Re-Demagnetization Characteristics Analysis of a variable-flux Memory Motor Using Coupled Preisach Modeling and FEM

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Abstract - **This paper deals with the PM performance evaluations in a variable-flux memory motor (VFMM) using a coupled finite element method (FEM) and Preisach modeling, which is presented to analyze the magnetic characteristics of permanent magnets. The focus of this paper is the operation characteristics evaluation relative to magnetizing direction and quantity of permanent magnets on re-, demagnetization condition in a VFMM.**

I. Introduction

Memory motors combine the flux controllability of a PM machine with the high power density of conventional electric machines [1], [2]. They utilize the flux concentration principle that allows the generation of air-gap flux densities that are typical for high-efficiency machines. Memory motors can be built either as variable-flux or pole-changing machines. In both machine types, the magnetization of PMs can be simply varied by a short current pulse, with no need for permanent demagnetizing current as in conventional internal PM machines at flux weakening mode. The distinguishing features of a variable-flux memory motor (VFMM) are the air-gap flux created by rotor magnets can be continuously varied within a fraction of the period of stator current and the re-magnetization current is smaller than rated machine current. The load current i_q cannot demagnetize the magnets. The effects of re- and demagnetization are important issues in the performance of variable-flux memory motor. Therefore, whereas in other kind of machines a rough estimation of magnetization of PMs is acceptable, their importance in variable-flux memory motors justifies a greater effort in calculating them more precisely. Finite element methods have the abilities to model the complicated internal structure within a memory motor and to model magnetizing characteristics to a high degree of accuracy. Preisach's model, which allows accurate prediction of magnetization of PMs, is adopted for this procedure to provide a nonlinear solution [3], [4]. In this paper, a coupled finite element analysis and Preisach's modeling for a variable-flux memory motor (VFMM) is presented and the characteristics analysis is performed under continuous re- and demagnetization.

II. Analysis Model

A cross-sectional view of a four-pole variable-flux memory motor is shown in Fig. 1.

Fig. 1 Cross-sectional view of a partially magnetized VFMM

Fig.2 Flux distribution at magnet 1.05 T and d-axis current 0

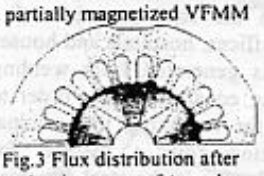

Fig.3 Flux distribution after d-axis current -5A apply

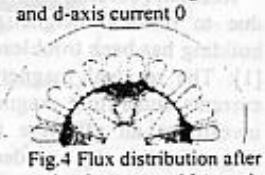

Fig.4 Flux distribution after d-axis current -10A apply

Fig.5 shows the flow chart for the proposed analysis method. The flux pattern in PMs of rotor and stator at full, half and magnetization situation etc. are shown in Figs. 2-4, respectively. In these three figures, the PM magnetizing quantity decreases after demagnetization ampere (d-axis current = from 0 to -10 A) turns were applied, resulting in air gap flux density values.

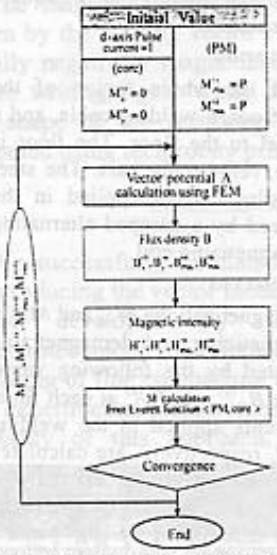

Fig. 5 Flow chart of FEM using Preisach's model

The magnetization of rotor Alnico magnets was varied in Figs. 2-4 in such a manner that the distance r_0 (negative magnetization) was geometrically increased at a given value to the stator MMF.

This procedure made investigation of the influence of d-axis stator current components on overall magnetization.

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