A Study of Preisach Model for Improving Numerical Stabilities by Using M-B Variables

Hyuk Won[1], Hyun Ju Chung[2], Chang Seob Yang[2], and Gwan Soo Park[1]
[1]School of Electrical Engineering, Pusan National University 30 Jangjeon-dong, Geumjeong-gu, Busan, 609-735, Korea
[2] The 6th R&D Institute-3, Agency for Defense Development, Jinhae, 645-600, Korea
raafil98@pusan.ac.kr;gspark@pusan.ac.kr

Abstract — It is necessary to describe the hysteresis characteristic of magnetic material precisely for the analysis of design of system with ferromagnetic materials. Although Preisach model is regarded as the most accurate method to describe the hysteresis characteristics, it is not applied widely to the real systems because of some difficulties. The conventional Preisach model shows the numerical instabilities during the iterative computations because the density distribution obtained from the sets of M-H curves are strongly localized. To remove such numerical instabilities, if we use a M-B variable instead of M-H variable would be better the results. In this paper, we suggest method for a M-H variable to change a M-B variable, and also, from the computed results of used normal Preisach, M-H cure method and M-B curve method, we shows better than numerical stabilities by using two dimensional finite element method.

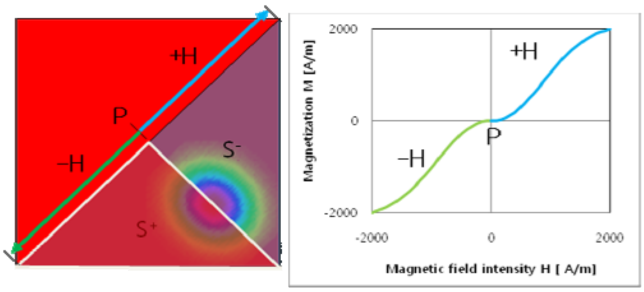
I. Introduction

Recently days, numerical analysis method of hysteresis characteristics has been used micromagnetics model[1], Stoner-Wohlfarth Model[2] and Preisach model[3] on electrical system with ferromagnetic material. Especially Preisach model is regarded as the most accurate method to describe the hysteresis characteristics with electrical system but conventional Preisach model shows the numerical unstabilities during the iterative computations because the density distribution obtained from the set of M-H curves are strongly localized.

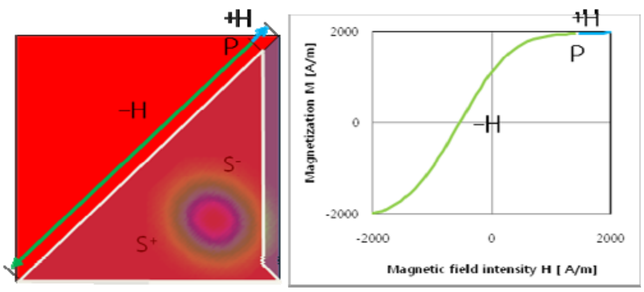
In this paper, we newly suggested M-B method for improving numerical stabilities on the conventional Preisach model and the numerical analysis results with hysteresis characteristics is described using conventional M-H variable model and suggested M-B variable model. Also, we presented method that easily changed method form conventional Preisach model with M-H variable to M-B variable.

II. Introduced the M-B Variable Preisach Method

Since the density of the interaction of particles is known to exhibit Gaussian distribution[4-5], 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. 1 and 3. From the given Preisach density shown in Fig. 1(a), the magnetic hysteresis curve under repeated computations is



(a) (b)
Fig. 1 Initial tracing curve definition. (a) Preisach plane. (b) M-H curve.



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

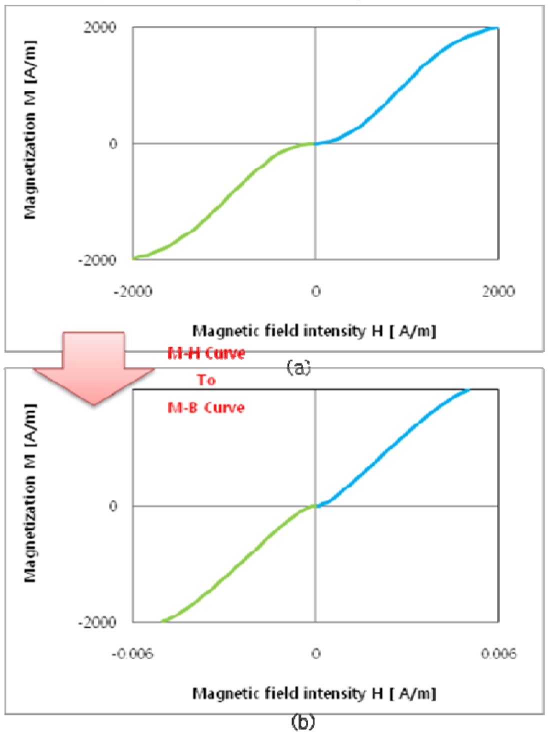


Fig. 3 Conversion method of M-H curve to M-B curve. (a) estimated M-H curve by Preisach plane (b) conversed M-B curve from M-H curve.

defined as in Fig. 1(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.

III. Results and Discuss

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 plot, the three results bear similar numerical values and exhibit, in effect, the same outcomes.

Fig. 5~7 is showed distributed magnetization at first input step and last input step on the three case models. The three results bear similar numerical values and exhibit, in effect, the same outcomes. Looking at the three results, the distribution of the residual magnetic field is very similar to the 2.0e03 ~ 1.57e03 [A/m], you can see that. and also – to the 1.99e01 ~ -1.02e01 in the final results are very similar.

Consequently, by virtue of the proposed estimated M-B curve, enhanced numerical stability is obtained.

IV. Conclusion

The numerical algorithm to analyze the system with hysteresis characteristics is constructed using modified Preisach model and finite element method, In this paper, an M-B variable based analysis technique is proposed, which resolves the numerical instability problem arising in the general Preisach modeling technique. Consequently, by virtue of the proposed estimated M-B curve, enhanced numerical stability is obtained

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.

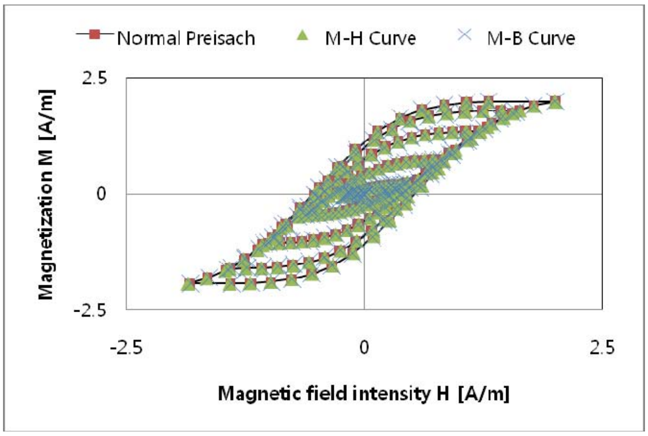
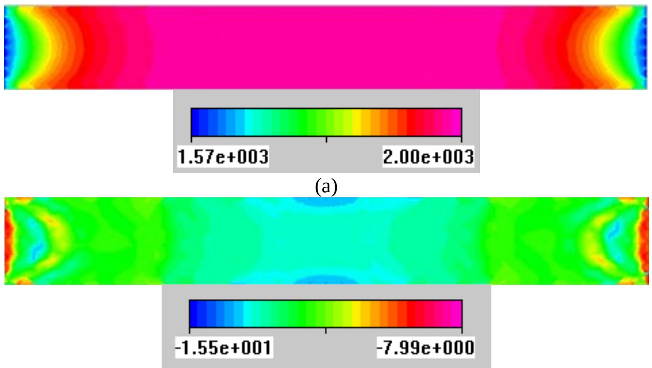
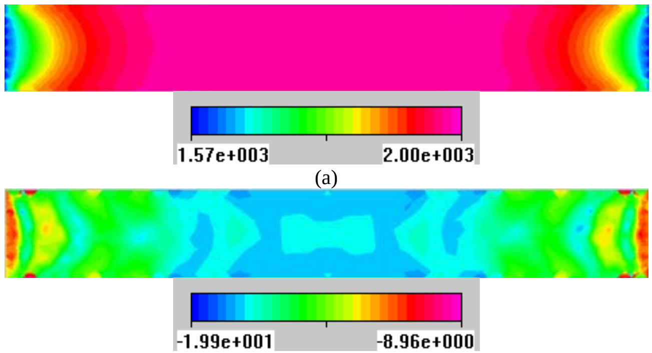


Fig. 4 Comparison hysteresis curve at selected a point.



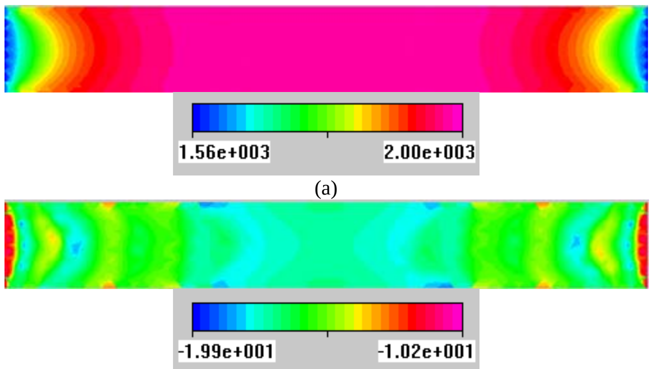
(b)

Fig. 5 Analysis results with normal M-H Preisach model. (a) distributed magnetization at first step. (b) distributed magnetization at last step.



(b)

Fig. 6 Analysis results with estimated M-H curve Preisach model. (a) distributed magnetization at first step. (b) distributed magnetization at last step.



(b)

Fig. 7 Analysis results with estimated M-B curve Preisach model. (a) distributed magnetization at first step. (b) distributed magnetization at last step.

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.

[4] J.Oti and E.Della Torre, "A Vector Moving Model of Non-Aligned Particulate Media", IEEE Trans. on Mag., Vol.25, No.5, September 1990.

[5] Christopher R. Pike, Andrew P. Reberts, Kenneth L. Verosub, "Characterizing interactions in fine magnetic particle systems using first order reversal curves", J. Appl. Phys., vol. 85, No.9, May 1999.