A Study on Actuator for High-Speed Linear Direct Drive (Fundamental Consideration on Concentration of Magnetic Flux to Improve Thrust)

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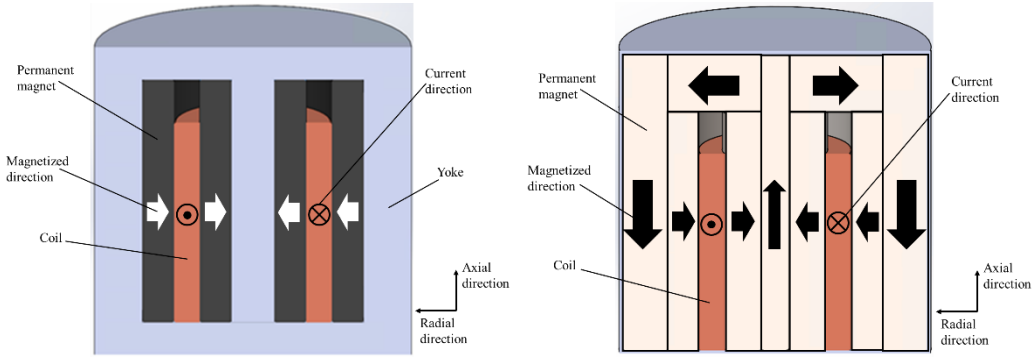
Abstract

Linear motion in a machine is converted from rotational motion by the mechanism. The performance of linear motion by a mechanism depends on the geometry of the mechanism. In addition, energy loss occurs by using mechanisms. However, by replacing these mechanisms with linear actuators that use Lorentz force and have a simple structure, direct drive can be realized and highly efficient linear motion can be achieved. In this study, a prototype actuator in which the magnetic flux is concentrated in the coil by the arrangement of magnets was fabricated, and the thrust characteristics in the reciprocating motion of the mover were evaluated.

1 Introduction

Currently, linear motion in a machine is converted from rotational motion by a mechanism. The performance of linear motion by a mechanism depends on the geometry of the mechanism. In addition, energy loss occurs with the use of mechanisms. However, by replacing these mechanisms with linear actuators, direct drive is possible and highly efficient linear



(a) Yoke model (b) Permanent magnet model

Figure 1: Schematic of linear actuator

motion can be achieved. Linear actuators can also be used to drive valves in engines, which is expected to improve engine efficiency. Other research groups have proposed intake and exhaust systems using actuators, but these systems have problems such as large actuator size, increased mass due to complex structure, and inability to obtain large thrust [1,2]. Therefore, we propose a linear actuator using Lorentz force. This actuator has a simple structure, can be operated at low alternating current frequencies by using a coil as a mover, and offers high responsiveness and precise motion by direct drive. There is no actuator that concentrates the magnetic flux in the coil by the arrangement of magnets to increase the thrust density of the actuator in previous research. In this study, a prototype actuator in which the magnetic flux is concentrated in the coil by the arrangement of magnets was fabricated, and the thrust characteristics were evaluated.

2 Thrust Characteristics of a Linear Actuator Using Flux Concentration by Permanent Magnets

Fig. 1 shows a schematic of the prototype linear actuator. The actuator consists of a permanent magnet and a coil yoke. The permanent magnet and yoke are the stator and the coil is the mover. The mover is driven axially by Lorentz force. Fig. 1(a) shows a yoke model in which the yoke forms a magnetic circuit. Fig. 1(b) is the permanent magnet model (PM model), which uses permanent magnets to concentrate the magnetic flux in the coil. In the yoke model, the yoke replaces the components other than the permanent magnets that were placed between the coils in the PM model. The external dimensions of the actuator are the same, and the two models were analyzed to study the thrust characteristics due to the mover motion reciprocating. The results showed that the PM model provided an average thrust of 48.8 N and the yoke model provided a thrust of 98.0 N.

3 Conclusion

In this report, a prototype model in which the magnetic flux is concentrated in the coil by permanent magnets was built, and the thrust characteristics were examined. The analysis results showed that the York model provided greater thrust; the PM model had a lower thrust because the ratio of each permanent magnet was not optimized. In the future, we plan to study the possibility of changing the ratio of each permanent magnet.

References

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