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RECORD OF THE FOURTH ASIAN SYMPOSIUM ON APPLIED ELECTROMAGNETICS

P1-35 Optimization Design of Electric Field Using Dynamic ANN
p : 47 *Cao Yundong, Liu Dong, Liu Xiaoming and Wang Erzhi*
Shenyang University, Shenyang, China

P1-36 Analysis of Axisymmetric Electrical Field of High Voltage Interrupter by Virtual Boundary Element Method
p : 48 *Tao Ruimin, Wang Erzhi and Li Peipei*
Shenyang University, Shenyang, China

P1-37 Numerical Simulation of Electric Field for High Voltage SF_6 Tank Type Circuit Breaker in Interrupting Process
p : 49 *Liu Xiaoming, Cao Yundong and Wang Erzhi*
Shenyang University, Shenyang, China

P1-38 Magnetization of a Rotor with Conductive Sleeve for a High-speed BLDC Motor
p : 50 *Y.H. Jeong, D. H. Kang, and S. M. Jang*
Korea Electrotechnology Research Institute

P1-39 Optimal Design of Piezoelectric Transformer for Maximum Efficiency Using Finite Element Method and Evolution Strategy
p : 51 *Hyun-Woo Joo, Jung-Moo Seo and Hyun-Kyo Jung*
Seoul National University, Seoul, Korea

Oral Section 3 (**O3**)	**Chairmen**
Devices & Applications I	Prof. Masato Enokizono, Japan
October 23, 15:20-17:30, Magnolia Hall	Prof. Zhiguang Cheng, China

O3-1 Improvement of Performance for Moving Magnet Linear Oscillatory Actuator Using the Neural Network
(15:20) *Dong-Yeup Lee, Kang-Jun Yoon, and Gyu-Tak Kim*
p : 52 *Changwon National University, Changwon, Korea*

O3-2 FEM Analysis and Design Optimization of an Actuator Made of Giant Magnetostrictive Material
(15:40) *Cao Zhitong, Cai Jiongjiong, and Fang Youtong*
p : 53 *Zhejiang University, Hangzhou, China*

O3-3 Characteristic of Induction Heating Device with Moving Permanent Magnets
(16:00) *Takashi WATANABE, Takashi TODAKA, Masato ENOKIZONO*
p : 54 *Oita University, Oita, Japan*

O3-4 Investigation of Permanent Magnet with Rotary Magnetic Type
(16:20) *Cao Yundong, Liu Xiaoming, and Wang Erzhi*
p : 55 *Shenyang University, Shenyang, China*

O3-5 Characteristic Analysis of Single-phase Line-start Permanent Magnet Synchronous Motor Considering Iron Loss Calculated by Iron Loss Curves and FEM
(16:40) *H. NAM, J.J. LEE, G.H. KANG, and J.P. HONG*
p : 56 *Changwon National University, Changwon, Korea*

Characteristic Analysis of Single-phase Line-start Permanent Magnet Synchronous Motor Considering Iron Loss Calculated by Iron Loss Curves and FEM

H. NAM, J. J. LEE, G. H. KANG, and J. P. HONG, *Senior Member, IEEE*

***Abstract*-- This paper deals with the characteristic analysis of the single-phase line-start permanent magnet synchronous motor using equivalent circuit. The iron loss can account for a significant component for accurate perdition of machine performance. Therefore, the iron loss resistor to account for the iron loss, calculated by iron loss curves and finite element method, is included in the equivalent circuit to improve the modeling accuracy. Finally, the analysis and the experimental results are compared to verify the validity of this approach.**

***Index Terms*—Single-phase line-start permanent magnet synchronous motor, equivalent circuit, iron loss.**

I. INTRODUCTION

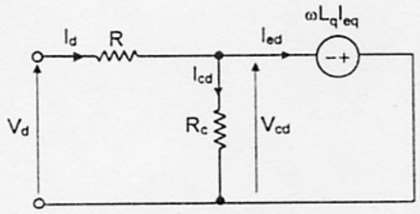
SINGLE-PHASE line-start permanent magnet synchronous motor(LSPM) is essentially an induction motor with added permanent magnet. Since the motor operates as a synchronous machine, the conductor bar loss is significantly reduced. In addition, it is possible to achieve unity-power-factor performance, thereby reducing the stator currents and the corresponding losses [1].

This paper deals with characteristic analysis of the single-phase LSPM using d-q axis equivalent circuit [2]. At this time, the iron loss can account for a significant component for steady state analysis and accurate perdition of machine performance. Therefore, the iron loss resistance to account for the iron loss is included in the equivalent circuit to improve the modeling accuracy. Furthermore, for the improved calculation of the iron loss, the loss is calculated by the finite element method (FEM) considering harmonic components in the flux density. Finally, the analysis results are compared with the experimental results to verify the validity of this approach.

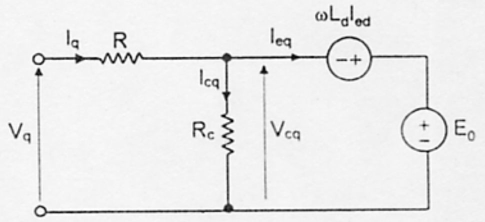
II. ANALYSIS METHOD AND RESULTS

Fig. 1 shows the d-q equivalent circuits with the iron loss. I_{cd} and I_{cq} are d- and q-axis iron loss currents, respectively. E_0 is the phase value of the induced EMF from the magnets. The iron loss resistance R_c can be expressed using iron loss P_{iron}, as shown in equation (1).

$$R_c \approx 2 \cdot E_0^2 / P_{iron} \qquad (1)$$



(a) d-axis



(b) q-axis

Fig. 1 d-q equivalent circuits with the iron loss included

TABLE I
ANALYSIS AND EXPERIMENTAL RESULTS AT THE RATED CONDITION

Items	Analysis results	Experimental results
Output(W)	159.1	160.0
Line current(A)	1.65	1.66
Efficiency(%)	87.99	87.63
Power factor(%)	98.10	98.65

The iron loss considering harmonics is 12.10W. Table. I shows the analysis and the experimental results by the proposed method. The efficiency by the analysis is 87.99% and similar to the experimental value.

III. CONCLUSION

This paper deals with the characteristic analysis of the single-phase LSPM using d-q axis equivalent circuit considering the iron loss, which is calculated by FEM to improve the modeling accuracy, and the validity of the approach is verified, as shown in Table. I.

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