Prediction of Electric Motor Performance Considering Variation of Initial Magnetization Curve of Electrical Steel Sheet according to Manufacturing Process

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Electrical steel sheets have a hysteresis phenomenon. This characteristic appears as initial magnetization curves (B-H curves) and it differs each classification. For the same steel sheet, however, B-H curve changes according to the manufacturing process. Consequently, there exist standardized measurement process of measuring the magnetic property and Epstein frame is international standard [1]. In electric motor application, stator yoke properties of electric motors are similar to the ring core. For this reason, the ring core specimen test is more appropriate method [2].

To acquire B-H curves from Epstein frame and the ring core specimen, the ring core specimen is manufactured. The constraint on the ring core specimen specification, ensuring the reliability of test results is outer diameter should be in 1.1~1.4 times of inner diameter [3]. From the manufactured ring core specimen and conventional Epstein frame, measure the each B-H curve. Comparison of these curves is in Fig. 1 and it shows the difference between manufacturing processes. In this paper, predict the no load electric motor performance through finite element analysis (FEA) using the ring core B-H curve. Furthermore, acquire iron losses from the ring core specimen along different frequencies to generate the iron loss map and applying them to predict the electric motor performance more accurately.

The 8poles 12slots surface mounted permanent magnet synchronous motor (SPMSM) is adopted to validate the previously acquired data. Obtain the no load back electromotive force (EMF) from FEA and Fig. 2 shows a comparison of no load back EMF between experiment result and FEA results using Epstein frame and the ring core specimen B-H curve [4]. An error between the experiment result and FEA results of Epstein frame and the ring core specimen is 3.8% and 0.6% respectively. As a future work, additionally acquire iron losses along different frequencies from the ring core specimen and applying them to predict the electric motor performance map.

***Index Terms*—Electric motor, Epstein frame, Hysteresis loop, Initial magnetization curve, Ring core specimen**

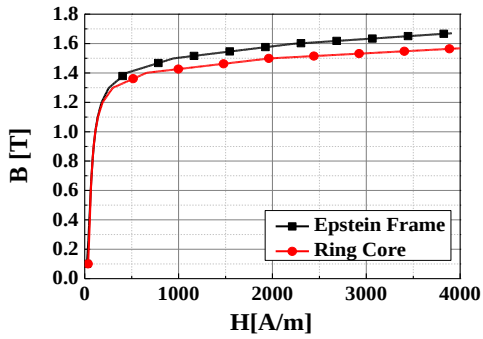

Fig. 1 Comparison of initial magnetization curve between Epstein frame and ring core specimen

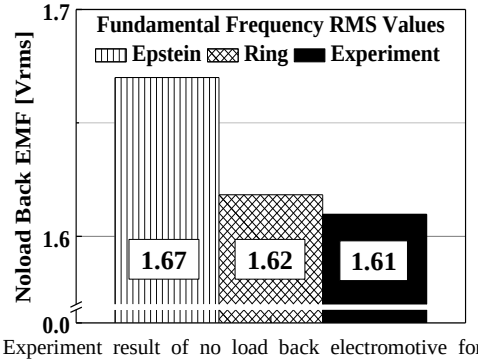

Fig. 2 Experiment result of no load back electromotive force and calculated result using B-H curve from Epstein frame and ring core specimen

REFERENCES

[1] IEC 60404-2:2008, "Magnetic materials - Part 2: Methods of measurement of the magnetic properties of electrical steel sheet and strip by means of an Epstein frame", International Electrotechnical Commission

[2] Alexander J. Clerc and Annette Muetze, "Measurement of Stator Core Magnetic Degradation During the Manufacturing Process", IEEE Transactions on Industry Applications, Vol. 48, No. 4, July/August 2012, pp.1344-1352

[3] Horst Czichos,Tetsuya Saito,Leslie R. Smith, "Handbook of Materials Measurement Methods", Springer

[4] Hyuk Nam, Kyung-Ho Ha, Jeong-Jong Lee, Jung-Pyo Hong, Gyu-Hong Kang, "A Study on Iron Loss Analysis Method Considering the Harmonics of the Flux Density Waveform Using Iron Loss Curves Tested on Epstein Samples", IEEE Transactions on Magnetics, Vol. 39, No.3, May 2003, pp. 1472-1475