CHOICE OF METHOD OF CALCULATION OF CHARACTERISTICS OF ASYNCHRONOUS MOTOR WITH INDUCTION RHEOSTATS

С’янов О.М.[1], д.т.н., професор, Alexandr.sianov@gmail.com;
Косухіна О.С.[2], к.т.н., доцент, e_kos@ukr.net;
Косухін О.В.[1], аспірант, kosukhin24@gmail.com;
Дерець С.О.[1], аспірант, deres993@ukr.net;
[1]Дніпровський державний технічний університет, м. Кам’янське. Україна
[2]Відокремлений структурний підрозділ «Технологічний фаховий коледж Дніпровського державного технічного університету, м. Кам’янське, Україна

To limit the large multiplicities of starting currents asynchronous motor (AM), the method of including a rheostat with a smooth or step contactor switching of the active resistance in the winding circuit of the phase rotor has become widespread. Typically, in such electric drive systems, the rheostats are located outside the motor and are connected to the phase winding by means of contact rings located on the shaft. In the nominal mode of operation of the engine the rheostat is disconnected, and a phase winding of a rotor is short-circuited.

Analytical calculation methods for determining the characteristics and electromagnetic parameters of the induction rheostat (IR), currently used, are based on the use of complex resistance obtained experimentally. The developed methods have the following disadvantages:

-they are not based on solving Maxwell's equations, but on experimentally obtained data;

- they do not take into account changes in current density in the screen of the IR disk structure along the radius;

-change of magnetic induction from the surface to the direction of propagation of the electromagnetic wave is represented in rectangular form.

These shortcomings can be eliminated by numerical solution of the field equation for IR. Physical processes in IR are described by a system of Maxwell's differential equations for anisotropic nonlinear media. Writing down Maxwell's equation with respect to the vector magnetic potential, we obtain

$$\nabla \times \left(\nu \nabla \times \vec{A}\right) + \sigma \frac{\partial \vec{A}}{\partial t} = \vec{J}\,, \qquad (1)$$

where $\vec{A}$ is the vector magnetic potential; ν - magnetic resistance of the material; σ - specific conductivity of the medium; $\vec{J}$ - current density.

To bring the three-dimensional field problem (1) to a simpler one, the following basic assumptions are accepted:

- contact electromotive forces (EMF) arising between the tangent conductors of different chemical composition and Thomson EMF, which occurs when the temperature gradient in the IR changes are not considered;

-conductance currents in dielectrics are not considered;

-significantly little mechanical stress affects the parameters and dimensions of the IR;

-in static and dynamic modes of operation, the IR temperature changes slightly and does not affect the parameters and size of the IR.

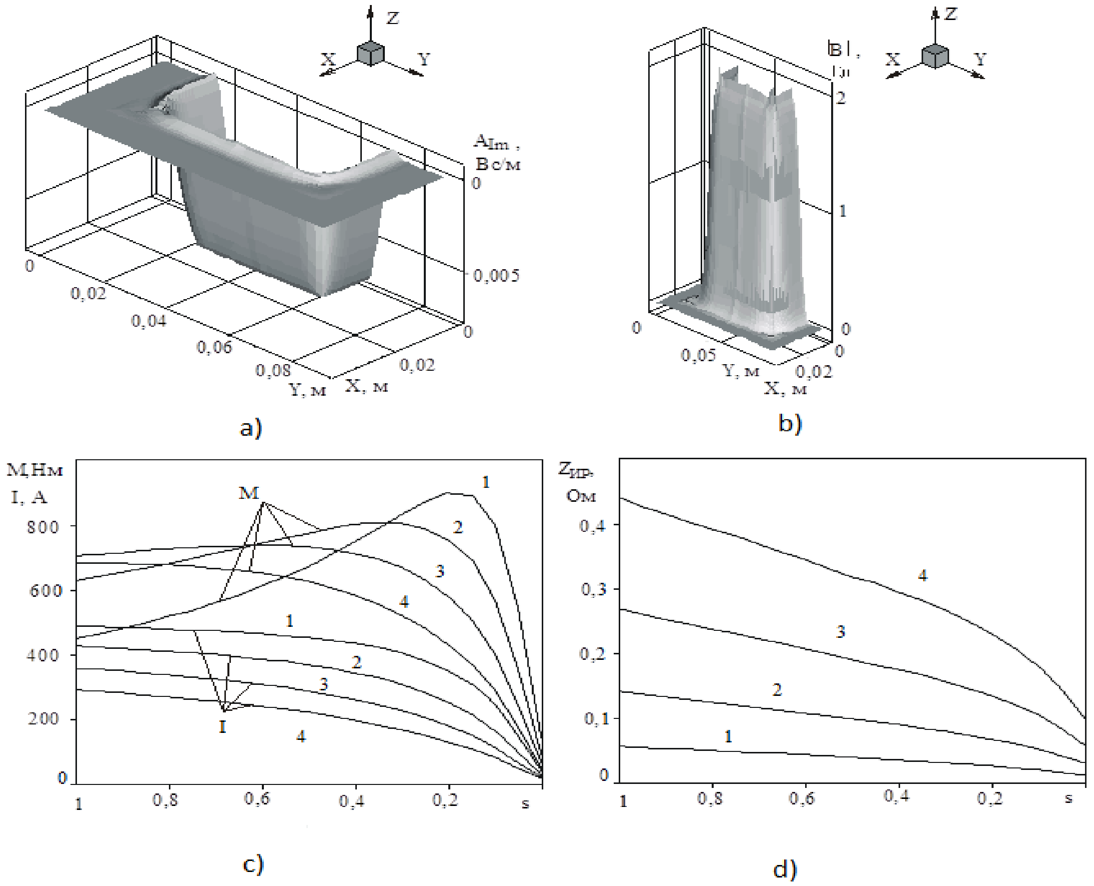

Figure 1. Characteristics of AM with IR

The accepted assumptions allow to reduce the three-dimensional field problem to a plane-parallel one. Equation (1) in this case in cylindrical coordinates will be in the form

$$\frac{\partial}{\partial r}\left(\nu\frac{\partial A}{\partial r}\right)+\frac{1}{r}\nu\frac{\partial A}{\partial r}+\frac{\partial}{\partial z}\left(\nu\frac{\partial A}{\partial z}\right)+\sigma\frac{\partial A}{\partial t}=J\,, \qquad (2)$$

where z is the coordinate of the area; r is the radius of the circle.

The obtained values of electromagnetic parameters of IR are used to calculate the static characteristics of AM with IR by the equation of the form

$$\left[\dot{U}\right]=\left[\dot{z}\right]\,\left[\dot{I}\right], \qquad (3)$$

where $[\dot{U}]$ - voltage matrix; $[\dot{Z}]$ - matrix of electromagnetic parameters of AM with IR; $[\dot{I}]$ - matrix of currents.

The solution of equations (1) is carried out by the finite element method [1,2,3].

The algorithm for calculating of the static characteristics of AM with IR is as follows:

1. As a result of solving equation (2), the characteristics and electromagnetic parameters of IR are determined.

2. Obtained values of electromagnetic parameters are used to calculate the static characteristics of equation (3). If the value of the stator current for today and the previous step differs by more than 0.01, the calculation starts with the first point. If the current values for the present and the previous step differ by no more than 0.01, the calculation starts with a new slip value from point 1. At s = 0.001, the calculation of static characteristics ends.

Fig.1 shows the results of calculating the IR of a disk structure. The change in the amplitudes A_{Im} relative to the cross section is shown in Fig.1,a and |B| in Fig.1,b. The calculations were performed for an IR with a screen thickness of 14 mm, an inner diameter of 200 mm, and an outer diameter of 346 mm at s = 1. The characteristics AM of an SMR250M4 type with an IR with a different number of coils turns (10 (1), 25 (2), 40 (3), 55 (4)) are shown in Fig.1c,d. The created program makes it possible to perform optimization calculations of the IR design considering the electromagnetic parameters of the engine.

Literature

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Анотація

Розглянуті основні конструкції індукційних реостатів. Показано використання чисельного методу кінцевих елементів для розрахунку характеристик асинхронного двигуна з індукційними реостатами.

Ключові слова: індукційний реостат, електромагнітні параметри, тривимірна модель.

Аннотация

Рассмотрены основные конструкции индукционных реостатов. Показано использование численного метода конечных элементов для расчета характеристик асинхронного двигателя с индукционными реостатами.

Ключевые слова: индукционный реостат, электромагнитные параметры, трехмерная модель.

Abstract

The main designs of induction rheostats are considered. The use of the numerical finite element method for calculating the characteristics of an induction motor with induction rheostats is shown.

Keywords: induction rheostat, electromagnetic parameters, three-dimensional model.