Physical and mathematical sciences

LYSENKO MYKOLA GRIGOROVICH

candidate of physical and mathematical sciences,

National Technical University of Ukraine "KPI"

KUZENKO MARIIA TARASOVNA

student of National Technical University of Ukraine "KPI"

DEFINITIONS THE EXPRESSION FOR COERCIVEFORCE OF CYLINDRICAL Nd-Fe-B MAGNETSTHAT DEPENDS ON MAGNETIC DISTANCE AND CURRENT

Summary: In this work is presented the solution of the expression for coercive force of cylindrical Nd-Fe-B magnets. The notion of magnetic current and the analogy of line conductor was used. The influence of magnetic distance and magnetic dimensions was investigated.

Key words: coercive force, cylindrical magnets, line conductor, magnetic distance.

Introduction

The relevance of the question posed is determined by large-scale use of magnets in technology and electronics.

Consider the problem of interaction between two cylindrical neodymium magnet with axial symmetry. Determine the dependence of the interaction of magnets depending on the distance by approaching model to a set of linear conductor. This approach can do as a result of the formation of magnetic currents on the surface of magnets.

To calculate $H_r(z)$ will make use of the condition of equivalence and the solenoid magnet, which comes from the equality of their magnetic moments. The magnetic moment of the magnet is equal to P: $P = MV = MSh$, M – magnetization magnet, V – its volume, S - square-section, h - height. The magnetic moment equivalent solenoid: $P = jhS, j = I/h$ – linear current density magnetization current. From it: $j = M$.

Determine the magnitude and direction of composite vector potential$\vec{A}$, which creates a current I, flowing through the linear conductor element lengthdl. Let the distance from the current element to an arbitrary point in space marked by$R$, $R \gg dl$.

In accordance with the general expression $d\vec{A} = \frac{\mu_a \vec{\delta} dV}{4\pi R}$, $\vec{\delta} dV = \vec{\delta} d\vec{S} d\vec{l} = i d\vec{l}$, where dS - conductor cross-sectional area.

We write the law of Biot-Savart Laplace vector potential: $d\vec{A} = \frac{\mu_a i d\vec{l}}{4\pi R}$.

Vector potential $\vec{A} -$ vector electromagnetic field, which is expressed by $\vec{E}$ and $\vec{B}$, ie svektor spilnyy for $\vec{E}$ and $\vec{B}$: $\vec{B} = rot\vec{A}$, $\vec{E} = -\frac{d\vec{A}}{dt}$.

$$d\vec{l} = dl_1 + dl_2$$

$$dl_1 = dlsin\alpha dl_2 = dlcos\alpha dl = r_0 d\alpha$$

$$\vec{A} = \overrightarrow{\alpha_0} A_\alpha = \overrightarrow{\alpha_0} \frac{\mu_a i}{4\pi} \int_0^{2\pi} \frac{r_0 cos\alpha d\alpha}{R}$$

$$R = \sqrt{Z^2 + r_0^2 + \rho^2 - 2\rho r_0 cos\alpha}$$

$$\vec{A} = (0, A_\varphi, 0)$$

$$\vec{B} = rot\vec{A} = \overrightarrow{e_\rho} \left(-\frac{\partial A_\varphi}{\partial z}\right) + \overrightarrow{e_z} \left(\frac{1}{\rho} \frac{\partial(\rho A_z)}{\partial \rho}\right)$$

$$\varphi = \alpha$$

$$A_\alpha = \frac{\mu_0 i}{4\pi} \int_0^{2\pi} \frac{r_0 cos\alpha d\alpha}{R}$$

$$B_\rho = -\frac{\partial A_\alpha}{\partial z} = -\frac{\mu_0 i}{4\pi} \int_0^{2\pi} r_0 \frac{\partial}{\partial z} \left(\frac{cos\alpha}{R}\right) d\alpha$$

$$i = jdz'$$

$$B_\rho = -\frac{\mu_0 j}{4\pi}\int_{z}^{z+h} dz' \int_{0}^{2\pi} r_0 \frac{\partial}{\partial z'}\left(\frac{cos\alpha}{R'}\right) d\alpha = |R' = R| =$$

$$= \frac{\mu_0 j}{4\pi} r_0 \int_{0}^{2\pi} \left[\frac{1}{\sqrt{Z^2 + r_0^2 + \rho^2 - 2\rho r_0 cos\alpha}} - \frac{1}{\sqrt{(Z+h)^2 + r_0^2 + \rho^2 - 2\rho r_0 cos\alpha}}\right] cosad\alpha$$

The magnitude and direction of the magnetic induction B at any point of the magnetic field generated by the conductor element of length dl with current dl with current I, can be found by Bio-Savart law.

For the calculation of axial symmetry we can use cylindrical coordinate system.

The strength of the interaction with the magnetic field flow per unit volume:

$$\vec{f} = \vec{j} \times \vec{B}$$

Where $\vec{j}$ – current density, $\vec{B}$ –magnetic field. Full strength is obtained after integration over the volume of the magnet:

$$\vec{F} = \int \vec{f} dV = \int \vec{j} \times \vec{B}\, dV = \int \vec{j} \times \mu_0 \vec{H} dV$$

$$dF_A = \mu_0 \int_{0}^{R} jH_r(z)\, dzdl = \mu_0 dzj \int_{0}^{R} H_r(z)dl = 2\pi R \mu_0 {J_m}^2/(4\pi)$$

So the expression for F is:

$$F_A = \int_{z_0}^{z_0+d} \frac{1}{2} R^2 \mu_0 dz {J_m}^2 \int_{0}^{2\pi} \left[\frac{1}{\sqrt{Z^2 + r_0^2 + \rho^2 - 2\rho r_0 cos\alpha}} - \frac{1}{\sqrt{(Z+h)^2 + r_0^2 + \rho^2 - 2\rho r_0 cos\alpha}}\right] cosad\alpha$$

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Picture of theoretical model: