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Functional Test for the Lateral Stiffness of a PWR Fuel Assembly using FAMeCT

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1. Introduction

This paper deals with the lateral stiffness test of a PWR fuel assembly (FA). The purpose of the fuel assembly lateral stiffness test is to obtain the lateral load vs. FA deflection characteristics of an axially preloaded fuel assembly. The test results will be used to verify the static lateral characteristics of a fuel assembly finite element model for the safety analyses.

2. Test Facility

2.1 Facility Description

The fuel assembly was positioned vertically in the test stand and restrained at the top and bottom nozzles with core plate simulators, which provide an actual support condition in a reactor. Preload of 1678 lbs was exerted on the hold-down plate by a motorized screw jack, which simulated the beginning of life (BOL) hot condition in the reactor core. The schematic configuration is shown in Figure 1.

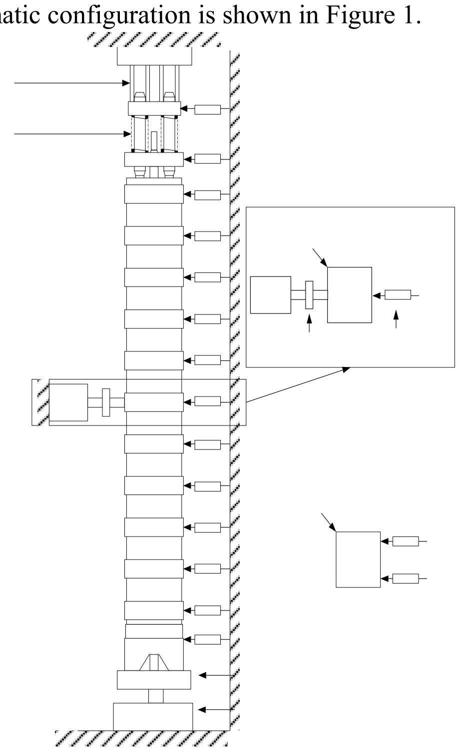

Fig. 1 Schematic diagram of the lateral stiffness test arrangement.

2.2 Mechanical Parts

In FAMeCT (Fuel Assembly Mechanical Tester), there were two screw jacks for a lateral and an axial loading [1]. In order to calibrate the perpendicularity and parallelism with respect to the fuel assembly stand, a plumb bob and square were used. The gage and loader brackets were positioned at every spacer grid and structural part location. In Figure 2, the mechanical parts, sensors and strain gages are described.

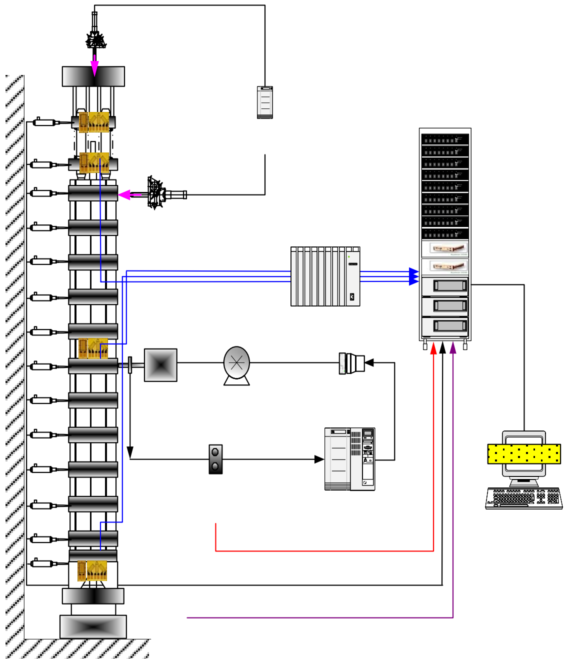

Fig. 2 Schematic diagram for the lateral stiffness test of a fuel assembly.

2.3 Electric Parts

The data collection and analyzing were executed using a commercial software, StrainSmart®. Two linear displacement sensors were placed at every spacer grid and structural parts position for collecting the displacement data under the same condition [2]. In addition to this, a piezoelectric type load cell (Lebow 3175-50K) was mounted on the bottom of the test stand for verifying the preload.

2.4 Strain Gage Parts

The unidirectional and rosette strain gages were mounted on the cylindrical surface of the guide and instrumentation tubes, and the top and bottom nozzles for obtaining the stress under the external loading. Totally 104 gages were used for one test. Some of them had a 0.7mm grid size because the area for a gage mounting was too narrows [3].

3. Functional Test

The preliminary lateral stiffness test was executed using the FAMeCT. This test was accomplished using a skeleton without fuel rods for verifying the performance of it. Figure 3 shows the lateral load vs. deflection at each spacer grid position. The Y-axis value was measured at the sixth grid position by a load cell (PCB 1344-01). The load vs. deflection characteristics was found to be non-linear mainly due to a fuel rod slippage at the grid-to-rod contacts. The fuel assembly did not return to its original position after an unloading due to the frictional forces of the fuel rods against the grids (i.e., springs/dimples). Also, Figure 4 shows the FA deflection shape and magnitude along the FA height measured at the very center grid (presently grid 6). In an actual test for a fuel assembly with rods, the deflection is usually up to 40 mm. However, the present test was carried out until the deflection reached 8 mm. It was regarded acceptable for the functional test which was the primary purpose of the present test.

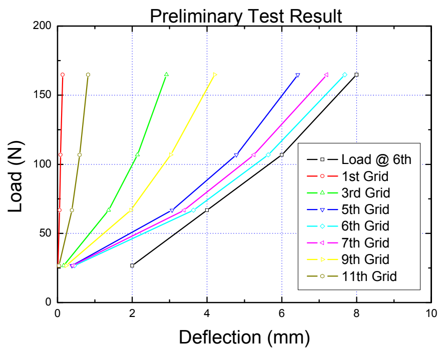

Fig. 3 Lateral load vs. deflection curve from the lateral stiffness test.

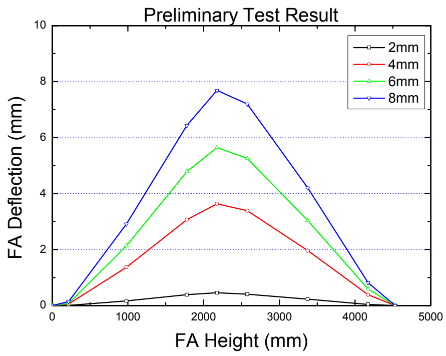

Fig. 4 FA deflection vs. FA height curve from the lateral stiffness test.

The strain gages on the guide/instrumentation tubes and the structural parts were monitored during the loading events. The strain levels of those parts were monitored for each of the test events. The representative strain values are shown in Table 1. These characteristic behaviors of a FA – load vs. grid deflection and FA deflection vs. FA height - showed the representative phenomena of a commercial FA. On the other hand, the typical membrane and bending stresses at the predefined gage positions were calculated using these two strain values.

Table 1 Representative strain values on the guide/instrumentation tubes at the 6 grid position. (Unit : micro strain)

Grid 6	Gage Identification Number					
δ (mm)	68	69	70	71	72	73
2	-5	-13	10	1	29	-38
4	75	-88	8	-45	43	-12
6	-12	-39	37	12	99	-116
8	-22	-50	48	23	135	-166

4. Concluding Remarks

The preliminary test for obtaining the FA characteristics was executed using the established test facility (FAMeCT). The test results revealed a similar behavior when compared with the previously conducted ones by a foreign vendor. Therefore, it was successfully verified that the present tester and methods provide reliable data of the FA behaviour during a lateral bending.

Acknowledgement

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References

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