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CHOICE OF A MATHEMATICAL MODEL OF A CURRENT CONVERTER BASED ON A GALVANOMAGNETIC EFFECT

Abstract. The article is devoted to the analysis and selection of a mathematical model of a current converter based on a galvanomagnetic effect. The dependences of the design parameters of the converter on the parameters of the magnetic material are obtained. The accuracy of calculating the magnetic circuit of a current converter based on the galvanomagnetic effect, which is determined depending on the accuracy of the mathematical model of magnetic induction from magnetic voltage, is investigated.

Keywords. Mathematical model, current converter, Hall effect, design parameters, properties of magnetic material, magnetic induction, magnetic voltage, output electromotive force.

Introduction. At present, current converters based on the galvanomagnetic effect are widely used in automated systems for monitoring and controlling devices whose process is connected by direct current, such as: rectifiers, direct current (DC) motors, switch drives, etc. Such converters have a number of requirements regarding accuracy, sensitivity and a wide range of the converted current. Special requirements are imposed on the calculations of the magnetic circuit of such converters [1-6].

Materials and Methods. The choice of a mathematical model of a current converter based on a galvanomagnetic effect, which will be the basis for calculating its magnetic circuit.

In [7], analytical expressions of the magnetization curve of magnetic materials used as the magnetic circuit of the converter, the design of which is shown in Fig. 1, are proposed.
Results and Discussion.

The converter contains a primary winding wound on a magnetic circuit made in the form of two parallel open rings, the opposite ends (A and B) of which are interconnected by a ferromagnetic jumper. The Hall elements, assembled from sequentially connected links, are located in the annular working gap $\delta_1$ between the forming surfaces of the rings. When measuring relatively large currents, the role of the primary winding is performed by a conductive bus passing through a magnetic circuit.

In order to make a calculation, it is necessary to determine the total magnetic resistance and calculate electrical parameters such as: inductance, mutual inductance or electromotive force. Based on the replacement circuit of the magnetic circuit shown in Fig.1 (c), it is possible to take into account the leakage resistance. At the same time, the cumbersomeness of the calculation can be simplified by assuming that the complex magnetic resistances of individual sections of the magnetic circuit $Z_1 - Z_4$, the magnetic resistances of the air gaps $R_1$ and $R_1$ and the conductivity of the leakage paths $Y_{11}$ and $Y_{22}$ are concentrated [8].

When calculating the resistance of a magnetic circuit magnetic circuit, it is necessary to take into account its dependence on the value of magnetic induction in the material, which is shown in Fig.2.
In the case of a constant magnetic field, the magnetic resistance of the above sections is calculated as

\[ R_{\mu} = l_i \mu_i S_i \]  

(1)

where \( l_i, \mu_i, S_i \) - respectively, the length, magnetic permeability and cross-sectional area of the \( i \)-th section.

To calculate DC magnetic circuits, we use formulas that take into account the magnetic resistance of the gap at known transverse dimensions.

\[ R_S = \delta l(\mu_0 S) \]  

(2)

where \( \mu_0 = 4\pi \cdot 10^{-7} \text{ Gnu/m} \) - is the magnetic permeability of the air;

\( S \) - the cross-sectional area of the gap.

In many cases, when calculating a magnetic circuit, it is necessary to take into account the parallel conductivity of the gap, the conductivity of leaks from the side surfaces, since the uniformity of the distribution of magnetic induction in the gap depends on the shape of the pole and the gap.

The main characteristics of current converters based on the galvanomagnetic effect, such as: sensitivity, accuracy, power consumption and dimensions depend on the magnetomotive force (MF). Consequently, with an increase in the number of turns of the input winding, we increase its inductance, i.e. the more current we pass through the winding, the more signal we will be able to receive at the output of the converter [9].

\[ L = \frac{w^2}{Z_\mu} \]  

(3)

where, \( L \) - is the inductance of the winding;

\( w \) - is the number of turns of the input winding;

\( Z_\mu \) - the total magnetic resistance of the magnetic circuit.
It follows from formula (3) that with an increase in the number of turns, the overall dimensions will increase, and with certain dimensions, the winding wires must be thin, which will lead to an increase in the number of turns and the active resistance of the winding. It is shown in [10] that the output EMF of the converter depends on the number of Hall elements connected in series:

$$E_{out} = K_h I_x \frac{\Phi_{\mu_0}}{S_{\mu_0}} n,$$

(4)

where, $K_h$ - is the proportionality coefficient depending on the material of the Hall element (EH);

$I_x$ - the magnitude of the current that flows through the edges of the EH;

$\Phi_{\mu_0}$ – the magnetic flux, which is proportional to the input converted DC current and penetrates the surface of the EH;

$S_{\mu_0}$ - the cross section of the C–shaped magnetic circuit;

$n$ - the number of sequentially connected EH.

It can be seen from (4) that the output signal increases in proportion to the input current, the number of EH elements and the EH current, and the accuracy depends on the accuracy of the mathematical model of magnetic induction from the magnetic voltage.

**Conclusions.**

As a result of an increase in the active resistance of the winding, the active power released in the converter increases, which will lead to heating, which is a source of error. It follows that the MDS and the number of turns of the winding of the electromagnetic converter must be selected taking into account a number of factors, such as: the resistance of the winding to direct current, the active power released in the converter, the permissible value of the flow is determined by the selected value of induction, etc.

An increase in the magnetic resistance of the magnetic circuit leads to a decrease in the relative change in the total magnetic resistance under the action of the converted current and to a decrease in overall dimensions with an increase in the number of turns of the output winding.

It is shown that the accuracy of calculating the magnetic circuit of a current converter based on a galvanomagnetic effect is determined with the accuracy of a mathematical model of magnetic induction from magnetic voltage.

**REFERENCES**


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