

Coupled Field-Circuit Analysis for Characteristic Comparison in Barrier Type Switched Reluctance Motor

Ji-Young Lee¹, Geun-Ho Lee¹, Young-Kyoun Kim¹, Jung-Pyo Hong¹, *Senior Member, IEEE*, and Jin Hur²

¹Dept. of Electrical Engineering, Changwon National University

#9 Sarim-dong, Changwon, Gyeongnam, 641-773, Korea, E-mail: jyecad@korea.com

²MPrecision Machinery Research Center of Korea Electronic Technology Institute (KETI)

Gyeonggi-do, 420-140, Korea, E-mail: jinhur@keti.re.kr

Abstract - This paper deals with two kinds of novel shape switched reluctance motors (SRMs) with magnetic barriers in order to improve operating performances of prototype. The configurations and specifications of the SRMs are introduced, and the operating performances are compared. The magnetic characteristics of each motor are obtained by coupled field-circuit method, and experiment results are presented to prove the accuracy of the method.

INTRODUCTION

In reluctance motors, design of magnetic barrier or salient pole is important portion for overall design process because the number or configuration affects d- and q-axes inductances, and that can change operating performance. Most papers about reluctance motor design, however, consider either the magnetic barrier or salient pole only.

This paper deals with two kinds of novel shape switched reluctance motors (SRMs) with magnetic barriers to improve operating performances of prototype. The configurations and specifications of the SRMs are introduced, and the operating performances are compared in aspect of magnetic torque characteristic and efficiency. The magnetic characteristics are obtained by coupled field-circuit method [1,2], and experiment results are presented to prove the accuracy of the method.

BARRIER TYPE SRMS

The rotors of prototype and barrier-type are shown in Fig. 1. The motor named SBSRM has magnetic barriers, which are modelled on transverse-laminated synchronous reluctance motor. The magnetic barriers are optimised by response surface methodology to improve torque characteristics [1]. The other named PBSRM has partial magnetic barriers of SBSRM. This shape is designed by considering magnetic flux paths of general SRMs because main flux path directly crosses the rotor when same phase winding is opposite side and switch turn on and off by phases.

COMPARISON

In the SRMs, the indicator diagram is a closed locus on coordinates of phase flux linkage vs. phase current, traced out by the operating point as the rotor rotates through one stroke. The diagram enables the calculation of torque ripple [3]. Fig. 2 shows the diagrams of the three motors. These diagrams are obtained by analysis using coupled field-circuit method. Despite of same operating condition, the loci are different because of the magnetic barriers. According to this comparison, SBSRM has less torque ripple than that of

prototype. Table I shows the several comparisons of performances under the same condition as Fig. 2. The more detail comparison and explanation will be presented in the extended paper.

REFERENCES

- [1] Young-Kyoun Kim, Ji-young Lee, Jung-Pyo Hong, and Jin Hur, "Optimization of Barrier type SRMs with Response Surface Methodology Combined with Moving Least Square Method," International Symposium on Electromagnetic Fields in Electrical Engineering (ISEF2003), vol.2/2, pp659-664, September 18-20, 2003, Maribor, Slovenia.
- [2] Longya Xu and Eric Ruckstadter, "Direct Modeling of Switched Reluctance Machine by Coupled Field-Circuit Method," IEEE Trans. on Energy Conversion, vol. 10, No. 3, pp446-454, September, 1995.
- [3] D. A. Staton, W. L. Soong, C. Cossar, and T. J. E. Miller, "Unified Theory of Torque Production in Switched and Synchronous Reluctance Motors," Conf. Rec of IEEE-IAS Annual Meeting, pp67-72, October, 1993, Toronto, Canada.

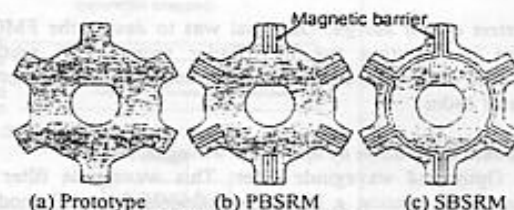


Figure 1. SRM configurations in comparison

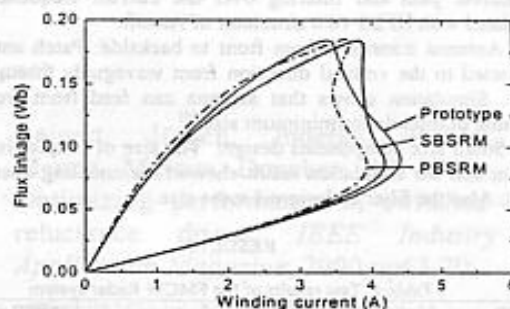


Fig. 2 Predicted Flux Linkage-Current Trajectory (@ V=150V, 1800rpm)

Table I. Comparison of characteristics (unit: %)

	PROTOTYPE	PBSRM	SBSRM
Average torque	100	99.78	102.72
Torque ripple	100	85.68	79.64
Current (rms)	100	94.51	101.58
Average torque per Current	100	105.57	101.11

The Eleventh Biennial IEEE Conference
on Electromagnetic Field Computation



CEFC 2004

Digest Book

June 6 - 9, 2004

Sheraton Grande Walkerhill, Seoul, Korea

Sponsored by



IEEE Magnetic Society



Seoul National University

In Corporation with



Electrical Engineering and Science Research Institute (EESRI)



Korea Electromagnetic Engineering Society (KEES)



Korea Institute of Information & Telecommunication Facilities Engineering (ITFE)



The Institute of Electronics Engineers of Korea (IEEK)



The Korean Institute of Electrical Engineers (KIEE)



The Korean Magnetics Society (KMS)

Supported by



Korea Science and Engineering Foundation (KOSEF)



Korea Research Foundation (KRF)



Korea National Tourism Organization (KNTTO)



PA3-29	A Novel Stator Design of Synchronous Reluctance Motor by Loss & Efficiency Evaluations Related to Slot Numbers Using Coupled Preisach Model & FEM <i>Jung Ho Lee, Sung Jun Park (Hanbat Nat'l Univ., KOREA), and Jung Pyo Hong (Changwon Nat'l Univ., KOREA)</i>	70
✓ PA3-30	Coupled Field-circuit Analysis for Characteristic Comparison in Barrier Type Switched Reluctance Motor <i>Ji-Young Lee, Geun-Ho Lee, Young-Kyoun Kim, Jung-Pyo Hong (Changwon Nat'l Univ., KOREA), and Jin Hur (KETI, KOREA)</i>	71
PA3-31	Integrated FMCW Radar Module Development with Optimized Waveguide at Ka-band <i>Wan-Sik Kim (Konkuk Univ., KOREA), Jae-Cheul Lee (Inst. for Advanced Eng., KOREA), and Jong-Arc Lee (Konkuk Univ., KOREA)</i>	72
✓ PA3-32	A Four Phase Switched Reluctance Motor & Control System Based on Geometry Similitude Theory <i>Ming Chuan Huang (Cardiff Univ., UK)</i>	73

Poster Session PB1: Material Modeling

Time & Date: June 7, 2004, Monday 13:30 - 15:00

Room: Cosmos (3F)

Session Chair: Gwan Soo Park (Pusan Nat'l Univ., KOREA)

PB1-1	A 3D Vector Magnetization Model with Interaction Field <i>J. J. Zhong and J. G. Zhu (Univ. of Tech., Sydney, AUSTRALIA)</i>	74
PB1-2	An Effective Reluctivity Model for Non-linear and Anisotropic Materials in Time-harmonic Finite Element Computations <i>Hans Vande Sande (Flanders' Mechatronics Tech. Centre, BELGIUM), François Henrotte (Rheinisch-Westfälische Technische Hochschule, GERMANY), Herbert De Gersem (Technische Universität Darmstadt, GERMANY), and Kay Hameyer (Rheinisch-Westfälische Technische Hochschule, GERMANY)</i>	75
PB1-3	A Study of Dynamic Characteristic of Rare-earth GMA <i>Cao Zhitong, Cai Jiongjiong, and Shao Bo (Zhejiang Univ., CHINA)</i>	76
PB1-4	Investigation of Current Dependences of Displacement and Force under Different Initial Load for Giant Magnetostrictive Actuator <i>Yan Rongge, Wang Bowen, Cao Shuying, and Huang Wenmei (Hebei Univ. of Tech., CHINA)</i>	77
PB1-5	Operation Comparison of Piezoelectric Transformer and Magnetic Transformer Using Modified Models <i>K. W. E. Cheng, Y. L. Ho, S. L. Ho, K. W. Kwok, X. X. Wang, and H. Chan (The Hong Kong Polytechnic Univ., HONG KONG)</i>	78
PB1-6	Matrix Circuit Model for Piezoelectric Transformer Operating under Square-wave Switching Mode Conditions <i>K. W. E. Cheng, Y. L. Ho, S. L. Ho, K. W. Kwok, X. X. Wang, and H. Chan (The Hong Kong Polytechnic Univ., HONG KONG)</i>	79