Lateral force Analysis of PMLSM for Magnetic Levitation stage based on 3-Dimensional Equivalent Magnetic Circuit Network

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Abstract – **This paper deals with the lateral force analysis of Permanent Magnet Linear Synchronous Motor (PMLSM) for the guidance in magnetic levitation stage. In order to analyze overhang effect of PMLSM and lateral asymmetry of secondary, 3-Dimensional Equivalent Magnetic Circuit Network (3-D EMCN) taking into account movement of the secondary in lateral direction is introduced.**

INTRODUCTION

The lateral force characteristics of PMLSM for magnetic levitation stage without guards is very important to its stability in speed and levitation control systems. PMLSM has much lateral airgap flux leakage because its width is finite with lateral edges and its effect airgap is very large. Furthermore, its lateral displacement by external disturbance makes its pulsation of not only levitation force and thrust but detrimental to the performance. Therefore, in PMLSM for magnetic levitation stage, the lateral characteristic analysis is required to precise design considering changing of lateral displacement for restoration [1].

To perform such a magnetic field analysis, 2-dimensional analysis cannot consider lateral characteristics. In this paper, 3-D EMCN is used to solve detail field computation. The purpose of this paper analyzes lateral force characteristics of PMLSM using 3-D EMCN considering overhang effect and lateral displacement and determine optimal current phase angle in controlled magnetic levitation stage.

METHOD OF ANALYSIS AND RESULT

3-D EMCN is the way analysis model is divided into elemental volumes of hexahedral shape according to regions, and then constructed by connecting the centroid of adjacent elements with their permeance. Fig. 1 shows analysis model of PMLSM for magnetic levitation stage with lateral direction (z-axis) length. A simplified 3-D EMCN model is shown in Fig. 2.

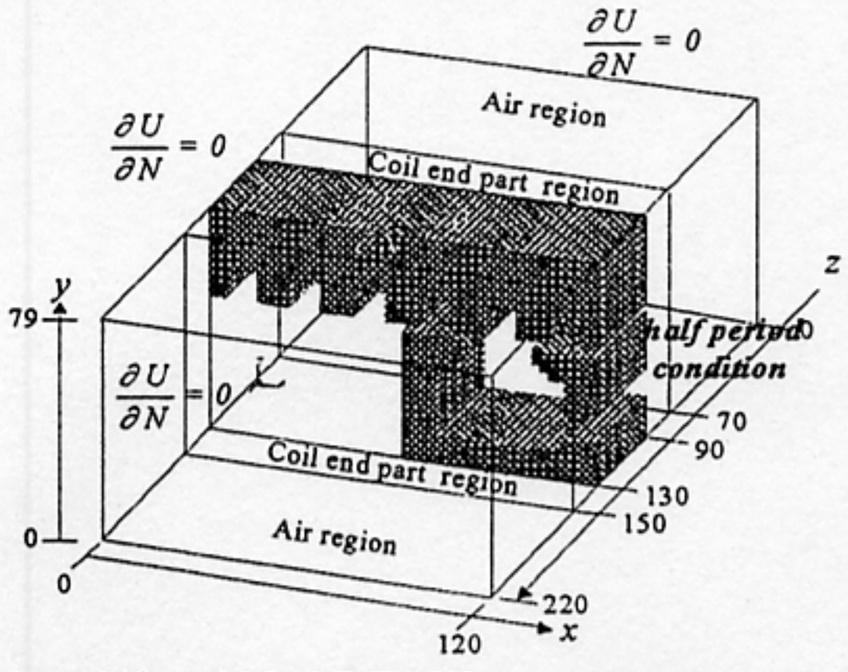


Fig. 1. Analysis model for 3-D EMCN

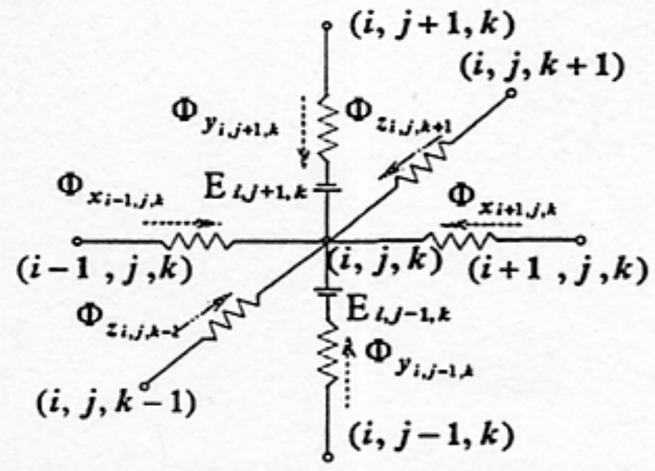


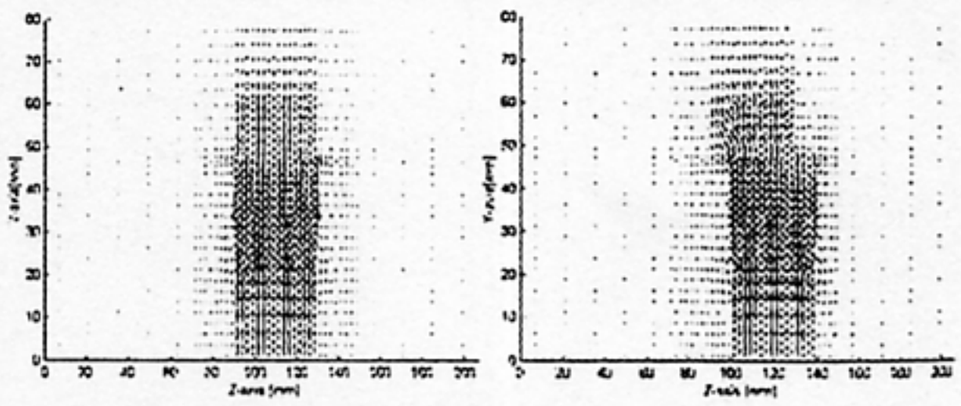
Fig. 2. Configuration of 3-D EMCN and flux flow at a node

Fig. 3 shows the distribution of the flux density vector compare align case and asymmetrical case of primary and secondary by 3-D EMCN. Lateral force change nonlinearly owing to lateral flux leakage. Therefore, it is indispensable to consider the lateral effect due to the variation of overhang length and lateral displacement. Fig. 4 (a) shows the lateral force according to offset length, it is variation nonlinearly due to overhang effect.

In the case of PMLSM for magnetic levitation stage, thrust and levitation force is controlled by current phase angle. Lateral force characteristics according to current phase angle at lateral displacement of 7.5[mm] are shown in Fig. 4(b). It is changed greatly with control scheme. From the analysis results, we confirm that it is necessary to lateral effect analysis consider control scheme in PMLSM for magnetic levitation stage.

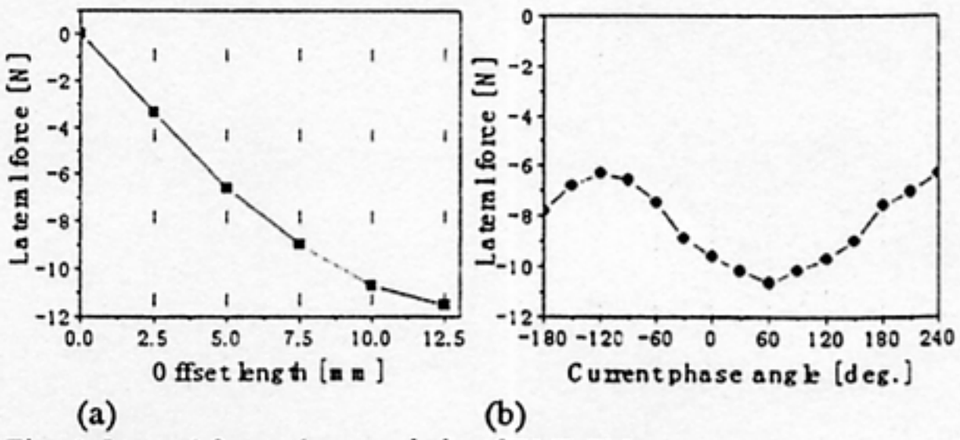
REFERENCES

[1] J. Hur, I. S. Jung and D. S. Hyun, "Lateral Characteristic Analysis of PMLSM Considering Overhang Effect by 3 Dimensional Equivalent Magnetic Circuit Network Method", *IEEE Trans. on Magn.*, Vol. 34, No.5, Sep, pp.3142-3145, 1998



(a) offset length = 0 (b) offset length = 7.5[mm]

Fig. 3. Flux distribution in y-z plan according to offset length.



(a) (b)

Fig. 4. Lateral force characteristic of PMLSM