УДК 621.3.078

ELECTRIC DRIVE WITH FIELD REGULATED RELUCTANCE MACHINE

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Introduction. The promising alternative to the most widely used induction electrical drive is one based on a field regulated reluctance machine (FRRM). Main advantages of this type of motors are: high efficiency factor within a wide speed range; a simple design and low production costs; high manufacturability and reliability; a wider speed control range in a zone of reduced magnetic flux; an easier heat removal. FRRM has a passive rotor with tooth structure and a stator with a classic distributed “star” 3-phase winding. Additionally, there is an excitation winding which is supplied from a direct current source. Electromagnetic flow of this motor, in its nature, is active.

Miscalculations during identification of the parameters of the equivalent circuit of the FRRM can be caused by assumptions used in an applied methodology, as well as by the lack of basic information. During the motor operation, resistance of windings may be changed because of heating, and inertia moment may be deviated through changes of the kinematics. These parametric deviations resulted in differences between estimated and actual parameters of the electrical drive, which, in turn, leads to worsening of control performance.

The FRRM, as well as other types of alternating current motors, is an interrelated controlled object, substantially dependent on influence of inducted eddy currents. In this case, electrical drive control requires compensation of negative influence of these coordinate disturbances.

Solution of the above-mentioned problems by the classic methods of the automatic control theory, under the under conditions of uncertainties in a mathematical model, is rather complicated because requires additional algorithms of identification, adaptation or compensation. Analysis of methods for control law optimization showed that solutions can be found based on a concept of reverse task of dynamics in combination with minimization of local functionals of instantaneous values of energies. The reverse task of dynamics is to identify the control law which would ensure a given quality of control with desired static and dynamic performance of the system.

This paper is aimed at the identification of respective control laws which would allow a lesser sensitivity to variations of the motor’s parameters, as well as the simplicity of realization of the control system, and consequently ensure good control performance of electrical drive, required for most of industrial technologies.

Materials and results obtained. A combination of the minimization of local functionals of energies’ instantaneous values with a concept of the reverse task of dynamics can be effectively used for control of the complex objects. The control action is to be found based on the mathematical model of the object and the desired trajectory of motion.

The control loop has the given Lyapunov function, which is the instantaneous value of energy. This ensures the system stability. The specificity of optimization is that it is necessary to obtain a certain minimal value, not zero, of the quality functional. This value assures the allowed dynamic error of the system with the absence of the static error.

This method provides the dynamic decomposition of the object, and this is the *first advantage* of this control method. During the operation, the system is splitting into a number of local control loops. The extent of the decomposition depends on their gain coefficients.

In this case, the control laws of the system controllers do not have paraments of the object, comparing with the classical control laws. Controllers provide motion of the object according to the desired trajectory, as well as a low sensitivity to variations of its parameters. This is the *second advantage* of this method of the control.

From the control point of view, the FRRM is similar to a classic synchronous motor, and its constructive features allow applying the direct vector control system with rotor position orientation. The vector control system consist of four control loops: for stator d-axis current, q-axis current, excitation current and motor speed. The speed loop is external to the internal loop of current. This current defines a value of the electromagnetic torque of a motor. The excitation current can be easily controlled within the range 1:8. This allows increasing a range of speed control with a constant power, in comparison with induction motor.

Fig. 1 illustrates the block diagram of the current controller. The designed controller does not include parameters of the controlled object. It has only one parameter.

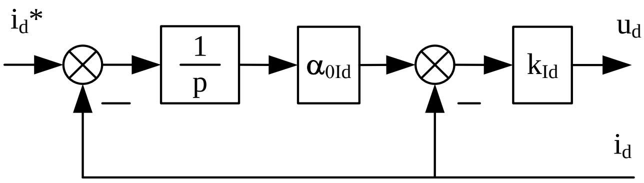

Figure 1. Block diagram of current controller

The technological conditions may require ensuring the type 2 astatism. In this case, the speed control has to be designed based on the desired equation with an order of one unit higher than an order of the equation of the local object. Block diagram of 2nd order speed controller is presented in Fig. 2.

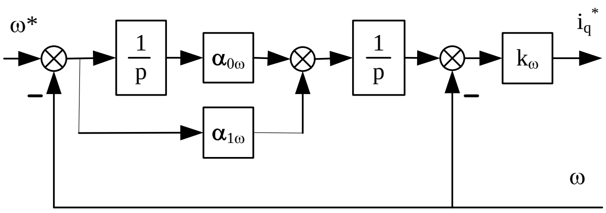

Figure 2. Block diagram of the 2nd order speed controller

Conclusions. Proposed electrical drive based on the field regulated reluctance machine (FRRM) can be designed based on the relatively simple methodology, which is based on combined using of i) the reverse task of dynamics and ii) minimization of local functionals of instantaneous values of energies. This approach allows practical development of the controllers of the electro-mechanical system which would ensure a given quality of control and adequately simple practical realization under conditions of variation of the parameters of the controlled object and the uncertainties in a mathematical model. As a result, this type of electrical drive can be recommended for further development and promotion, to be used in technological processes and installations of various industries.