# Demagnetizing field correction of rare earth permanent magnets using finite element method

J. Fujisaki[1], A. Furuya[1], H. Shitara[1], Y. Uehara[2], K. Kobayashi[3], Y. Hayashi[4], K. Ozaki[5]
[1]Fujitsu Ltd., Kawasaki, 211-8588, Japan
[2]Magnetic Device Laboratory Ltd., Kawasaki, 215-0011, Japan
[3]Shizuoka Institute of Science and Technology, Fukuroi, 437-8555, Japan
[4] Toei Industry Co. Ltd., Machida, 194-0035, Japan
[5]National Institute of Advanced Industrial Science and Technology (AIST), Nagoya, 463-8560, Japan

Among the problems with performance improvement of electric vehicles, recently the accurate measurement of magnetic curves of the rare earth permanent magnets such as Nd-Fe-B sintered magnets[1)] is attracting much attention. The problem is the difficulty of measurement of full loops of permanent magnets having high coercivity using closed magnetic circuit measurements, due to the magnetic saturation of pole piece in apparatus. It is possible to avoid such problem with measurements of open magnetic circuit, such as VSM, and employing the demagnetizing field correction method with single coefficient *N* of the sample (conventional method). Although the above correction method works well for most magnetic materials, there are some cases that the open magnetic circuit curves for Nd-Fe-B sintered magnets are not fully corrected by using conventional method. In order to overcome this problem, many researches on the accurate correction method are being performed[2)]. In this presentation, a new demagnetizing field correction method is proposed and some results are shown.

The detailed algorithm is as follows: First, the mesh model of the magnet and the measured open magnetic circuit hysteresis curve are prepared. Second, temporary closed magnetic circuit curve defined as the following equation is set at all meshes in the model,

$$M_{close}(H) = M_r{}^{open} \tanh\{A(H - H_c{}^{open})\} + B(H - H_c{}^{open}) \quad \cdots\cdots(1)$$

where, $M_r{}^{open}$ and $H_c{}^{open}$ are the remanence and the coercivity of the measured open magnetic circuit curve. *A* and *B* are the parameters that are initially set to zero. Then, the distribution of the demagnetizing field and the magnetization of the mesh model are calculated by using finite element method for all steps of the applied magnetic field. Next, the averaged magnetization of the whole meshes is compared with that of the measured open magnetic circuit curve, and the difference between them is evaluated. Based on the difference, the parameters in Eq. (1) are modified. The procedure explained above is repeated until the difference becomes smaller than the threshold.

The result for 4mm-cubed $Nd_2Fe_{14}B$ sintered magnet is shown in Fig. 1. The dotted curve is the measured closed magnetic circuit curve and the solid one is the calculated closed magnetic circuit curve. Moreover, the long dashed curve is measured by VSM with ceramic superconducting magnet and the dashed one is obtained by convectional method. From Fig. 1, it could be said that the new demagnetizing field correction method is able to reproduce the squareness of the measured closed magnetic circuit curve with higher accuracy than conventional method.

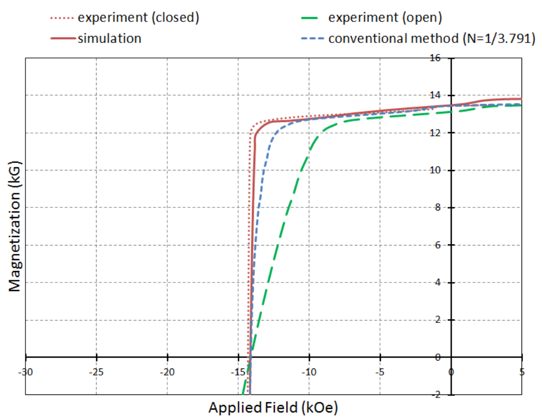


Fig. 1 Demagnetizing field corrected curves and the measured curve

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## Reference

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