Test Results of SMC Cores as Some Types of Motor Cores

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Abstract

SMC(Soft Magnetic Composite) materials which we have newly developed were studied for their applying effects. It shows almost the same motor output power as the laminated Si-steels of 0.35mm in thickness, although core loss of SMC is about 1.5 times that of the laminations. As shown in the results, the SMC motor core is sufficient for real use as a motor core. Furthermore, a 3-D shaped motor core made of SMC can improve approximately 20% of the output compared with the same size motor made of laminations.

Keywords : soft magnetic composite, motor core

1. Introduction

Recently, SMC(Soft Magnetic Composite) materials were studied for their applications in many fields.

We have been producing anode reactor cores and common-rail injector cores using SMC materials. And we have also developed a superior SMC for motor cores and are studying their applying effects as motor cores. In this paper, our applied results on two types of motor cores will be reported compared with laminations.

2. Experimental Procedule and Results

Our SMC material "EU-67xH" was used to make the specimens. It was compacted to blank specimens maintaining their density of 7.6Mg/m^3 with a compact pressure of more than 1GPa, then heat treated at 500℃ for 30mins in a nitrogen gas atmosphere and machined to the specific shapes. To compare the magnetic properties of SMC with laminations, two types of Si steel sheets were prepared which are JIS 35A300 and JIS 50A470 of which the thickness are 0.35mm and 0.5mm respectively. These Si steel sheets were stamped and laminated to the specific shapes as stator cores of motors. Each specimen was assembled with winding to the specific motor and the motor properties were measured. The motor specifications will be shown in each section.

Fig.1 shows the B-H curves and core losses of SMC material "EU-67xH" and two laminated Si-steels. The SMC material EU-67xH shows a slightly lower magnetic flux density than both laminations. However, it shows a lower core loss at the region of frequency of more than 500Hz than Si-steel 50A470 and at the region of more than 4kHz than Si-steel 35A300.

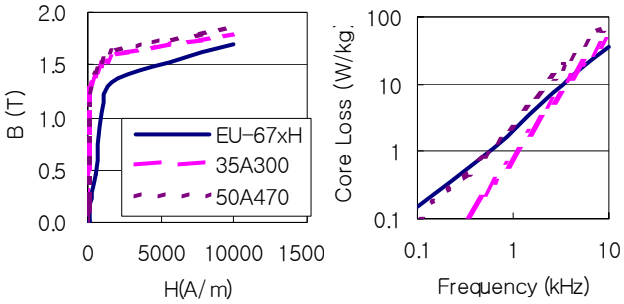

Fig. 1. B-H curves and core losses of EU-67xH and two laminated Si-steels.

Fig.2 shows the construction and appearance of the testedsynchronous motor. Each teeth specimen was assembled with the same stator core back which is made of Si-steel 35A300. Table 1 shows the tested motor specifications.

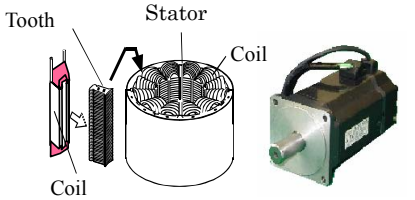

Fig. 2. The construction and appearance of the tested motor.

Table 1. Tested motor specifications

Item	Specifications
Phase number	3
Pole number	10
Rated speed	3000 rpm
Motor type	Synchronous
Residual induction of magnet	1.04T
Rated power	400W
Slot number	12
Rated torque	1.273 N·m
Magnet type	Radial SPM
Outside diameter of stator core	About 80mm

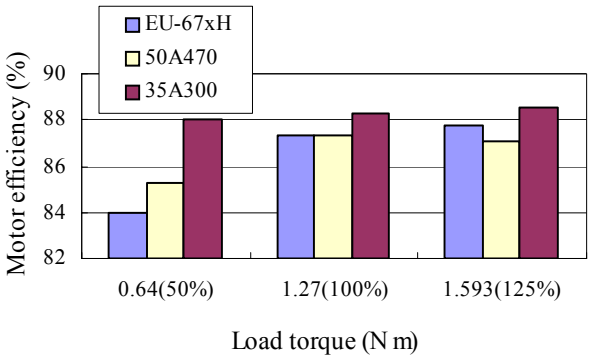

Fig. 3. Relation between motor efficiency and load torque.

Fig.3 shows the results, EU-67xH shows almost the same properties as laminated Si-steel 50A470, however, laminated Si-steel 35A300 shows the best motor performance. These tendencies are similar to the differences of core loss of the based material shown in Fg. 1. As is seen in this result, the SMC core does not show better properties than the laminated Si steels under the same motor core shape. In order to overcome this disadvantage and create a better SMC, a newly designed shape for the motor core was tested as an oil pump motor. Fig.4 shows the comparison of the motor construction. In the case of laminated steel, the total length of the motor is fixed by the coil end. Contrary to this, the SMC core can involve the coil end in the core. As shown in the results, the longer magnet for the rotor can be accepted effectively,

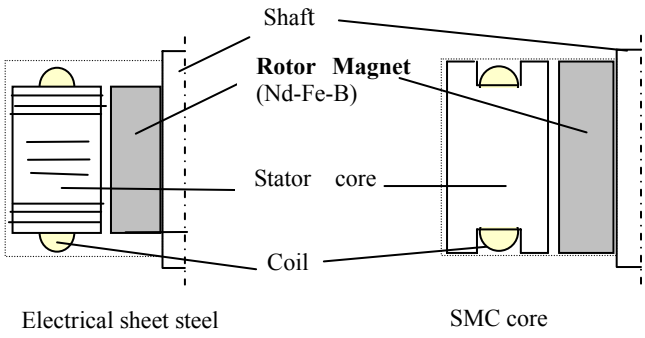

Fig. 4. Comparison of DC brushless motor structure between electrical sheet steel and 3-D designed SMC core.

and thus the motor properties will be improved.

Fig.5 shows the appearance and structure of plot typ emotor with SMC core, and Table 2 shows the motor parameters. Table 3 shows the properties of both oil pump motors. Every property of the SMC motor is superior than that of the Si steel motor. As the result shows, the SMC motor shows a higher motor efficiency by more than 5% under the load of 36W output.

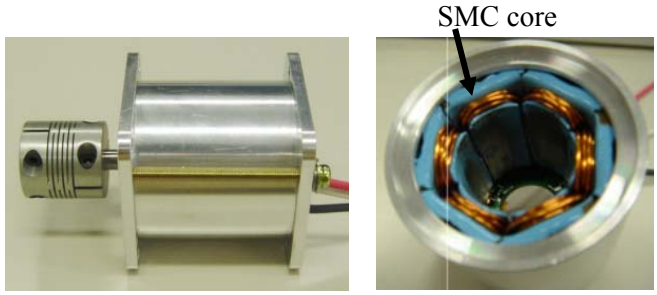

Fig. 5. Appearance and structure of plot type motor with SMC core applied to it.

Table 2. Pump motor parameters

Item	Specifications
Phase number	3
Rated power	36W
Rated speed	7200 r/min
Rated torque	50 mN · m
Motor type	Synchronous
Magnet type	Radial SPM
Residual induction of magnet	1.04T
Outside diameter of pump unit	About 35mm
Pump type	Centrifugal turbine
Total length of pump unit	About 50mm
Pressure	3.0kg/cm2
Flow late	60L/h

Table 3. The properties of both oil pump motors

Item	Si steel motor		SMC motor	
Output(W)	No-load	36.0	No-load	36.0
Motor current (A)	1.194	5.132	0.851	4.021
Motor input (W)	7.8	50.4	6.5	47.0
Whole loss(W)	5.8	14.48	5.5	11.08
Copper loss(w)	0.32	5.48	0.16	3.59
No-load Iron loss (W)	5.48		5.34	
Stray loss(W)	0.00	3.15	0.00	2.15
Motor efficiency (%)	14.7	71.3	15.4	76.4
Measurement conditions : 7000r/min, Coil Resistance 74mΩ/phase				

3. Conclusion

We would like to conclude that the most important item for applying the SMC materials as motor cores is to develop a new designing the motor core which makes the most of its 3-D features.