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Modelling of magnetizing system equipment for measuring of magnetic characteristics of permanent magnets

***Abstract**. Modelling features of magnetizing system, electromagnetic processes of the equipment for measuring of magnetic characteristics and its performances research are considered.*

Keywords: magnetizing system, mathematical model, current supply.

Introduction

Magnetizing systems of modern equipment for measuring the magnetic characteristics of permanent magnets consist as a rule of two main parts: electromagnets of strong fields, in which interpolar space is a research model and secondly DC sources, which frequency is combined with the automatic control system. Current supply of electromagnet coils belong to spesificly controled sources of DC source, which have to fullfill the following requiments:

- Warranty of the double polar current with pulsation not more than 1 % and exact fixation of "zero".
- High speed of outgoing voltage change that provides necessary dynamic diapason of current of electromagnet coils.

A combination of the listed above requirements on the current supply and the special characteristics of an electromagnet, which is the strain on the current supply (considerable inductrance and non-linear characteristics), define expedience of application of the puls-network modulation principle in the process of projecting such sources [1].

Using mathematical models for the analysis of the electromagnet processes during adaptation of these schemes allows discovering of the most favorable combination of the scheme-parameters for the gaining of optimal characteristics of the measuring equipment in general.

Mathematical model

The mathematical model of a magnetizing system is developed on the basis of simultaneous solving of differential state equations of equivalent electric and magnetic circuits of the system [2].

One assumes that in such a model, electrical and magnetical fields are connected through the current of an i_H branch. The i_H branch is equivalent to the winding of the electromagnet. Current is the magneto driving power in the magnetic circuit. The amount of the power is proportional to the number of coils of this winding. In this way we are getting the only calculation scheme with the magnetic curcuit sustituted by the equivalent electrical circuit. We approximate then magnetic system of classifiers with the planish curcuit in a grid, where the nonlinear magnetic resistors are equivalent to the resistance of magneto conductor, and line-areas – to sectors of diamagnetic space. The magnetic resistance of the schema defined for finite areas of space that have the form of cylinders and cuboids, taking into account dependencies B $= f$(H) for the respective items. Then the equation of this circle of famous magnetic position [2] can generate for selected paths in the form of

$$\Gamma_{\mathrm{M}} \mathbf{R}_{\mathrm{M}} \frac{d\vec{\mathbf{\Phi}}}{dt} = \Gamma_{\mathrm{M}} \mathbf{W} \frac{d\vec{\mathbf{i}}_{\Gamma_{\mathrm{M}}}}{dt} \qquad (1)$$

where $\mathbf{\Gamma}_{\mathrm{M}}$ - loop matrix of magnetic circuits; $\vec{\mathbf{i}}_{\mathrm{M}}, \vec{\mathbf{\Phi}}$ - vectors of currents and magnetic fluxes; $\mathbf{R}_{\mathrm{M}}$ - magnetic impedance matrix; $\mathbf{W}$ - number of coils matrix.

In order to obtain common system of state equations we create unique topology of electric and magnetic circuits by the loop matrix Γ:

$$\mathbf{\Gamma}\begin{vmatrix} L & W \\ W & -R_m \end{vmatrix}\mathbf{\Gamma}_t\left(\frac{d\vec{i}_k}{dt}, \frac{d\vec{\Phi}}{dt}\right)_t = \mathbf{\Gamma}\left(\vec{e}\text{-}r\vec{i}\text{-}\overline{u_c}, 0\right)_t;$$

$$\left(\vec{i}, \vec{\Phi}\right) = \Gamma_t\left(\vec{i}_k, \vec{\Phi}_k\right); \quad C\frac{d\overline{u_c}}{dt} = \vec{i}; \qquad (2)$$

In this system of equations the following abbreviations are used:

$\vec{\mathbf{i}}_{\mathrm{K}}, \vec{\mathbf{\Phi}}_{\mathrm{K}}$ - vectors of currents and magnetic fluxes respectively; $\vec{\mathbf{e}}, \vec{\mathbf{i}}, \vec{\mathbf{u}}_c$ - vectors of electric motive forces, currents and capacitor voltages of branches of investigated object; $\mathbf{r}, \mathbf{L}, \mathbf{C}$ - matrices of resistances, inductances, capacities of branches respectively.

In the diagram in the process of differentiation researched equations (2) will change the value of the nonlinear parameters of the scheme which are included in the matrix of R_M and r (running value resistance valves). These changes are determined by the values of the magnetic flow of electromagnet and the values of the corners of the open, polarity and current of valves, respectively. To resolve the system of equations (2) a software package is used [3], which allows you to consider changing the settings of the scheme, which are caused by their physical unlinearity or regulation.

The described approach of modeling processes in the scheme considered magnetized system allows studying the influence of various circuits and design parameters on performance and power source and magnetized system as a whole. In turn, this allows you to select the optimal parameters of the power system for its desirable characteristics and dynamic range adjustment, pick a sensible law regulation, to achieve the optimal structure of the electromagnet.

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