Optimal Design of Line-Start Permanent Magnet Motor with Cost Reduction and Performance Improvements

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Abstract—**With the increasing price of permanent magnet, the line start permanent magnet motor is getting difficult in acceptance by industrial. In this paper, we will deal with the cost reduction design of a three-phase line start permanent magnet motor (LSPM). Cost reduction was effectively achieved by reducing PM volume through optimization of PM slot and PM shape. Therefore, Experiment data and FEM results of the LSPM motor performances were analyzed according to slot form of PM. We can finally select the proper slot form of PM which improves the performance and reduces manufacturing cost of the LSPM motor.**

I. Introduction

The line start permanent magnet motor (LSPM) is well known as alternative routes comparing with the induction motor that it offers high efficiency and unity power factor. However, higher manufacture cost mainly caused by permanent magnet slows its developing process in wide applications such as the compressor of air-condition and refrigerator. The reduction of magnetic materials in PM motor has an optimistic view from a cost standpoint. Lower amount of magnetic materials usage also alleviate several problems that we have in PM motor. The distortion of machine performance caused by the reduction of magnet could be compensated through motor structure optimization. [1,2]

II. FEM Simulation And Experiment Result

In this paper, we discussed an design method to PM and the manufacturing costs by optimizing pm and pm slot shapes. A 3.7kW three phase LSPM motor was design and analyzed. The specifications of this machine are given in Table 1 and Fig.1 shows the prototype of three-phase LSPM motor The structure of this prototype is that the arc shaped PM is inserted in the rotor of three-phase induction motor. Fig.1 is the original model and Fig. 2 shows the optimized model. Time stepping two-dimensional finite element analysis was utilized to investigate the performance during optimization. Fig. 3 shows the comparison of the air-gap flux densities for the two motor. It is obvious that the optimized model has a more sinusoidal air gap flux density while original model has a rectangular shape. In order to find exact simulation harmonic frequencies, a preliminary FFT study on both original model and modified model has been carried out. The FFT spectrum is shown in Fig. 4 corroborates the prediction of original model and modified model. Fig. 5 shows the comparison of torque ripple at rated torque and rated speed.

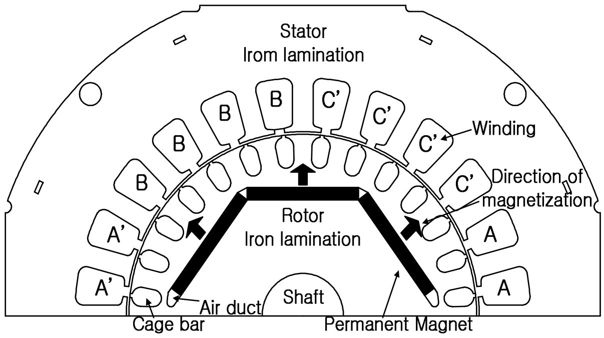


Fig. 1 Original model of LSPM

Table I
DESIGN SPECIFICATION OF MODEL

Item	*Specification*
Phase	3
Poles	2
Rated Torque [Nm]	9.8
Rated Speed [rpm]	3600
Frequency [Hz]	60
Stator Diameter [mm]	159
Rotor Diameter [mm]	87.8
Lamination [mm]	90
Slots number	24
Rotor bar number	28
Rotor bar material	Aluminum
Material of Magnets	Nd-Fe-b
Br at 100 °C [T]	1.21
Hc at 100 °C [KA/m]	735
Thickness [mm]	3

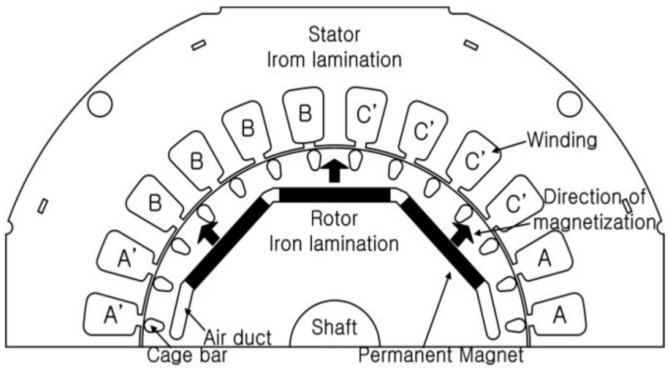


Fig. 2 Optimal structure of modified LSPM model

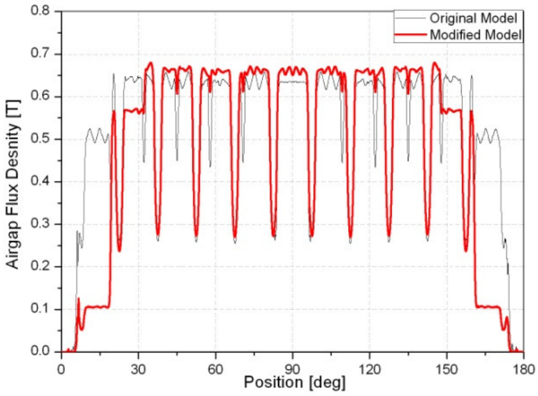


Fig. 3 Comparison of air-gap flux density

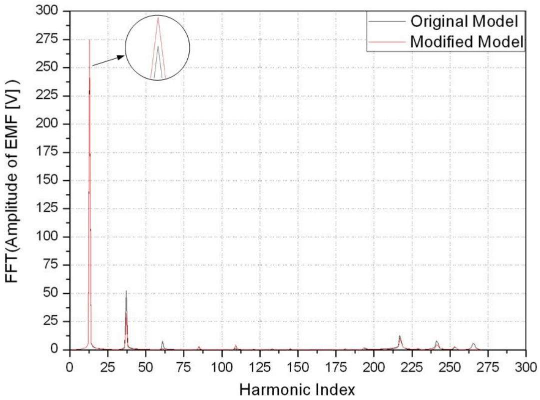


Fig. 4 Comparison of harmonics analysis

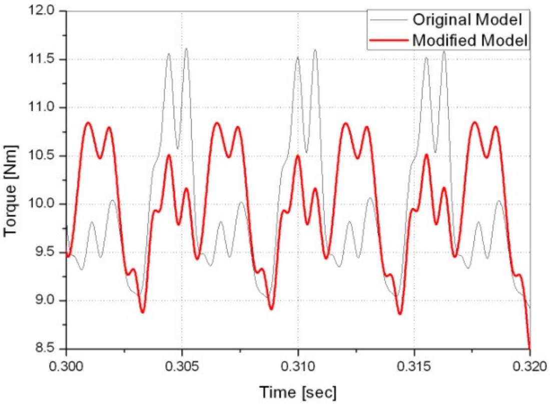
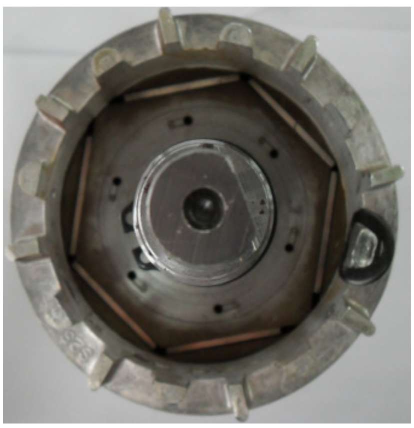


Fig. 5 Ripple at rated torque



(a)

(b)

Fig. 6 Photos of rotor (a) original model (b) modified model

III. CONCLUSION

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[3] Liang Fang, Byeong-Hwa Lee, Jung-Pyo Hong, Hyuk Nam, Seung-Hyung Ha, "Study on the Permanent Magnet Reduction Design in Single-phase Line-Start Permanent Magnet Motor for Household Appliance" *International Conference on Electrical Machines and System,* pp.3289-3292, October 2008.

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