Optimization for Reduction of Torque ripple in Interior Permanent Magnet Motor by Using Taguchi Method

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***Abstract* – This paper deals with the optimization of rotor shape, based on finite element method, to improve performance of an interior permanent magnet (IPM) motor. In general, average operational torque (AOT) and torque ripple of an IPM motor is greater than those of the other type permanent magnet motors. Therefore, this paper presents an optimal design of rotor in the IPM motor by the robust design, called Taguchi method, to obtain more AOT and reduce torque ripple.**

INTRODUCTION

Interior permanent magnet (IPM) motor is one of the most attractive motors applied in compact systems. Since the motor generates both magnetic torque and reluctance torque, it can have high power density per motor volume. In an IPM motor, however, torque ripple increased by reluctance torque causes vibration and noise [1], and the amplitude of torque ripple is generally dependent on magnet arrangement in a rotor. Therefore, with changing rotor shape, this paper presents the rotor design to minimize torque ripple by the Taguchi method. The characteristic analysis is performed by 2D finite element method (FEM).

ANALYSIS MODELS

Fig. 1 shows the configurations of the two analysis models, named S-type and V-type. S-type is a prototype and V-type is an improved type, introduced in this paper, to keep average operational torque (AOT) and reduce torque ripple. Analysis condition of the two models is the same except arrangement and volume of the permanent magnet in the rotor.

EXPERIMENT DESIGN AND ANALYSIS

The design parameters, from A to D, are described in Fig. 1. (b). Taguchi's robust design method provides the designers with a systematic and efficient approach for conducting the numerical experimentation to determine optimum settings of design parameters. The robust design method uses orthogonal arrays to research the parameter space. The Taguchi's orthogonal arrays provide a method to select an intelligent subset of the parameter space, and significantly reduce the number of experimental configurations. Analysis results of the IPM motors are obtained by 2D FEM. After conducting these numerical experiments and acquiring all the experimental data, Analysis of Means and Analysis of Variance are carried out to estimate the effects of the design parameters on the AOT and torque ripple and determine the relative importance of each design parameter. The optimum settings for each design parameter are then obtained from the plot of main factor effects [2]. Fig. 2 shows the overall process of the rotor optimization by the robust design.

CONCLUSIONS

We can obtain optimized shape of the rotor reducing torque ripple and ensuring AOT over that of the S-type, and the results show that robust design method is an effective approach in the rotor optimization.

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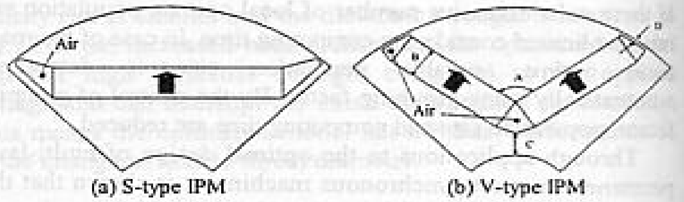

Fig. 1. Rotor configuration of Analysis models

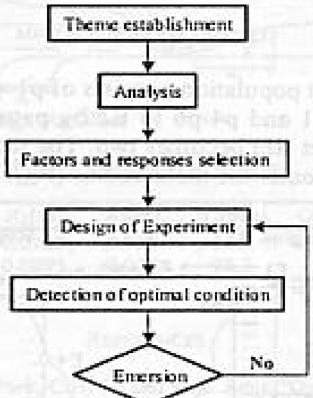

Fig. 2. Optimal design of process

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