РАЗДЕЛ XX. ТЕХНИЧЕСКИЕ НАУКИ

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Research of the magnetoelectric induction generator with the change
of the magnetic flux direction (I)

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Abstract

The structure and working principals of the magnetoelectric induction generator with change of the magnetic flux direction have been investigated; the characteristics of the magnetic system have been discovered through modeling. The main features and principles of connecting with load are presented.

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

Аннотация

Исследованы структура и принцип работы магнитоэлектрического индукционного генератора с изменением направления магнитного потока. С помощью моделирования выявлены особенности магнитной системы. Представлены основные характеристики и принцип соединения нагрузки.

Ключевые слова: 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 direction, where 1 and 2 are PMs, 3 is an induction winding (IW), 4 is a ferromagnetic anchor, 5-13 are components of the magnetic wire, 14 is the resisting spring, 15 is the base of the spring.

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

In Fig. 1a MIG is in its initial state and the magnetic flux Φ_1 , that passes through the anchor and is conditioned by the PM1, passes through the 12-(6, 11)-4-8-13 details of the magnetic wire.

Under the pressure of an external force the lever 7 moves pressing on the spring 14, as a result 5 and 6 components of the magnetic wire move to the opposite directions, hence spinning around the axis 0, as a result the anchor changes its position, and the Φ_2 flux, that was passing through it, now conditioned by the PM2 passes through 12-(5, 10)-4-9-13 details of the magnetic wire (Fig. 2b).

In the figure, γ stands for the angle between the magnetic flux of the anchor and the spirals of the IW. In case of the structural symmetry of MIG $\gamma_1=\gamma_2=\gamma$.

When eliminating the external force, the lever 7 comes to the initial position by the impact of the resisiting spring 14.

The magnetic field of the MIG was modeled by the program package FEM-4.2. Fig. 2 illustrates the magnetic field of the MIG according to the Fig. 1a.

Fig. 2. The image of the modeled magnetic field of the MIG

The analysis of the image of the magnetic field show that due to the opposed position of the PMs and the structural features of the magnetic chain, the magnetic flux passing through the part of the winding including the anchor is conditioned by only one PM (by the PM1 in Fig. 2). The image also shows that the dispersing magnetic fluxes are tiny, thus they can be ignored. As a result of the modeling the value of the $k\sigma$ coefficient was evaluated dispersing coefficient according to the BPM induction. It was around 6% which needs to be considered in the mathematical model.

As a result of the change of the anchor's position in the MIG, the working magnetic Φ_w flux changes its direction from Φ_1 to Φ_2 in (t_1-t_2) period of time. The duration of the time period depends on the dimension of the external force. The anchor returns to its initial position in (t_3-t_4) period of time due to the resisting force of the spring. The dimension of (t_1-t_2) can vary from action to action depending on the magnitude of the external force, but (t_3-t_4) is comparatively permanent, as it is conditioned by the resisting force of the spring. In case of the identical parameters of the PMs and the magnetic chain $\Phi_1=\Phi_2=\Phi$.

As a result of the change of the magnetic flux eIW electromotive force (EMF) is induced in the IW, the dimensions of which are calculated according to the Maxwell's second law

$$e_1 = -w_{IW} \frac{2\pi}{t_1 - t_2} \sin\gamma, \quad e_2 = -w_{IW} \frac{2\pi}{t_3 - t_4} \sin\gamma. \quad (1)$$

Fig. 3 illustrates the generalized form of the dependence of the working magnetic Φ_w and the induced eIW EMF from t time.

Fig. 3. Dependence of the working magnetic Φ_w and the induced e_{IW} EMF from t time.

The load is connected to the IW parallelly. The back turn of the anchor is the stable working state of the load power. The simplest way to neutralize the induced voltage in unstable mode is to connect a VD diode with certain polarity parallelly to the IW (Fig. 4).

Fig. 4. IW-diode-load connection scheme

The diode strictly decreases the amplitude of e_1 , conditioned by the measure of the e_{VD} voltage drop, but it doesn't affect the amplitude of the e_2 (Fig. 5).

Fig. 5. Induced voltages in the IW-VD-load chain depending on time

When choosing a diode one needs to consider the fact that while inducing EMF with e_1 amplitude the diode works in a short circuits mode, means a huge impulsive electricity passes through it.

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. 6. Electric scheme of the replacement of MIG's magnetic system

PMs located in MIG system are magnetized out of the system, that's why the working point of the PM is on its characterizing refining $B(-H)$ curve, on the position A_1 (Fig. 7), which is characterized by the values of the H_1 voltage of the magnetic field and B_1 induction. When the PM is inserted into the magnetic cytem of the generator by adding the conduction of the magnetic system, the working point of the PM changes to position A_2 characterized by the values of H_2 and B_2 . The working position A_2 is conditioned by a magnetic wire closing of the polars of the PM, as a result $H_2=0$. 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. 7. $B(-H)$ and $W(B)$ characteristics and working points of PM

Conclusion

The results of the research on the structure, working principals, features of the magnetic system of the magnetic induction generator with change of the magnetic flux direction can become a base to develop, productively use the equipment, and to design calculating mathematical apparatus.

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