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Calculation of Magnetic Chains with Mobile Screens

Amirov S.F., Boltayev O.T., Axmedova F.A.

Tashkent Institute of Railway Transport Engineers, Tashkent, Uzbekistan

ABSTRACT: With the help of parametric structural schemes, the analysis and calculation of magnetic circuit converters with movable electromagnetic screens and with distributed parameters is carried out.

KEYWORDS: structural diagram, distributed parameter, angular displacements, magnetic circuit, moving screen.

I. INTRODUCTION

Analysis and calculation of magnetic circuit converters with movable electromagnetic screens and with distributed parameters is greatly facilitated if it is carried out on the basis of parametric structural schemes (PSS). In order to correctly compile the PSS transducer, it is necessary to know on the interaction of which physical circuits its work is based, what is taken as the input and output values, as well as the sequence of transformation of the circuit of one physical nature into another.

Angular displacement transducers with movable electromagnetic screens are widely used in various devices and devices of modern automation and information-measuring equipment. Currently, such converters are performed mainly with one moving screen. However, studies show that transducers with several moving screens have several advantages compared to transducers with one moving screen: high sensitivity, a slight zero signal, and a wide limit of the linear portion of the static characteristic.

II.PARAMETRIC STRUCTURAL SCHEMES

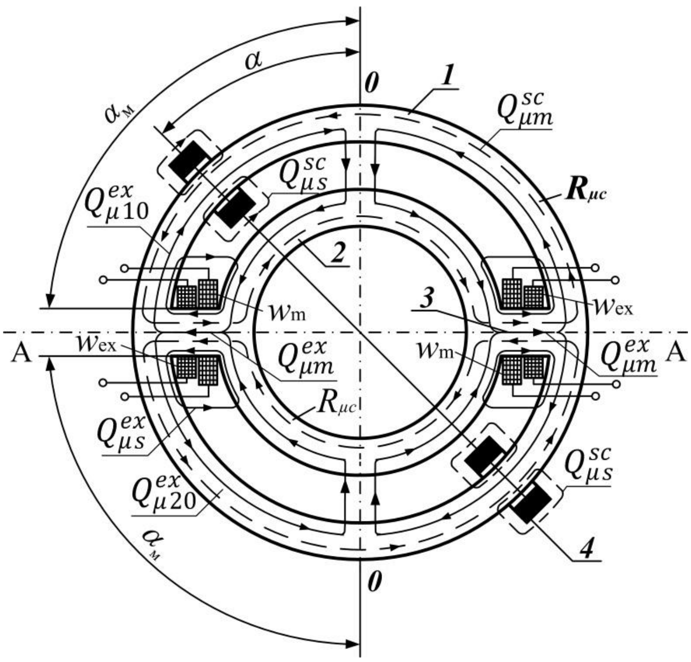

Fig.1. General View of the developed magnetic circuit

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Let us consider the compilation of an PSS for an angular displacement transducer with movable electromagnetic screens and with distributed parameters proposed by the author. The considered converter is shown in fig. 1 and contains two identical annular magnetic cores 1 and 2 with through slits made along the circumference. The winding sections of the excitation and measuring windings, which are connected in series-counter, cover the respective rods 3 located in through gaps of the annular magnetic cores 1 and 2. On the outer annular magnetic core there are electromagnetic shields 4 interconnected.

For the magnetic circuit under consideration, the PSS can be represented as shown in Fig. 2

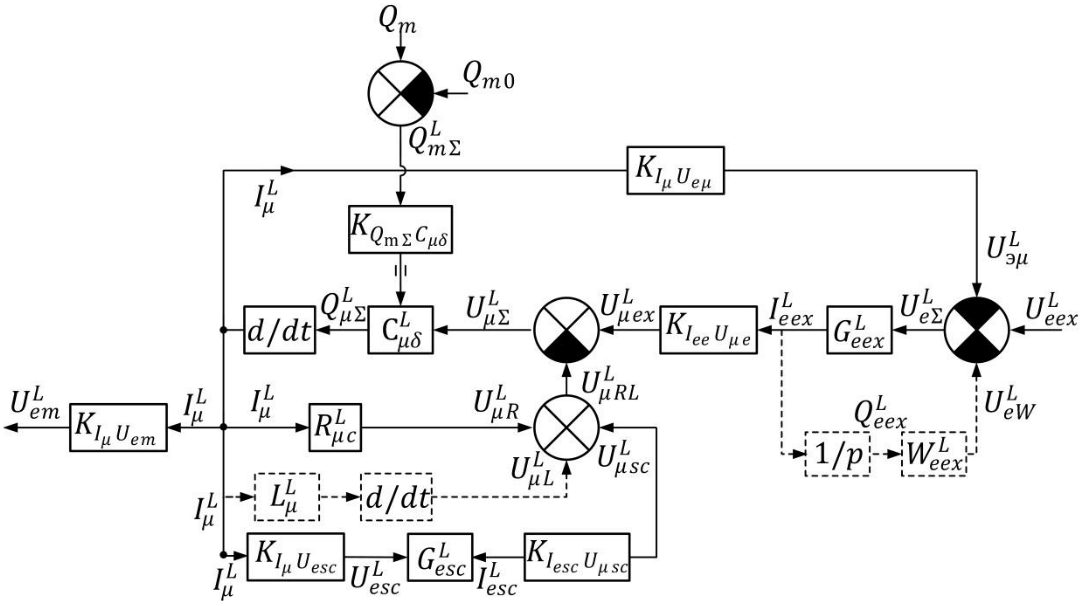

Fig.2. PSS developed magnetic circuit

Perform the calculation of the magnetic circuit converter with movable electromagnetic screens and with distributed parameters. The magnetic circuit under consideration is symmetric; therefore, the calculations of the left and right parts are carried out similarly. Based on the PSS for the left side of the magnetic circuit, the voltage of the measuring winding will be written in the following form:

$$U_{em}^L = K_{I_\mu U_{em}} I_\mu^L = K_{I_\mu U_{em}} d/dt C_{\mu\delta}^L (U_{\mu ex}^L - U_{\mu R}^L - U_{\mu sc}^L - U_{\mu L}^L), \quad (1)$$

here

$C_{\mu\delta}^L = K_{Q_\mu C_{\mu\delta}} (Q_{m_0} - Q_m)$ –magnetic capacity of the chain;

$U_{\mu ex}^L = K_{I_{ee} U_{\mu e}} G_{eex}^L (U_{eex}^L - I_\mu^L K_{I_\mu U_{e\mu}})$ – magnetic voltage of the magnetic circuit;

$U_{\mu R}^L = I_\mu^L R_{\mu c}^L$- magnetic voltage drop in the magnetic core;

$U_{\mu sc}^L = K_{I_\mu U_{esc}} K_{I_{esc} U_{\mu esc}} G_{esc}^L I_\mu^L$ - magnetic screen voltage;

$I_\mu^L = d/dt C_{\mu\delta}^L (U_{\mu ex}^L - U_{\mu R}^L - U_{\mu sc}^L - U_{\mu L}^L)$– eddy current.

Based on the expression of magnetic capacity and magnetic voltage, we find the eddy magnetic current in the core material in the form:

$$I_\mu^L = \frac{d/dt K_{I_{ee} U_{\mu e}} K_{Q_\mu C_{\mu\delta}} (Q_{m_0} - Q_m) G_{eex}^L U_{eex}^L}{1 + d/dt K_{Q_\mu C_{\mu\delta}} (Q_{m_0} - Q_m)(K_{I_{ee} U_{\mu e}} K_{I_\mu U_{e\mu}} G_{eex}^L + R_{\mu c}^L + K_{I_\mu U_{esc}} K_{I_{esc} U_{\mu sc}} G_{esc}^L)}. \quad (2)$$

Based on the expression (2), the expression for the voltage (1) is converted to the form:

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$$U^L_{em} = \frac{d/dt K_{I_\mu U_{em}} K_{I_{ee} U_{\mu ex}} K_{Q_\mu C_{\mu\delta}} (Q_{m_0} - Q_m) G^L_{eex} U^L_{eex}}{1 + d/dt K_{Q_\mu C_{\mu\delta}} (Q_{m_0} - Q_m)(K_{I_{ee} U_{\mu e}} K_{I_\mu U_{e\mu}} G^L_{eex} + R^L_{\mu c} + K_{I_\mu U_{esc}} K_{I_{esc} U_{\mu sc}} G^L_{esc})}. \quad (3)$$

Due to the symmetry of the magnetic circuit of the converter, the calculation for the right side is carried out in the same way as for the left side, and the voltage of the measuring winding for the right side can be obtained as follows:

$$U^R_{em} = \frac{d/dt K_{I_\mu U_{em}} K_{I_{ee} U_{\mu ex}} K_{Q_\mu C_{\mu\delta}} (Q_{m_0} + Q_m) G^R_{eex} U^R_{eex}}{1 + d/dt K_{Q_\mu C_{\mu\delta}} (Q_{m_0} + Q_m)(K_{I_{ee} U_{\mu e}} K_{I_\mu U_{e\mu}} G^R_{eex} + R^R_{\mu c} + K_{I_\mu U_{esc}} K_{I_{esc} U_{\mu sc}} G^R_{esc})}. \quad (4)$$

Then the output voltage of the converter, obtained by algebraic summing the voltages of the right and left windings, will be presented as

$$U_{em\Sigma} = U^L_{em} - U^R_{em} = \frac{2Q_m T_1}{[1 + T_2(Q_{m_0} - Q_m)][1 + T_2(Q_{m_0} + Q_m)]}, \quad (5)$$

here

$$T_1 = -d/dt K_{I_\mu U_{em}} K_{I_{ee} U_{\mu ex}} K_{Q_\mu C_{\mu\delta}} G^L_{eex} U^L_{eex} = -d/dt K_{I_\mu U_{em}} K_{I_{ee} U_{\mu ex}} K_{Q_\mu C_{\mu\delta}} G^R_{eex} U^R_{eex};$$

$$T_2 = d/dt K_{Q_\mu C_{\mu\delta}} (K_{I_{ee} U_{\mu e}} K_{I_\mu U_{e\mu}} G^L_{eex} + R^L_{\mu c} + K_{I_\mu U_{esc}} K_{I_{esc} U_{\mu sc}} G^L_{esc}) = \\ = K_{Q_\mu C_{\mu\delta}} (K_{I_{ee} U_{\mu e}} K_{I_\mu U_{e\mu}} G^R_{eex} + R^R_{\mu c} + K_{I_\mu U_{esc}} K_{I_{esc} U_{\mu sc}} G^R_{esc}).$$

The expression for the output voltage of the measuring winding (5) makes it possible to determine the magnetic circuit voltage for different positions of the electromagnetic moving shields.

III. CONCLUSION

Thus, using the structural calculation method using the PSS, one can determine mathematical expressions for magnetic voltage, magnetic flux, eddy current and converter output voltage, which makes it possible to simplify the calculation of complex magnetic circuits, including circuits with moving electromagnetic shields.

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