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Electrical machines with nanocomposite structure parts

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Abstracts: Recent achievements in nanocomposite materials technology had opened the new possibilities in electrical machinery which are connected with further increasing of machines efficiency. Nanocomposite materials give also the possibility to receive almost any necessary characteristics and parameters. The prototype machine was designed, built and tested. Obtained machine data confirmed the expectancies.

Key-Words: - electrical machine, nanocomposite, materials motor parameters, nanotubes technologies, electromagnetic field, combination of electric, magnetic and mechanical characteristics

1 INTRODUCTION

Nanostructures which is intended to use in new electrical machines generation are connected with nanotubes represented by superthin (about ~ 100 nm) carbon filaments. Combination of nanotubes in a form of fullerenes (new mechanical carbon structure of about 60 atoms), ferrous and particles gives the new material with proper values of $\mu\rho$ where μ - specific magnetic permeability, ρ - specific resultant material resistivity and required mechanical properties.

2 PROBLEM FORMULATION

As an example, the a.c. motor with solid rotor is under consideration as perspective design solution for small electrical machine and in case of using high speed motors ore generators.

As it is known motors with solid rotor have poor efficiency. The main problem is to receive optimal combination of electrical conductivity and specific magnetic permeability of solid rotor.

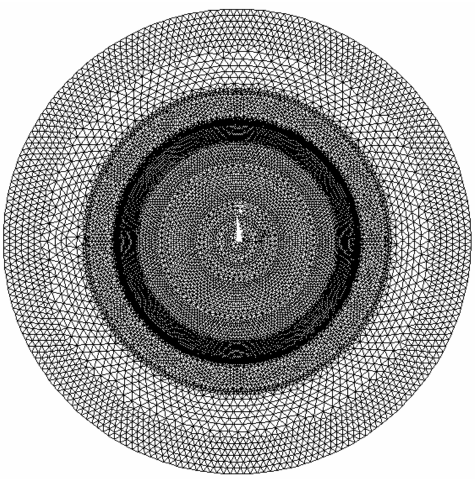

Fig. 1. The finite element model of the prototype motor

Proper values of material conductivity and specific magnetic permeability which are different for various motors.

The proper mechanical level can be also satisfied by adding some percent of nanotubes (also different for various and specific required mechanical properties) to the whole rotor material composition.

Small prototype rotor have been produced and tested. Test results confirms that the efficiency in prototype motor is in a range of about 70% that more larger than in comparable short-circuit used motor. Besides the motor technology is much simpler.

The motor can operate at high frequency and speeds of rotation up to 25000 rpm and higher using light metal ceramic material with nanotubes.

The cross section of the prototype rotor is shown on Fig. 1. This is the finite element model of the prototype motor.

The material for solid rotor shown on Fig. 1 was received as a result of joint investigations of a team including both chemists and metallurgists. As it is known alloys with high content of silicon are brittle and poor mechanically treated. The material received is not brittle and is easy for machining.

The necessary level of mechanical properties is reached by adding proper amount of fullerenes into the basic ferrous material.

2 PROBLEM SOLUTION MODELING RESULTS

The technique of calculating the electromagnetic field in the rotor body and as well as the electromagnetic torque has been developed by numerical analysis using material properties of each model material to represent a real physical system.

Some results of numerical analysis for the motor with nominal rating of 250W are represented in Fig. 2 – Fig. 3. (Magnetic flux distribution in the rotor).

The purpose of our study was to determine some composite parameters and to obtain the required motor performance.

After a number both numerical and experimental investigations we went to the conclusions that the best results can be received for proper values of material conductivity and specific magnetic permeability which are different for various motors.

According with our previous investigations [1], [2], for the particular motor under consideration with nominal rating of 100W, 500000 rpm it was established that the best combination of electrical conductivity and specific magnetic permeability will be approximately $(12\text{-}24)\cdot 10^{-8}$ Ohm·m/m (electrical conductivity), approximately $(8\text{-}16)\cdot\mu_0$

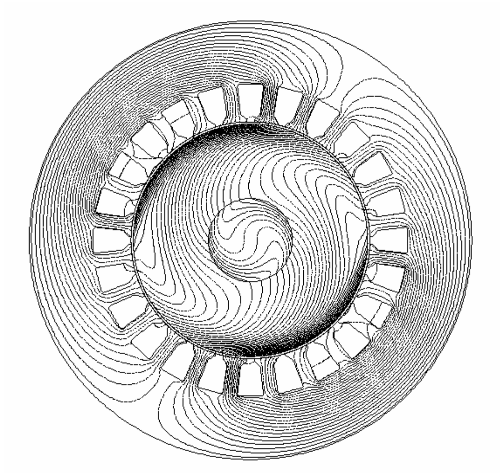

Fig. 2. Magnetic lines of flux distribution

(specific magnetic permeability), where μ_0 – vacuum magnetic permeability.

For the particular motor under consideration with nominal rating of 22 kW, 750 rpm it seems that the best combination of electrical conductivity and specific magnetic permeability will be approximately $20\cdot 10^{-8}$ Ohm·m/m (electrical conductivity), approximately $100\mu_0$ (specific magnetic permeability). For the particular motor under consideration with nominal rating of 250 W, 3000 rpm it seems that the best combination of electrical conductivity and specific magnetic permeability will be approximately of the level with $\mu \approx 230$ and $\rho \approx (30 \div 45)\cdot 10^{-8}$ ohm·m.

Fig. 3. Magnetic flux distribution

3 CONCLUSIONS

We have established some new data on designing of a new type of electrical machine with the desired operating characteristics and a higher efficiency.

Application of nanocomposite materials for the rotor body gives the possibility to design new motors with various and specific required mechanical properties for different applications and allows to operate at high frequency.

This prototype motor have not specially made for super high velocities. The motor stator has been performed as 6-phase. With according to our opinion the better results can be achieved for 9-phase solution.

The optimal magnetic parameters for rotor have been proposed and now the study of this problem is in progress.

Our investigations have shown that it is possible to receive a new class of porous materials with precise values of porous by means of nanotubes technology. These materials can be used for energy accumulation in fuel cells technology.

Acknowledgement

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