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Research of the magnetoelectric induction generator with the change of the magnetic flux value (2-I)

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Abstract

The structure and working principals of the magnetoelectric induction generator with change of the magnetic flux value have been investigated; the characteristics of the magnetic system have been discovered through modeling. The structure, the image of the magnetic field, electric schemes of replacement, and the main features of the generator are presented.

Keywords: research, induction, generator, voltage, autonomous, permanent magnet, winding.

Аннотация

Исследованы структура и принцип работы магнитоэлектрического индукционного генератора с изменением величины магнитного потока. С помощью моделирования выявлены особенности магнитной системы. Представлены конструкция, картины магнитного поля и электрические схемы замещения, а также основные характеристики генератора.

Ключевые слова: исследование, индукция, генератор, напряжение, автономный, постоянный магнит, обмотка.

Introduction

Overall, the main task of the magnetoelectric induction generator (MIG) is converting non-electric quantities (speed, force, etc.) to electric measures providing the needed electric power pressure; these generators are easily connected to external devices, are simple and accessible from structural and operational points of view. The sources of the magnetic field in the generator is a permanent magnet (PM) that enables MIG to be autonomous, hence excluding the use of extra power voltage source [1-3].

Problem settings and method justification

Fig. 1 illustrates the structure of the MIG with change of the magnetic flux value, where 1 and 2 are PMs, 3 is an induction winding (IW), 4 is a ferromagnetic anchor, 5 and 6 are components of the magnetic wire, 7 is the lever, 8 is the resisting spring, 9 is the working gap. The magnetic system is symmetric and the anchor is included in the IW.

Fig. 1. Structure of the MIG:
 a) anchor's position is in initial state, b) anchor's position in working state

In order to analyze the magnetic field of the it was modeled by the program package FEM-4.2 [4]. Fig. 2 illustrates the magnetic field of the MIG: a) anchor's position is in initial state, b) anchor's position in working state.

Fig. 2. The image of the modeled magnetic field of the MIG:
a) anchor's position is in initial state, b) anchor's position in working state

In MIG's initial state the anchor is stretched because of electromagnetic force. The working gap is fully covered by the anchor and the magnetic flow in IW is maximum Φ_1 (Fig. 2a).

In order to induce electromotive force (EMF) in the IW we need to get a change of magnetic conductivity. That's why at the moment t_1 with an external force *the anchor is moved upwards* to the moment t_2 , as a result a working gap appears (Fig 1b). The conductivity of MIG's magnetic system decreases. The magnetic flow in IW also decreases becoming Φ_2 (Fig. 2b).

Eliminating the external force (moment t_3) the lever gets back to the initial position by the influence of the resisiting spring and electromagnetic force (moment t_4).

In t_1 - t_2 period of time the working magnetic Φ_w flux changes its value from Φ_1 to Φ_2 , and e_1 EMF is induced in the IW. During t_3 - t_4 , Φ_w magnetic flux increases from Φ_2 to Φ_1 and e_2 EMF is induced in the IW.

The dimensions of the induced magnetic flux are calculated according to the Maxwell's second law.

$$e_1 = -w_{IW} \frac{\Phi_2 - \Phi_1}{t_2 - t_1}, \quad e_2 = -w_{IW} \frac{\Phi_1 - \Phi_2}{t_4 - t_3}, \quad (1)$$

where w_{IW} is the number of springs in IW.

Fig. 3 illustrates the generalized form of the dependence of the working magnetic Φ_w and the induced e_{IW} EMF from t time.

The lifting of the nucleus is done by the influence of an external force, and the return by the influence of resiisting spring and the electromagnetic dragging force. The difference between those forces results in difference in duration of magnetic flux change, which also results in difference in amplitudes of EMFs ($\Delta_1 = t_2 - t_1 > \Delta_2 = t_4 - t_3$, $e_2 > e_1$). Δ_1 time period is instable, and Δ_2 is comparably stable.

Fig. 3. Dependence of the working magnetic Φ_w and the induced eiw EMF from t time

4. The electric scheme of the replacement of MIG's magnetic system is presented in Fig.

Fig. 4. Electric scheme of the replacement of MIG's magnetic system

The following notations have been used in the Fig. 4 F_{f1} and F_{f2} are correspondingly the sources of fake MMFs characterizing the PMs, R_{PM1} and R_{PM2} are inner magnetic resistances of the PMs, R_{6m1} and R_{6m2} are magnetic resistances of the magnetic wire 6, R_{5m1} and R_{5m2} are magnetic resistances of the magnetic wire 5, R_{bm1} and R_{bm2} are magnetic resistances between magnetic wires 5 and 6, R_{01} and R_{02} are magnetic resistances of the gap between magnetic wire 6 and the anchor, R_a is magnetic resistances of the anchor, R_{wg} is magnetic resistances of the working gap, Φ_1 and Φ_2 are magnetic fluxes generated by correspondingly PM1 and PM2, Φ'_1 and Φ'_2 are the fluxes passing through the anchor, Φ''_1 and Φ''_2 are magnetic fluxes passing through the area between magnetic wires 5 and 6. Φ'_1 and Φ'_2 are included in the IW. Φ''_1 and Φ''_2 magnetic fluxes are included in the springs of some part of the IW.

R_{PM1} , R_{PM2} , R_{5m1} , R_{5m2} , R_{6m1} , R_{6m2} and R_a magnetic resistances are not linear because of characteristics of the ferromagnetic materials. R_{bm1} , R_{bm2} , R_{01} and R_{02} magnetic resistances are constant, as they do not depend on the movement of the anchor. R_{wg} magnetic resistance of the working gap is variable and depends on the position of the anchor.

Based on the symmetry of the induction generator's magnetic system we can do the calculations for the half of the magnetic chain, in other words for system of one PM. In that case we need to take half of the magnetic resistances of the working and air gaps.

Magnetic resistances of magnetic wires and the anchor are small compared to the air gaps, that's why they can be ignored.

The simplified replacing electric chain of MIG's magnetic chain for half of the system will look like in the Fig.5.

In order to design the calculating apparatus of the MIG's magnetic chain, it is important to have the replacing chain of the magnetic chain. That's why the following features have been considered: the absence of the loose caused by air gaps and storm electric flux, magnetic wire's lack of saturation, negligence of the dispersing magnetic flux, and symmetry of the magnetic system towards the two PMs. As a result the magnetic chain is simplified and gets the final form in Fig. 6, where F_{f1} is the source of the false EMF characterising PM1, R_{PM1} is the inner magnetic resistance of PM.

Fig. 5. Electric scheme of the replacement of MIG's magnetic system
a) anchor's position is in initial state, b) anchor's position in working state

PMs in MIG's system are magnetized out of the generator's system, that's why the working point of PM is on its characterizing demagnetizing B(-H) curve in position A1 (Fig. 6), which is characterized by H_1 voltage and B_1 induction of the magnetic field. When PM is inserted into MIG's magnetic system by increasing the conductivity of the magnetic system PM's working position moves to A2 characterized by values of H_2 and B_2 . When the anchor moves up the conductivity decreases and the working point moves to position A3 characterized by the values of H_3 and B_3 .

The point A_m characterizes the maximum value of PM's magnetic energy, and W_m characteristic of $W(B)$ corresponds to A_m by W energy of the magnetic induction.

Fig. 6. B(-H) and W(B) characteristics and working points of PM

Conclusion

The analyzes of the structure, working principals, features of the magnetic system of the magnetic induction generator with change of the magnetic flux value assist on evaluation the positions of working points on PM's main characteristics, which can become a base to design calculating mathematical apparatus of magnetic system.

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