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Development of Seismic Resistance Position Indicator for the Integral Reactor

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1. Introduction

The present paper is related to position sensing means and more particularly, to a magnetic position sensor using a permanent magnet and a compact arrangement of reed switches in a nuclear power plant. The reed switch position transmitter (RSPT) is used as a position indicator for the control rod in commercial nuclear power plants made by ABB-CE. But this position indicator has some problems when directly adopting it to the integral reactor. Its indicating resolution (1-1/2 inch (38.1mm)) is suitable to measure the position of a control rod which is driven by a motor having steps of 3/4 inch (19.05mm). But the Control Element Drive Mechanism (CEDM) for the integral reactor is designed to raise and lower the control rod in steps of 2mm in order to satisfy the design features of the integral reactor which are the soluble boron free operation and the use of a nuclear heating for the reactor start-up. These design features require a CEDM for the integral reactor to have a fine-step movement for a fine reactivity control. [1] Therefore the resolution of the position indicator for the integral reactor should be achieved to sense the position of the control rod more precisely than that of the RSPT of the ABB-CE. This paper adopts seismic resistance reed switches to the position indicator in order to reduce the damages or impacts during the handling of the position indicator and earthquake. The control rod position indicator having a seismic resistance characteristic for the integral reactor was developed on the basis of the RSPT technology identified through the survey. [2-4]

2. System Description

In this s Fig. 1 shows a general view of the position indicator assembly and the angular position detector assembly on the pressure housing of CEDM. The CEDM consists of four CEA Position Indicators (PIs), a Rotary Step Motor (RSM), an Angular Position Detector (APD), an Extension Shaft Assembly (ESA) connecting CEDM and a Control Element Assembly (CEA). Each of the CEDMs is attached to a CEA by an extension shaft. The CEDM is used to vertically position the CEA and the position indicator is used to sense the position of the CEAs in the reactor core by using the reed switches outside the upper pressure housing. Each CEDM is capable of withdrawing, inserting, holding, or tripping the attached CEA from any point within its stroke in response to an operating signal. The position indicator is designed to have 4 channels in order to satisfy the design requirements of a sufficient independence and redundancy for the indication of a safety related signal. The permanent magnet is connected to the end of the Control Element Assembly (CEA) extension shaft and move together with the CEA inside the upper pressure housing. The reed switch assembly outside the upper pressure housing detects the position of the permanent magnet.

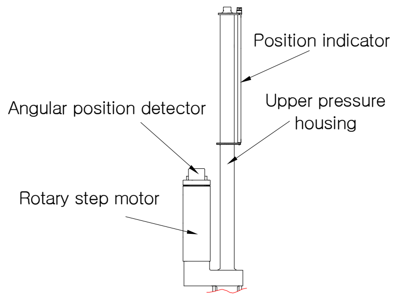

Fig. 1 General view of the CEDM assembly

The position indicator provides an analog voltage signal proportional to the CEA position by using precision resistors and it magnetically actuates the reed switches.

3. Position Indicator

The Two reed switches are provided at each elevation along the voltage divider network. These two switches are connected in series. It is important that the redundant switches (i.e. two switches in series) are included in the design to protect against the possibility of a single switch being stuck in the closed position. At the 20mm level there are two switches which are wired in parallel to the moving direction of the magnet. In order to enhance the resolution of the position indicator the arrangement of the reed switches is designed to be more compact than that of the ABB-CE. Fig. 2 is the position indicator assembly which contains the seismic resistance reed switches.

Fig 2 Photograph of position indicator assembly

If the magnetic attracting force overcomes the resistive force caused by an elasticity of the reed, the reeds come in contact (Pull-In) i.e., the circuit is closed. Once the magnetic field is removed, the reeds are separated again by the effect of the elasticity of the reed (Drop-Out) i.e., the circuit is opened. The seismic resistance reed switch KR5S-1 is selected to embed the position indicator assembly of the integral reactor instead of because it is small size and good seismic resistance character relative to existing reed switch HYR-2001 as shown Fig.3 and Table 1.

Dimensions unit: mm (inch)

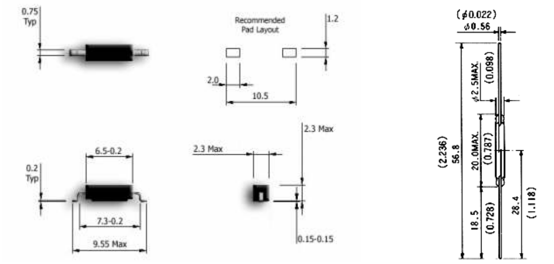

Fig. 3 Dimension of two reed switches

Table 1: Characteristics of two reed switches

	HYR-2001	KR5S-1
Contact Rating Max. [W]	10.0	5.0
Switching Current Max. [A]	0.5	0.35
Switching Voltage Max. [V]	200	100
Breakdown Voltage Min. [V]	300	150
Contact Resistance Max. [mΩ]	100	200
Operating Temperature [^{o}C]	.	-40~140
Seismic Resistance (1/2 Sinewave for 11ms) [g]	.	30
Vibration Resistance (10-2000Hz) [g]	.	20

The magnetic flux density for operating was calculated by using the Pull in Value (AT) and the grouping test was carried out for seismic resistance reed switch KR5S-1 as shown Fig. 4.

Fig 4 Photograph of device for grouping test of KR5S-1

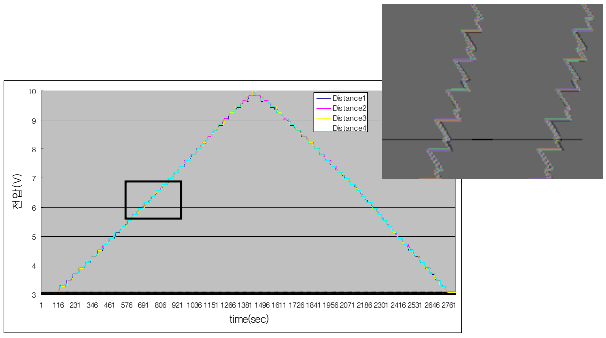

Fig 5 Experimental results

Fig. 4 shows the experimental result of the position indicator manufactured for the performance test. Experimental results of the 4 channels of the position indicator were achieved simultaneously when the magnet was moving up and down in the upper pressure housing. The output signal voltage was in good agreement with the calculation data.

4. Conclusion

Simulation In the design of a small and medium reactor, it is necessary to develop a CEDM with a seismic resistance characteristic as well as a fine-step movement capability for a fine reactivity control. Thus, it is also necessary to develop a position indicator with a high resolution as well as a high reliability for a fine reactivity control. The performance test of a position indicator with a compact arrangement of the seismic resistance reed switches for a high resolution was successfully carried out. The results of this study have shown that a position indicator including seismic resistance reed switches and a compact arrangement can be applied effectively to the integral reactor CEDM after the environmental tests.

REFERENCES

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