical, thermal, vibration and other types of loads that occur during the operation of technological machines gradually cause wear, deformation or breakage of their main parts. If the dynamics of these processes are analyzed with sufficient accuracy, it will be possible to plan maintenance or modernization measures before the end of the machine's operational life. This will reduce downtime in production, increase productivity and reduce unnecessary costs. In algorithmic forecasting, a large amount of data from the history of the operation of mechanical parts, real-time parameters measured by sensors and strength indicators obtained in laboratory tests are combined into a single database. This data is then processed using mathematical regression, time series analysis or a model based on artificial intelligence.

Among modern approaches, there is a growing trend to consider not only technical parameters, but also environmental and economic factors when assessing the life of a machine. For example, if energy consumption increases in the final stages of a machine's operation or the quality of the processed product decreases, this indicates that its service life is approaching its end. Therefore, algorithms are often based not only on mechanical damage models, but also on system efficiency indicators. Using digital twin technology,A virtual copy of a technological machine used in the production process is created and its operating scenarios are modeled based on real-time data. This approach allows for a much more accurate forecast of the machine's future state.

When developing forecasting algorithms, it is very important to model the performance characteristics of the machine under different operating conditions. For example, a technological machine of the same design can wear out at different rates in cold climates and in environments with high humidity. Therefore, algorithms must have parametric flexibility, that is, they must have the ability to automatically update the results taking into account the results of operation in different conditions. In this process, technologies such as physical and mathematical models, statistical analysis, and neural networks are used together. While physical and mathematical models explain the stress, deformation, and fatigue processes in machine parts on a theoretical basis, statistical analysis uses real data to represent them with precise numbers. Neural networks, on the other hand, allow for the identification of complex and nonlinear relationships.

The accuracy of diagnostic systems also plays a major role in the creation of reliable forecasting algorithms. Modern technological machines are equipped with smart sensors and IoT technologies that continuously measure hundreds of different parameters — such as vibration amplitude, rotational speed, temperature, pressure, oil condition, etc. Time series models based on these parameters provide a more accurate picture of the wear process. For example, when the oil viscosity drops below a certain threshold or the bearing temperature increases, it indicates that a future failure is approaching.

Algorithms for predicting the service life not only improve maintenance strategies, but can also be used to optimize machine design. By anticipating the most common wear points when developing new machines, designers can take measures to strengthen the structure or redistribute loads. In addition, from an economic point of view, such algorithms can optimize costs over the life of technological machines, reduce the cost of storing excess spare parts, and minimize production downtime.

Thus, algorithms for predicting the operational life of modern technological machines are becoming an indispensable tool for increasing the efficiency of the production process, optimizing maintenance planning, and reducing overall operating costs. Advanced algorithms created through the integration of digital technologies, big data analysis, physical-mathematical modeling, and artificial intelligence serve not only to accurately determine the operational life of machines, but also to ensure their optimal operation throughout their entire life cycle.

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