Optimum LIM Interval Selection of Vector Controlled Moving Secondary Plate Conveyor System Using FEM & SUMT for Constant Speed Control

Young Hyun Kim, Young Gak Rha and Jung Ho Lee
Department of Electrical Engineering, Hanbat National University
Dukmyung-Dong Yuseong-Gu Daejeon, 305-739, Korea
Pearls85@hanmail.net

Abstract **— It is necessary to modify the state-of-the-art of speed control theory because of the phase asymmetry in the Linear Induction Motor (LIM) and in order to the constant speed control of mover (aluminum plate) using single vector control inverter system, it is important that primary stack is located in appropriated intervals in the 3D conveyer system using LIM because of control parameters are varied.**

The dynamic characteristic analysis method of the vector controlled LIM using coupled FEM and control algorithm taking into account the movement is proposed.

Moreover, in order to obtain the detailed intervals, optimization algorithm, sequential unconstrained minimization technique (SUMT) is used.

The focus of this paper is the analysis relative to selecting primary stack intervals in order to constant speed control in the 3D conveyer system using LIM.

To prove the propriety of the proposed method, the Digital Signal Processor (DSP) installed experimental devices are equipped and the experiment is performed.

Index Terms— **Finite Element Method (FEM), Linear Induction Motor(LIM)Introduction, selecting primary stack intervals, constant speed control**

I. INTRODUCTION

Linear Induction Motor (LIM) has been developed for use in the industry, transportations, OA, FA, because of the merits of direct drive and simple structure.

This paper deals with the three dimensional conveyor systems for light objects out of the auto conveyor systems.

In this system, since LIM is turn on only when carrier is over it, it can be reduced much energy and obtained many merits of high speed, automation (acceleration and deceleration control, the control of precision position), and removing the power supply cable or lead wire.

For the constant speed control of mover using single vector control inverter system, it is important that primary stack is located in appropriated intervals. And for a LIM, the constants of each phase are different due to the motor structure.

Thus, it is difficult, especially in moving secondary plate system, for the accurate speed control of LIM by the state-of-the-art of rotating machine theory.

The finite element approach has been gaining progressively greater importance than the equivalent circuit method in solution of non-linearity, anisotropy characteristic and motion analysis, especially selecting appropriated motor intervals of this paper, etc.

These approaches, which are coupled with control algorithm and numerical analysis method, have an interest for researchers now [1]-[3].

In this paper the dynamic characteristic analysis method of the controlled LIM sets of 3D conveyer system using coupled FEM and control algorithm taking into account the movement is proposed and it has been selected a appropriated interval of primary motors in order to constant speed control through the optimization algorithm (SUMT).

II. ANALYSIS MODEL

The two dimensional model of LIM is shown in Fig.1

The primary stack intervals increasing (2m, 1.6m, 1.2m, 0.8m, 0.6m, 0.4m) are considered by enlarging full boundary condition of both sides to x direction.

The mesh should be changed according to the movement of the mover in moving mesh area. A moving line is introduced to save computing time and to perform the process efficiently in FE analysis.

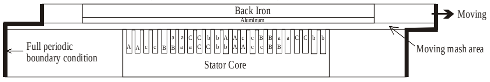


Fig. 1. Analysis model of LIM

III. ANALYSIS METHOD

Fig. 2 shows the block diagram of system. Asymmetrical slip angular velocity algorithm is applied to the control logic for the comparison with flux angle of FEM.

The proposed analysis method is applied to the step velocity commend (2.0 m/sec) in the vector control logic part using 10(μ sec) sampling time.

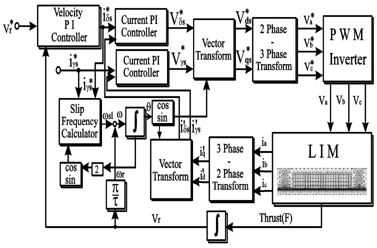


Fig. 2. Block diagram of the system

IV. SIMULATION & DISCUSSION

Fig.3 show the flux plot of analysis model example considered movement out of numerous data.

Fig 4 (a) – (e) shows the primary stack intervals (2m, 1.6m, 1.2m, 0.8m, 0.6m, 0.4m) due to the enlarging full periodic boundary condition of both side.

In the case of each primary stack intervals, it is observed that whereas speed responses highly oscillate as motor intervals is wider, speed responses in the 0.4m and 0.6m motor interval is nearly match constant speed commend 2 m/sec as shown in Fig. 5.

Fig. 6, Fig.7 represents forward-reverse speed response characteristics of each primary stack intervals.

It is observed that whereas speed responses in the 0.4m motor interval is nearly match constant speed commend, others highly delayed as motor intervals is wider and constant speed responses (2 m/sec) in 0.6m motor interval is nearly match, but especially, forward-reverse speed response is delayed as shown in Fig. 6, Fig. 7.

Therefore stator stack interval between 0.4m and 0.6m can be defined as the optimum ones for the speed vector control of the 3D conveyor system.

Moreover, in order to obtain the detailed intervals, optimization algorithm, sequential unconstrained minimization technique (SUMT) is used as shown in Fig. 8.

The more detailed optimum procedure and discusses will be represented in next extended version.

To prove the propriety of the proposed method, the Digital Signal Processor (DSP) installed experimental devices are equipped and the experiment is performed.

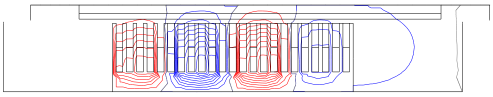
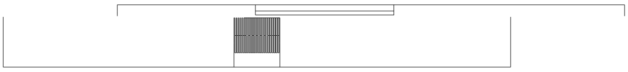
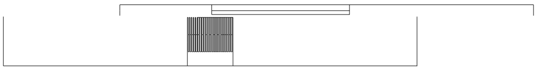


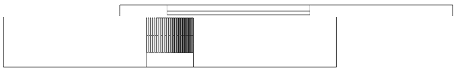
Fig.3. Flux plot example of analysis model considering movement



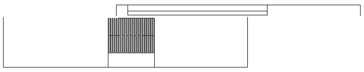
(a) Primary stack interval (2 m)



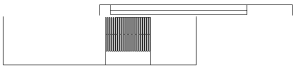
(b) Primary stack interval (1.6 m)



(c) Primary stack interval (1.2 m)



(d) Primary stack interval (0.8 m)



(e) Primary stack interval (0.4 m)

Fig.4. Primary stack interval increasing considering periodic boundary condition

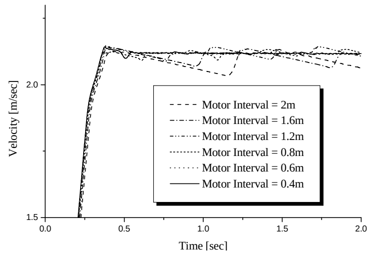
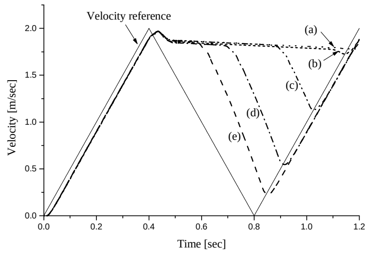
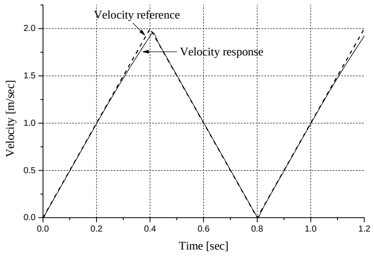


Fig.5. Velocity responses in constant speed commend



(a) Motor interval = 2m (b) Motor interval = 1.6m
(c) Motor interval = 1.2m (d) Motor interval = 0.8m
(e) Motor interval = 0.6m

Fig. 6. Velocity responses in forward-reverse speed commend



Motor interval = 0.4m

Fig. 7. Velocity responses in forward-reverse speed commend

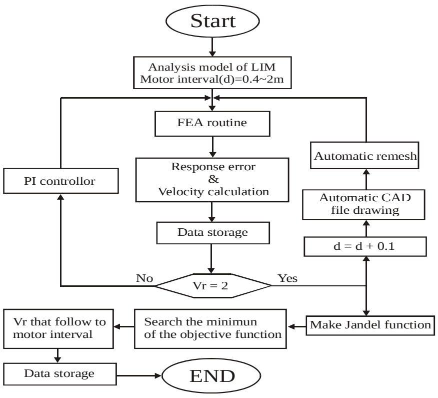


Fig.8. Flow chart of total design procedure

More detailed design procedure, results and discussion will be given in final paper.

REFERENCES

[1] D. H. Im and J. H. Lee, “Dynamic characteristics analysis of LIM’s vector control using FEM,” *Proceedings of LDIA’95*, pp. 307-310, 1995.

[2] D. H. Im, and C. E. Kim, “Finite element force calculation of a linear induction motor taking account of the movement,” *IEEE Trans. on Magnetics*, Vol. 30, No. 5, pp. 3495-3498, 1994.

[3] J. H. Lee, D. S. Hyun, “Dynamic Characteristic Analysis of LIM Using Coupled FEM & Control algorithm,” *IEEE Trans. on Magnetics*, Vol. 36, No. 7, pp 1876-1879, July 2000.