DD03

Design of an Eddy Current Brake System using Microstructures

Jae Seok Choi[1] and Jeonghoon Yoo[2*]

[1]Graduate School of Mechanical Engineering, Yonsei University, 262 Seongsanno, Seodaemun-Gu, Seoul 120-749, Korea
[2]School of Mechanical Engineering, Yonsei University, 262 Seongsanno, Seodaemun-Gu, Seoul 120-749, Korea

*Corresponding author: Jeonghoon Yoo, e-mail: yoojh@yonsei.ac.kr

This study introduces a design method of an eddy current brake system which slows a piece with nonzero conductivity using electromagnetic induction. Eddy current brakes are generally used for the secondary brakes of heavy trucks, buses and rail vehicles and they are classified into a DC-excited electromagnet (EM) type and a permanent magnet type. In this study, the optimization problem of an EM type brake to increase the braking force is investigated as shown in Fig. 1. In the figure, the tail of the magnetic field to the moving direction is represented because of the generation of the eddy current in the moving part with conductivity.

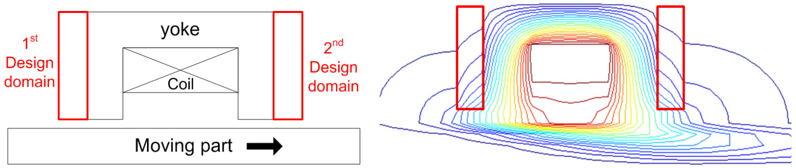

Fig. 1. Eddy current brake system and its magnetic flux line plot.

For the design of the eddy current brake system, we present an optimization method using a microstructure concept. The proposed microstructure is a sort of a stacked composite composed of very thin ferromagnetic membranes and paramagnetic material and its exact geometry is calculated based on the homogenization theory [1]. The composite is assumed to play a role as a guide to control the magnetic field and is attached to the left and the right side of the yoke, i.e., the 1st and the 2nd design domain described. If we know the optimal rotation direction of the stacked composite in the discrete region, the magnetic field can be modulated and the braking force may be increased. Simultaneously, we may manage the topology optimization problem for the macro-scale design of the end part of the yoke. To solve the mixed optimization problem, i.e., the micro-scale design of the direction of microstructures and the macro-scale design of the the yoke shape, numerical optimization techniques such as the sequential linear programming and the adjoint variable method [2] are used. The magnetic system is analyzed based on the two-dimensional finite element analysis.

This work is supported by Korea Science and Engineering Foundation (KOSEF) under the Grant R01-2006-000-10074-0.

REFERENCES

[1] E. Sanchez-Palencia, Non-homogeneous Media and Vibration Theory, Springer-Verlag, Berlin (1980).
[2] R. T. Haftka et al., Elements of Structural Optimization,Kluwer Academic Publishers, Dordrecht (1992).

DD04

A 3D-field Permanent Magnet Flux-switching Machine

C. F. Wang and J. X. Shen*

College of Electrical Engineering, Zhejiang University, Hangzhou, 310027, P.R.China

*Corresponding author: J. X. Shen, e-mail: J_X_Shen@zju.edu.cn

The paper describes a novel 3D-field, three-phase permanent magnet flux-switching (PMFS) machine, as shown in Fig.1, which combines the merits of tubular linear machine, external-rotor machine and axial-flux machine technologies. It offers a high power density and peak torque capability, as well as efficient use of magnets owing to the unique structure of triple air fields. Therefore, it is suitable for a wide range of applications industry and aerospace.

In the proposed machine, the tangential magnetized magnets of alternate polarity are sandwiched between slotted stator cores, which accommodate the three-phase windings. The external rotor, with a U-shaped cross section, wraps the three sides of the inner stator, where the rotor teeth locate on each side. Due to this unique mechanical configuration of the triple air fields in a slightly enlarged volume, the torque density is substantially boosted, since the output torque is proportional to the air-field surface area [1].

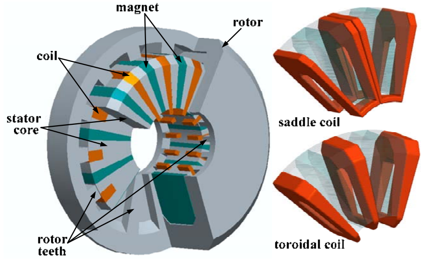

Fig. 1. Configuration and coil types.

Two coil types, viz. saddle coil and toroidal coil, as shown in Fig.1, are comparatively analyzed. Both have short end windings since the inner diameter of the stator is small, and their performances are similar in terms of back electromagnetic force (EMF) and space for locating coils. A further consideration is that, the armature reaction field of saddle coil is essentially perpendicular to the axis of magnetization, hence, the risk of irreversibly demagnetizing the magnets is low [2]. This allows high peak electric loading, and a high peak torque capability. In contrast, the armature reaction field of toroidal coil is in the same direction with magnets and could cause higher risk of demagnetizing. Fig.2 shows the phase back-EMF waveforms per turn of the 14-pole/12-slot 3D-field PMFS machine and a 2D-field (external rotor) PMFS machine of the same size. As is evident, the amplitude of the former one is much larger than that of the latter one, whilst the slot area is slightly smaller, which means a higher power output.

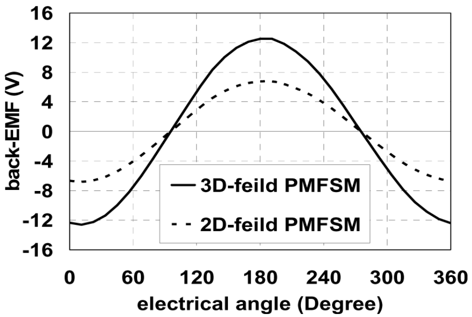

Fig. 2. Waveforms of phase back-EMF.

REFERENCES

[1] R. Qu *et al.*, IEEE Trans. Ind. Appl. 39(6), pp.1665-1673 (2003).
[2] J. Wang *et al.*, J. of Appl. Phys. 103, 07F105 (2008).