

## Tolerance Allocation of Barrier Shape in Switched Reluctance Motor Based on Stochastic Response Surface Methodology

Sung-Il Kim<sup>1</sup>, Student Member IEEE, Jung-Pyo Hong<sup>1</sup>, Senior Member IEEE, Young-Kyoun Kim<sup>2</sup>, and Ji-Young Lee<sup>3</sup>

<sup>1</sup>Department of Electrical Engineering, Changwon National University, Changwon, 641-773, Korea  
ksi1976@dreamwiz.com, jphong@changwon.ac.kr, Fax: +82-55-263-9956

<sup>2</sup>Power Electronics Group, Digital Appliance Business, Samsung Electronics Co. LTD, Suwon, 443-742, Korea

<sup>3</sup>Transverse Flux Machine Research Group, Korea Electrotechnology Research Institute, Changwon, 641-120, Korea

**Abstract**— This paper proposes tolerance design of a switched reluctance motor with barriers. The shape and dimensional tolerance of the rotor barrier directly influence the motor performance such as torque ripple. Therefore, a manufacturing design guide with respect to the barrier is required, and it can be achieved by the tolerance allocation of the shape of the rotor barrier. In this paper, stochastic response surface method combined with genetic algorithm is introduced to predict more accurately the tolerance analysis and design.

### I. INTRODUCTION

The dimensional tolerance of electric machines can have an effect on electric performances, and the rigorous tolerance in manufacturing process result in the increase of production cost. Therefore, the tolerance design considering dimensional allowance is required in the design stage of the motor. In fabricating the motor, the design considering the tolerance is helpful to predict the tolerance band of design variables, which is not only to improve the quality but to reduce the production cost.

The usual method for the tolerance analysis and design is Monte Carlo Simulation [1]. However, the major drawback of the method is that it requires a great number of computations to obtain statistically significant results. Accordingly, with a very large computational cost, the number of the samples will be very numerous.

In this paper, a new numerical approach to the tolerance design is introduced. The new method based on stochastic response surface methodology (SRSM) [2] is combined with genetic algorithms (GA).

### II. APPLICATION MODEL

Fig. 1 shows the barrier type 8/6 switched reluctance motor (SRM) used in this paper. In the model, the effects on torque characteristics according to the shape and manufacturing tolerance of the barrier are investigated, and an effective manufacturing design guide as regards the barrier is proposed.

### III. THE PROCEDURE OF TOLERANCE ALLOCATION

The schematized procedure of tolerance allocation is shown in Fig. 2. The objective function is defined as the variance of torque ripple of the barrier type SRM, and the constraint condition is to satisfy the torque performance.

### IV. NUMERICAL RESULTS FOR TOLERANCE ALLOCATION

Fig. 3. (a) shows the probability distributions of the torque ripple, when the allowance is controlled with the allocated tolerance. At the 10% variation of the torque ripple, the joint probability distributions between with the torque ripple and average torque is shown in Fig. 3. (b).



Fig. 1. Cross section and design variables of barrier type SRM

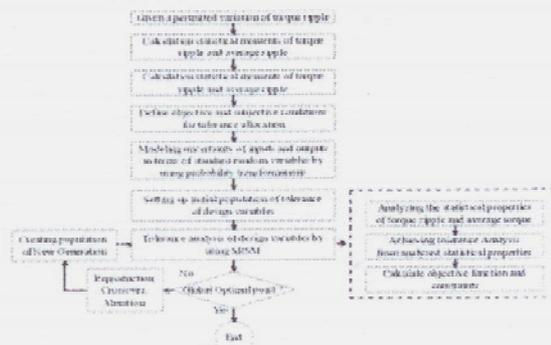
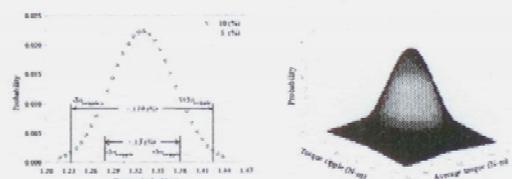


Fig. 2. Procedure of the tolerance allocation



(a) Probability distributions (b) Joint probability distributions at 10% variation of torque ripple

Fig. 3. Distribution of the torque performances

### V. REFERENCES

- [1] Y. K. Kim, J. P. Hong, and J. Hur, "Torque characteristic analysis considering the manufacturing tolerance for electric machine by stochastic response surface method," *IEEE Trans. Ind. Appl.*, vol. 39, no. 3, pp. 713-719, June 2003.
- [2] S. S. Isukapalli, A. Roy, and P. G. Georgopoulos, "Stochastic response surface methods (SRSM's) for uncertainty propagation: Application to environmental and biological systems," *Risk Anal.*, vol. 18, no. 3, pp. 351-363, June 1998.

THE TWELFTH BIENNIAL IEEE CONFERENCE ON  
ELECTROMAGNETIC FIELD COMPUTATION

**Digest Book**



April 30<sup>th</sup> - May 3<sup>rd</sup>, 2006

IEEE Catalog Number: 06EX1354

ISBN: 1-4244-0319-7

Jointly Sponsored by  
IEEE Magnetics Society, IEEE Miami Section, and  
Florida International University



PF5-4	<b>Optimization of Material and Structural Parameters of Nonlinear Stress Control Tubes in Cable Terminations</b> .....	468
	<i>Le Liu<sup>1</sup>, Shuhong Wang<sup>1</sup>, Jie Qiu<sup>1</sup>, Ruitei Gong<sup>2</sup>, Jianguo Zhu<sup>2</sup>, and Youguang Guo<sup>2</sup></i>	
	<sup>1</sup> Xi'an Jiaotong University, China, <sup>2</sup> University of Technology, Australia	
PF5-5	<b>Optimum Design of TFLM With Constraint to Maximize Thrust Force, Minimize Detent Force for Weight Reduction Using Characteristic Function</b> .....	469
	<i>Do-Kwan Hong, Byung-Chul Woo, and Do-Hyun Kang</i>	
	Korea Electrotechnology Research Institute, Korea	
PF5-6	<b>Parameter Evaluation of the Equation of the Electrostatic Discharge Current Using Genetic Algorithms as Optimization Tool</b> .....	470
	<i>Georgios Fotis, Fani Asimakopoulou, Ioannis Goros, and Ioannis Stathopoulos</i>	
	National Technical University of Athens, Greece	
PF5-7	<b>R-FL-C Model for Design Optimization of PM Generators</b> .....	471
	<i>A. A. Arkadan, M. A. Mneimneh, and N. Al-Aawar</i>	
	Marquette University, USA	
PF5-8	<b>Shape Design Sensitivity Analysis and Optimization of HVDC Joint Considering Nonlinear Conductivity</b> .....	472
	<i>Hyang-beom Lee<sup>1</sup>, Jeffrey Braunstein<sup>2</sup>, Hyeong-sook Kim<sup>2</sup>, and Kyung Choi<sup>1</sup></i>	
	<sup>1</sup> Songsil University, Korea, <sup>2</sup> Chung-Ang University, Korea,	
	<sup>3</sup> Kangwon National University, Korea	
PF5-9	<b>Study of Magnet Shifting for Reduction of Cogging Torque in Permanent Magnet Motors</b> .....	473
	<i>Xiuhua Wang<sup>1</sup>, Yubo Yang<sup>1</sup>, Xin Zhang<sup>1</sup>, Ran Zhang<sup>1</sup>, and Shiyao Yang<sup>2</sup></i>	
	<sup>1</sup> Shandong University, China, <sup>2</sup> Zhejiang University, China	
PF5-10	<b>The Optimal Design of an Improved Monohedral Magnet for MRI</b> .....	474
	<i>Junpeng Xie, Yingying Yao, Guangzheng Ni, and Shiyao Yang</i>	
	Zhejiang University, China	
PF5-11	<b>Thrust Optimization of Synchronous Permanent Magnet Planar Motor With Halbach Array by Using Genetic Algorithm</b> .....	475
	<i>Jianpei Zhou, Rui Huang, Dong-Yeup Lee, and Gyu-Tak Kim</i>	
	Changwon National University, Korea	
PF5-12	<b>Tolerance Allocation of Barrier Shape in Switched Reluctance Motor Based on Stochastic Response Surface Methodology</b> .....	476
	<i>Sung-II Kim<sup>1</sup>, Jung-Pyo Hong<sup>1</sup>, Young-Kyoun Kim<sup>2</sup>, and Ji-Young Lee<sup>3</sup></i>	
	<sup>1</sup> Changwon National University, Korea, <sup>2</sup> Samsung Electronics Co. Limited, Korea,	
	<sup>3</sup> Korea Electrotechnology Research Institute, Korea	
PF5-13	<b>Topology Optimization Based on Immune Algorithm and Multi-Grid Method</b> .....	477
	<i>Kota Watanabe, Felipe Campelo, and Hajime Igarashi</i>	
	Hokkaido University, Japan	