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Rotation Impact of Reed Switch

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1. Introduction

A CRDM (Control Rod Drive Mechanism) is an electromagnetic device which drives a control rod assembly linearly to regulate the reactivity of a nuclear core [1]. A RPIS (Rod Position Indication System) is used as a position indicator of a control rod assembly for a CRDM of a nuclear reactor, SMART. This uses the reed switches, as shown in Fig. 1 activated by the magnetic force from a permanent magnet, and the resultant system electrical resistance of the RPIS is converted to the position of the control rod assembly. A highly accurate RPIS for SMART is required because the reactivity of a nuclear core for a small modular reactor is more sensitive than the commercial ones [2].

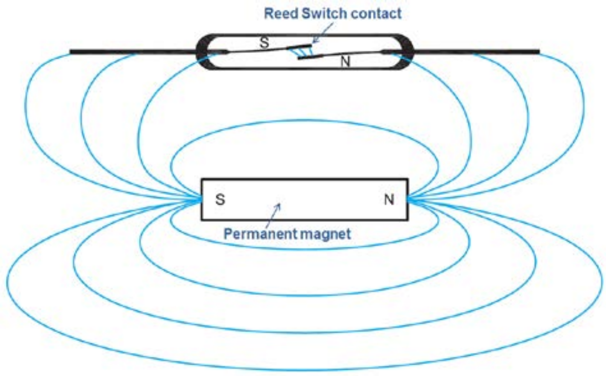


Fig. 1. Reed switch and permanent magnet [3]

In general, measuring accuracy of each reed switch is checked on a test coil system before the RPIS production process. A test coil system consists of a core and coil instead of permanent magnet as shown in Fig. 2.

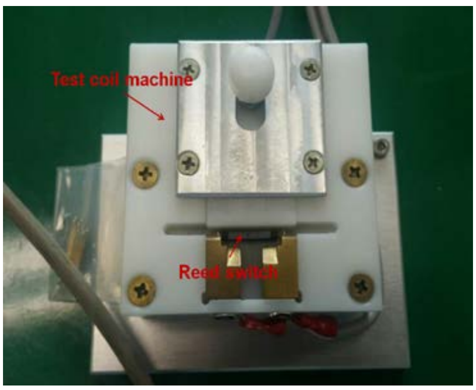


Fig. 2. Test coil system

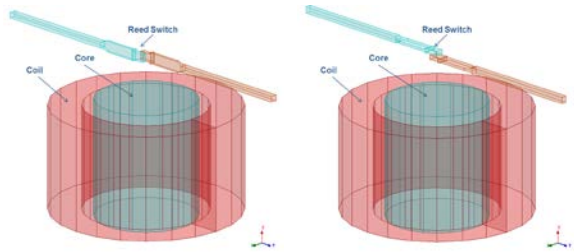
Reed switch is convenient to measure operate characteristics using the units of ampere-turns. Reed switch is easy to make the measurement of its closure, release and contact resistance using a coil with a given geometry, wire size and number of turns [3].

However, it is difficult to align the reeds contact direction in a reed switch on a test coil system during the accuracy check because the reeds are surrounded by a protection tube which is translucent or opaque for some reed switches. Thus, the assessment of the effect of reeds contact direction of the reed switches for a CRDM RPIS is required in order to confirm the accuracy check process and result.

When a reed switch turns axially on a test coil system, the distance from the magnet to each reed and the sectional area exposed to the magnetic field vary. It may have an effect to form attraction between reeds and the sensitivity may change. The effect should be checked. Therefore, in this study, magnetic analysis was performed using ANSYS Maxwell which is the electromagnetic FE-analysis commercial program.

2. Magnetic Analysis

3D analysis model is composed of reed switch, coil, and core to simulate the test coil system. The reeds are positioned in a vertical or horizontal direction as shown in Fig. 3.



(a) Vertically positioned (b) Horizontally positioned
Fig. 3. Analysis model of the reeds and test coil system

Magnetic force from a permanent magnet is modeled by using the electric values of the ampere-turns and the current. Following formula shows that the magnetic flux density (B) is associated with the turns (N) and the current (I) [4].

$$B = (0.4\pi \cdot N \cdot I) / \text{Coil length} \qquad (1)$$

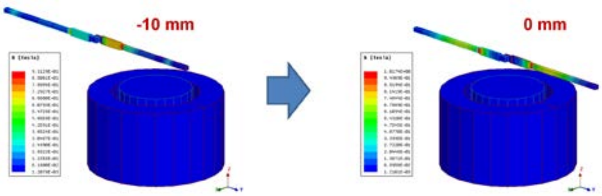
Table I shows input properties of the test coil system for the magnetic analysis. The each value means dimensions for cylinder type core of inner part and through cylinder type coil of outer part. It is assumed that a reed switch moves 60 mm from left to right and a test coil system is stationary while the positioning direction is fixed.

Table I. Analysis input

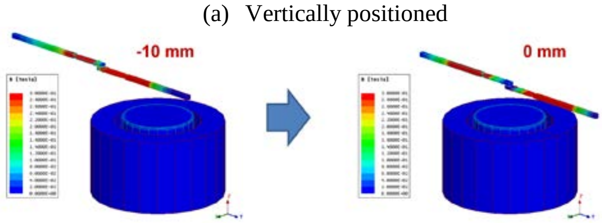
Coil (Copper)	Inner Diameter	5.53 mm
	Outer Diameter	9.49 mm
	Height	8.48 mm
Core (Iron)	Diameter	4.53 mm
	Height	10.65 mm
Electric properties	Ampere	8.6 mA
	Turns	5,000 turns
	Magnetomotive force	43 A·T
Reed Switch(Alloy 52) moving distance		60 mm (-30 ~ +30)

3. Magnetic Analysis results

Fig. 4 shows the electromagnetic analysis results according to the reed switches movement from -10 mm to 0 mm for the vertically-positioned or horizontally-positioned reeds. It is proved by the experiment that the reed switches are close at -10 mm from the test coil system center and open at the test coil system center.



(a) Vertically positioned

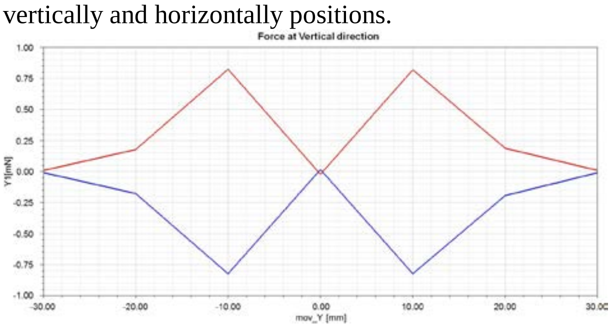


(b) Horizontally positioned

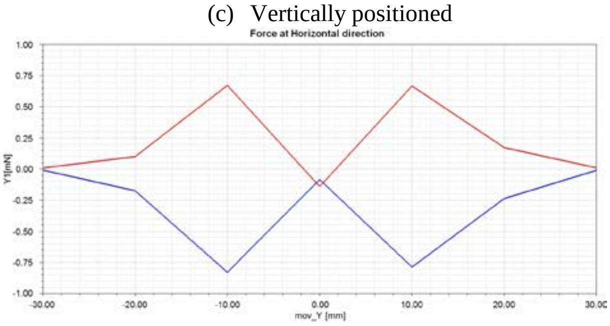
Fig. 4. Magnetic flux density at each direction

The attraction forces between the reeds according to relative position of the reeds and the core center are shown in Fig. 5. If the attraction is greater than 0.6 mN, the reed switches are close as proved by the experiment with the test coil system at -10 mm center deviation. On the other hand, if the attraction is smaller than a threshold level, the reed switches are open.

However, the analysis results for the differently-positioned reeds look similar. Numerical calculation results of attraction have 9.3% difference between vertically and horizontally positions.



(c) Vertically positioned



(d) Horizontally positioned

Fig. 5. Attraction between reeds

4. Conclusions

In this study, the effect of positioning direction of the reeds in a reed switch for the CRDM RPIS has been studied using the electromagnetic FE analysis. It is found that the positioning direction of the reeds slightly but not significantly affects the formation of attraction. Analysis results will be used as the basis on estimated accuracy of full RPIS system.

5. Acknowledgement

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