UDC 621.313.333
Hizenko Mykola
PhD stud., National University "Zaporizhzhia Polytechnic"

FEATURES OF RESEARCH ON ELECTROMAGNETIC PROCESSES IN ELECTROMECHANICAL CONVERTERS WITH A COMMON SHAFT

The labor intensity of testing electrical machines can reach up to 13% of the labor intensity of their manufacturing, and the energy consumption for testing powerful asynchronous machines can amount to hundreds of thousands of kWh. Therefore, researching energy-saving methods for testing asynchronous machines is highly relevant. The energy-efficient method of machine testing using mutual load with energy recuperation into the grid involves operating electrical machines with connected shafts, where one asynchronous machine operates as a motor and the other, connected to the first by a common shaft, operates as a generator. The motor is powered by a high-frequency source, such as a frequency converter, while the generator, connected to the motor by a common shaft, feeds energy back into a lower-frequency grid. Both machines are tested simultaneously. The energy drawn from the grid is returned to it, minus the losses in the electromechanical converters themselves. Currently, there are only a few existing test setups for powerful asynchronous motors with energy recuperation into the grid. This is partly due to insufficient research on methods for predicting electromechanical processes in asynchronous machines with a common shaft.

The operation of multiple asynchronous motors on a common shaft—sharing a mechanical load—can be applied in various systems, such as belt conveyors and rolling mills. In powerful marine electric propulsion systems, a dual-motor unit (dual-motor configuration) with a single common shaft is used. This approach enhances the reliability of the installation: if one of the motors fails, the other continues to carry the mechanical load, albeit at a reduced capacity. This setup reduces the required emergency power reserve of the motors and allows for energy savings under low mechanical loads by deactivating some of the electromechanical converters. It also provides other well-known benefits of parallel operation. In transport systems, particularly in hybrid electromechanical transmissions, the use of multiple traction asynchronous machines is a promising approach. In electromechanical vehicle transmissions, asynchronous in-wheel motors each carry their share of the mechanical load. Under certain conditions, some of the motors operating in parallel on a common shaft may experience overload, while others may transition into generator mode or function as an electromagnetic brake.

It can be assumed that in electromechanical converters with a common shaft, electromechanical processes are interconnected, as the torques of the machines on the shaft are interdependent. Currently, modeling of electromechanical converters with a common shaft is carried out using standard but unconnected equivalent circuit models of electrical machines. These models do not account for mutual electromechanical interactions, magnetic saturation, variations in machine winding parameters depending on operating conditions, or the non-sinusoidal nature of the supply voltage from a frequency converter. The error in determining electromagnetic parameters in dynamic operating modes of asynchronous machines with a common shaft can reach several tens of percent when using simplified models. Thus, accurate and interconnected modeling of electromechanical processes in asynchronous machines with a common shaft has not yet been sufficiently developed.

Refined modeling of electromechanical processes in asynchronous machines with a common shaft is challenging due to the complexity of simultaneously describing all electromechanical converters mathematically. This complexity arises from factors such as varying levels of magnetic circuit saturation in different machines, the presence of torque interdependence equations, the need to account for changes in winding parameters as operating modes shift, and the possibility of one machine being powered by a frequency converter while the other operates on the grid. It is essential to develop accurate methods for analyzing electromechanical processes during startup, testing, and loading of asynchronous machines with a common shaft, as well as for predicting hazardous operating conditions. These conditions may include the transition of some machines into electromagnetic braking mode, inrush currents during startup, and potential issues associated with high-power machines. Therefore, the development of precise methodologies for studying asynchronous machines with a common shaft is a relevant scientific and technical challenge.