Research of the Motor characteristics with Nanocrystalline Soft Magnetic Alloy Stator Cores

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Recently, a series of nanocrystalline alloys (NANOMET®) that exhibit excellent soft magnetic properties has been developed[1)] and its applications to motor cores have been reported[2)]. In our previous study, we promoted research on the NANOMET® lamination process and constructed a prototype motor with NANOMET® stator cores[3)]. The iron loss of the motor with NANOMET® stator cores was reduced by a factor of >2 compared with that of motors with conventional electromagnetic steel cores. However, the torque density of the NANOMET® stator core is lower than that of an electromagnetic steel core. To improve the torque density of the core, it is necessary to improve both the space factor and flux density. In this study, we fabricated a toroidal core with NANOMET® and an electromagnetic steel sheet and evaluated its magnetic properties. In addition, we investigated the cause of the decrease in the space factor of the NANOMET® stator cores.

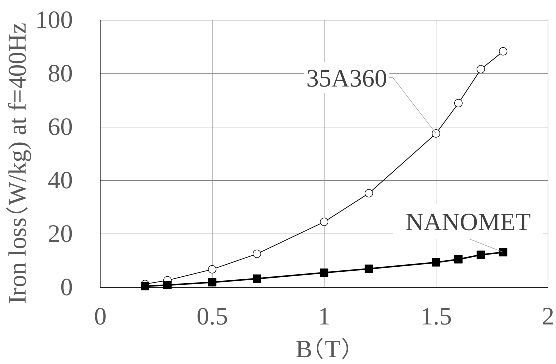
A toroidal core was fabricated by laminating NANOMET® and electromagnetic steel sheets. Table 1 lists the specifications of the toroidal cores. The space factors of the core were 98.1% for 35A360 and 87.0% for NANOMET®, respectively. Fig. 1 shows the measurement results of the iron loss characteristics. Compared to 35A360, the core loss of NANOMET® was significantly reduced, and the core loss at 1 T, 400 Hz($W_{10/400}$), was 5.5 W/kg (22% of that for 35A360). Subsequently, to consider the difference in the space factor, the surface roughness of the sheet was evaluated. Fig. 2 shows a comparison of the surface roughness of sheets. The sum of the surface roughness of the obverse and reverse sides of NANOMET® is a factor of ~3 greater than that of electromagnetic steel, and therefore the space factor was decreased.

Reference

1) A. Makino, IEEE Trans. Magn. 48, 1331 (2012).
2) N. Nishiyama, K. Tanimoto, and A. Makino, AIP Advances 6, 055925 (2016)
3) T. Nonaka, S. Zeze, S. Makino, and M. Ohto, J.Eng PEMD2018 (2019)

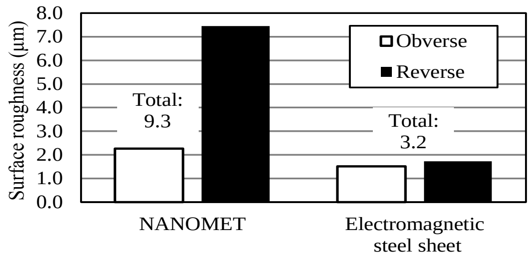
Table 1. Toroidal core specifications.

Item		Unit	35A360	NANOMET
Thickness	*t*	mm	0.35	0.025
Weight	*W*	g	14.7	12.5
Height	*h'*	mm	4.93	4.84
Density	*ρ*	g/cm³	7.65	7.50
Space factor	*SF*	%	98.1	87.0

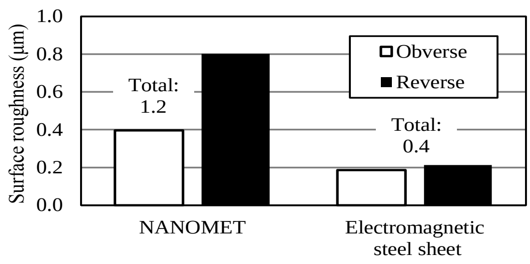


Magnetic flux density (f = 400Hz).

Fig. 1. Iron loss characteristics.



(a) Maximum height: Rz.



(b) Calculated average roughness: Ra.

Fig. 2. Comparison of surface roughness.