High-efficiency IPM motor design and iron loss evaluation

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The expectation for higher-efficiency motors has been increased because the demand for the motorized vehicles and the energy-saving consumer electrical appliances has been grown. For that reason, Motors and Magnetic Materials R&D Center, which is a branch of Technology Research Association of Magnetic Materials for High-Efficiency Motors (MagHEM), develops the design technology of high-efficiency interior permanent magnet synchronous motors (IPMSMs) applying the newly developed magnetic materials and the magnetic material evaluation technology. It is important to develop the design technology of high-efficiency IPMSMs to utilize the newly developed magnetic materials (i.e. high-remanence permanent magnets). High-remanence permanent magnets tend to be adopted as the motor structure is the same, because it is thought that the high efficiency motors can be obtained by using the high-performance materials. However, as shown in Table I, the efficiency of this motor decreases due to increase in the iron loss by using high-remanence permanent magnets in order to reduce the copper loss. Furthermore, the motor structures have a significant influence on the efficiency of the motor if the same magnets are adopted. Therefore, in order to increase the motor efficiency, it is necessary to evaluate the iron loss generated by the magnetic flux including the fundamental components and the harmonic components.

First, the authors developed an ultra-high-precision motor loss analysis system equipped with magnetic bearing in which there is no mechanical friction loss because the rotor is levitated. It enables to reduce the variation in the mechanical friction loss that is a cause of an error of motor loss evaluations, because the iron loss is estimated by subtracting obtained losses, such as the copper loss and the mechanical loss, from the total loss.

Second, because the iron loss density is distributed in the motor, it is necessary to develop a technique for evaluating local iron loss in order to design motors. Therefore, by using search coils and sensors (H coil) for measuring the magnetic field strength, we have developed a technique for evaluating local iron loss under excitation by an inverter. As measurement examples, we report the comparison result of the loss of the ring core using conventional electromagnetic steel sheets and FeBPCu nanocrystalline alloy ribbon.

Acknowledgments

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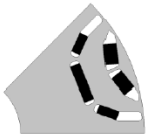
[1] Y. ASANO, S. ARAKI, A. YAMAGIWA, K. OHYAMA “Trend of the Amount of Heavy Rare-earth Elements used in IPMSM for Air-conditioner and Action for the Future.” The papers of Joint Technical Meeting on Motor Drive, Rotating Machinery and Vehicle Technology, IEE Japan, MD-14-074,RM-1-037,VT-1-009 (2014)

[2] M. Sanada, Y. Inoue, S. Morimoto, T. Kosaka “High efficiency IPM motor, high efficiency variable field motor” 35th Motor Technology Symposium (2015)

Table I Influences of remanence and rotor structures on motor losses (City-driving evaluation point)

Model	Type 1V-1	Type 1V-2	Type 1V-3	Type 2D	Type ▽
Rotor structure					
Remanence Br[p.u.]	1	1.143	1.268	1	
Current [p.u.]	1	0.892	0.813	1.054	0.973
Copper loss [p.u.]	1	0.796	0.660	1.110	0.947
Iron loss [p.u.]	1	1.152	1.327	0786	0.914
Total loss [p.u.]	1	0.984	1.016	0.938	0.929