Improved Characteristic Analysis Procedure of Hybrid Stepping Motor Considering Overhang Effect

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Abstract— The analysis of Hybrid Stepping Motors is a truly 3-dimensional (3D) problem, and it is challenge for motor designer in an aspect of computation time. When the core is highly saturated, the problem becomes more severe. Therefore, this paper presents an analysis methodology for hybrid stepping motors which takes account of both saturation and overhang effects. This proposed method is improved to get more rapid and accurate results in comparison with previous method which these authors suggested in another paper.

I. Introduction

The equivalent magnetic circuit (EMC) method with the lumped parameters has been widely used to analyze the hybrid stepping motors [1]. It is not always accurate enough, but flexible and timesaving. In comparison with EMC method, Finite Element Method (FEM) provides more accurate analysis results due to the consideration of the nonlinear characteristics and the complex geometry, so that computational time and resources are excessively demanded.

In this paper, 2D FEM is used to calculate the circuit parameters representing the stator/rotor teeth and airgap region. For the other region, EMC method is used. The axi-symmetric analysis is performed to supplement the 2D analysis results by considering the overhang effect occurred by the extension of rotor teeth over PM in axial direction. The EMC method coupled with FEM is solved by the net parameter matrix, which describes the relationship between the rotor position and the circuit parameters. Moreover, a numerical analysis technique is used to find proper permeance or energy instead of the neural network used in [2] to more reduce the computational time. The static torque can be determined by the virtual work technique, and the calculated results are compared with experiment ones.

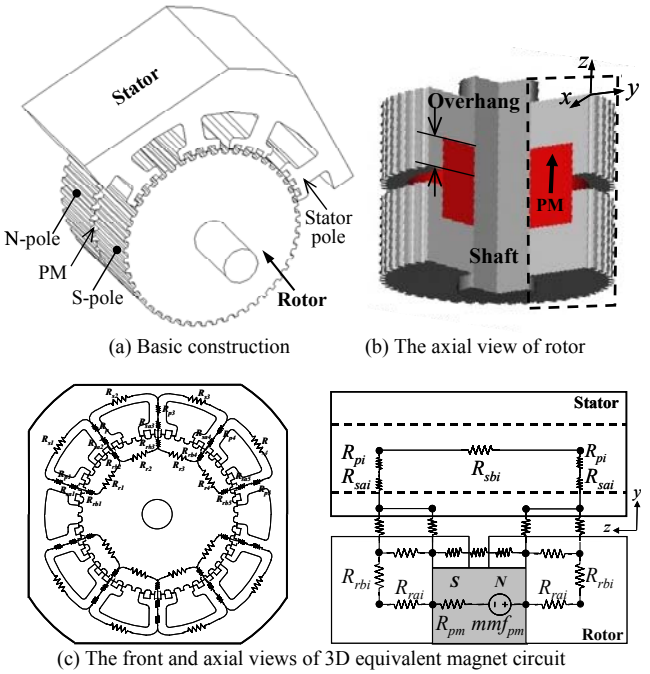
II. The Improved Characteristic Analysis Method

The object analysis model and the proposed analysis process are as shown in Fig. 1 and Fig. 2, respectively. The detail explanation for the model and the process, and the verification of the proposed method by comparisons of simulate and experiment results as shown in Fig. 3 will be discussed in the extended paper.

III. References

[1] M K Jenkins and D Howe and T S Birch, "An improved design procedure for hybrid stepper motors", *IEEE Transaction on Magnetics*, vol. 26, No. 5, pp.2535-2537, September 1990

[2] Ki-Chae Lim, Jung-Pyo Hong, and Gyu-Tak Kim, "Characteristic Analysis of 5-Phase Hybrid Stepping Motor Considering the Saturation," *IEEE Transaction on Magnetics,* vol. 37, No. 5, pp. 3518-3521, September 2001



(a) Basic construction (b) The axial view of rotor

(c) The front and axial views of 3D equivalent magnet circuit

Fig. 1. The 5-phase hybrid stepping motor

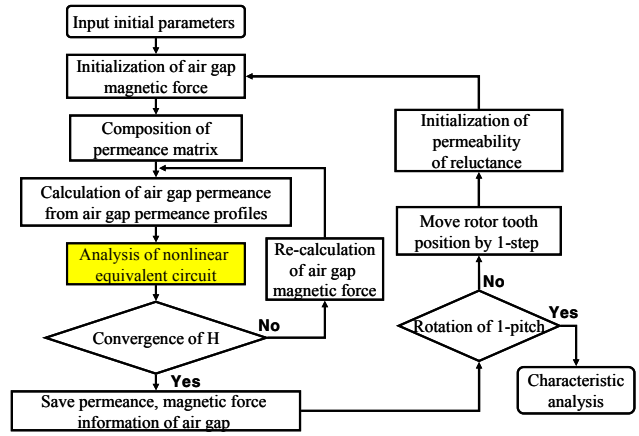
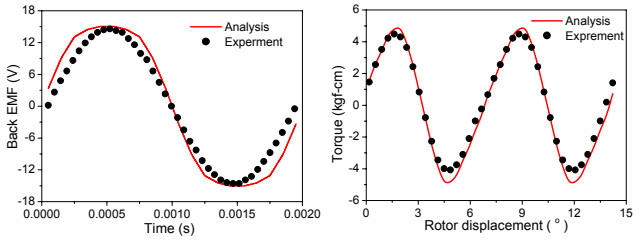


Fig. 2. Flow chart of characteristic analysis



(a) Back EMF @600rpm (b) Static torque

Fig. 3. The comparison of analysis and measured characteristics