講演番号 041

文献番号 20225041

Comparative Study on Measured and Analyzed Drive Performances of HEFSM Employing Variably Magnetizable PM for Improving Torque Density and Efficiency Based on Optimizations of Aspect Ratio and PM Arrangement

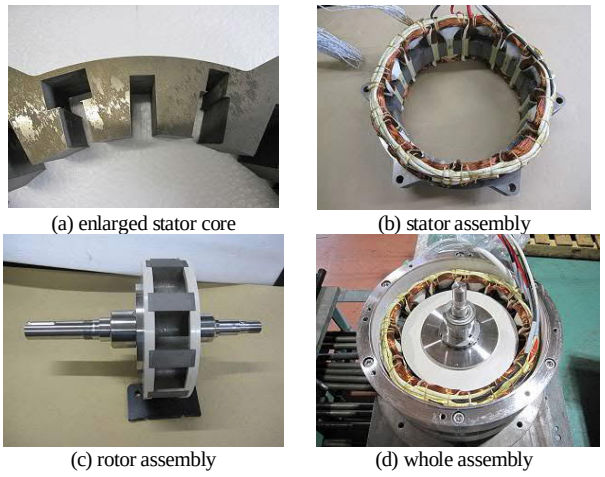
Takshi Kosaka Mitsuru Saito Takeshi Okada Hiroaki Matsumori Nobyuki Mastui

Nagoya Institute of Technology, Graduate School of Engineering,
Gokiso, Showa Nagoya, 466-8555, Japan (E-mail: kosaka@nitech.ac.jp)

KEY WORDS: **EV and HV systems, motor, motor characteristics,** hybrid excitation flux switching motor [A3]

This paper presents comparative study on measured and analyzed drive performances of a newly designed hybrid excitation flux switching motor (HEFSM) with variably magnetizable permanent magnets (VM-PMs) as a variable flux motor for EV/HEV propulsion. The newly designed machine introduces a novel PM arrangement as well as a flat motor shape with an optimum ratio of stator core diameter *D* to core stack length *L* for torque density and motor efficiency improvements under given limitations of motor core volume and total PM usage.

According to the design results, a prototype shown in Fig. 1 is built and tested. Fig. 2 depicts the measured and the 3D-FEA predicted maximum torque and power vs. speed characteristics at +85%MS of VM-PMs. From the figure, it is found that the maximum torque of 167.7N·m measured in the test motor is good agreement with that predicted by 3D-FEA at the design stage and meets the target requirements of 163N·m under the given design constraints. However, the measured maximum power of 51.7kW at 6,000r/min is smaller than the predicted maximm power by 3D-FEA and does not satisfy the target requirements of 53kW slightly. Tables 1 and 2 show the 3D-FEA predicted and the measured motor efficiencies and the losses at the frequent low-torque operating points at the strengthened MS of VM-PM with +90%. As can be seen from Table 1, the 3D-FEA predicted motor efficiency of the newly designed HEFSM is very high more than 96%. However, the measured motor efficiency is lower than the 3D-FEA predicted one. Even so, the measured motor efficiency is still pretty good more than 92% at under the middle speed range of a few thousand r/min. As a result, it is reasonable to suppse that the new design approach for the HFESM empoying the VM-PMs and the optimum aspect ratio would be a better solution.



(a) enlarged stator core (b) stator assembly

(c) rotor assembly (d) whole assembly

Fig.1. Photographs of Tested HEFSM newly designed.

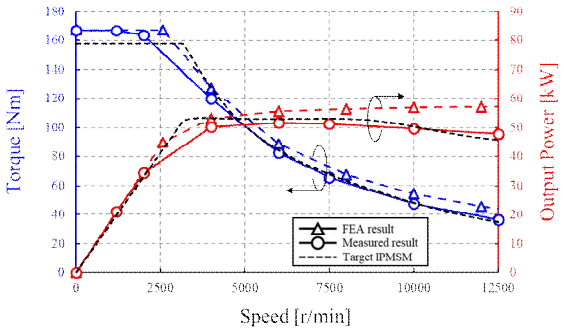


Fig. 2. Measured and 3D-FEA Predicted Maximum Torque and Power vs. Speed Characteristics at +85%MS of VM-PM.

Table 4. 3D -FEA Predicted Motor Efficiency and Losses

Frequent operaing points		Newly designed HEFSM at +90%MS of VM-PM			
N [r/min]	T [Nm]	η_m [%]	P_{ca} [W]	P_{cf} [W]	P_i [W]
1,200	10	93.7	67	0	13
2,500	10	96.0	67	0	37
4,000	10	96.9	75	0	56
10,000	10	96.8	109	0	236
12,500	10	96.7	119	0	326

Table 5. Measured Motor Efficiency and Losses

Frequent operaing points		Newly designed HEFSM at +90%MS of VM-PM			
N [r/min]	T [Nm]	η_m [%]	P_{ca} [W]	P_{cf} [W]	P_i [W]
1,200	10	91.6	70	0	50
2,500	10	93.0	62	8	124
4,000	10	92.5	55	18	256
10,000	10	NA	NA	NA	NA
12,500	10	89.6	69	49	1390