Modeling a Distribution of Uniaxial Hysterons

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We recently published an article on a new model for a single uniaxial hysteron[i]. We have now extended this model to collections of such hysterons. This extension is designed to be expandable so that it can describe such phenomena as accommodation, aftereffect and magnetostriction. The current model assumes that all the hysterons are aligned perfectly, but have different switching characteristics. We discuss how this model can be incorporated for an assembly of such hysterons.

Index Terms—**Preisach modeling, hysteresis modeling, uniaxial anisotropy, hysteron distributions.**

I. INTRODUCTION

A model is presented for an assembly of hysterons that have uniaxial anisotropy [1]. The magnetization is computed as the sum of an irreversible component, $\mathbf{M_I}$, and a reversible component, $\mathbf{M_R}$. Since $\mathbf{M_I}$, has no reversible component and $\mathbf{M_R}$ has no irreversible component, this decomposition is unique, as discussed in [1]. The model assumes that $\mathbf{M_I}$ is a function only of the applied field. The magnetic state of the system is the function of contribution to $\mathbf{M_I}$ as function of the critical field of the hysteron. On the other hand $\mathbf{M_R}$ is a function of the magnetic state as well as the applied field.

The critical field of the hysteron depends on the orientation of the applied field. The locus of points of the critical field as a function of the direction of orientation of the applied field. This locus is a closed surface called the critical surface. For a uniaxial hysteron, the critical surface can be an ellipse with the easy axis along its minor axis. As long as the applied field lies inside the critical surface, $\mathbf{M_I}$, is unchanged. Upon exiting the critical surface the magnetization will switch to alignment with the nearest easy axis. If the material is AC-demagnetized or zero-field-cooled the resulting $\mathbf{M_I}$ will be zero. Thus, in this model, the possible values for $\mathbf{M_I}$ are along the easy axis in either the positive or negative direction or zero depending upon the history of the applied field.

In this paper it is assumed that the easy axes of the hysterons are perfectly aligned. This restriction will be lifted in the more general model. Other modifications to the model will be presented so that the more general model can describe accommodation, aftereffect, magnetostriction and others effects.

II. ROTATING APPLIED FIELD

The magnetization, when the field is applied along the easy axis, is also along the easy axis. As the field starts to rotate, $\mathbf{M_R}$, will start to start to rotate, however, $\mathbf{M_I}$, will not at first. Thus, the direction of the magnetization will lag that of the applied field. As the field continues to rotate, the lag angle will continue to increase until the applied field lies along the hard axis. Further rotation of the applied field will start reversing the magnetization of the $\mathbf{M_I}$ of the hysterons with smaller critical fields, and the lag angle will start to decrease. In fact, when a sufficient number of hysterons have switched, the magnetization will start to lead the applied field.

Result of the described model is shown in Fig 1. This result is consistent with lag angle curves for the measurement of MP tapes [2].

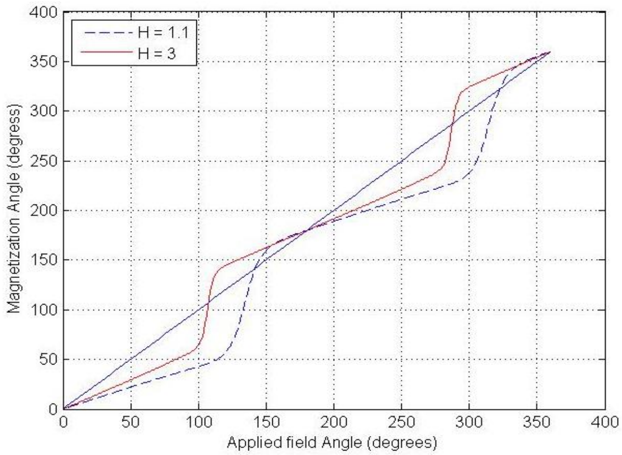

Fig. 1. Model results for magnetization vs applied field angle curves for tw applied fields. The solid straight line is a reference line where th magnetization angle equals the applied field angle. Applied field i normalized by coercivity.

III. EXTENSIONS OF THE MODEL

A. Accommodation

Accommodation model tries to account for the change in magnetic states caused by the motion of hysterons in the Preisach plane. Similar to the differential equation accommodation model [3], this model can be extended to display accommodation as well. Whenever the applied field attempts to set the irreversible component, it will be prevented from doing it in one step. A legitimate way of doing this would have to be found.

B. Aftereffect

The decay of magnetization with time could be approximated by the Arrhenius law as in [4]. In the case of low temperatures or small particles this would have to be modified as in the case of Bose-Einstein condensation of bosons [5].

IV. CONCLUSIONS

The model presented is very promising for a general model for uniaxial hysterons. Since the vector properties are determined by a critical surface, using other shapes than ellipses could be used. It remains to be seen if other shapes will be able to describe other anisotropies, such as cubic anisotropy.

V. REFERENCES

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