Practical Model for Ferromagnetic Materials

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Abstract **Preisach model was found to be a good tool for accurate description of technical ferromagnetic materials. Material in the model is given by the weighting function that must be found from experiment. The use of well-known statistical functions as an approximation of the weighting function results in a good agreement with experimental data. The practical use of the technically exact model is in the determination of switching currents or the study of ferro-resonance, for instance.**

Keywords **Preisach model, hysteresis loop, ferromagnetic materials, weighting function.**

I. Introduction

Exact model that includes both the non-linearity and hysteresis is necessary for the exact study of many effects in real devices using ferromagnetic materials. These phenomena include transition effects or ferroresonance. For instance, the switching current can be 10 times higher that that predicted by linear model.

The suitable model for such purposes is the Preisach model [1]. Main problem in its application is the determination of the weighting function. A suitable method is presented in this paper.

II. Theory

Basic elements of Preisach model are elementary hypothetical hysterons that has two orientations of dipole momentum. If external magnetic field exceeds the level H_u, the dipole momentum is in up direction. If the field decreases under the level H_d, the dipole is oriented into down direction. Therefore, the dipole exhibit hysteresis of its momentum. The systematic elementary hysteresis loop arrangement in Preisach model is in Fig. 1. No hysteresis is on the main diagonal. Symmetry loops are on the secondary diagonal. On rows the H_d increases, in columns the increase is for the parameter H_u.

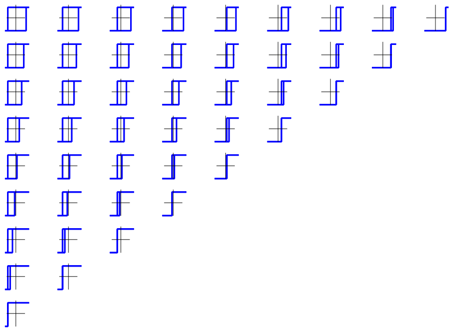

Fig. 1. Geometrical interpretation of Preisach model.

Mathematically the Preisach model for the computation of material magnetic momentum M at time t excited by magnetic field H is given by the formula [1]

$$M(t) = \iint_{H_u \geq H_d} w(H_u, H_d)\hat{m}(H_u, H_d)H(t)dH_u dH_d. \quad (1)$$

Main task is to determine the weighting function $w(H_u, H_d)$. Several methods exist, but the method of its estimation is found as the best one.

III. Results

The hysteresis loop was measured in the current excitation, since there are no peaks. It was necessary to use low frequency of 1 Hz. The transformer core was from annealed material having hysteresis loop near to the rectangular one. It follows from physical considerations that the centre of weighting function must be on the secondary diagonal, Fig. 1. Its shape was supposed to be a product of two functions of probability density, since they have well-defined maximum. The function parameter (standard deviation) was found by the best fit with experiment. The MATLAB procedure *fminsearch* was used for the automated parameter finding.

The comparison with experiment is in Fig. 2. In order to see details only the loop knee is shown. The agreement with experiment is good and comparable with results presented in literature.

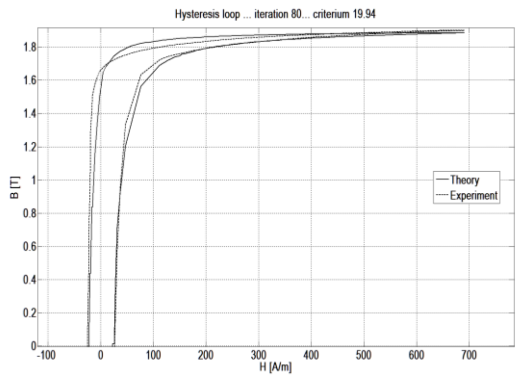

Fig. 2. Comparison with experiment

IV. Conclusion

The presented simple method of weighting function estimation completes the Preisach model for the core with almost rectangular hysteresis loop. Therefore, the model can be used for the prediction of real transformer properties. The method success depends on the loop shape. For another shape the agreement with experiment is not so good, but can be improved.

Acknowledgements

The work was supported by the Student Grant Competition of Technical University of Liberec.

References

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