DETERMINATION OF MAGNETIC FIELD INTENSITIES OF TWO-FUNCTION ELECTROMAGNETIC CONVERTERS

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Introduction. Solving problems and performing methods of obtaining information characteristics of two-function electromagnetic converters (TFEMC) are impossible in the absence of mathematical models of their input of a converter from an object under control and from environment. The output parameters are determined depending on the input ones. It necessitates development of mathematical models, of TFEMC basic parameters allowing to determine their information and metrological characteristics.

Statement of the problem. This paper treats a problem of analytical determination of mathematical models of magnetic field intensities for TFEMC of great linear and angular shifts.

For determining intensities of magnetic field (Fig.1) a cross-section of one pair of volts is given. Within this section is shown a field around a winding system of linear shift-closed loops 1, 2, 3, 4, 5, 6, 1 and 1', 2', 3', 4', 5', 6', 1 ' and are marked intensities of magnetic field together with sizes of movable and stationary magnetic circuit.

Solution method. The determination of magnetic field intensities requires that ampere's circuital law for the mentioned closed loops be written in the following form:

$$(H^l_{12m}+H^l_{45m})2\alpha+(H^l_{23\delta m}+H^l_{61\delta m})\delta+(H^l_{34m}+H^l_{56m})h=I_{1l}W_{1l} \quad (1)$$

$$(H^l_{1'2'm}+H^l_{4'5'm})2\alpha+(H^l_{2'3'\delta m}+H^l_{6'1'\delta m})\delta+(H^l_{3'4'm}+H^l_{5'6'm})h=I_{1l}W_{1l} \quad (2)$$

where: I_l is exciting current in linear shift circuit; W_{1l} is excitation winding of linear shift circuit; 2α, δ, h -width of one slot; size of air gap between movable and stationary magnetic circuit; slot depth respectively. ….with different indices stand for magnetic field intensity corresponding to the sides of closed loop (as in Fig.1). These magnetic field intensities are functionally related to one another. To determine this relation it is necessary to employ the agnatic flux continuity principle for different sub circuits.

As noted above, the width of the middle projection between the slots is chosen on the depth of field penetration. Electromagnetic field in this thickness is practically uniform and, hence, the intensities H^l_{56m} and $H^l_{3'4'm}$ are equal to each other. According to the magnetic flux continuity principle $H^l_{32\delta m}=\mu H^l_{34m}$ and $H^l_{3'2'\delta m}=\mu H^l_{3'4'm}$ and here we have $H^l_{61m}=H^l_{3'2'\delta m}$.

In accordance with this magnetic flux penetrating the cross-section, of the middle projection is determined from the formula:

$$\Phi^l_y=\frac{2\mu\mu_0 H^l_{56m}\alpha_0}{k}\,\mathrm{thkd} \quad (3)$$

This magnetic flux is ramified into Φ_1^l и and Φ_2^l .each latter of which is written in the following form:

$$\Phi^l_1=\mu\mu_0\int_0^{\Delta_1}H^l_{12m}e^{-ky_1}\alpha_0 dy_1=H^l_{12m}(1-e^{-k\Delta_1})\mu\mu_0\frac{\alpha_0}{k} \quad (4)$$

$$\Phi_2^l = \mu\mu_0 \int_0^{\Delta_1} H_{1'2'm}^l e^{-ky_2} \alpha_0 dy_2 = H_{1'2'm}^l (1 - e^{-k\Delta_2}) \mu\mu_0 \tfrac{\alpha_0}{k} \quad (5)$$

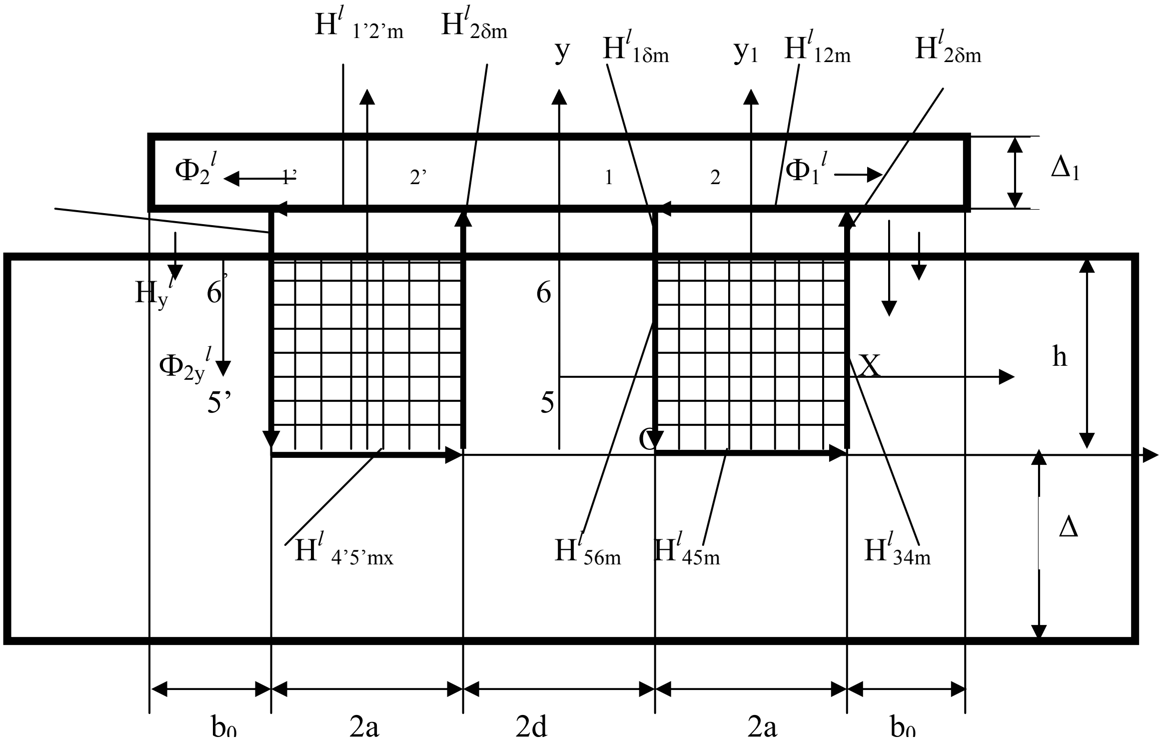

Fig. 1 Magnetic fluxes around TFEMC winding

According to (3) with consideration for (4) and (5) we have

$$H_{56m}^l = \tfrac{1}{2}(H_{12m}^l + H_{1'2'm}^l)(1 - e^{-k\Delta_1}) \tfrac{1}{thkd} \quad (6)$$

In the initial state of stationary magnetic circuit magnetic field around slot winding is found to be identical and respectively, equality of the intensities is observed, i.e.

$$H_{12m}^l = H_{1'2'm}^l; \quad H_{45m}^l = H_{4'5'm}^l; \quad H_{23m}^l = H_{6'1'm}^l; \quad H_{61m}^l = H_{2'3'm}^l;$$
$$H_{34m}^l = H_{3'4'm}^l; \quad H_{56m}^l = H_{5'6'm}^l \quad (7)$$

In this situation it is enough to use one of equations of Ampere's circuital low. Lets use the equation (1). In this equation it is necessary to create a functional relation between

H_{12m}^l *and* H_{45m}^l, H_{23m}^l *and* H_{12m}^l, H_{61m}^l *and* H_{12m}^l, H_{34m}^l *and* H_{12m}^l, H_{56m}^l *and* H_{12m}^l,

when $X_1=\alpha$, we shall get $H_{23m}^l = n_0 H_{12m}^l$ as at the initial state of a movable element we have the following:

$$H_{23m}^l = n_0 H_{12m}^l$$

After investigating the field within the sub circuits 3-4 at $X_1=0$, we shall have similarly that $H_{34m}^l = H_{34m}^l e^{-ky_1}$.

Using the magnetic flux continuity principle we shall have $H^l_{45m} = \alpha_2 H^l_{12m}$.

Considering that $H^l_{45m} = \alpha_2 H^l_{12m}$ and, respectively, we shall have from (6) that

$$H^l_{56m} = n_1 H^l_{12m} \quad and \quad H^l_{61m} = \mu n_1 H^l_{12m}$$

By substituting the above equations into (1) and performing some transformations we shall further have the following:

$$H^l_{12m} = \frac{I_l W_l}{(1+\alpha_2)2\alpha + (n_0 + \mu n_1)\delta + (\frac{n_0}{\mu} + n_1)h} \tag{8}$$

$$\Delta E_l = -j\omega W_{2l} \frac{2\mu\mu_0\alpha_0 Z}{kb_0} \frac{I_l W_l}{(1+\alpha_2)2\alpha + (n_0 + \mu n_1)\delta + (\frac{n_0}{\mu} + n_1)h} \times$$
$$\times arctg \frac{4m_0(b_0 - a)}{1 - 4m_0^2((b_0 - \alpha)^2 - X^2)} \tag{9}$$

The obtained formula of electromotive force ΔE_l represents all geometrical sizes of magnetic circuits and electromagnetic parameters of the measuring circuit.

As seen from (9) ΔE_l is linearly dependent on shift *Z*. When *Z=const* and $X=R_n\beta$ ΔE_l changes.

For angular shifts we similarly use the following formulae to determine ΔE_u :

$$\Delta E^u_{yx} = -jW_{2u}\omega\mu\mu_0 H^{u\ 2}_{12m} \frac{(b_0 - X)}{k\alpha_0} arctg \frac{4m_0(\alpha_0 - \alpha)}{1 - 4m_0^2((\alpha_0 - \alpha)^2 - Z^2)} \tag{10}$$

The intensity H^u_{12m} is determined in the same way as H^l_{12m}. As sizes of slots and their middle projections of the measuring circuits are the same, the formula H^u_{12m} will be written in the following manner:

$$H^u_{12m} = \frac{I_u W_u}{(1+\alpha_2)2\alpha + (n^u_0 + \mu n_1)\delta + (\frac{n^u_0}{\mu} + n_1)h} \tag{11}$$

where $n^u_0 = \frac{2b_0 shk\Delta_1}{k\alpha_0^2}$.

By substituting (11) into (10) for ΔE_u we shall have:

$$\Delta E_u = -j\omega W_{2u} \frac{2\mu\mu_0 b_0 X}{k\alpha_0} \frac{I_u W_{ul}}{(1+\alpha_2)2\alpha + (n^u_0 + \mu n_1)\delta + (\frac{n_0}{\mu} + n_1)h} \times$$
$$\times arctg \frac{4m_0(\alpha_0 - a)}{1 - 4m_0^2((\alpha_0 - \alpha)^2 - Z^2)} \tag{12}$$

Conclusions. As is seen, slot sizes of the measuring circuits of linear and angular shifts are assumed to be the same. The obtained formulae represent all geometrical dimensions of a magnetic system and its electromagnetic parameters.

References

1. Osadchy E.P. Design of Transducers for Measuring Mechanical Quantities, Moscow, "Machine Building", 1979, 479 p.
2. Asadova R.Sh., Sattarov V.K., Mamedov J.F. "Two-dimension Electromagnetic Transducer of Differential Type", "Automation and Modern Technologies", Moscow, "Machine Building", № 10, pp. 6-8.
3. Asadova R.Sh., Mamedov J.F. "Two-dimension Electromagnetic Converter of Shifts", "Electrical Engineering", Moscow, № 6, 2002, pp. 55-57.
4. Asadova R.Sh., Mamedov J.F., Asadova K.F. "Inductive Converter of Linear and Angular Shifts", Patent of Azerbaijan Republic, Baku, 2008.