Chapter 3. Electromagnetic Field of the Generator

Contents

Introduction

Let us view the roller in constructions of Seal and Roschin-Godin [10, 13, 14]. Each of its sides may be considered as a circle on which the poles of permanent magnets are located. In the constructions of our project rotor in simplest cases also may be considered as a circle where the poles of permanent magnets are located – see Fig. 3. Further it is shown that with the roller's or rotor's rotation a magnetic field of a certain configuration is generated, and this field's characteristics are explored.

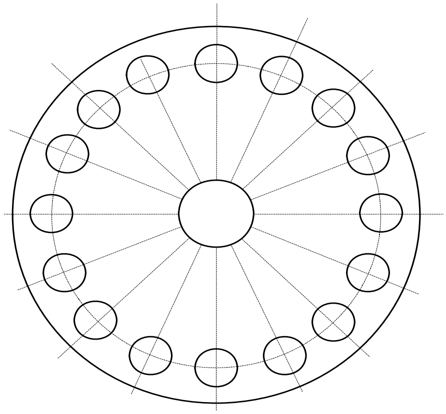

Fig. 1.

1. Mathematical Model

If the rotor's radius is big (as in our problem) it is possible to consider the involute of circle as infinitely long line of poles, and use the Cartesian coordinate system, where the OZ axis passes along the circle through the poles' centers, the OX axis is perpendicular to the rotor's plane, and the OY axis passed along the rotor's radius – see Fig. 2.

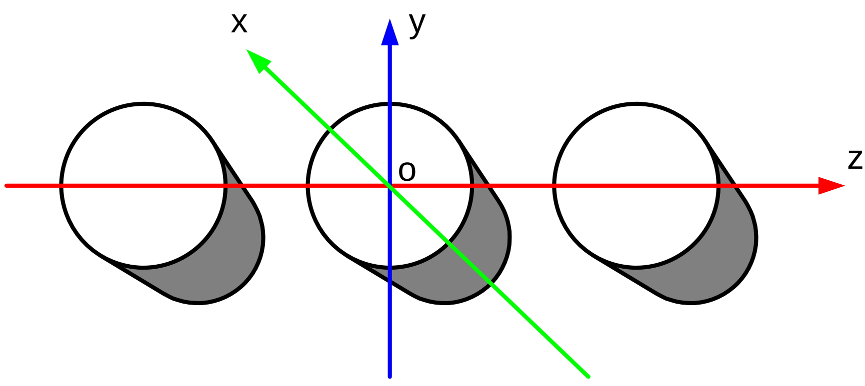

Fig. 2.

We shall now discuss magnetic charges density. In Chapter 2 and Supplement 2 we have shown that the distribution function of magnetic charges density on the face plane of each magnet has the following form:

$$\sigma(x, y, z) = \sigma_o (1 + \mathrm{Cos}(\gamma y))(1 + \mathrm{Cos}(\gamma z))\lambda'(x) \qquad (1)$$

- see formula (2.3.1). Consider now the density distribution of magnetic charges along the involute – see Fig. 3. Above each pole the following function is depicted.

$$\sigma(z) = \sigma_o (1 + \mathrm{Cos}(\gamma z)). \qquad (1a)$$

The function of all magnetic charges density distribution as a whole, as a function of coordinate z, may be approximated by a function of the form

$$\sigma(z) = \sigma_o [1 + \mathrm{Cos}(\beta z)], \qquad (2)$$

where

$2\sigma_o$ is maximal density,

β is coefficient differing from γ and found on the assumption, that in the middle of interval d мbetween the maximums of density, the minimal density is equal to zero, i.e. $\text{Cos}(\beta \cdot d/2) = -1$ or

$$\beta = 2\pi/d\ . \tag{3}$$

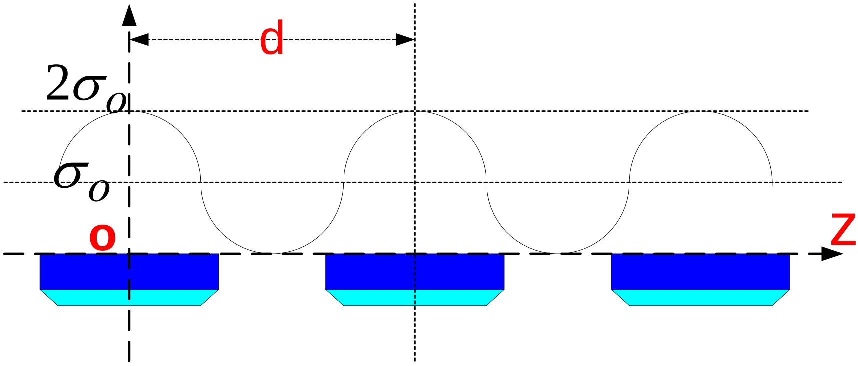

Fig. 3.

The multitude of poles is rotating and one may say that the flow of charges is moving along the involute with constant speed

$$v = \frac{dz}{dt}.$$

An observer permanently located in a certain point z_{fix} and observing this flow of charges, may fix the density, changing with time, which, on account of (2), is described by a following function

$$\sigma(t) = \sigma_o[1 + \text{Cos}(\omega t)]. \tag{4}$$

From this and from (3) follows that

$$\omega = 2v\pi/d\ . \tag{5}$$

In the point z'', located at some distance z from the point z', another observer may fix the density, changing with time

$$\sigma(t) = \sigma_o[1 + \text{Cos}(\omega t + \varphi_z)], \tag{7}$$

where $\varphi_z = 2\pi \cdot z/d$, as the magnets are placed along the axis oz with the period d – see Fig. 3. From this, taking into account (3), we get

$$\varphi_z = \beta \cdot z, \tag{8}$$

So,

$$\sigma(z,t)=\sigma_o[1+\mathrm{Cos}(\omega t+\beta z)], \qquad (9)$$

Thus, by formula (9) we may describe the density of charges on the rotor. It may be identified with the motion of a charge distributed along a circle where the charge is changing with time.

From (1) it follows also that the magnetic charges density distribution function on the face plane of each magnet with respect to coordinates $0y$ and $0x$ have the following form:

$$\sigma_1(y)=\sigma_o(1+\mathrm{Cos}(\gamma y)), \qquad (11)$$

$$\sigma_1(x)=\sigma_o\lambda'(x). \qquad (12)$$

Evidently, the density distribution functions for all the multitude of magnetic charges with respect to coordinates $0y$ and $0x$ may be described by these functions. Thus, the functions (9, 11, 12) may be generalized as

$$\sigma(x,y,z,t)=\sigma_o(1+\mathrm{Cos}(\gamma y)\mathrm{Cos}(\omega t+\gamma z)\lambda'(x)). \qquad (13)$$

> So, in future we shall regard as a known function the function (13) magnetic charges density distribution with respect to the arguments x,y,z,t.

2. Magnetic field

Using the method presented in Supplement 3, we have shown in this project that the moving magnetic charges, distributed according to (1.13), create a magnetic wave. The equations of this wave are

$$H_y(x,y,z,t)=-h_y\mathrm{Cos}(\beta z+\omega t)\mathrm{Sin}(\chi x)\mathrm{Sin}(\lambda y), \qquad (1)$$

$$H_z(x,y,z,t)=-h_z\mathrm{Sin}(\beta z+\omega t)\mathrm{Sin}(\chi x)\mathrm{Cos}(\lambda y), \qquad (2)$$

$$H_x(x,y,z,t)=-h_x\mathrm{Cos}(\beta z+\omega t)\mathrm{Cos}(\chi x)\mathrm{Cos}(\lambda y), \qquad (3)$$

where

H_x, H_y, H_z are projections of the vector of magnetic field density

h_x, h_y, h_z are amplitudes

χ - parameter.

In the project is shown that the parameters of such magnetic wave and the parameters of distributed magnetic charges are connected as and follows

$$h_x = \sigma_o / \mu , \quad (5)$$

$$\chi \approx \sqrt{\left(\lambda^2 + \beta^2\right)}, \quad (6)$$

$$h_z = -h_x \beta / \chi , \quad (7)$$

$$h_y = -h_x \lambda / \chi . \quad (8)$$

Thus, along the oz axis there appears a magnetic field H_z, which constitutes a longitudinal magnetic wave (as H_z is dependent on z).

3. Electric Field

Electric field in the generator may be generated by a source of direct voltage included between stator and rotor. The electric induction on this magnet face plane of is equal to εE_r, where ε is the absolute electric permeance of air , E_r is the intensity of electric field on the face plane. It is believed that an equivalent electric charge of the face plane of a permanent magnet is equal to

$$q_r = \varepsilon E_r \cdot S . \quad (10)$$

where S – area of magnet face plane. Therefore, the face plane of a permanent magnet with electric intensity E_r may be regarded as the source of charges. If the intensity E_r is created by the voltage u, applied between the poles of stator and rotor, on the gap Δ, then

$$E_r = u / \Delta . \quad (12)$$

and

$$q_r = \varepsilon \cdot u \cdot S / \Delta . \quad (13)$$

There exists a relativist effect [19], consisting in the fact that in a moving magnet the charges compensation is disturbed, and the magnet becomes electrically polarized. It means that each magnet bears an electric charge. A magnet moving with speed v and having induction B_r creates an electric field [19], which may be determined by the formula

$$\overline{E}_r = \overline{v} \times \overline{B}_r . \quad (14)$$

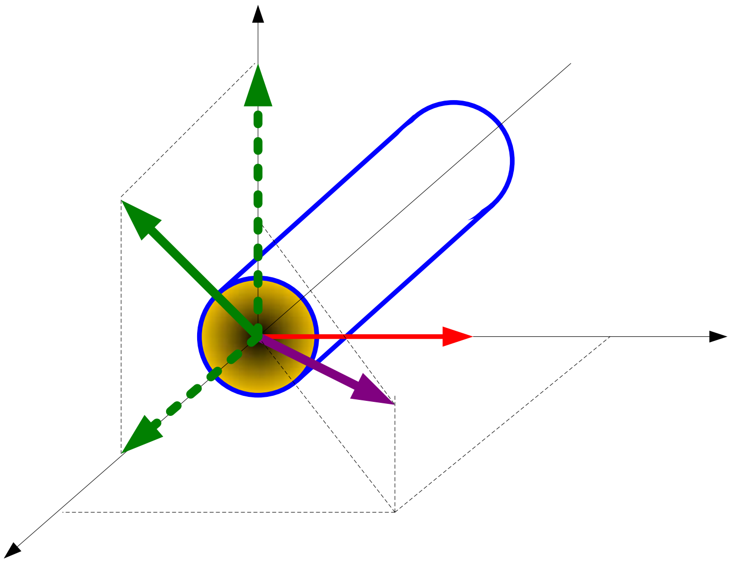

Fig. 2

Fig. 2. shows the connection between these two values. Hence, the face plane of a moving magnet may be identified with an electric charge whose value is

$$q_r = \left|\overline{v} \times \overline{B}\right| \varepsilon \,. \tag{15}$$

From (14), assuming that

$$E_r = vB \,, \tag{16}$$

we find

$$q_r = vB\varepsilon \tag{17}$$

Comparing (13) and (17), we notice that electrical charges caused by the magnet's motion, and the charges caused by the field's intensity are equal with

$$\frac{u}{v} = \frac{B \cdot \Delta}{S} \,. \tag{18}$$

Thus, the face plane of a permanent magnet bears a magnetic and an electric charge. It can be shown that the density distribution of electric charges is described by a function similar to function (1.13):

$$\rho(x, y, z, t) = \rho_o \left(1 + \mathrm{Cos}(\gamma y)\mathrm{Cos}(\omega t + \gamma z)\lambda'(x)\right). \tag{19}$$

In this project we have shown that the moving electric charges, distributed according to (19) , create an electric wave similar to the above mentioned magnetic wave. The equation of this wave is

$$E_y(x,y,z,t) = -e_y \mathrm{Cos}(\beta z + \omega t)\mathrm{Sin}(\chi x)\mathrm{Sin}(\lambda y), \quad (1)$$

$$E_z(x,y,z,t) = -e_z \mathrm{Sin}(\beta z + \omega t)\mathrm{Sin}(\chi x)\mathrm{Cos}(\lambda y), \quad (2)$$

$$E_x(x,y,z,t) = -e_x \mathrm{Cos}(\beta z + \omega t)\mathrm{Cos}(\chi x)\mathrm{Cos}(\lambda y), \quad (3)$$

where

E_x, E_y, E_z are the projections of intensity vector of the electric field

e_x, e_y, e_z are amplitudes,

χ is a parameter.

It is significant that in such construction oscillations of electrical intensity in the direction of the *0X* axis are generated (with parameter χ) as a consequence of the "splash" of charges on the surfaces - see Supplement 3.

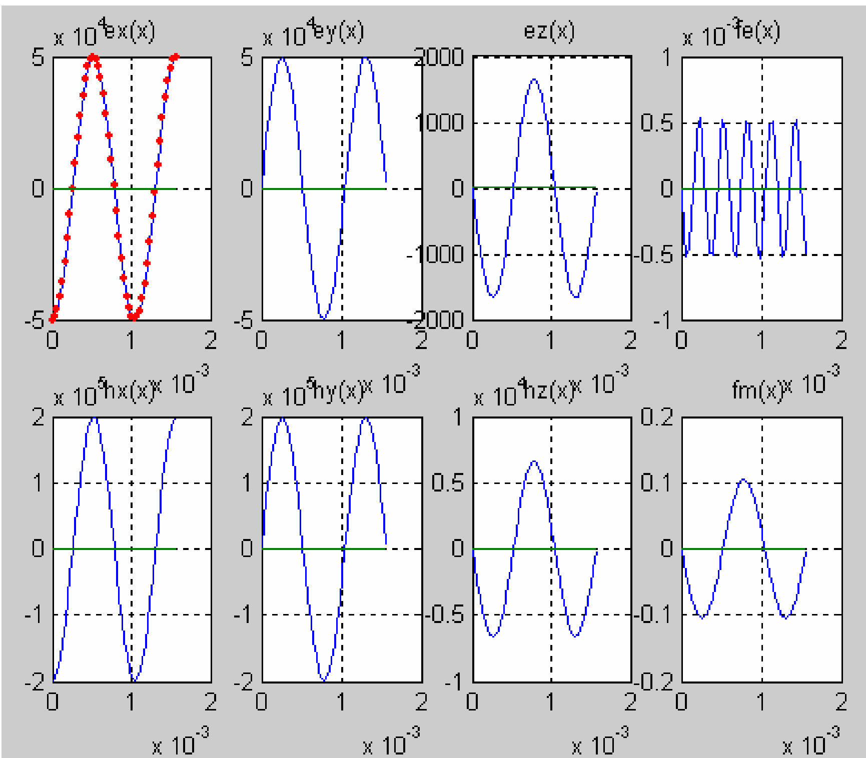

Fig. 3.

In the project is shown that the parameters of such magnetic wave and the parameters of distributed magnetic charges are connected as (2.6) and follows

$$e_x = \rho_o / \mu, \qquad (5)$$

$$e_z = -e_x \beta / \chi, \qquad (7)$$

$$e_y = -e_x \lambda / \chi. \qquad (8)$$

The solution of Maxwell's equations are valid for simultaneously given magnetic and electric charges. The separation of electromagnetic wave into unconnected magnetic and electric wave occurs in the process of solution. Fig. 3 shows the functions obtained as a result of numerical solution for $\omega = 2500,\ \gamma = 6000,\ \beta = 200,\ \rho_o = 5 \cdot 10^4,\ \sigma_o = 2 \cdot 10^5$. In the first window for comparison a graph of cosine function is shown by points.

4. A Volatile Stationary Wave

So, in this case due to the "splash" of charges density along the ox axis there appears a magnetic field H_x, which constitutes a stationary wave. Indeed, the nodes of this wave along ox axis do not shift with time.

Let us look into this question. From a well-known formula

$$\mathrm{Cos}(\omega t + \beta z) = [\mathrm{Cos}(\beta z)\mathrm{Cos}(\omega t) + \mathrm{Sin}(\beta z)\mathrm{Sin}(\omega t)]$$

it follows that the considered magnetic wave $H_x(x, y, z, t)$ may be represented by a superposition of two waves: first wave of the form

$$H_x(x, y, z, t) = -h_x \mathrm{Cos}(\beta z)\mathrm{Cos}(\omega t)\mathrm{Cos}(\chi x)\mathrm{Cos}(\lambda y), \qquad (1)$$

and second wave of the form

$$H_x(x, y, z, t) = -h_x \mathrm{Sin}(\beta z)\mathrm{Sin}(\omega t)\mathrm{Cos}(\chi x)\mathrm{Cos}(\lambda y), \qquad (2)$$

In Chapter 4 it is shown that such waves are volatile – they exchange energy with the environment. The existence of permanent stationary magnetic waves is proved by us experimentally – see Supplement 2, and the existence of stationary magnetic waves follows from the experiments of Roshchin-Godin – see the description of magnetic walls in Chapter 4.

The stationary magnetic waves are generated in the same way. Evidently, they could be detected in the device of Roschin-Godin.