ANALYSIS OF VIBRATION MICROGENERATOR

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Summary This contribution brings numerical results of the analysis of gravitation generator. The draft was created as a part of project trying to increase safety of air traffic.

1. INTRODUCTION

By development of new devices is always bigger emphasis put on their safety and reliability. One of the devices, where the safety demands are especially great, is civil and military aircrafts. Reduced reliability could lead to the heaviest losses – losses of lives.

One of the ways, how to increase the safety of an aircraft, is to build up a sensor net placed on critical places in the aircraft. These sensors monitor during the flight important quantities, e.g. temperature or pressure, and after landing of an aircraft operator just walks around the aircraft and by using a wireless transmission the needed data are gained from all sensors. Those will be compared with data from a previous flight and all other data available.

This contribution brings the results of a microgenerator (MG) analysis. The microgenerator is intended to provide power to sensors. Principle of a microgenerator is based on utilization of changes in gravity with the help of Faraday's law [1], [2]. The required output parameters are: output voltage in ideal case between 3 – 5 V, output power 200 – 1000 μW. The value of output power depends on type of used sensor.

The MG body is tightly connected with source of vibration - fuselage and thanks to oscillation of system spring – MG core comes up to motions of MG core towards the shell.

2. MATHEMATICAL MODEL

Analysis of a MG model is possible to carry out as a numerical solution, with the Finite element method (FEM). The electromagnetic part of the model is based on solving of reduced Maxwell equations.

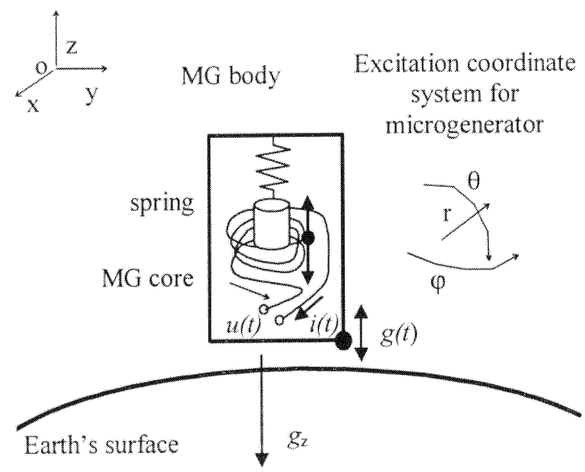

Fig. 1 Basic concept of microgenerator

$$rot\, \boldsymbol{H} = \boldsymbol{J}, \qquad (1)$$

$$div\, \boldsymbol{B} = 0, \qquad (2)$$

where $\boldsymbol{H}$ is magnetic field intensity vector, $\boldsymbol{B}$ is magnetic flux density vector, $\boldsymbol{J}$ is of current density vector.

$$rot\, \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t}, \qquad (3)$$

$$div \boldsymbol{J} = 0, \qquad (4)$$

where $\boldsymbol{E}$ is electric field intensity vector. Material relationships are represented by the equations

$$\boldsymbol{B} = \boldsymbol{H}\, \mu_0 \mu_r + \mu_0 \boldsymbol{M}, \qquad (5)$$

$$\boldsymbol{J}_v = \boldsymbol{E}\gamma, \qquad (6)$$

where μ_0 is permeability of vacuum, μ_r is relative permeability, $\mu = \mu_r\mu_0$, $\boldsymbol{M}$ is the remanent intrinsic magnetisation vector of a permanent magnet, γ is conductivity. Vector functions of an electric and magnetic field are specified by scalar electric potential ϕ_e and vector magnetic potential $\boldsymbol{A}$

$$E = -\operatorname{grad} \phi_e - \frac{\partial A}{\partial t}, \qquad (7)$$

$$B = \operatorname{rot} A. \qquad (8)$$

The resulting current density vector $\boldsymbol{J}$ from equation (10) is superposed from source current density J_{circ} and eddy current density J_{v}. Motion is in model respected by current density J_m

$$J_m = \gamma\left(v \times B\right), \qquad (9)$$

$$J = J_{\mathrm{v}} + J_{circ} + J_m. \qquad (10)$$

Part of MG electromagnetic model with the equation (11) can be described with matrix representation (12).

$$\begin{bmatrix} L_A + L_{A\varphi} & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -\Theta L_S \end{bmatrix} \begin{Bmatrix} \dot{a} \\ \dot{\phi} \\ \dot{S} \end{Bmatrix} + \begin{bmatrix} K_{A1} + K_{A2} - (1-\Theta) K_{A3} & 0 & 0 \\ 0 & K_\varphi + K_{\varphi\varphi} & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} a \\ \phi \\ S \end{Bmatrix}$$
$$= \begin{bmatrix} z_J & z_{\varphi\varphi} & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} j_s \\ \rho \\ 0 \end{Bmatrix} + \begin{bmatrix} z_M & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} m \\ 0 \\ 0 \end{Bmatrix} \qquad (11)$$

3. MODEL OF A MICROGENERATOR IN ANSYS PROGRAM

The geometrical model was created with standard tools in ANSYS with help of automated generator of mesh and nodes and then is the mathematical model formed. The applied element is SOLID97. The model is in ANSYS described by characteristic data:

DISPLAY FEM MODEL SIZE INFORMATION

***** FEM MODEL SIZE *****

Maximum Node Number	=	90489
Number of Defined Nodes	=	90489
Number of Selected Nodes	=	90489
Maximum DOF per Node	=	3
Maximum Element Number	=	91780
Number of Defined Elements	=	91780
Number of Selected Elements	=	91780

In the Fig. *2* is represented the characteristics geometrical form MG model. It consists of passive magnetic bearings and additional magnetic circuits, by that can the conditions be set for functioning of gravitational generator [3].

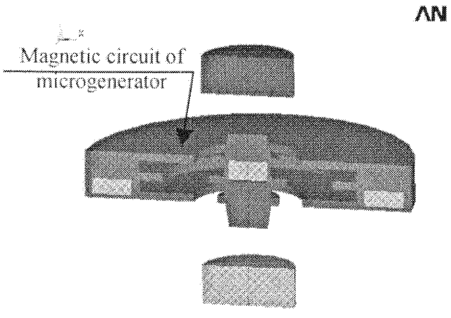

Fig. 2. Geometrical model of microgenerator.

4. RESULTS OF THE STATICAL ANALYSIS

In the Fig. 3 are showed module of vector functions magnetic field density *B* and intensity *E*. For the right model design is necessary to evaluate the distribution of forces. These were gain from virtual works.

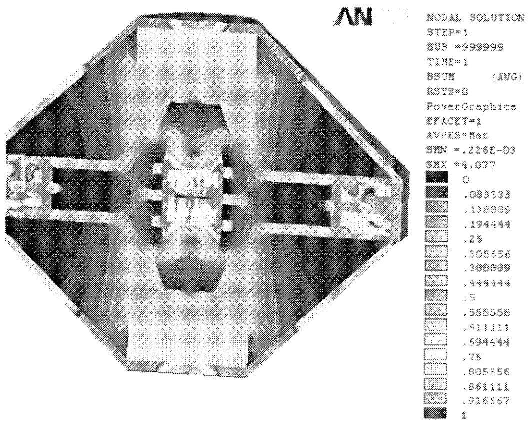

Fig. 3. Evaluation of modules of magnetic field density and intesity B and H.

5. CONCLUSION

This contribution is a part of introductory study of gravitational microgenerator. It originates as a preparation for suggested 6 Th General European Project.

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