Secondary Optimization of Linear Induction Motor by Finite Element Method and Analytical Method considering Transverse Edge Effect

Seok-Myeong Jang[1], Yu-Seop Park[1], Kyoung-Jin Ko[1], Jang-Young Choi[1], So-Young Sung[2]
[1] Dept. of Electrical Engineering, Chungnam Nat'l Univ., 220, Gung-dong, Yuseong-gu, Daejeon, Korea
[2] Ocean System Research & Development Division, Korea Ocean Research & Development Institute, Korea
wavec@cnu.ac.kr

Abstract — This paper deals with secondary optimization of linear induction motor (LIM) for efficiency improvement. For the process, finite element method (FEM) and analytical method interact to take advantages of both methods. Due to transverse edge effect caused by secondary structure, 3D FEM is applied for the electromagnetic characteristic analysis, and the analytical method supports the analysis to reduce analysis time. With the electromagnetic propulsion force and efficiency showing identical characteristic results in the condition of over a certain overhang length, this paper optimizes the best model.

I. Introduction

Due to various advantages and high demands, plenty of researches on linear induction motor (LIM) have been actively performed, and many researches applied analytical method and finite element method (FEM). Unfortunately, due to the transverse edge effect, the 2D FEM cannot be applied, so 3D FEM must be employed causing very long analysis time. Besides, since the impedance of LIM is varied according to its structure, considering every case by only 3D FEM might be impossible. However, 3D FEM shows high reliability in comparison with experimental results, so it cannot be avoidable. Therefore, this paper suggests the coupling method using both analytical method and 3D FEM to reduce the analysis time. In addition, the efficiency of the analysis model is evaluated and manufactured to perform experiment for validation.

II. Secondary Structure Optimization

A. Analysis Model

The analysis model shown in Fig.1 has three phase coil wound in laminated silicon steel plate, and its secondary consists of aluminum plate and back-iron. Here, primary is a stator, and secondary is mover which only moves to x-direction. Its rated speed is 7[m/sec] at 220[V] and 60[Hz] input voltage condition. Here, for the characteristic analysis, the analysis model is simplified.

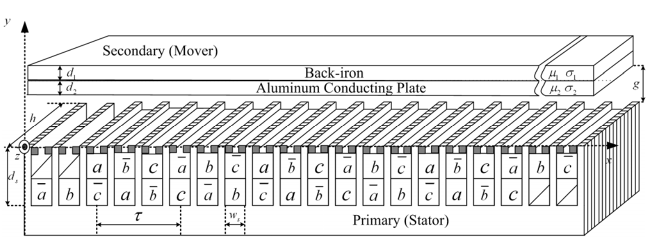

Fig. 1. Analysis model.

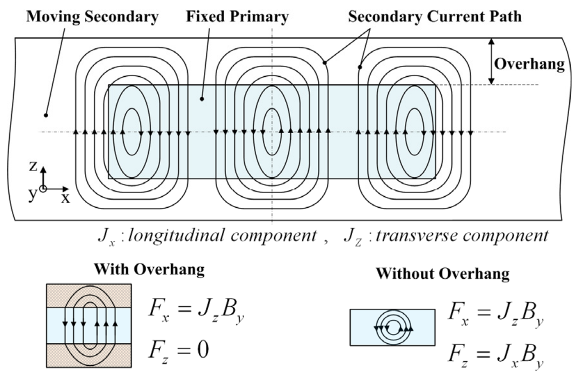

Fig. 2. Induced Current Distribution on Aluminum Conduction Plate.

B. Overhang and Transverse Edge Effect

Fig. 2 presents the induced current distribution in secondary aluminum conducting plate by primary current. Here, the overhang length determines the induced current distribution characteristic causing transverse edge effect, and it effects on the secondary impedance and output characteristic. In other words, the induced current has both x component and J_x generating lateral force F_z=J_xB_y and z component J_z generating electro-magnetic propulsion force F_x=J_zB_y. In particular, J_x is the main reason of transverse edge effect, and increased overhang length has more J_z than J_x resulting higher electro-magnetic propulsion force. However, over a certain overhang length, LIM shows identical performance making secondary material waste, so the determination of optimized overhang length is essential considering manufacturing cost and efficiency.

C. Coupling Method for Secondary Optimization

This paper will describe the coupling procedure of analytical method and 3D FEM as shown in Fig.3. Firstly, applying analytical method, the electromagnetic propulsion force, and equivalent circuit parameters are derived, and FEM models are determined considering the result variation.

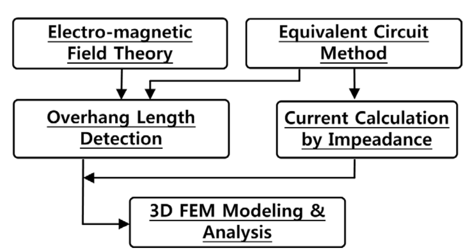

Fig. 3. Secondary Optimization Procedure.

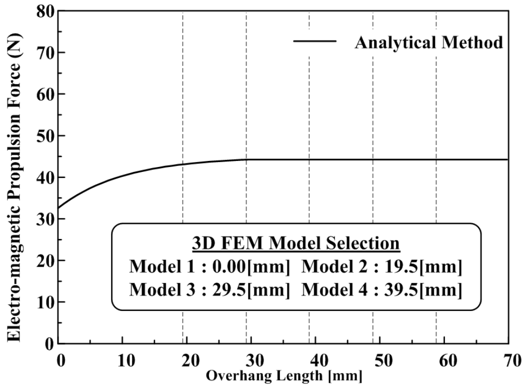

Fig.4. Electromagnetic propulsion force by analytical method.

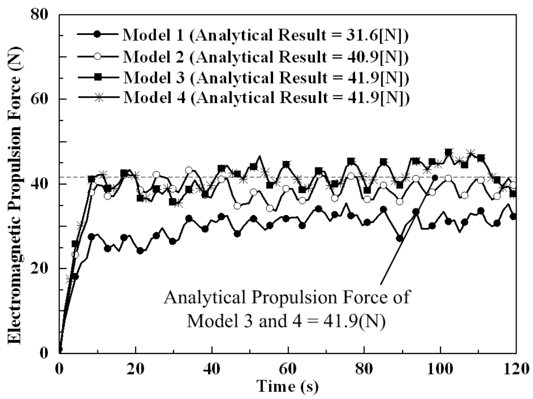

Fig.5. Electromagnetic propulsion force by 3D FEM.

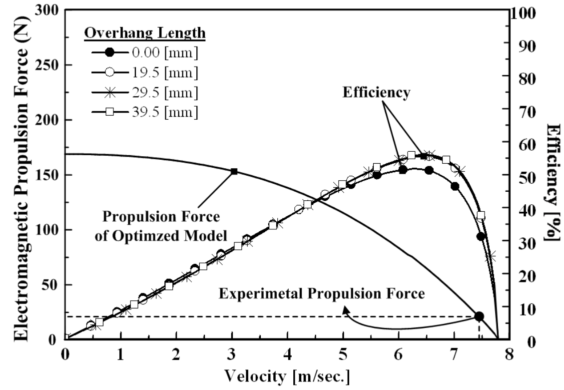

Fig.6. Efficiency according to overhang length and speed.

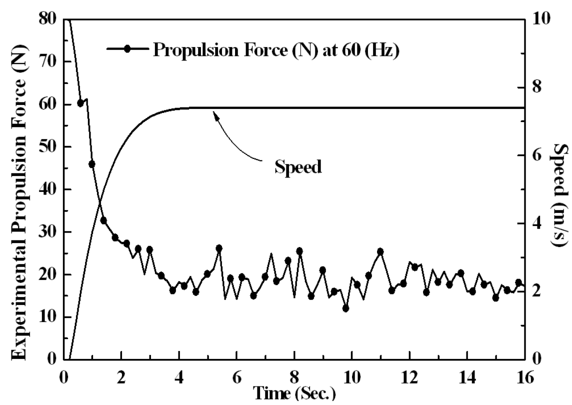

Fig.7. Experimental electromagnetic propulsion force.

Besides, the equivalent circuit parameters are employed to calculate the phase current of each FEM model. Fig. 4 shows the electromagnetic propulsion force according to overhang length, and the equivalent circuit parameters will be presented in later full paper. The most important point is that both results show no variation over 29.5[mm] overhang condition.

D. Electromagnetic Field Analysis by 3D FEM

Among various overhang conditions, 4 models are selected for 3D FEM as indicated in Fig.4, and the electro-magnetic field analysis is performed by 3D FEM with the calculated input current for each model,. Fig.5 shows the electromagnetic propulsion force according to overhang length, and it is increased by overhang length increment. Here, model 3 and 4 do not show the difference, and their overhang length is over 29.5[mm]. Therefore, this paper determined it the optimized overhang length.

D. Efficiency and force evaluation

Since it is possible to calculate the efficiency with the derived propulsion force, and equivalent circuit parameters, the efficiency can be obtained. Fig.6 shows the efficiency considering overhang length and electromagnetic propulsion force with optimized secondary structure according to velocity. As anticipated, the efficiency in the condition of over 29.5[mm] shows identical result. In addition, based on the analysis results, the analysis model is manufactured, and its experiment is performed as shown in Fig.7. The experimental result shows the electromagnetic propulsion force, and its result is well corresponded as indicated in Fig.6.

III. CONCLUSION

In this paper, the efficiency improvement of LIM is performed by secondary overhang optimization. Taking advantages of both methods, the analysis time can be dramatically reduced. If the whole process is performed by only 3D FEM, it might be actually impossible. Besides, the validity is demonstrated by experimental result. More specific illustration will have been offered in later full paper.

IV. REFERENCES

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