Analysis of Irreversible Magnet Demagnetization in Line-Start Motors based on Finite Element Method

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Abstract – **This paper deals with the analysis for the irreversible demagnetization characteristics of a ferrite magnet in line-start motor using Finite Element Method (FEM). The irreversible demagnetization analysis by FEM considering not only the non-linearity of core but also magnet B-H curve is performed due to peak current in transient analysis.**

INTRODUCTION

The starting torque of Line-Start Permanent Magnet Motor (LSPM) is generated by electromagnetic induction phenomenon at rotor induction cages. The instantaneous current at starting or locked rotor condition with line frequency can cause the demagnetizing field in permanent magnets. In the case of ferrite type permanent magnet, it is taken the irreversible demagnetization point that is knee point. Accordingly, ferrite type permanent magnet is occurring the irreversible demagnetization due to the external demagnetizing field and this causes the motor performance deterioration [1]. Therefore, the demagnetizing characteristics of permanent magnet must be considered for designing the rotor shape of LSPM.

This paper presents the demagnetizing characteristics analysis of ferrite magnet in LSPM by coupled equivalent circuit analysis and FEM. FE analysis considering not only non-linearity of core but also magnet B-H characteristics is performed by applying peak current calculated by transient analysis.

METHOD OF ANALYSIS

The irreversible demagnetization analysis is performed by FE analysis considering not only core characteristics but also magnet operating characteristics. When the flux density of divided element in permanent magnet region is less than knee point flux density by external demagnetizing field, the residual flux density of the element renews in analysis process. Fig. 1 shows the irreversible demagnetization analysis process of permanent magnet in LSPM.

RESULT AND DISCUSSION

The analysis model is interior type PM, the regional saturation degree according to the relation of flux phase angle is different so irreversible demagnetization characteristic in permanent magnet is regionally different. Fig. 2 shows the demagnetizing characteristics by (-) d-axis peak current.

The irreversible demagnetization phenomenon of LSPM cause the reduction of residual flux density and back emf, after all the peak current and the external demagnetizing field are grown gradually.

Fig. 3 shows the back emf between the fully magnetized magnet and demagnetized condition after external field is applied.

The back emf is decreased from 55.2[V] to 23.6[V], so the reduction rates are 53 [%]. Therefore, the shape design to reduce demagnetizing effects is required because the LSPM using ferrite magnet is seriously influenced by external demagnetizing field

REFERENCES

[1] Howard C. Lovatt and Peter A. Watterson, "Energy Stored in Permanent Magnets", *IEEE Trans. on Magn.*, Vol. 35, No.1, Jan, pp.505-507, 1999

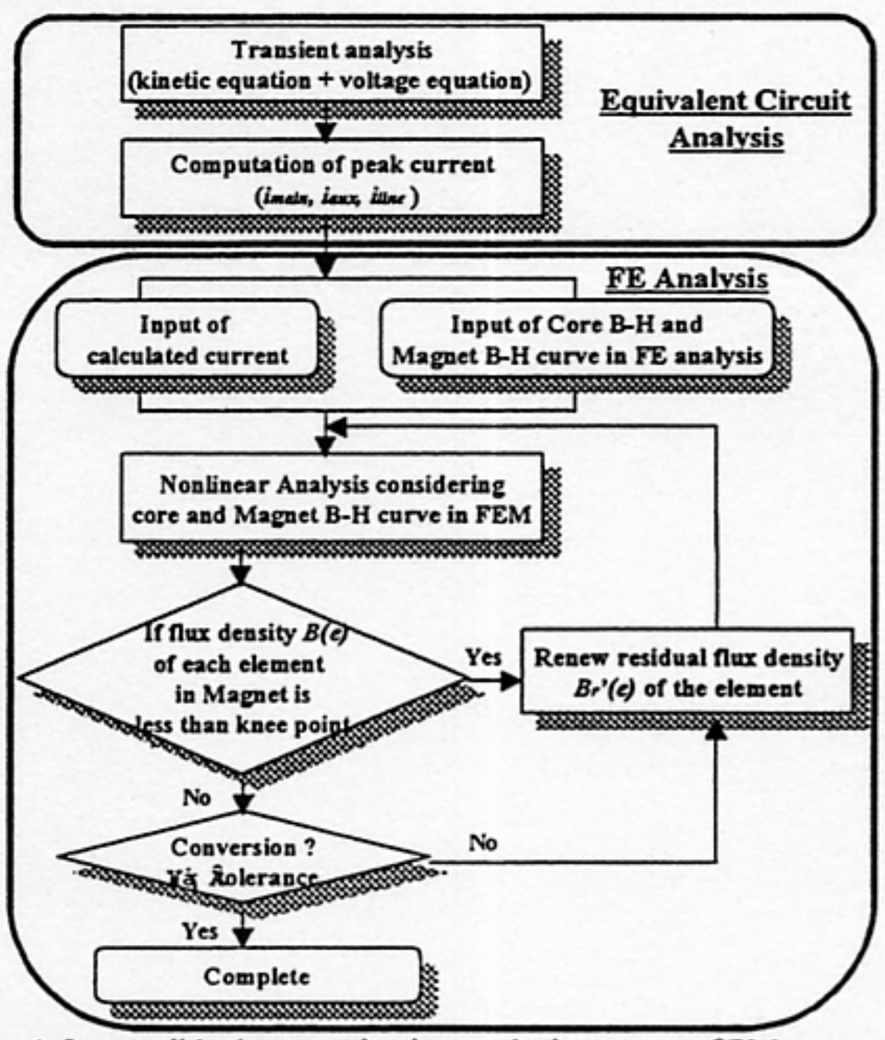

Fig. 1. Irreversible demagnetization analysis process of PM

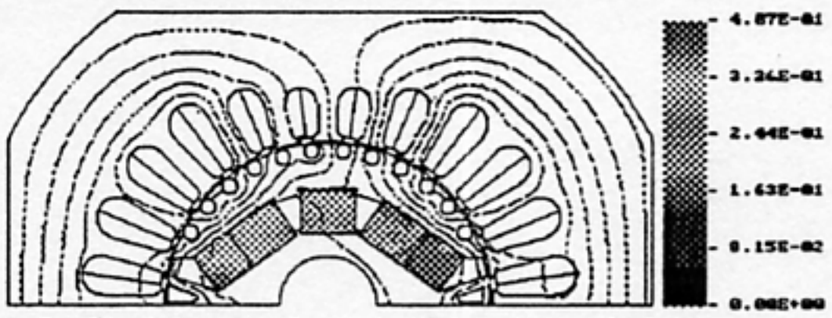

Fig. 2. Residual flux density B_r in PM by (-)d-axis field.

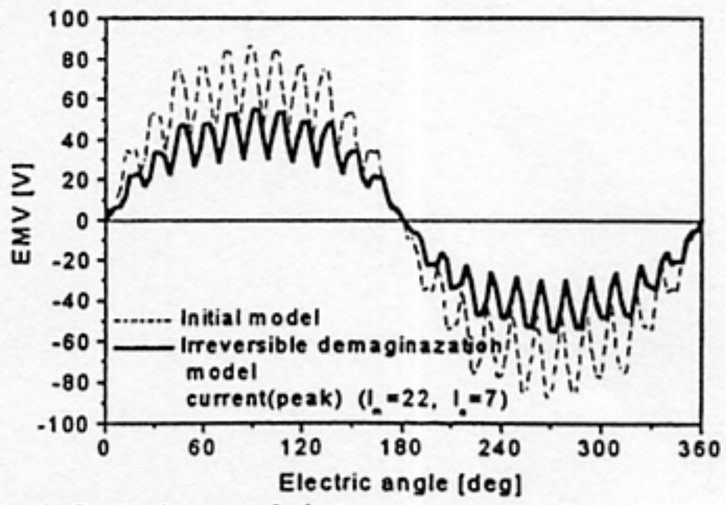

Fig. 3. Back EMF characteristics.