SECTION 6. ELECTRIC POWER ENGINEERING, ELECTRIC ENGINEERING AND ELECTROMECHANICS

DOI https://doi.org/10.30525/978-9934-26-612-6-10

SYSTEMS FOR INTELLIGENT MONITORING AND PREDICTIVE DIAGNOSTICS OF COLD ROLLING MILLS ELECTRIC DRIVES

СИСТЕМИ ІНТЕЛЕКТУАЛЬНОГО МОНІТОРИНГУ ТА ПРОГНОЗНОЇ ДІАГНОСТИКИ ЕЛЕКТРОПРИВОДІВ СТАНІВ ХОЛОДНОЇ ПРОКАТКИ

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Electric drives of rolling production, which are connected to each other by a strip of rolled metal, are the most complex mechanisms. They have elastic links, variable moments of load and inertia, a wide range of changing operating speeds. A number of strict requirements are imposed on these control systems: high speed, smoothness of movement, absence of over-regulation in transient modes, required margin of stability, reliability, manufacturability and maintenance. The use of a database of electro-mechanical processes in the creation of an intelligent system of automated control of multi-mass electric drives of cold rolling mills will allow to improve the existing protection systems and algorithms for exiting an emergency situation. Therefore, the development of an automated intelligent control system for a multi-mass electric drive of a cold rolling mill is an actual task.

Monitoring and diagnostics systems for electric drives in cold rolling mills are crucial for ensuring reliable and efficient operation of rolling mills. Such systems monitor the technical condition of electric drives, detect malfunctions at early stages and help prevent accidents [1, 2]. The main diagnostic systems are divided by methods and level of automation.

It is possible to conditionally distinguish the main types of systems for diagnosing electric drives for cold rolling. Systems based on the analysis of electrical parameters – they measure voltage, current, frequency, power and other parameters to detect deviations [3]. For example, the analysis of harmonics in current and voltage (detection of imbalances, short circuits) or spectral analysis of the motor current. Vibration diagnostics – monitors the vibrations of the motor, gearbox or other elements, which allows you to detect mechanical malfunctions (imbalance, bearing wear, loosening of fasteners). Temperature monitoring – thermal sensors or thermal imagers are used to monitor the temperature of the motor, bearings and windings. PLC and SCADA-based systems, which constantly monitor the state of the electric drive in real time, are integrated with the rolling mill control system. Intelligent systems based on machine learning, which analyze large data sets from sensors and build forecasts based on behavior models [4].

This principle has been used to implement the functions of failure prediction, adaptive maintenance, and self-learning based on data on past failures [5]. Expert diagnostic systems – contain a knowledge base of typical failures of electric drives and use logical inference algorithms to identify problems [6]. Complex systems – integrate several methods simultaneously.

Operators can intuitively notice the status and problems in the operation of cold rolling mills through a human-machine interface that displays various statistical status signals and diagnostic results of the rolling mills [7]. Hot and cold rolling of steel strips are mainly monitored by optical or radiometric measuring systems. However, they still face challenges due to harsh environmental conditions. To address some of these challenges, a prototype system consisting of eight radar sensors is being developed to measure the thickness of steel strips on hot and cold rolling mills [8].

The prospects for the development of monitoring and diagnostic systems for metallurgical rolling mills are directly related to the introduction of intelligent technologies capable of providing a new level of automation and reliability. The use of artificial intelligence and machine learning will allow for timely detection of anomalies in the operation of electric drives and predicting equipment failures. Intelligent sensors and Internet of Things systems will ensure continuous collection and transmission of data in real time from all nodes of the rolling mill. Based on large data sets, it will be possible to create digital twins of electric drives for modeling and optimizing their operating modes. This will help reduce energy consumption and increase the service life of equipment. The development of cloud technologies will provide centralized access to monitoring data and the integration of diagnostic systems into a single production complex. The introduction of intelligent technologies will allow for the transition from reactive to predictive and preventive maintenance of rolling mills. In the future, this will significantly increase the efficiency, reliability and competitiveness of metallurgical production.

The prospects for using fuzzy logic systems in rolling production are associated with their ability to work effectively in conditions of uncertainty and complex nonlinear processes. Unlike classical control algorithms, fuzzy systems can take into account approximate and linguistic rules, which allows formalizing the experience of operating engineers. This opens up the possibility of quickly predicting the development of potentially emergency situations, even in the absence of complete information about the state of the system. By integrating fuzzy logic with IoT sensors, it is possible to create adaptive diagnostic modules that will analyze critical parameters (vibrations, loads, temperature, rolling speed) in real time. Combining fuzzy logic with machine learning methods will allow systems to self-learn and improve their rules during operation. This will help reduce the likelihood of accidents, reduce downtime and increase the resource of equipment. In the future, such systems will become an important element of complex intelligent rolling mill control platforms, integrated into the concept of "digital twins" and "smart factories."

Conclusions. Thus, the prospects for the development of monitoring and diagnostic systems for metallurgical rolling mills are determined by the transition to intelligent technologies within the framework of the Industry 4.0 concept. The use of artificial intelligence and machine learning will provide automated detection of faults and prediction of failures of electric drives. Integration of IoT sensors will allow organizing continuous monitoring of operating parameters in real time, while digital twins will open up the possibility of modeling operating modes and optimizing technological processes. The use of Big Data and cloud services will contribute to the effective management of large volumes of information and provide centralized access to analytics. The transition to predictive and preventive maintenance will increase the resource and reliability of equipment, reduce energy consumption and repair costs. In the future, integrated intelligent monitoring systems will become the basis of cyber-physical complexes that will ensure increased efficiency, safety and competitiveness of metallurgical production.

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