MODELLING OF INDUCTION MOTOR WITH ANSYS MAXWELL RMXPRT PROGRAMM

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Abstract. *The article illustrated the design and modeling of an asynchronous electric motor by using the program Ansys Maxwell. Ansys Maxwell RMxprt is used in order to demonstrate the result of design and modeling of electrical machines. The advantages of using the program module Ansys Maxwell RMxprt for the design of electrical machines are revealed and the results of the analysis of their performance are showed. The results of the calculation of the operating characteristics are given in the data tables and in the form of graphical characteristics.*

Keywords: *asynchronous electric motor, stator, rotor, Ansys Maxwell RMxprt, performance characteristics, net power, power factor, efficiency.*

Asynchronous electric motors (AM) are used in almost all industries due to their simple design and ease of operation. Asynchronous electric motors consume about 65% of the electrical energy generated by the country's power plants [1].

The issues of design and simulation of asynchronous electric motors remain very acute, since the performance requirements of modern electric motors have increased significantly. Computer-aided design systems are often used to solve such problems, however, most of the models created in them are not interactive. In this regard, the use of the latest software products, in particular, the Ansys software module, is of considerable interest. Maxwell RMxprt [2]. Users only need to enter the initial data: the type of windings and the connection scheme, the properties of the stator and rotor materials, geometric parameters, data on power supply, load, fan, etc. At the same time, all Maxwell tools for parameterization and optimization calculation are available. Thus, this software tool allows you to significantly speed up the process of developing an electric machine with a standard configuration.

The Ansys package includes three software products with which you can implement the simulation of the electric drive system of various types of electric machines: RMxprt , Maxwell 2D / 3D and Simplorer . Moreover, the same model is launched in conjunction RMxprt - Simplorer , Maxwell 2 D /3 D - Simplorer at the same time [3]. RMxprt supports the following types of electrical machines: three-phase IM, single-phase IM, three-phase synchronous motors (SM) and generators, variable frequency SM and generators, permanent magnet DC motors, etc. [4].

The RMxprt program allows you to perform engineering calculations of electrical machines based on circuit theory. The developer can create a configuration in RMxprt , convert the model into

a Maxwell task , where he can already make all the required changes. This will be much faster than designing a model from scratch.

As an example, consider the construction of a 4A80A4UZ engine model. To do this, enter in the control window (Project Manager) passport data of the engine 4A80A4UZ: $P_{2nom} = 1.1$ kW; U_1 \u003d 380 V; 2 p =4, the geometric dimensions of its active parts: D_{in} \u003d 131 mm; D = 84 mm; l_1 \u003d 78 mm; D_a \u003d 83.5 mm; D_v =22 mm, parameters of the stator slot: shape of the slot - semi-open trapezoidal; Z_1 =36; b_1 \u003d 4.4 mm; b_2 \u003d 6.1 mm; h = 12.1 mm; m = 2.5 mm; e =0.5 mm, parameters of the rotor slot: shape of the slot - half-open pear-shaped; Z_2 =28; b_1 \u003d 4.5 mm; b_2 \u003d 1.5 mm; h_p =16.4 mm; m =1.0 mm; e \u003d 0.5 mm, stator winding parameters: S_p \u003d 60; n =1; d = 0.67 mm; winding type - single-layer concentric.

Before running a software analysis of an electric motor, it is necessary to enter its general parameters, for example, power, voltage, operating temperature, number of poles, rated speed, power loss.

After that, verification (*Validate*) and calculation of the project (*Analyze All*). The calculation results in RMxprt are presented in the form of data (Table 1) and as a set of characteristics (Fig . 2). All results can be viewed by selecting the *Solution command Data* on the RMxprt toolbar , characteristics - via the *Curve command* .

Table 1

Performance data obtained using the RMxprt program

R_2, W	I_f, A	η, %	$cos\varphi$	M_2, N·m
0	2.38	0	0.08	0
270	2.39	64.5	0.25	1.73
400	2.43	72	0.33	2.57
540	2.45	76.4	0.42	3.49
640	2.56	78.3	0.47	4.15
700	2.6	79.1	0.51	4.54
900	2.78	80.5	0.61	5.88

Figure 2 shows the performance characteristics of the designed electric motor. Stator current versus motor power ($I_1 = f(P_2)$), efficiency versus motor power ($\eta = f(P_2)$), power factor versus motor power ($cos\varphi = f(P_2)$) and the dependence of the torque on the power of the electric motor ($M_2 = f(P_2)$).
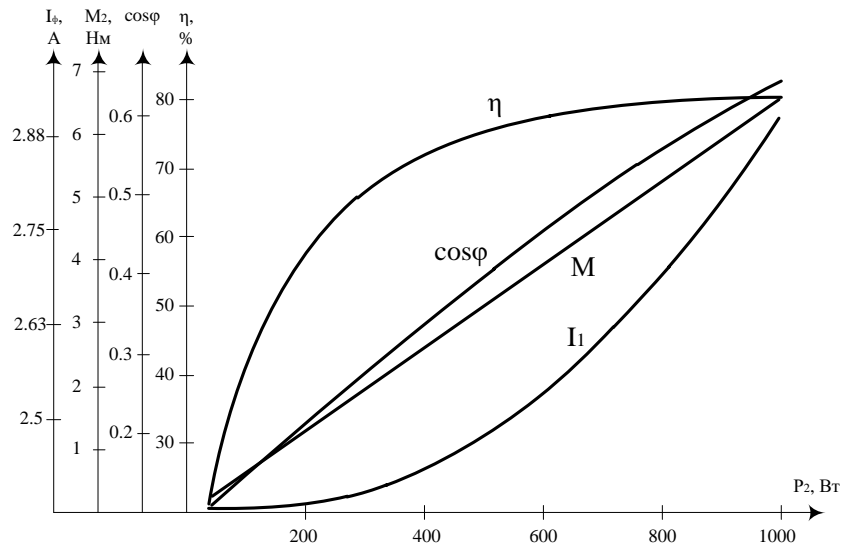
Rice. 2. Operating characteristics of the 4A80A4UZ asynchronous electric motor obtained using the module RMxprt

As shown by the results of the performance characteristics of the 4A80A4UZ asynchronous motor using the module RMxprt useful power reaches the value $P_2 = 0.9$ kW at $\eta = 80.5\%$, $\cos\varphi = 0.61$, $I_1 = 2.78$ A, $M_2 = 5.88$ Nm .

Experimental studies have been carried out to compare the accuracy of induction motor performance results obtained with the RMxprt software .

Experimental data for building the performance characteristics of an asynchronous motor are given in table. 2.

table 2

Experimental performance data

R_2, W	I_f, A	η, %	$\cos\varphi$	M_2, N·m
0	2.4	0	0.18	0
270	2.4	56.25	0.29	1.74
400.5	2.4	66.75	0.36	2.60
537.5	2.45	74.65	0.43	3.50
637.5	2.5	75.89	0.49	4.17
701.2	2.6	73.05	0.54	4.60
900	2.8	75.00	0.62	5.94

Figure 3 shows the experimental data on the performance characteristics of the electric motor in the form of graphically expressed dependences of the useful moment (torque on the shaft) M_2 , efficiency . η , phase current I and power factor $\cos\varphi$ for different values of useful power P_2 when operating at rated voltage and frequency .
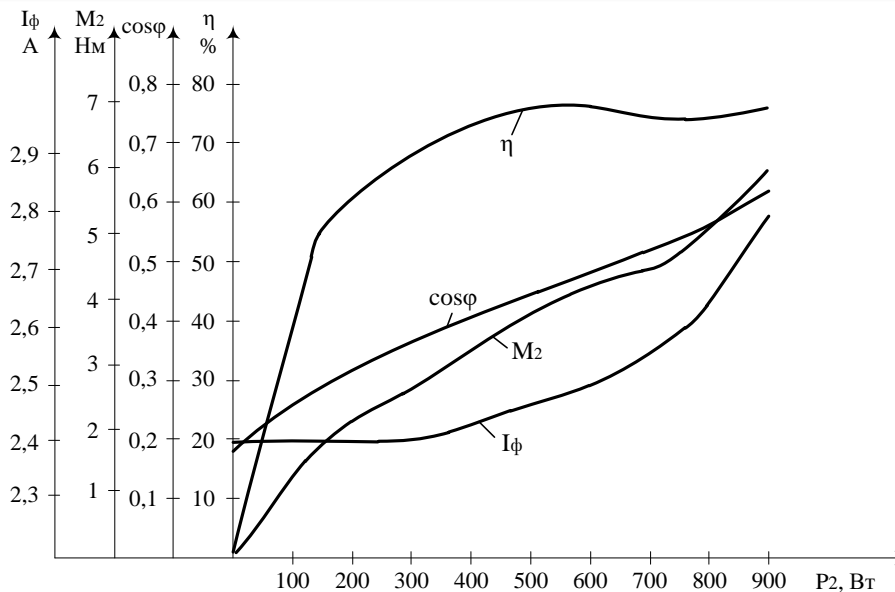
Rice. 3. Performance characteristics of asynchronous motor

As shown by the results of the experiment given with an asynchronous electric motor, the useful power reaches the value P_2=0.9 kW at η=75%, cos φ=0.62, I_1=2.8 A, M_2=5.94 Nm .

When comparing the results obtained using the RMxprt program and the experiment with a useful power P_2=0.9 kW , the efficiency error . 0.72%, power factor 6.8%, phase current 1.6%, shaft torque 1% respectively . This means that experimental studies were carried out on analog measuring instruments, which have errors.

An analysis of the main parameters of a three-phase asynchronous electric motor with a squirrel-cage rotor of a general industrial design allows us to notice that two different calculation methods give almost identical results with the same initial data when solving the problem of improving the energy efficiency of an electric machine, the calculation using the RMxprt module is most preferable , since it is simpler .

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