The Design, Fabrication, and Characteristic Experiment of the Electromagnet of Bottom-mounted Control Rod Drive Mechanism for Research Reactor

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1. Introduction

A control rod drive mechanism (CRDM) is located in the reactor pool top (Top-mounted) or the room below the reactor pool (Bottom-mounted). The function of the CRDM is to insert, withdraw, or maintain neutron absorbing material at any required position in the reactor core in order to maintain reactivity control of the core.

There are so many kinds of CRDMs, such as magnetic-jack type, hydraulic type, rack and pinion type, chain type and linear or rotary step motor and so on.

As a part of a new project, we are investigating the bottom-mounted control rod drive mechanism as shown in Fig. 1. To have a better knowledge of the electromagnetic and magnetic characteristics, numerical models of bottom-mounted CEDM are investigated. [1,2,3].

In this study, we clarified thrust force characteristics of the electromagnet by experiment and simulation, and verified the propriety of the FEM analysis by comparing it with the results.

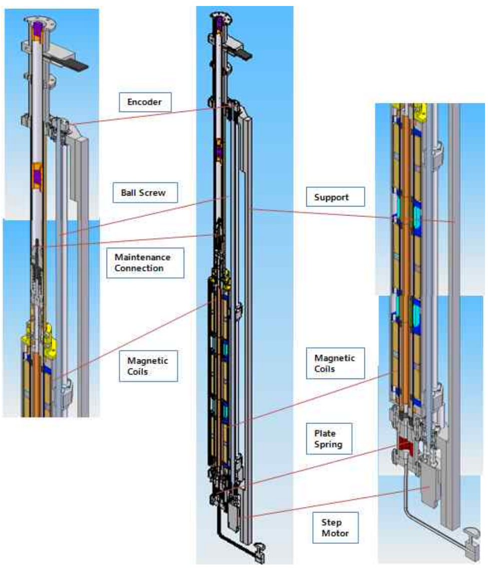

Fig. 1. Schematic of bottom-mounted CEDM

2. Methods and Results

In this section the numerical magnetic field calculation with finite element method for the design of electromagnet is described and compared with the thrust force characteristics of fabricated electromagnet.

2.1 Electromagnetic FEM Analysis Results

In recent year, the FEM has become widely accepted by the engineering professions as an extremely valuable method of analysis.

Its application has enabled satisfactory solutions to be obtained for many problems which had been regarded as insoluble, and the amount of research effort currently being devoted to the FEM ensures a rapidly widening field of application.

Table 1 shows the input data for electromagnet FEM analysis.

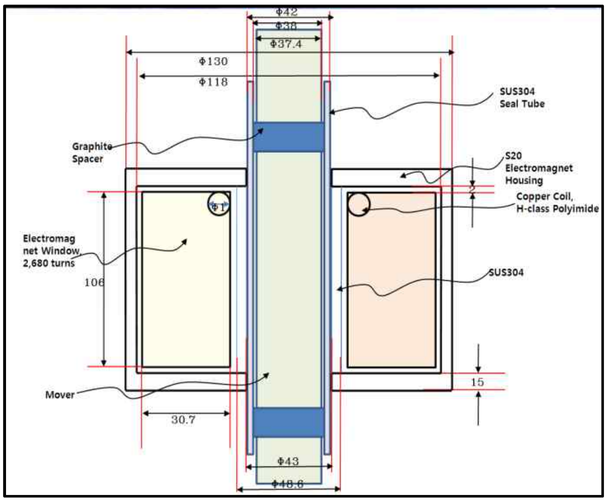

Fig. 3. A dimension of proposed electromagnets.

Table 1: A design specification of electromagnet model

Component	Material	Remark
Lifting coil, mm	Copper	30.7x106
Coil housing	S20	
Mover	SS400	Surface Cr - plated
Seal tube	STS316	
Air-gap, mm	Air	2.8
Current, A		2
Coil diameter, mm		ϕ1.0
Coil turn		2,680
Space factor		0.65

A proposed model for such a computation is given in Fig. 4, where the exact course of the magnetic equi-flux of electromagnet is shown.

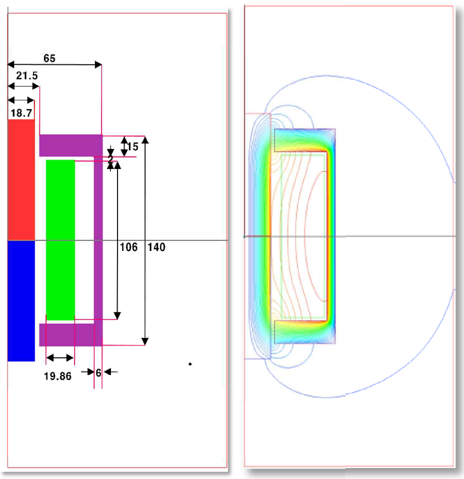

Fig. 4. A proposed FEM model and equi-flux distribution lines FEM result

2.2 Electromagnetic Experiment Results

Fig. 5 shows the experimental setup for measuring the thrust force of fabricated electromagnet which is designed by FEM analysis result.

Fig. 5. Experimental setup of electromagnet

Fig. 6 is the results of the measured thrust force of electromagnet.

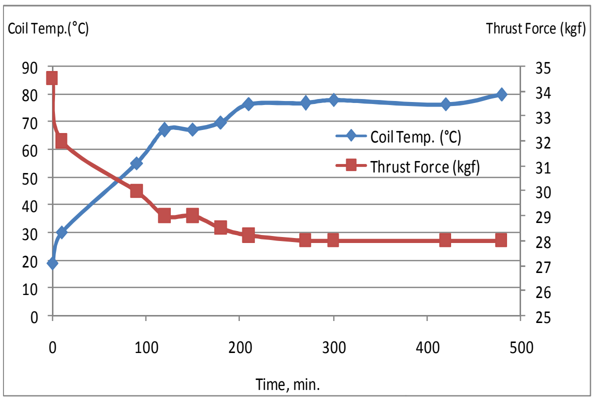

Fig. 6. A measured thrust force of electromagnet.

Fig. 7 is the results of the measured and the calculated thrust force of electromagnet. As a result, the measured thrust force of electromagnet is larger than the calculated thrust force using FEM analysis.

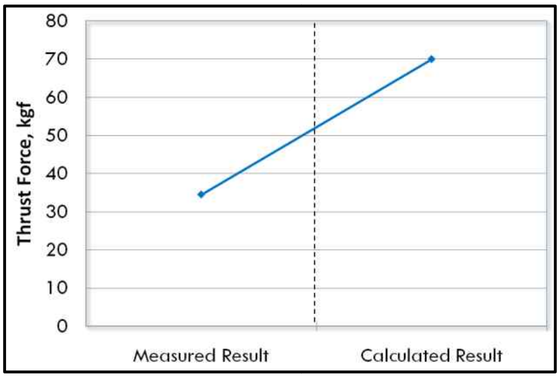

Fig. 7. Comparison of measured and calculated thrust force of electromagnet.

3. Conclusion

The Results of a FEM and the experiments in this work lead to the following conclusions:

(1) The FEM result for the design of electromagnet is compared with the measured thrust force of prototype electromagnet. As a result, it is shown that the thrust force of FEM result is doubled than that of prototype electromagnet.

(2) The major reasons of the disagreement between the measured and calculated results are as follows.
   A. B-H Curve differences of ferromagnetic materials
   B. Tolerance of manufacturing
   C. Tolerance of measuring

(3) To investigate the disagreement of the thrust force, we will try to fabricate an optimized electromagnet and experimental setup.

REFERENCES

[1] Hyung Huh et al., "Electromagnetic Analysis of Magnetic-Jack type CRDM for Thrust Force Improvement," Transaction of the KNS Spring Meeting, 2007

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[3] Hyung Huh et al., "A Study on the Electromagnet Thrust Force Characteristics of Newly Proposed Hybrid Bottom-mounted CRDM for Research Reactor," Transaction of the KNS Spring Meeting, 2007