Moving Carriage Remedy of the FAMeCT for Fuel Assembly Performance Test

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1. Introduction

The purpose of this work is to re-design the upper carriage of the fuel assembly mechanical characterization tester for axial stiffness test of a fuel assembly. As the established test facility, the upper carriage of it designed with the two guide rods type for maintain the rigidity under the axial loads and the bending moments.

The axial stiffness test is to measure the fuel assembly axial load and deflection, and is to determine the strain distributions in the guide tubes under the axial load and also the axial stiffness characteristics of the fuel assembly [1].

As the authorized test method, the axial stiffness test is executed by compressed load on the top end piece, at that time the axial displacements are measured by many setup linear displacements as the grid and the structural components positions. The axial load and the momentum by preload for beginning of life hot boundary condition make to excess deflection in the above two guide rods. Due to these excess deflections, the distorted test data obtained. Therefore, there are need to modify the upper carriage design.

The re-designed system will be introduced the linear guide rail. In point of design view, the soundness and the integrity of it will be verified.

2. Fuel assembly axial stiffness test

The axial stiffness test of a fuel assembly was executed using FAMeCT as shown in Fig. 1.

The static displacements were applied by screw jack at the hold-down plate position [2, 3]. The maximum axial load and the increment for KSNP fuel assembly were 35 kN and 1 kN, respectively.

At the every grid and the structural components positions, two linear transducers were mounted for measuring. All sensors for measurement were calibrated at the national calibration laboratory at every other year cycle.

The number of 28 linear transducers and 109 uni-directional strain gages were measured for one step. If there were occurred the strain beyond elastic range or the lateral deflection at the 6^{th} grid position happened 5 mm, the test interrupted.

3. Moving carriage design

3.1 Previous design

The moving carriage of the original design was designed two guide rods and ball bush system. The outside diameter and the length of them were 30 mm, 1360 mm, respectively.

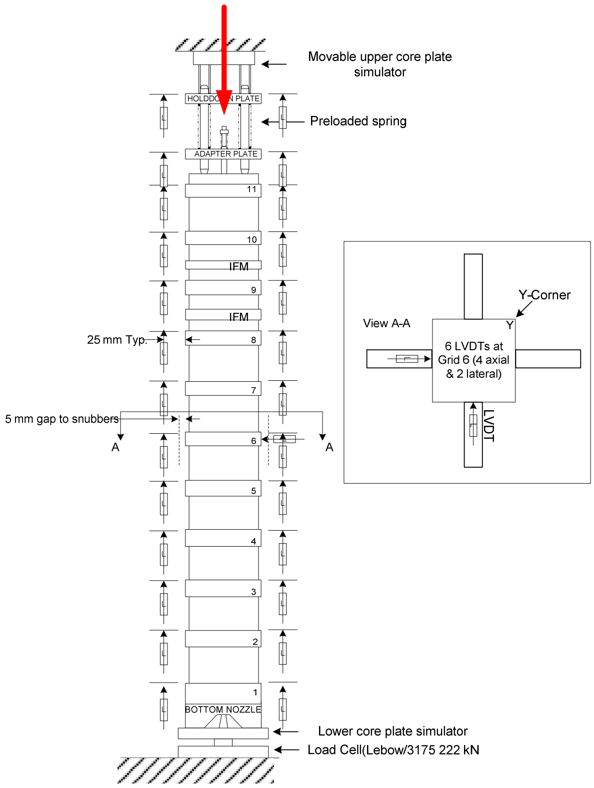

Fig.1 Schematic drawing for the axial stiffness test using FAMeCT.

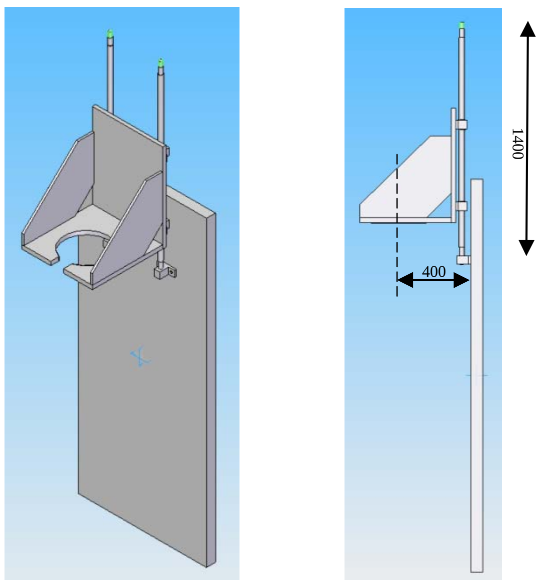

Fig.2 Schematic drawing of the initial designed upper carriage for the FAMeCT.

The schematic drawing of the previous design was shown in Fig. 2. The maximum bending moment at the center point of the guide rod for bending moment at both ends simply supported boundary condition [4] was calculated eq. (1).

$$y = 0.0642\frac{M_0 l^2}{EI} \qquad (1)$$

The maximum deflection at the near center of the guide rod using eq. (1) was about 74.2 mm. Of course, this value was computed much conservatively. Therefore, the axial stiffness test could not be executed up to 35000 N axial loads.

The obtained test data were distorted due to the excessive deflection of the guide rods. So, it was found that the rigidity of the moving carriage was very important for the axial stiffness test.

3.2 Modified design

The new design concept was adopted for the upper moving carriage. The maximum applied bending moment was 20 kN·m, and the safety factor of the LM guide was 1.5.

The LM guide model was selected by above information, which was HSR 45HA. The basic specified load (C_0) of that was 127 kN·m.

The horizontal load components of the upper carriage were calculated as follows. The equilibrium state diagram was shown in Fig. 3.

$$P_1 = -F_{load1}\frac{l_2}{2\times l_1} + F_{load2}\frac{l_3}{2\times l_1} \qquad (2\text{-}1)$$

$$P_{1T} = \frac{F_{load2}}{4} + F_{load2}\frac{l_3}{2\times l_1} \qquad (2\text{-}2)$$

$$P_{2T} = \frac{F_{load2}}{4} - F_{load2}\frac{l_3}{2\times l_1} \qquad (2\text{-}3)$$

where, F_{load1} is axial load (compression), and F_{load2} is lateral load (normal).

The maximum axial and the lateral load for the axial stiffness test were 50000 N and 4000 N, respectively.

The schematic drawing of the upper carriage was shown in Fig. 3. The computed static loads P_{1T}, P_{2T} using eq. (2) were 15.5 kN, and -13.5 kN, respectively. The specified allowable load (C_0L) of the LM guide for two guide rods for adhesion case as lateral direction was 54.6 kN. This specified load has to be larger than those of the computed values. Therefore, the selected LM guide will be maintained the maximum combined load. Finally, the soundness of the upper carriage was evaluated using eq. (3).

$$C_{0L} > P_1 \qquad (3\text{-}1)$$

$$C_{0T} > P_{1T}, P_{2T} \qquad (3\text{-}2)$$

In addition to this, the maximum deflection of the loading carriage was evaluated by finite element method [5]. The tip of the bottom plate of the loading cage was about 0.9 mm under the 5000 kg_f loading case.

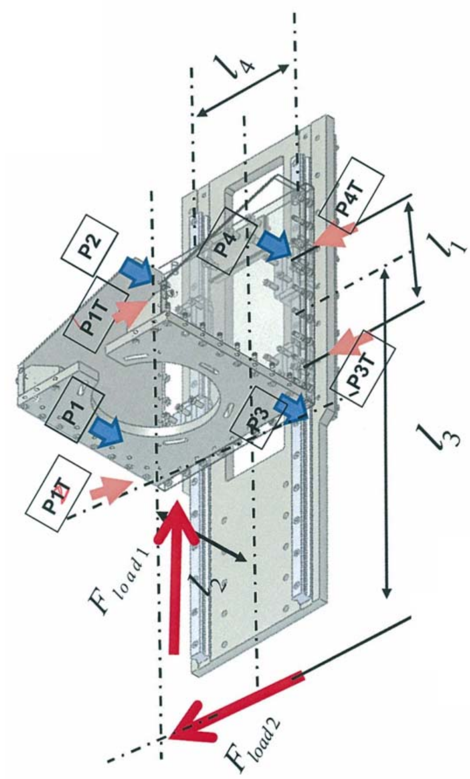

Fig.3 Schematic drawing of the re-designed upper carriage for the FAMeCT.

4. Conclusion

The upper carriage for the axial stiffness test of a fuel assembly was re-designed. The present design was satisfied the basic specified load condition. Also, the displacement of the upper carriage as the maximum moment case was minimized due to robust design.

The accredited axial stiffness test will be executed using this newly equipped test facility.

ACKNOWLEDGEMENTS

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