Considering axial phenomenon, axial permanent magnet segment motor Analysis

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Background

Rare earth permanent magnet is used in many industrial region, IPMSM(Interior Permanent Magnet Synchronous Motor) is most of motors which are used in industrial region. As used in many application. Researches on increasing power, efficiency and stiffness are underway. As results of those researches, there are many ways to increase power, efficiency and stiffness. Segment structure is used to increase stiffness. But there are effect on increasing power through z-axis permanent segment structure.

Objectives

❖ Using 2D model on analysis has high efficiency on analysis, But it is hard to consider z-axis structure(z-axis segment) on 2D analysis model. This paper shows how to consider z-axis segment on 2D model and effect of z-axis segment on motor power

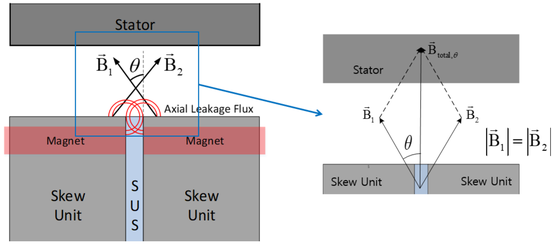
Conclusion

❖ Because of SUS plate, it is hard to analyze on 2D model. To match analysis model to experiment model, no-load back EMF is used. After matching analysis model and experiment model, compare result of experiment result and analysis result.

❖ Using measured magnet Br and Calculated magnet Br, no-load Back EMF Analysis result is not matched to experiment result. After considering axial phenomenon, it is possible to match analysis result to experiment result.

Introduction

❖ Axial Phenomenon of z-axis segment



Additional flux on segment section

$$B_{total,\theta} = \overrightarrow{B_1} + \overrightarrow{B_2}$$

$$B_{total,\theta} = |\overrightarrow{B_1}|\cos\theta_1 + |\overrightarrow{B_2}|\cos\theta_2$$

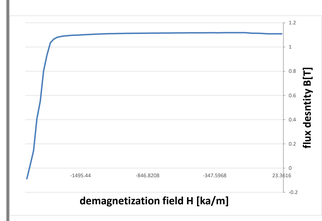
Fig 1. Axial phenomenon on segment section

❖ Analysis Model Parameter

Table 1. Analysis model design parameter

	Value	Unit
Pole/slot	4/36	-
Power[kW]	10	kW
Base RPM [rpm]	6000	rpm
Base torque [Nm]	15.9	Nm
R_stator[mm]	75	mm
R_rotor[mm]	44.1~42.8	mm
air__gap[mm]	0.9~2.2	mm
L_stk[mm]	116.8	mm
L_stk_core[mm]	57.4	mm
L_stk_sus[mm]	2	mm

❖ Permanent magnet characteristic



Measured magnet Br(100℃)

$Br_{100} = 1.01965\,[T]$

Calculated magnet Br(20℃)

$Br_{20} = 1.127931\,[T]$

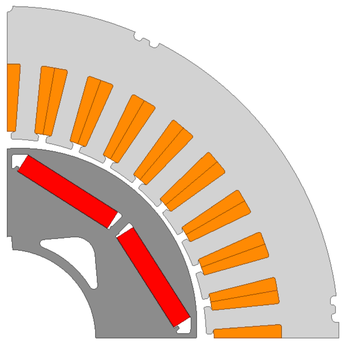
Considering additional fluxline Br

$Br_{axial} = 1.24\,[T]$

Fig 2. Permanent magnet characteristic

Design Process

❖ Analysis Model



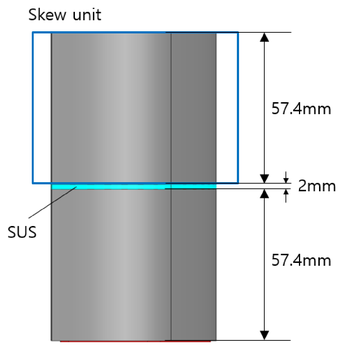
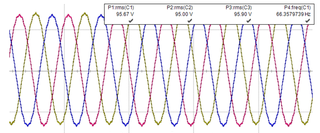
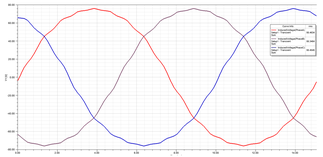


Fig 3. Analysis model

❖ Analysis Result



(a)experiment



(b) analysis

Fig 4. No_load Back EMF

Table 2. No-load Back EMF

	Value	Unit
Experiment Back EMF	55.15	Vrms
Analysis Back EMF(1.24T)	55.42	Vrms
error	0.5	%

- From matching no-load Back EMF of experiment and analysis, it is clarified that analysis model is matched to manufactured motor

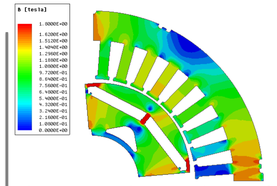


Fig 5. Magnetic saturation result

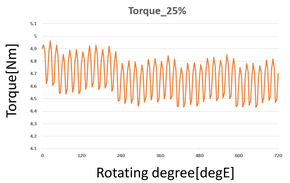


Fig 7. 25% load Torque graph

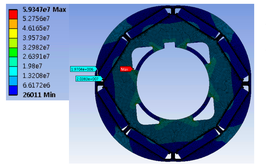


Fig 6. Stiffness analysis result

Table 3. 25% load analysis result

	Experiment	Analysis	Unit
Torque	3.98	6600	Nm
Power	2.75	2.84	kW
Current	6.32	6.32	Arms
Efficiency	88.6	88.6	%

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