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THE INFLUENCE OF THE TOTAL AREA OF THE ROTOR CONDUCTOR MATERIAL IN ITS CROSS SECTION ON THE ELECTROMAGNETIC TORQUE FOR AN INDUCTION MOTOR

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Annotation. *Modern engines have a dependence of their energy characteristics on the design of the squirrel-cage rotor winding. The dimensions of the rotor slot affect the starting and operating torque of the motor, slip, efficiency and power factor. This paper analyzes the results of a study of the influence of the cross-sectional area of the rotor groove on the energy characteristics*

Key words*: induction motor, rotor slot cross-section, magnetic induction, efficiency*

A 15 kW motor was adopted as the basic variant, which was studied and brought to the level of an energy-efficient induction motor. The geometry of the rotor sheet was changed as follows: given that the number of stator slots is 36, we will take 38 slots on the rotor [1, 2]. Firstly, it is recommended to choose an even number of slots, and secondly, these numbers should have the lowest multiplicity. We will adopt the shape of the slot so that, as an option, it would be possible to use a welded copper cage.

The sketch of the toothed zone of the simulated version of the electric motor is shown in Figure 1. The calculation of the electromagnetic field by the finite element method in the Ansys program was used [3, 4]. Recalculation of the slip in the nominal mode gives a value of 1.15 Hz. We will use it as a basis for further calculations.

For the calculation, as before, we apply the finite element method and low-frequency harmonic analysis. The distribution pattern of magnetic field lines in the cross-section of the electric motor under nominal load is shown in Figure 2.

The distribution curve of the magnetic induction vector along a pair of poles in the air gap of the simulated electric motor is shown in Figure 3.

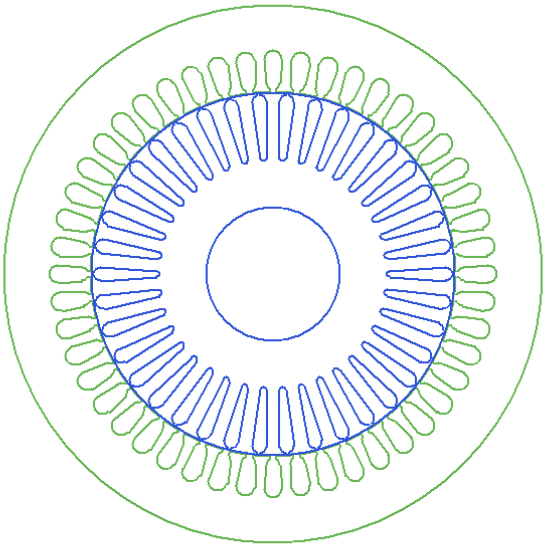

Fig. 1 - Sketch of the toothed zone of the modernized induction motor

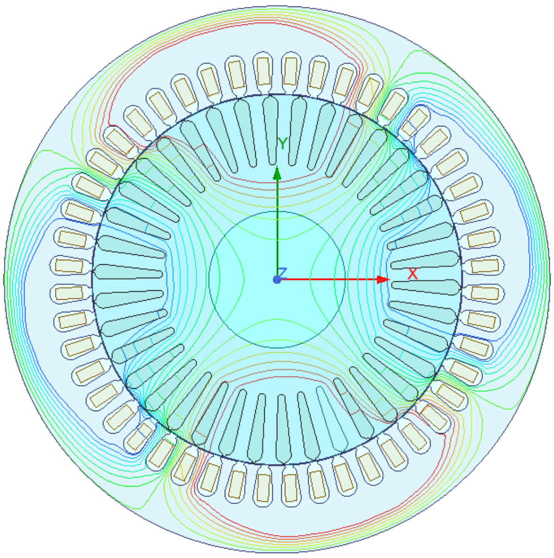

Fig. 2 - Field lines of the simulated electric motor at nominal sliding

The torque at nominal slip (its arithmetic mean value) was determined. If we take it as the base, then in this case the torque increase by 24% is achieved. This increase is obtained by varying the rotor slot area with their number remaining constant.

Calculations show that the nominal torque can be obtained with a much lower stator current, 11% less than in the basic version. The power consumed by the motor from the network will decrease, almost to the same extent. In other words, an outdated version of an electric motor can be upgraded to a higher level of energy efficiency by optimizing its tooth zone.

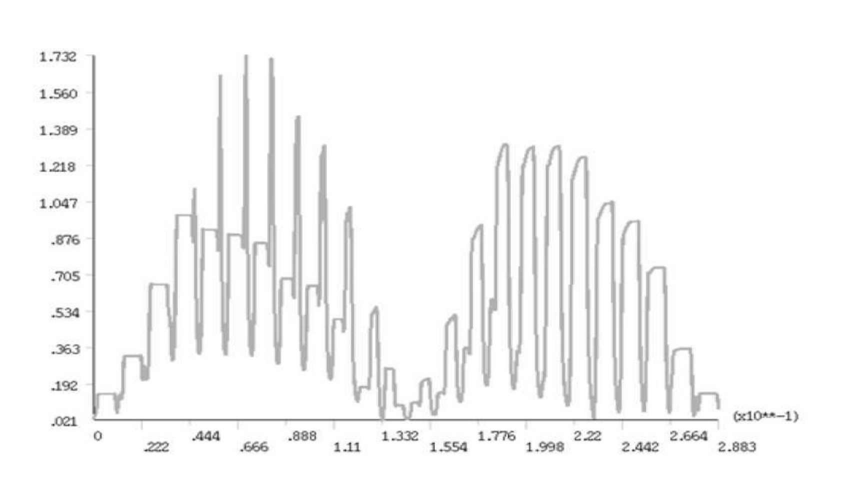

Fig. 3 - Magnetic induction curve (in Tl) at pole pitch

The nature of the saturation of the magnetic circuit of the modernized engine can be judged by the data in Figure 4.

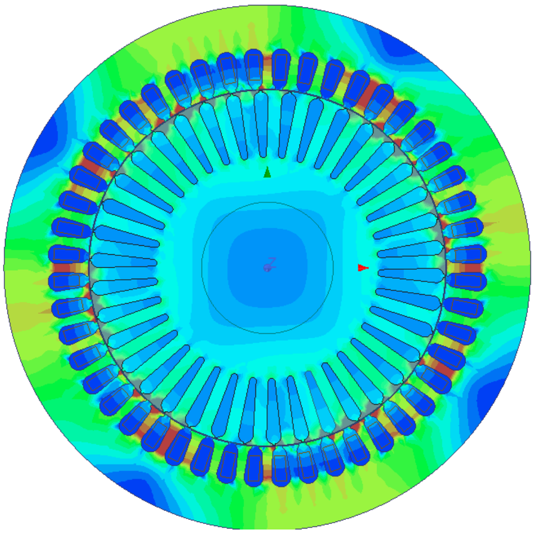

Fig. 4 - Induction levels in the cross section of the modernized Engine

This figure shows that the rotor back, under saturation conditions, will allow the placement of axial ventilation ducts if necessary.

To estimate the total area of the rotor slots obtained as a result of optimization, we will present its ratio to the area of the rotor circumference. The area of one rotor slot is 85.7 mm^2. There are 50 slots on the rotor. The area of the rotor aluminum is 85.7 - 50 = 4285 mm^2. The area of the rotor circumference is 26577 mm^2. We will call this coefficient the rotor slot coefficient. The required coefficient is

$$K_{pr} = 4285/26577 = 0.161.$$

The similar coefficient for the base engine is 0.267. In other words, upgrading the rotor slot layer results in a reduction of the conductive material in its cross-section.

Conclusions.

By varying the total area of the rotor slots, it is possible to select its extremum, which for different modes (starting and at nominal slip) is achieved at different values. The rotor slot ratio (the ratio of the total area of the rotor slots to the circle described around the rotor) in optimized engines is, as a rule, less than the standard values of serial products.

References

1. Özsoy, M., Kaplan, O., & Akar, M. (2024). FEM-based analysis of rotor cage material and slot geometry on double air gap axial flux induction motors. Ain Shams Engineering Journal, 15(2), 102393.

2. Iegorov, O., Glebova, M., & Forkun, J. Dependence of starting characteristics on the shape of rotor slots. Scientific Collection «InterConf+», 2023, 35 (163), 278-286.

3. Kaduskar, S., Parab, P., Panda, A., Rajput, M., Patil, H., Varma, S., & Bindu, R. Revolutionizing Aviation and EV Industries: Advancements in Axial Flux Motors for Electric Propulsion Systems with ANSYS Electronics. In 2024 IEEE 9th International Conference for Convergence in Technology (I2CT) (pp. 1-6). IEEE.

4. Iegorov, O., Iegorova, O., Potryvaieva, N., & Zaluzhna, H. The traction induction motor magnetic circuit saturation influence on the variable electric drive energy efficiency. In 2021 IEEE International Conference on Modern Electrical and Energy Systems (MEES) (pp. 1-5). IEEE.