Experimental Analysis of Demagnetization in Magnetic Materials by Using Preisach Model with M-B Variables

Hyuk Won[1], Hyun-Soo Park[2], Hyang-Beom Lee[2], Hyun Ju Chung[3], Chang Seob Yang[3], Sungkyung Park[1] and Gwan Soo Park[1]

[1]School of Electrical Engineering, Pusan National University, San 30, Jangjeon-dong, Geumjeong-gu, Busan 609-735, Korea

[2] Department of Electrical Engineering, Soongsil University, Sangdo-dong, Dongjak-gu, Seoul, 156-743, Korea

[3] The 6th R&D Institute-3, Agency for Defense Development, Jinhae 645-600, Korea

raafil98@pusan.ac.kr;gspark@pusan.ac.kr

Abstract — A great deal of external magnetic variation is required to demagnetize a magnetic material. In order to analyze a demagnetization model, hysteresis is employed and the best numerical analysis technique so far, regarding hysteresis, is Preisach model. In general, Preisach model, however, bears the instability problem with respect to convergence and hence in this paper, a method adopting M-B variables is proposed to solve the problem. In addition, comparison is made between the experimental MTF equipment and the hysteresis modeling technique for the purpose of developing an effective demagnetization protocol.

I. Introduction

Demand for study on demagnetization techniques is growing, namely, reducing the magnetization inside ferromagnetic materials caused by external earth magnetic field. This need is augmented by the advanced precision of systems using ferromagnetic materials. A numerical analysis technique considering both the saturated magnetization inside ferromagnetic materials and the hysteresis is needed for effective demagnetization[1-3]. The best model to copy the hysteretic behavior of ferromagnetic materials is Preisach model. However, the general Preisach model is subject to numerical instability, which leads to divergence in case of frequent and repetitive computations.

In this paper, an estimated M-B curve Preisach model is proposed, by which the numerical instability problem with the general Preisach model is solved. With the proposed model, a detailed interpretation is conducted with respect to demagnetization of ferromagnetic materials and comparison is made with the experimental MTF equipment on the same condition.

II. M-B Variable Preisach Method

The general Preisach model exploits the variation of output magnetization, M, versus the input magnetic field strength, H. However, as plotted in Fig. 1, if the M-H curve is used, the output magnetization, M, rapidly varies against the input magnetic field strength, H, leading to instability when applied to the hysteresis model. If the M-B curve is used instead, as shown in Fig. 1, the variation of output magnetization, M, as a function of the input magnetic flux density, B, is evenly distributed to a great extent, resolving the numerical instability problem.

Since the density of the interaction of particles is known to exhibit Gaussian distribution, the general Preisach model using M-H variables is readily defined. On the other hand, it is difficult to apply Gaussian distribution to the model based on M-B variables. In this paper, to solve this problem, the material quality is defined by means of the general M-H variables and utilized is the fact that the magnetic hysteresis variation in a single cell can be represented by a single curve during repeated calculations. This is plotted as simplified diagrams in Figs. 2 and 3. From the given Preisach density shown in Fig. 2(a), the magnetic hysteresis curve under repeated computations is defined as in Fig. 2(b), from which the M-H curve is readily transformed to the M-B curve, as displayed in Fig. 3. With the proposed method, the material quality is easily defined using Gaussian function and also transformed to M-B variables as well as the numerical instability problem being resolved.

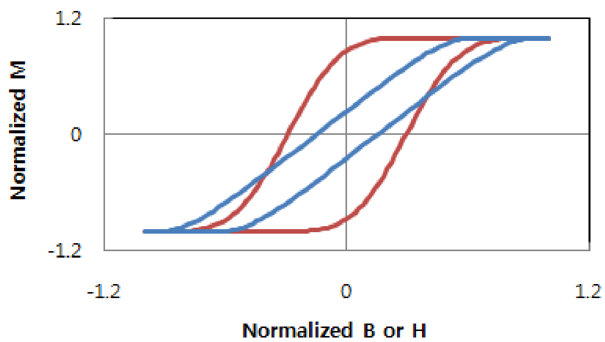
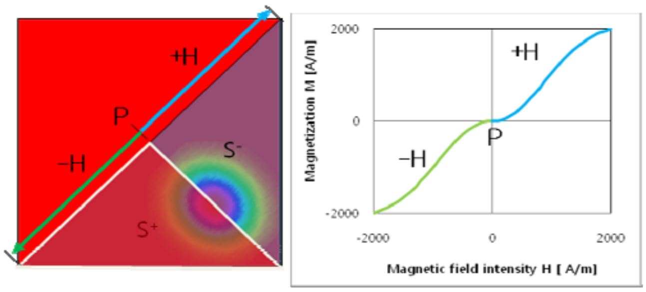


Fig. 1 The comparison of M-H and M-B major curves



(a) (b)

Fig. 2 Initial tracing curve definition. (a) Preisach plane. (b) M-H curve.

III. Results and Discussion

Variations of magnetic hysteresis against input variations between the general Preisach modeling scheme, the proposed estimated M-H curve scheme, and the proposed estimated M-B scheme are compared after the numerical analysis, as plotted in Fig. 4. As is evident in the

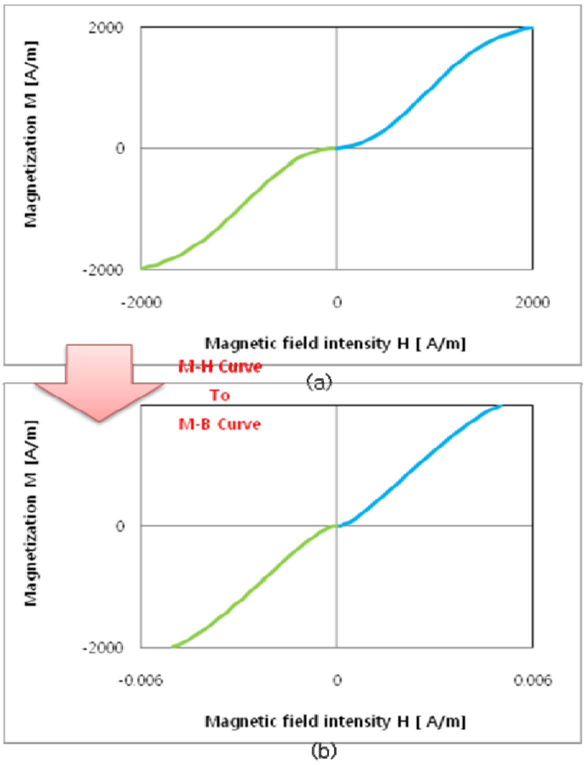


Fig. 3 Conversion method of M-H curve to M-B curve. (a) estimated M-H curve by Preisach plane (b) conversed M-B curve from M-H curve.

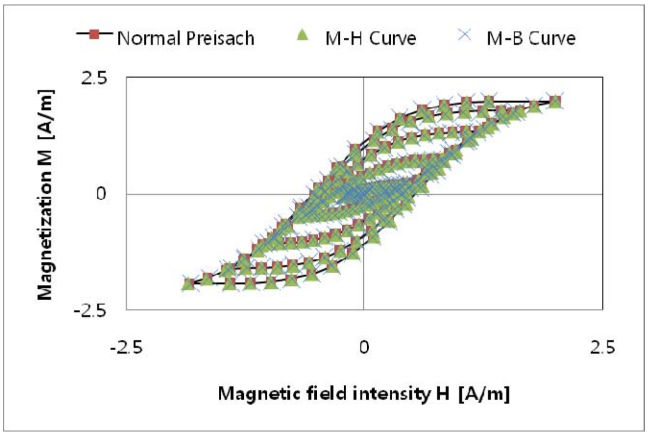
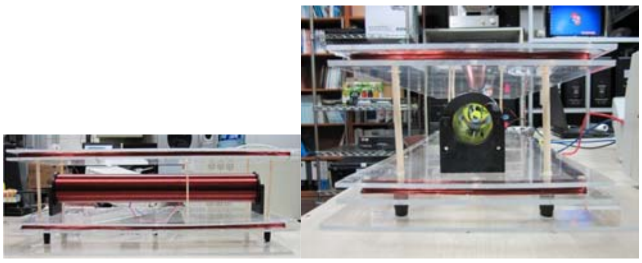


Fig. 4 Comparison hysteresis curve at selected a point.



(a) (b)

Fig. 5 Lab MTF System. (a) side view. (b) front view.

plot, the three results bear similar numerical values and exhibit, in effect, the same outcomes. Consequently, by virtue of the proposed estimated M-B curve, enhanced numerical stability is obtained.

Fig. 5 shows the profile and the frontal view of the experimental MTF system. This MTF system demagnetizes the substance by varying the input frequency of a plain solenoid-type coil. Fig. 6 compares the practical and the interpretation models for demagnetization. The input magnetic field is changed 200 steps in total and the interpreted result and the experimental result are compared from the view point of the produced flux distribution outside the demagnetized body after demagnetization, which is plotted in Fig. 7. As is apparent from the figure, the results are in good harmony with each other.

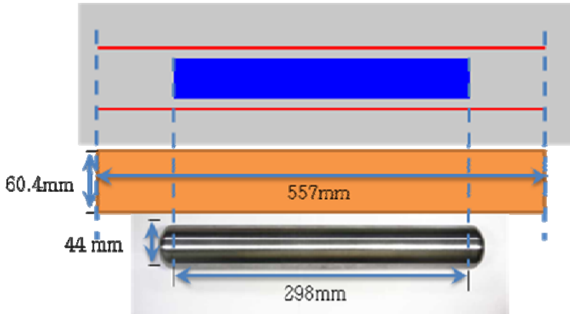


Fig. 6 Analysis and measurement model.

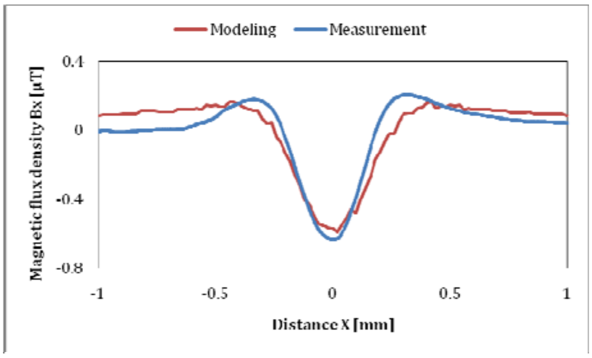


Fig. 7 Comparison analysis and measurement results.

IV. Conclusion

In this paper, the demagnetization process is investigated by means of the proposed Preisach modeling technique. In addition, an M-B variable based analysis technique is proposed, which resolves the numerical instability problem arising in the general Preisach modeling technique. The experimental demagnetization model and the interpreted result agree well.

V. Acknowledgment

This work has been supported by the Low Observable Technology Research Center program of Defense Acquisition Program Administration and Agency for Defense Development.

VI. References

[1] E.Della Torre, "Numerical Micromagnetics Calculations", IEEE Trans. On Mag., Vol. MAG-15, No.5, September 1979

[2] E.C.Stoner and E.D.Wohlfarth, "A Mechanism of Magnetic Hysteresis in Heterogeneous Alloys", IEEE Trans. on Mag., Vol.27, No.4, July 1991.

[3] I.D.Mayergoyz, G.Friedman and C.Salling, "Comparison of the Classical an Generalized Preisach Hysteresis Models with Experiments", IEEE Trans. on Mag., Vol.25, No.5, September 1989.