Study on the Characteristics for A Novel Segmental Switched Reluctance Motor

Tao Sun[1], Ji-Young Lee[2], Jung-Pyo Hong[3]
[1] Changwon Nation University, [2] Korea Electrical Research Institute, [3] Hanyang University
[1] Changwon, 641-773, Korea
[2] Changwon, 641-120, Korea
[3] Seoul, 133-791, Korea
[1] laplace_sun@hotmail.com, [2] jyecad@korea.com, [3] hongjp@hanyang.ac.kr

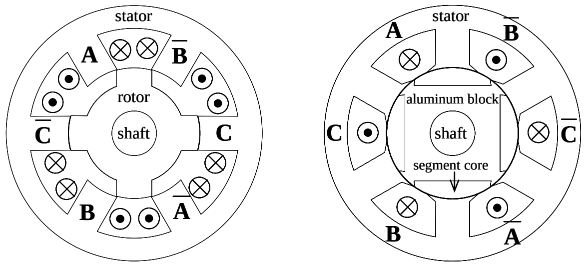
Abstract — This paper deals with the study of a novel SRM with the embedded segment core type rotor. First, the static characteristics of this motor are investigated by finite elements analysis. And then, according to voltage equations and motor parameters including inductance profiles generated in the last step, the dynamic characteristics are calculated. Finally, the total characteristics are compared with those of conventional SRM which are already examined for verification of the analysis method.

I. INTRODUCTION

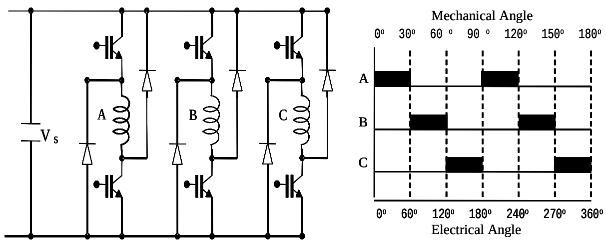
Switched Reluctance Motor (SRM) has been used in various fields for many years, which is due to its a few benefits such as simple structure, low cost, extremely high speed, high starting torque and running under fault condition and dash environment. However, the high torque ripple and wind resistance seriously weaken its performance and reduce using life. For conventional SRM (CSRM), these drawbacks are inherent because of the toothed rotor and stator structure. Although many papers have presented some solutions to improve them, the complex operations and control algorithms still did not change the essential performances of motor. The author of [1] proposed a novel SRM structure with segmental rotor (SSRM). And in [2], based on [1] the author proposed an improved structure which has simpler and stronger rotor. However, [2] only gave a few comparisons of the general performances of CSRM and SSRM by experimental results. In spite that some merits of SSRM have been proved in theory, the specific results have not been analyzed and presented yet [3]. According on the electromagnetic field computation theories, this paper will concentrate on static and dynamic analysis for SSRM proposed in [2]. First, in the static analysis, the inductance profiles are calculated in Finite Elements Analysis (FEA). And then, according to the voltage equation considering drive topology, the dynamic characteristics are investigated. The total analysis characteristics will be compared with those of conventional SRM which are already examined for verification of the analysis method.

II. THE NOVEL SEGMENTAL SRM

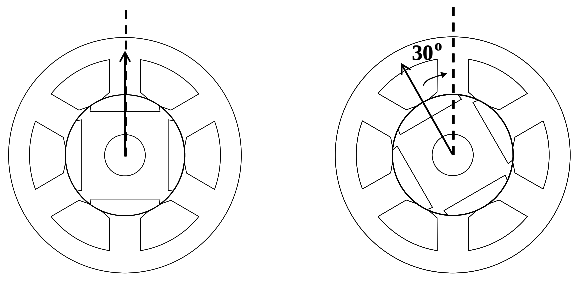
In this paper, the analyzed novel SSRM has 6 slots and 4 segment cores embedded in the aluminum rotor block as shown in Fig. 1(b). Compared with the CSRM shown in Fig.1 (a), it is obvious that the other big difference of these two models is the winding strategy except rotor structure.



(a) (b)
Fig. 1. (a) the model of CSRM; (b) the model of SSRM



(a) (b)
Fig. 2 (a) the asymmetric converter for driving the 2 SRMs; (b) the switching sequence of the converter



(a) (b)
Fig. 3. (a) the aligned position of SSRM; (b) the unaligned position of SSRM

Although there are such big differences, the both kinds of SRM can be driven by same asymmetric converter and switching sequence as shown in Fig. 2. The Fig. 3 shows the aligned position and unaligned position of the SSRM. In theory, because of four magnetized stator poles in each stroke, short flux path in each phase and the more horizontal magnetization direction in rotor core, the SSRM has high average torque, lower iron-loss and lower vertical force than those of CSRM. The detail discussion and results will be presented in the extended paper.

III. ANALYSIS METHOD

A. Inductance Calculation

Owing to the domination of the inductance in SRM, the FEA is employed to get the inductance profiles considering magnetic nonlinearity. The analyzed SSRM model with flux pattern is shown in Fig. 4. The inductance profiles and flux linkage vs. current profiles of the CSRM and SSRM are shown in Fig. 5, respectively. It is obvious that the SSRM has bigger area of field energy and sharper inductance shape when the two motors have same dimensions and low excited current.

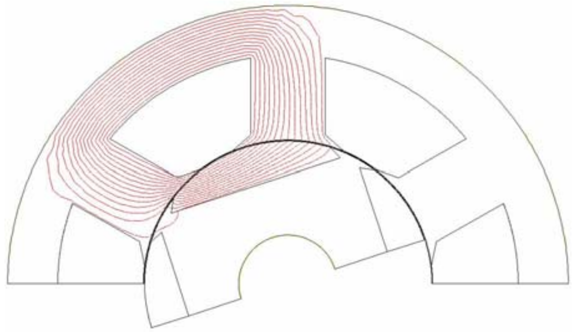
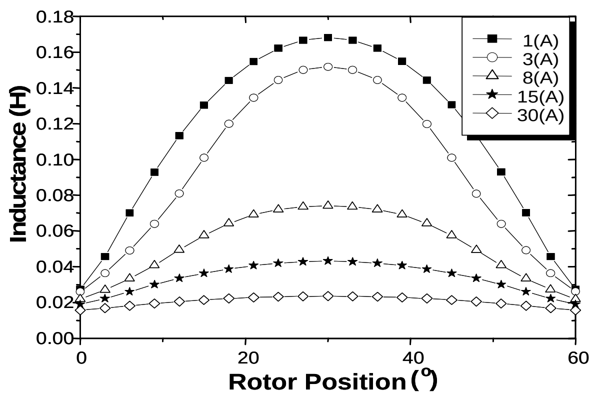
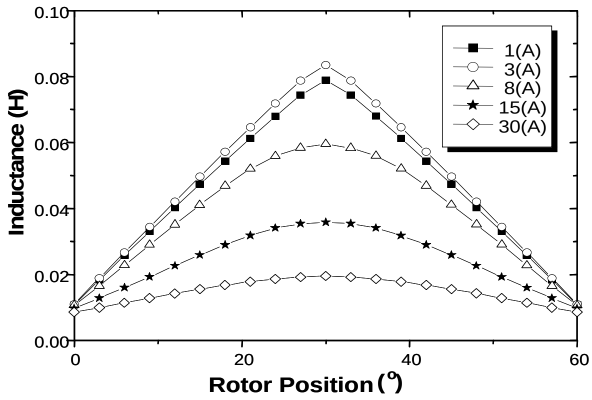


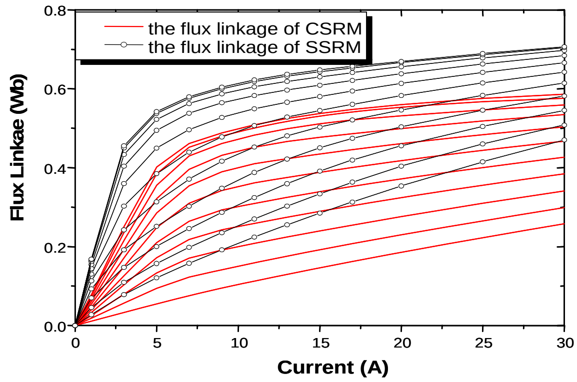
Fig. 4 the flux pattern of the SSRM



(a)



(b)



(c)

Fig. 5. (a) the inductance profile of the SSRM; (b) the inductance profile of the CSRM; (c) the flux linkages of the SSRM and CSRM

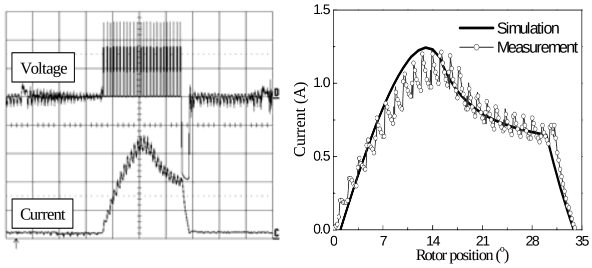


Fig. 6. the comparison of experimental current and simulated current

B. Characteristics Analysis

The characteristics analysis is performed in constant current source and constant voltage source. Particularly, in the constant voltage source case, the output torque and torque ripple will be analysis and compared in different fire on and off angle. The coupled field circuit modeling method which considers both motor flux patterns and the terminal equations is used for the characteristics analysis. The analyzed CSRM has been manufactured and experimented. The experimental current waveform and the simulated current waveform are shown and compared in Fig. 6, which shows the validity and accuracy of the proposed method.

IV. ANALYSIS RESULTS

As mention before, the torque and torque ripple will be calculated considering different fire on and off angle. In addition, by means of the proposed method, the results of the dynamic characteristics such as current, voltage, output power and efficiency will be shown in the extended paper.

V. REFERENCES

[1] B. C. Mecrow, J. W. Finch, E. A. EI-Kharashi and A. G. Jack: "Switched Reluctance Motors with Segmental Rotors" IEE Proc. of Electrical. Power Application., Vol. 149, No. 4, pp. 245-254 (2002)

[2] Oyama. J.; Higuchi. T.; Abe. T.; Tanaka. K. “The fundamental characteristics of novel switched reluctance motor with segment core embedded in aluminum rotor block”. Electrical Machines and Systems, 2005. ICEMS. Volume 1, Issue , 27-29 Sept. 2005

[3] T. J. E. Miller, Ed., *Switched Reluctance Motors and their Control*, Lebanon, OH:Magna Physics/Oxford University Press (1993)

Compumag 2007
Aachen, Germany

INSTITUTE OF ELECTRICAL MACHINES
CHAIR OF ELECTROMAGNETIC ENERGY CONVERSION
RWTH AACHEN UNIVERSITY

Proceedings
of the

16th Conference on the Computation of
Electromagnetic Fields

COMPUMAG 2007

June 24th - 28th

Aachen, Germany

ITG INFORMATIONSTECHNISCHE GESELLSCHAFT IM VDE

The Knowledge Network

Wednesday, June 27th

OC1 – Optimisation - Software Methodology EUROPA SAAL

08:30–10:10 Session chair: **Gabriela Ciuprina, Jan Sykulski**

PC1 – Electrical Machines and Drives BALUSTRADE

10:30–12:10 Session chair: **Erich Schmidt, Yoshihiro Kawase**

PC2 – Numerical Techniques BALUSTRADE

10:30–12:10 Session chair: **Igor Tsukerman, Georg Wimmer**