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PECULIARITIES OF AC MOTOR MODELING

The modeling of electric machines, particularly AC motors, plays a key role in analyzing their operation, designing new structures, and developing efficient control systems. Modern modeling approaches not only allow for the prediction of motor characteristics but also enable the optimization of its parameters, improving energy efficiency and reliability [1].

Let us consider the mathematical and computer modeling features of asynchronous and synchronous motors, the main methods and tools, and the challenges in modeling electromechanical processes [1].

Several approaches to modeling AC motors are analytical, numerical, and hybrid. Analytical methods are based on classical equations of electromagnetic processes (Maxwell's equations, energy balance equations). They allow for obtaining exact expressions for key characteristics but require system simplifications [1].

Numerical methods include finite difference methods (FDM) and finite element methods (FEM). They are used to model complex electromagnetic fields and current distribution in windings.

Hybrid methods combine analytical and numerical approaches to achieve more accurate and faster calculations of motor parameters.

When modeling asynchronous motors, the following features are considered [2]:

1. Electromagnetic processes in the stator and rotor. Equations are used to calculate magnetic flux, current in the windings, and electromagnetic torque. In asynchronous machines, the current in the rotor is induced by electromagnetic induction, which requires accounting for slip.

2. Coordinate transformation (α , β , or d-q models). This simplifies the equations and allows for switching to a convenient reference frame, especially useful for analyzing transient processes.

3. Accounting for magnetic saturation. Under real conditions, the motor's magnetic circuit is not ideal, so it is necessary to consider the nonlinearity of magnetic permeability.

Synchronous motors are characterized by a rigid relationship between the rotational speed and the supply voltage frequency. Their modeling includes [2]:

1. Accounting for rotor excitation. For synchronous machines, it is important to model the excitation system, whether it consists of permanent magnets or windings with current supply;

2. The influence of the load angle (δ -angle). Synchronous machine models analyze the dependence of the electromagnetic torque on the angle between the stator voltage vector and the rotor magnetic flux;

3. Dynamic operating modes. These include processes such as starting, synchronization, and transient phenomena during load changes;

4. Numerical methods for field calculation. These assess electromagnetic forces and temperature conditions, which are particularly important for high-power machines.

Modern software packages enable the solution of complex electric motor modeling tasks. Some of the most popular tools include: MATLAB/Simulink (convenient for simulation modeling, control system creation, and transient process analysis); ANSYS Maxwell (uses the finite element method (FEM) for modeling magnetic fields and thermal processes); COMSOL Multiphysics (allows simultaneous modeling of electromagnetic and mechanical processes); Motor-CAD (optimized for calculating thermal and mechanical characteristics of electric motors) [2].

Despite the advanced modeling methods, there are still unresolved issues [2]:

1. High computational complexity (Full-scale numerical modeling requires significant resources, especially for 3D analysis);

2. Model accuracy (Simplified models result in deviations from real characteristics, while complex models require much calculation time);

3. Accounting for nonlinear effects (Hysteresis losses, magnetic core saturation, and turbulent processes in cooling systems).

Modeling AC motors is crucial for designing, diagnosing, and optimizing their operation. Modern methods and software tools allow for detailed analysis of machine behavior, but challenges related to computational complexity and model

accuracy remain. The development of computational technologies and the implementation of intelligent algorithms offer the potential for significant improvements in this field, which will contribute to creating more efficient and reliable electrical machines.

REFERENCES

1. Mali P. Design, Modeling, and Analysis of a Permanent Magnet Synchronous Motor (PMSM) for Electric Vehicles [Electronic resource] / P. Mali, D. Susitra. – Access mode: <https://ieeexplore.ieee.org/document/10482354/> (accessed: 02.04.2024). – Title from the monitor.
2. Mou B. A Transient Conducted EM Disturbances Source Modeling Method for Electromagnetic Launch System Based on the Cascaded Multi-Port Circuit Model [Electronic resource] / B. Mou, Q. Liu, Zh. Chen, X. Wu, Y. Li, Ch. Huang. – Access mode: <https://ieeexplore.ieee.org/document/10811917/> (accessed: 2024.12.23). – Title from the monitor.