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Continuous current converters in the electrosphere

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Abstract. The article presents the structure of non-contact ferromagnetic devices for the continuous conversion of strong direct currents and the features of our proposed wide-profile magneto modulating non-contact DC current converter with an extended controllable range for various industrial enterprises, transport, agriculture, and water management. It is distinguished from known devices by several advantages: the ability to continuously control strong and small currents, compact size and low weight, relatively high accuracy and sensitivity, simple and technologically advanced design, and the capability to continuously measure large constant and alternating currents. The study examines the influence of external magnetic fields on the proposed current converter from adjacent busbars with currents flowing in the same and opposite directions, as well as from a single busbar. The results show that the magnetic field from busbars with counter-directed currents has a greater influence. The developed magneto modulation non-contact device for the continuous conversion of strong direct currents is intended for use in various automatic systems in water supply, electrolysis plants, rolling mills, electricity meters, and many other areas.

1 Introduction

Powerful electric motors are widely used in irrigation, farms, transport, as well as in drilling rigs. In their work and automatic fixation systems, large direct currents are used, the values of which must be fixed.

It has been revealed that changes over time in the integrity of the joints of current pipelines in the power supply of large-capacity consumers and disruption of their operating modes lead to their downtime and unjustified power losses on shunts [1,2].

Research conducted in practice has revealed that many large objects in land reclamation, at many enterprises in industry, metallurgy, transport and in many other areas need to control the breaking current converters in circuits without breaking them using lightweight and easy–

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to-operate non-breaking current converters (BCC) and current meters (CM) with an error of 1-3% [3].

In practice, such BCC and CM are now known [4-6], but they have disadvantages and, in particular, a narrow range of controlled currents, large dimensions and masses [7].

Currently, magnetic modulating break-free ferromagnetic current converters (FBCC) are most widely used for non-rupture fixation of BCC. However, the known FBCC have the same disadvantages listed above. In this regard, the production of effective FBCC is important.

2 Materials and methods

We have developed and investigated efficient FBCC, widely used in practice and having a number of advantages - the ability to determine large currents flowing both in one direction and in different directions with a low measurement error, while having small dimensions and a simple device [7].

Let's consider the FBCC proposed by us, shown in Figure 1, and the effect on the developed current converter of external influences of outflows in adjacent busbars in a separate busbar.

The proposed FBCC design is based on the design of non-discontinuous conversion of strong direct currents, given in [8]. The proposed design has a closed ferromagnetic ring, each section 1 of which is made with a pair of air gaps in which separate components 2 and 3 of the exciting winding are placed. On these windings there is a measuring winding 4, to the output of which the measuring device 5 is connected. The exciting winding is powered by an alternating current source. For continuous monitoring of high currents in the current line 6, the closed ferromagnetic ring FBCC is made to open [9].

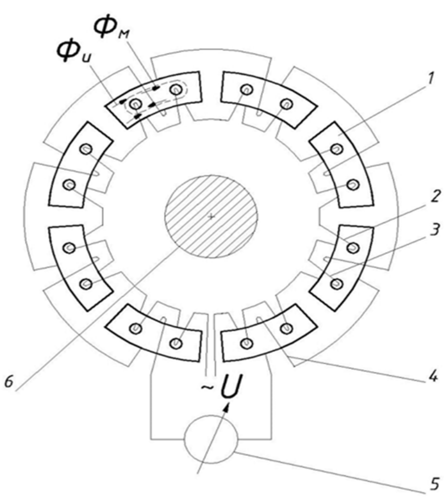

Fig. 1. Magneto modulating ferromagnetic continuous current converter.

The principle of operation of the FBCC is as follows. When alternating current flows through the exciting winding, alternating magnetic fluxes Fm are created in each ferromagnetic section 1, directed into the area of each measuring winding according to and normally to the centerline of the detachable closed ferromagnetic ring. In this case, there will be no signal at the output of the measuring winding. When controlling direct current in a detachable closed ferromagnetic ring, a controlled current creates a longitudinal magnetic flux Phi, which, due to summation with an alternating magnetic flux of excitation FM, leads to the appearance of an output signal in the windings 4 with a frequency twice the frequency of the alternating excitation current, and is measured by a measuring device.

3 Results and discussion

Consider the effect on the proposed current converter of currents in adjacent buses flowing in them in the opposite and opposite directions, and in one bus.

We investigate the effect of currents in adjacent tires on the proposed current converter.

Let the closed ring of the FBCC be located in the middle of a pair of current leads with currents I_1 and I_2 (Figure 2). Let the currents in the current lines flow according to and from us. At the same time, we will take the direction of these currents that is consonant with us. In this case, the expressions of the magnetic field strengths from the currents in these conductors at point A of the closed ring FBCC without a magnetic circuit in it will be written as follows

$$\mathrm{H}_1 = \frac{I_1}{2\pi\tau_1} \quad (1)$$

$$\mathrm{H}_2 = \frac{I_2}{2\pi\tau_2} \quad (2)$$

and for their tangent components, expressions (1) and (2) will be rewritten in the following form

$$\mathrm{H}_{\mathrm{T}1} = \frac{I_1}{2\pi\tau_1} sin\,\alpha_1; \quad (3)$$

$$\mathrm{H}_{\mathrm{T}2} = \frac{I_2}{2\pi\tau_2} sin\,\alpha_2 \quad (4)$$

Now we obtain analytically the distribution of the tangential component of the strengths of these fields along the closed ring of the FBCC without a magnetic circuit in it, expressing it through the central angle, in the following form

$$\mathrm{H}_{\mathrm{T}\Sigma} = \mathrm{H}_{\mathrm{T}1} \pm \mathrm{H}_{\mathrm{T}2} = \frac{I_1}{\pi D_{cp}}\left[\frac{K_{d1}\,sin\,\phi - 1}{1 + K_{d1}^2 - 2K_{d1}\,sin\,\phi} \pm \frac{K_1(K_{d2}\,sin\,\phi + 1)}{1 + K_{d2}^2 + 2K_{d2}\,sin\,\phi}\right] \quad (5)$$

Here$K_{d1} = \frac{d_1}{R_{cp}}$; $K_{d2} = \frac{d_2}{R_{cp}}$; $K_I = \frac{I_2}{I_1}$.

If the currents I_1 and I_2 flowing in the tires located next to the FBCC flow in the consonant direction, then in expression (5) put a minus, and if in the opposite direction, then put a plus.

Graphs of functions (5) at 1.5; 2.0; 2.5 are shown with the concordant flow of currents I_1 and I_2 in Figure 3, and with their counterflow are shown in Figure 4.

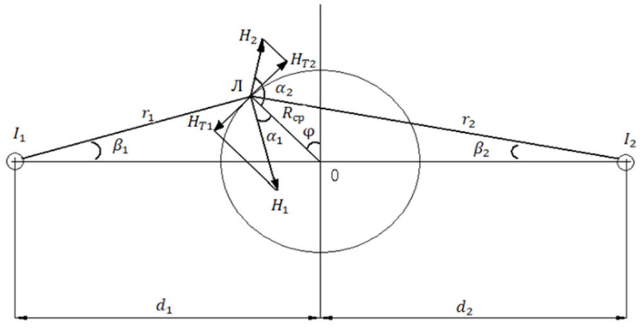

Fig. 2. The location of the closed ring FBCC in the middle of a pair of current leads with currents I_1 and I_2.

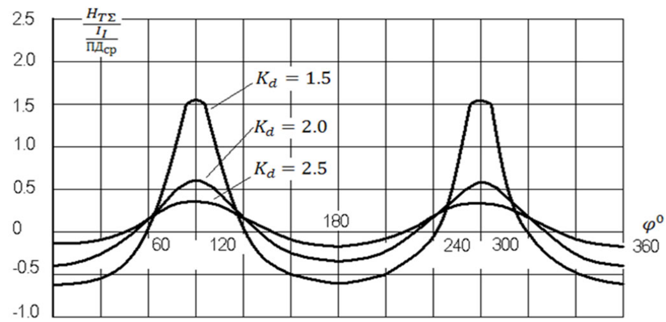

Fig. 3. Changes in magnetic fields in a closed FBCC ring from currents of the same magnitude in two adjacent current lines with a consistent flow of currents.

The value of the tangential component of the magnetic field strength in the presence of only one adjacent busbar with a current at = 0 is determined from (5) as

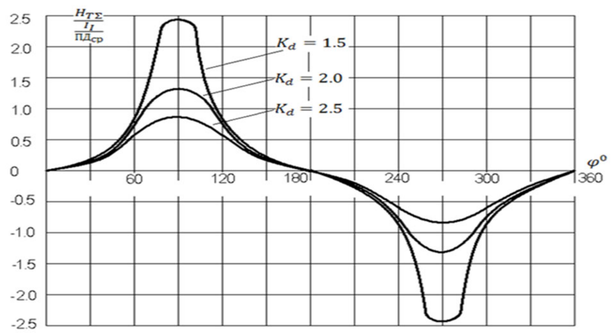

Fig. 4. Changes in magnetic fields in a closed FBCC ring from currents of the same magnitude in two adjacent current lines with a counter current flow.

$$H_{T1} = \frac{I_1}{\pi D_{cp}} \cdot \frac{K_{d1} \sin\phi - 1}{1 + K_{d1}^2 - 2K_{d1} \sin\phi} \tag{6}$$

Here I_1 is the fixed current; D_{sr} is the diameter of the detachable magnetic circuit FBCC.

The changes in the magnetic fields in this case, plotted at different values, are shown in Figure 5.

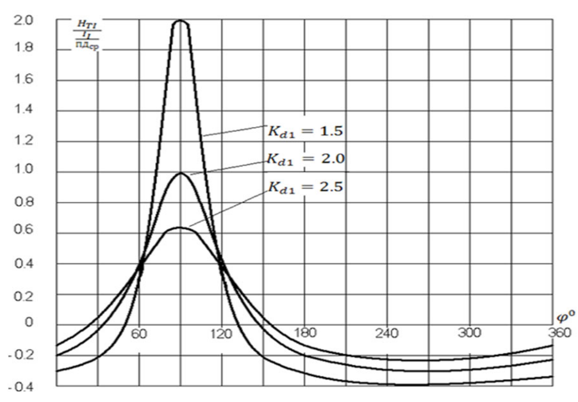

Fig. 5. Changes in magnetic fields in a closed FBCC ringfrom the current in a nearby current line at different temperatures.

4 Conclusion

Effective non-destructive non-destructive current converters with extended functionality have been developed for various objects in the agricultural sphere for the continuous conversion of direct and alternating currents with relatively high and acceptable accuracy.

With increasing distances between the current lines with currents, as well as from the current lines to the middle of the closed ring of the current converter, the magnetic fields decrease in magnitude with consonant and counter directions of currents in the current lines;

With the opposite direction of currents in the current lines, the magnetic field from adjacent current lines with currents changes more than with their consonant direction.

When exposed to the magnetic field of an adjacent current line with a current, the magnetic field increases in magnitude with a decrease in the distance between the busbar and the center of the continuous current converter.

The developed non-explosive current converters are intended for use in the agricultural sphere, the chemical industry, transport, rolling mills, drilling rigs, science and technology.

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