DYNAMIC CHARACTERISTERIC ANALYSIS OF MOVING COIL TYPE LINEAR OSCILLATORY ACTUATOR

Kil-Whan Kang, Jung-Pyo Hong, Gyu-Tak Kim
Dept. of Electrical Engineering, Chang-won National University, Chang-won 641-773, KOREA
Duk-Hyun Kim
Dept. of Electrical Engineering, An-dong Tech. College, An-dong 762-170, KOREA

Abstract - This paper designed a Moving Coil type Linear Oscillatory Actuator (MC-LOA) using the combination of mechanical dynamic equation with electric dynamic equation and equivalent circuit. Finite Element Method (FEM) is used in obtaining the parameters of electric dynamic equation. In order to uniforming the air gap flux density distribution, the center yoke of the initial designed MC-LOA is carried out by means of the shape optimization. Then, the dynamic characteristics of the initial designed MC-LOA are compared with those of optimized MC-LOA.

I. Introduction

Linear Oscillatory Actuator (LOA) is used in the system reciprocating short stroke. Because of MC-LOA includes Permanent Magnet (PM) it has several advantages: compactness, low weight and reduced energy consumption. It is most suitable for a system where is required an accuracy stroke control because it has less inertia in comparison to other types of LOA[1] [2].

In this paper, MC-LOA with sinusoidal displacement is designed and its dynamic characteristics are analyzed through the time difference scheme. It takes a long time to compute time by FEM in its design and analysis. In order to complement this defect, equivalent circuit is used. The parameters of equivalent circuit are obtained by FEM. The distortion of flux density in air gap is also confirmed by FEM, and its dynamic characteristics are analyzed through the development of air gap flux density distribution.

II. Design

The designed MC-LOA is shown in Fig.1.

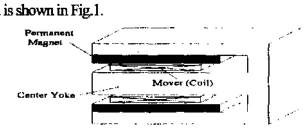


Fig. 1 Structure of MC-LOA

The requirement thrust from mechanical dynamic Eq.1 should be equal to the linear magnetic thrust from Eq.2[1][2].

$$F_{dyna} = M\frac{d^2x}{dt^2} + D\frac{dx}{dt} + K_s x \qquad (1)$$

$$F_m = K_f \cdot i = NB_g l_c \cdot i \qquad (2)$$

▷ Kil-Whan Kang
Dept. of Electrical Eng. Changwon National Univ.
9 Sarim-dong, Changwon, Kyungnam, 641-773, Korea
Tel : 82-551-279-7519
▷ FAX : 82-551-263-9956
▷ E-mail : haebin@netian.com

The initial design of magnetic circuit is performed by a permeance method. In this model, flux density at operation point is different from the residual magnetic density because PM and air gap coexist. Therefore, permeance should be considered here.

The equivalent circuit of driving circuit in MC-LOA can be represented by the following equation[1].

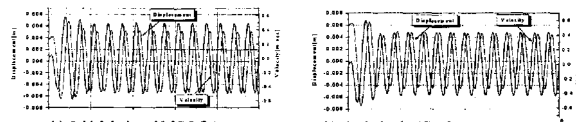
$$V = RI + L\frac{dI}{dt} + e_b \qquad (3)$$

III. Shape optimization

To find an optimal condition of the air gap flux density distribution, which is linear, we changed the shape of center yoke, that is an arc type in this case of the same position and width as PM[3].

IV. Characteristics analysis

Fig.2 shows characteristics of displacement and velocity according to time in the initial designed MC-LOA and optimized MC-LOA.



(a). Initial designed MC-LOA (b). Optimized MC-LOA

Fig. 2 Dynamic characteristics of MC-LOA

V. Conclusion

This paper designed an MC-LOA using the combination of mechanical dynamic equation with electric dynamic equation and it is analyzed dynamic characteristics of designed MC-LOA. Dynamic characteristics are analyzed by the time difference scheme. In order to uniforming the air gap flux density distribution, the center yoke of initial designed MC-LOA is carried out by means of the shape optimization then, dynamic characteristics of initial designed MC-LOA is compared with those of optimized MC-LOA

REFERENCES

[1] Naila Mikhaeil-Boules, " Design and analysis of linear actuator for active vibration cancellation.", General Motors Corporation, 1995.
[2] H. Wakiwaka, H. Yajima, S. Senoh and H. Yamada, "Simplified Thrust Limit Equation of Linear DC Motor", IEEE, Vol. 32, pp. 5073-5075, 1996.
[3] Sang-Baeck Yoon, Jin Hur, Yon-Do Chun, Dong-Seok Hyun, Dal-Ho Im and Jung-Pyo Hong, "Shape Optimization of Solenoid", Procd. of SMIC'96, PP. 201-204, 1996

0-7803-5555-5/99/$10.00 ©1999 IEEE.