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# Numerical Research on LVDT Sensor for Electromagnet Rigidity Measurement of Bottom Mounted CRDM

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## 1. Introduction

A bottom mounted control rod drive mechanism (BMCRDM) in a research reactor is composed of an electromagnet, stepping motor, ball screw, guide tube, armature and extension shaft assembly, damping mechanism and Linear Variable Differential Transformer (LVDT) as shown in Fig. 1. The stepping motor directly drives the ball screw, and the nut of the ball screw makes the electromagnet move up and down along the guide tube.

At this time the higher force of an electromagnet will greatly result in less position fluctuation of the armature for a given variation of loadings.

The magnetic rigidity represents one of the most important characteristics of the electromagnet.

For this reason, it is necessary to measure control rod position including sagging rate due to loadings exactly.

Therefore, KAERI has developed electromagnet rigidity measuring sensor using LVDT.

This paper presents the case numerical research of prototyping a LVDT sensor for BMCRDM. [1][2][3]

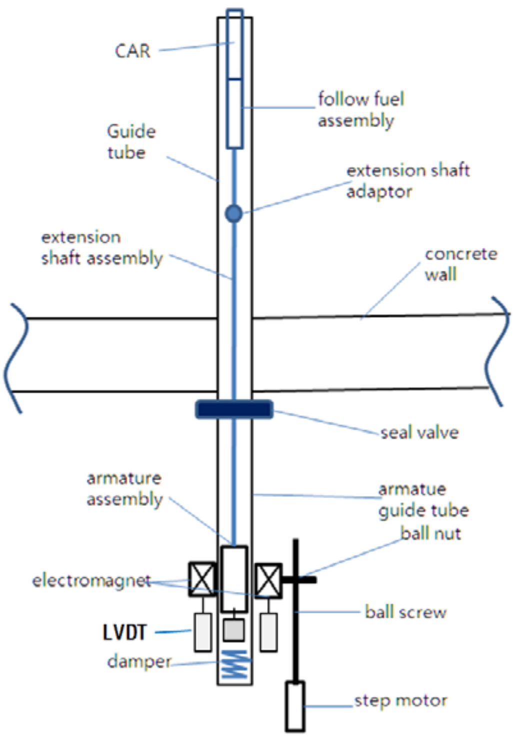


Fig. 1. Schematic of BMCRDM.

## 2. LVDT Sensor for Electromagnet Rigidity Measurement

The LVDT Sensor for electromagnet rigidity measurement consists of core, winding housing, primary coil, and secondary coils.

Fig. 2 shows a newly proposed LVDT for measuring control rod sagging displacement.

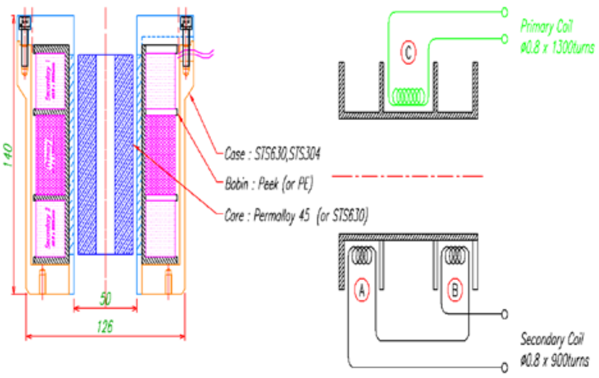


Fig. 2. A detailed view of proposed LVDT for control rod sagging measurement system.

## 3. Methods and Results

In this section the numerical magnetic field calculation with finite element method is described as well as the details of configuration and function for the LVDT.

### *3.1 LVDT 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.

A newly developed technique of the LVDT for such a computation is given in Fig. 3.

Fig 4 shows FEM results as induced voltage from secondary coils of LVDT 2D-model.

Table 1 shows the input data for electromagnet FEM analysis corresponding Fig. 3 designated names.

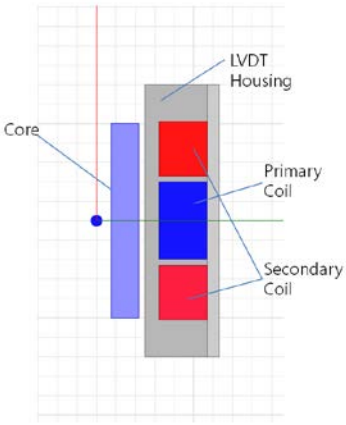


Fig. 3. FEM model of LVDT

Table 1. Design specification of LVDT model.

| No | Component | Material | Remark |
|---|---|---|---|
| 1 | Primary coil, mm | Copper | 24x40 1,300turns |
| 2 | Secondary coil, mm | Copper | 25x28 900turns |
| 3 | Housing | STS630 | |
| 4 | Core | Permalloy45 | |
| 5 | Input | 30*SQRT(2)*Cos(2*pi*400 *time), 400Hz, 30Vrms | |
| 6 | Initial output | 0[V] | |
| 7 | FEM solver | ANSYS-Maxwell, Axis-symmetric, Transient | |

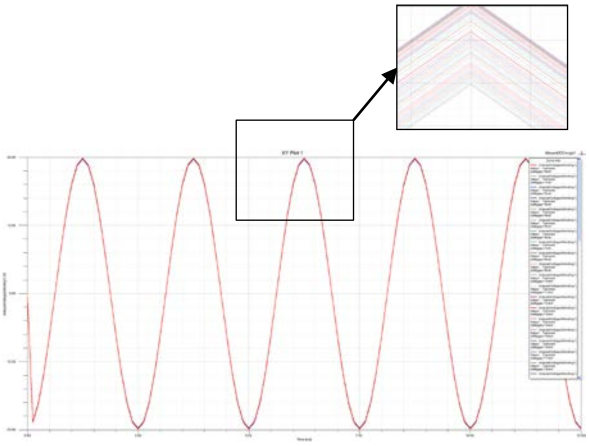

Fig. 4. FEM result of induced voltage from secondary coils.

Fig 5 shows summarized induced voltages from secondary coils when the core moves up and down from the center of LVDT. As a result, it is shown that the linearity of the LVDT have a good agreement between 0[mm] and ±15[mm].

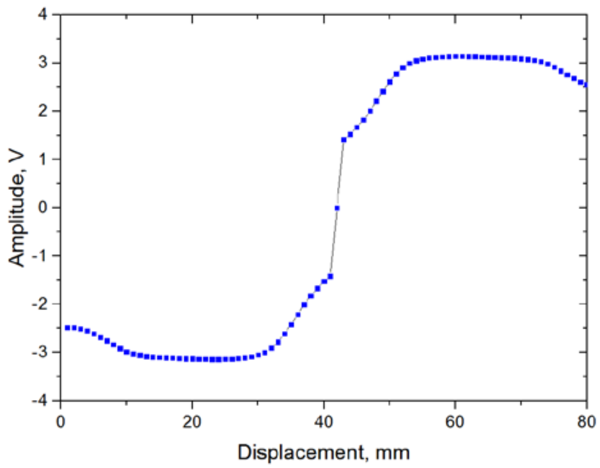


Fig. 5. FEM result of induced voltages of LVDT

## 4. Conclusion

The results of a FEM in this work lead to the following conclusions:

(1) The FEM result for LVDT shows good linearity of displacement vs. induced voltage between 0[mm] and ±15[mm] intervals.

(2) For the extension of linearity interval, additional research work is necessary for the configuration and arrangement of primary and secondary coils.

## REFERENCES

[1]Hyung Huh et al., “Magnetic Actuation Connector Between Extension Shaft and Armature for Bottom Mounted Control Rod Drive Mechanism,” Transaction of the KNS Autumn Meeting, 2013

[2]Hyung Huh et al., “Analysis on Electromagnet Characteristics of Research Reactor CRDM for Thrust Force Improvement,” Transaction of the KNS Autumn Meeting, 2010

[3]Yau-Pin Chyou et al., “Performance Validation on the Prototype of Control Rod Driving Mechanism for the TRR-II Project,” Nuclear Engineering and Design 227 (2004) 195-207.