Loads on the Latch Tips of the Magnetic Jack Type CEDM

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1. Introduction

The latches of a magnetic jack type CEDM (Control Element Drive Mechanism) operate with frequent impact loads from a drive shaft holding a CEA (Control Element Assembly). The impact loads cause degradations of the latches which mainly determine the life duration of the CEDM. It is very hard to inspect the latches for they are located inside the pressure boundary of a reactor system. Even worse is that we have to cut the pressure housing of the CEDM to replace its degraded latches. Since the newly designed NPP (Nuclear Power Plant) has been required to be operated during the 60-year life time without significant replacements of its subcomponents, the repairs or the replacements for the CEDM shall be minimized. Especially the requirements also refer the load following operation of the new NPP, and so the loading conditions for the latches are more severe than those for old ones. With this aspect, because of the requirement of load following operation for the new NPP causing the more severe loading conditions on the latches than those for old ones, the optimized latch design base on the more precise structural integrity analysis shall be needed. In this paper, the loading conditions and the progress of degradation of the latches during the normal operation are discussed.

2. Magnetic Jack Type CEDM and Latches

The first figure, Fig. 1, shows the magnetic jack type CEDM and its motor assembly with the upper and lower latches. There are four electric magnet coil units; each latch set has two coil units one for latching and the other for lift up.

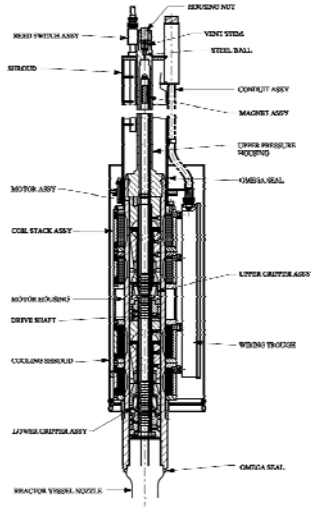

Fig. 1. Magnetic jack type CEDM

Fig. 2 (a) and (b) show the opened and closed conditions of a set of latches. The closed latches are grasping the CEA drive shaft and the loads from the CEA drive shaft, such as the dead weight load and the drop impact load, are applied to the latches. In Fig. 2(c), the red lines are the contact lines between the latches and the CEA drive shaft that the loads are imposed on.

Fig.3 shows the latch tips before and after the endurance test conducted for KNGR[1]. The latch tip remarkably degraded after 220,000ft operation.

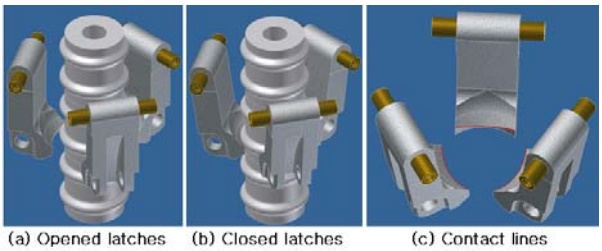

Fig. 2. Opened and closed latches around the drive shaft, and contact lines on the latches

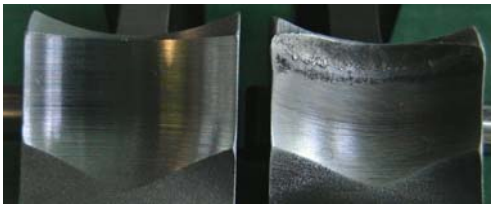

Fig. 3. Degradation of a latch tip

During the normal operation, the CEA is withdrawn from or inserted into the core by series of on and off the electric magnet coil units. Fig. 4 and Fig. 5 are the graphical description of the CEA withdrawal and insertion sequences where the latch on the left side of the CEA shaft depicts the set of upper latches and the other one the lower set, and the green, the red, and the white arrows are for the latch motion, the loading point, and the CEA shaft motion, respectively.

2. Loads on Latch Tips

Static and impact loads are imposed on the latch tips during the withdrawal and the insertion of a CEA. Table 1 and 2 are summaries of the sequences and the loads on the latch tips. The dead weight of a CEA is a static load, and the lift up load is also from the weight but it is bigger than it because of the acceleration of lifting motion. The fallings of the CEA during the sequences result in drop impact loads on the latch tips. The case of longer drop distance results in bigger impact load. The most severe case is of 14/32in. drop during the insertion sequence. These loads are solely

from the weight of CEA, but there are also other impact loads from the electric magnet forces such as the latching impact loads and the lifting impact load. The electric magnet coil units were designed to lift up the whole weight of a CEA and to hold on it resisting the drop impact loads with good reliability. Therefore the electric magnet force may exert none negligible impact loads on the latch tips and the CEA drive shaft.

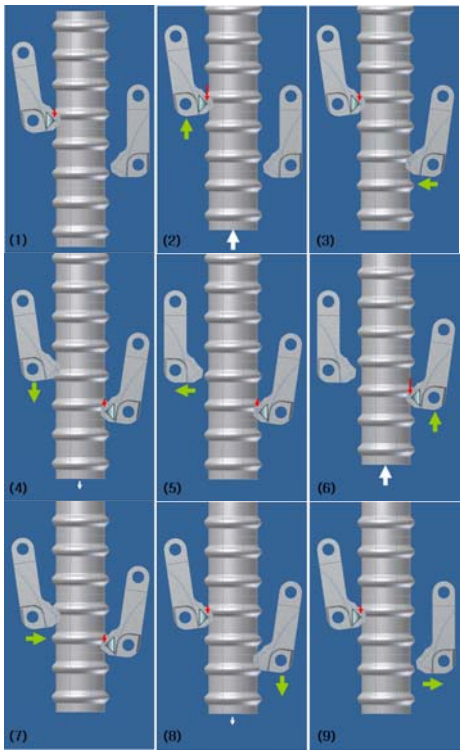

Fig. 4. CEA withdrawal sequence

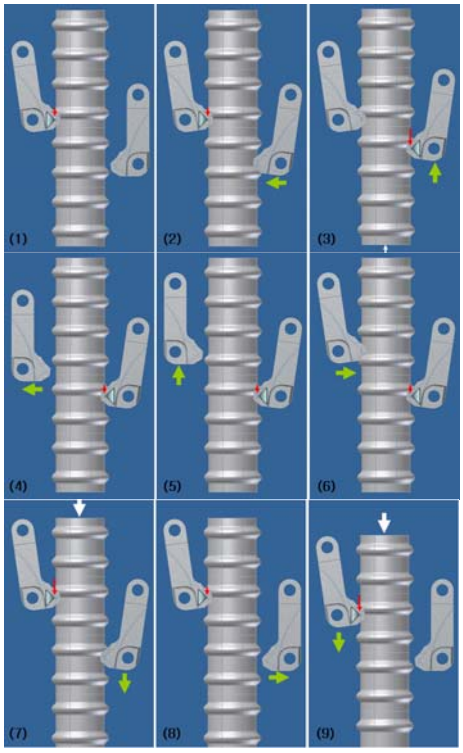

Fig. 5. CEA insertion sequence

Table 1: CEA withdrawal sequence and loads on the latch tips

step	Latch	Latch Coil	Lift Coil	CEA drive shaft	Load on latch
1	Upper	on	off	Stationary	Static load
	Lower	off	off		-
2	Upper	on	on	Up 14/32in.	Lift up load
	Lower	off	off		-
3	Upper	on	on	Stationary	Static load
	Lower	on	off		Latching impact
4	Upper	on	off	Down 1/32in.	-
	Lower	on	off		Drop impact
5	Upper	off	off	Stationary	-
	Lower	on	off		Static load
6	Upper	off	off	Up 12/32in.	-
	Lower	on	on		Lift up load
7	Upper	on	off	Stationary	Latching impact
	Lower	on	on		Static load
8	Upper	on	off	Down 1/32in.	Drop impact
	Lower	on	off		-
9	Upper	on	off	Stationary	Static load
	Lower	off	off		-

Table 2: CEA insertion sequence and loads on the latch tips

step	Latch	Latch Coil	Lift Coil	CEA drive shaft	Load on latch
1	Upper	on	off	Stationary	Static load
	Lower	off	off		-
2	Upper	on	off	Stationary	Static load
	Lower	on	off		Latching impact
3	Upper	on	off	Up 1/32	-
	Lower	on	on		Lifting impact
4	Upper	off	off	Stationary	-
	Lower	on	on		Static load
5	Upper	off	on	Stationary	-
	Lower	on	on		Static load
6	Upper	on	on	Stationary	Latching impact
	Lower	on	on		Static load
7	Upper	on	on	Down 11/32in.	Drop impact
	Lower	on	off		-
8	Upper	on	on	Stationary	Static load
	Lower	off	off		-
9	Upper	on	off	Down 14/32in.	Drop impact
	Lower	off	off		-

3. Concluding Remarks

Analyses considering the loads from the CEA weight have been reported in a couple of articles, but the studies considering the loads from the electric magnet forces are rare although they can be more significant ones. Classifications and estimations of the loads on the latch and the CEA drive shaft shall be conducted carefully before the structural analysis and the optimization.

ACKNOWLEDGMENTS

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REFERENCES

[1] H. G. Jun, et al., Analysis of CEDM Test Results (II), KAERI Report, KAERI/TR-2112, 2002.