Development of the Fuel Assembly Mechanical Characterization Tester (FAMeCT)

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1. Introduction

From the mid-eighties, Korea has continuously developed the technology of the light water reactor (LWR) fuels. As of today, all the fuels for the Korean LWRs are designed, fabricated and supplied domestically except for some source materials such as uranium and fuel rod cladding tubes. Most of the previous fuel developments have been done as a form of a joint project with foreign technologies. So, it is one of the apparent tasks to develop a nuclear fuel for ourselves without help from foreign countries. It is regarded certainly possible to achieve it since a lot of experiences have been accumulated so far. In this regard, one of the weakest technologies for the self-development is the fuel assembly test technology.

A fuel assembly test is defined as a test with a full size fuel assembly. It is the very mandatory test to check the reliability and compatibility of a fuel assembly after the completion of a fuel development. Data from the tests are also used for acquiring the license of the fuel use as well as for verifying the fuel assembly (finite element) model for a core structural analysis. During the fuel technology development in Korea, test equipments for the fuel components are mostly developed and procured such as a grid impact tester, a fretting wear tester, a flow-induced vibration (FIV) tester etc. However, the fuel assembly tests relied on the facilities of foreign partners. The fuel technology cannot be owned completely without having the fuel assembly test facilities and technologies.

To this end, Korea Atomic Energy Research Institute started to develop the fuel assembly testers under the Mid- and Long-Term Nuclear R&D program by the Ministry of Science and Technology of Korea. It consists of two facilities: a mechanical tester and a hydraulic tester. The former characterizes the mechanical behaviour of a fuel assembly such as the stiffness, vibration and impact while the latter is used for investigating the hydraulic performance such as the pressure drop, FIV and wear due to the FIV. In this paper, the mechanical tester, named the Fuel Assembly Characterization Tester (abb. *FAMeCT*), is introduced since the construction is completed and performance tests are underway. The hydraulic tester will be completed this year as well. It will also be introduced after a completion.

2. Fuel Assembly Mechanical Characterization Tester

2.1 Fuel Assembly Mechanical Test Items

A brief description of the fuel assembly mechanical tests is as listed below.

- Stiffness test: this test is to basically examine the static response of a fuel assembly while it is loaded laterally as well as axially. As for the data, deflection at each grid location and strains of the guide thimbles are measured during a loading and unloading. The test result is used for verifying the fuel assembly model for the reactor analysis.
- Vibration test: the vibration test is conducted to obtain the vibration behaviour of a fuel assembly. It is a dynamic test to investigate a fundamental vibration characteristic of a fuel assembly. Natural frequencies, model shapes and critical damping ratios are the important outputs. These are used for the fuel assembly accident analysis under the condition of a seismic and LOCA.
- Impact test: the purpose of this test is to find the fuel assembly performance subjected to the lateral and axial impact condition. Possible case of a fuel assembly impact is a banging of a fuel assembly against an adjacent one or a core baffle under the conditions of a seismic and LOCA. Integrity of the fuel assembly is the major concern under such an accident. Impact force, displacement and rebound height are measured.

2.2 Feature and Structure of the FAMeCT

The structure of the FAMeCT is carefully designed to achieve a reliable performance of the required tests. The data obtained from the FAMeCT is extremely important since it is to be used for what has been mentioned previously (verification, analysis and license). The fundamental design requirements of the FAMeCT are: i) it should have a sufficient rigidity to prevent any external causes that can influence the data reliability, ii) the system of the data acquisition and processing including the instrumentation should have sufficient reliability.

Consequently, a reinforced concrete column is constructed for a basic skeleton. Then, other necessary equipments are installed in the column. Major components of the FAMeCT are as follows:

- Concrete column, steel bed and work platform

Overall shape is like an “L” with the dimension of 1000, 1600, 6000 mm^3 (upper part) where the steel beds of 50 mm thickness are attached to the 1000, 2700, 500 mm^3 (lower part) where the fuel assembly sits on. The straightness, the flatness as well as the perpendicularity of the panels are carefully controlled so that the tolerance of

each is less than 0.1 mm. A moving carriage is installed in the top of the upper part for applying a compression onto the fuel assembly to simulate the weight of the upper core plate of a reactor.

A truss structure surrounding the concrete column is constructed for accessing the fuel assembly. It is a three story structure. Fuel storage devices for accommodating up to five fuel assemblies are also prepared on one side of it.

- Upper and lower core plate simulators

For simulating the loaded condition of a fuel assembly in the reactor, upper and lower core plate simulators are fabricated that fit the upper and the lower end pieces of a Korea Standard Nuclear Power Plant fuel, respectively. Especially, the lower core plate simulator is attached to a loadcell for measuring the compressive and impact forces. In turn, the loadcell is on a rotary table, by which the fuel assembly can be rotated by a specified angle.

- Shaker and loader

For the vibration test, the fuel assembly should be vibrated by an external source, so an electromagnetic shaker is procured. It is installed in a bracket that is attached to the steel bed. The frequency range of the shaker is up to 9 kHz so that all the natural frequencies of a fuel assembly can be covered. By a special controller, sine sweep and dwell tests are available.

For the stiffness test, a loader that uses a screw jack is installed on the same bracket for the shaker. The displacement by the loader is remote controllable and a continuous characteristic curve can be generated. Since the location of the bracket is adjustable along the fuel axis, various responses of the fuel assembly can be obtained.

- Linear gauges, loadcells and gauge brackets

The basic data from the fuel assembly mechanical tests are the load and displacement. More than 60 linear gauges and 10 loadcells with various measuring ranges are procured. These are installed to specially designed gauge brackets that are attached to a steel bed.

The number of strain gauges for the test is more than 100. Those are pasted on every location of the guide thimbles as well as the upper/lower end pieces. Therefore, three junction boxes (each has 40 strain gauge terminals) are fabricated and installed on each story of the work platform for minimizing the signal noises caused by the length of the signal lines.

- Data acquisition and processing system (DAS)

Totally nine data scanners (7 static and 2 dynamic) are procured to collect and process all the data obtained during the tests. A vendor supplied software StrainSmart [1] is used for the data analysis. For the vibration analysis, IDEAS T-DAS [2] is also used.

- Other facilities

Two cranes (capacity of 3 ton and 1 ton) are installed for handling the fuel assembly. A fuel assembly handling tool is procured to grip the fuel assembly. A fuel assembly container is fabricated to transport the test fuel assembly. All the necessary appliances including the tools and fixtures are prepared including a self-propelled scissors lift.

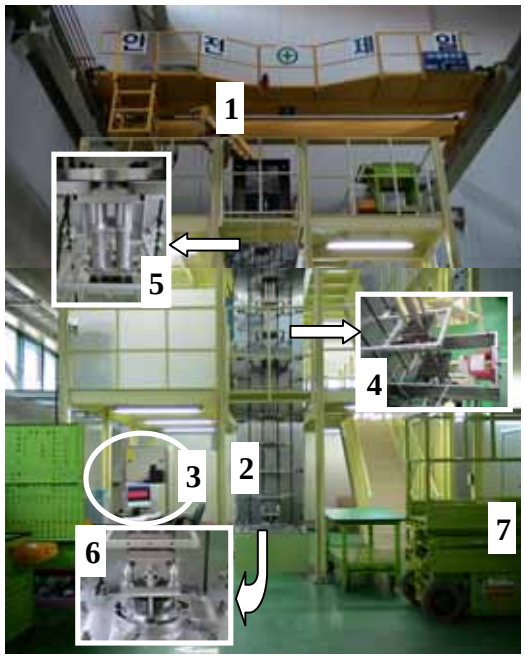

Fig. 1 View of the FAMeCT; 1: Cranes 2: Concrete column and Steel bed 3: DAS and PC 4: Shaker (or Loader) and Brackets 5: UCP Simulator 6: LCP Simulator and Rotary Table 7: Self-propelled scissors lift.

3. Concluding Remarks and Future Plan

The fuel assembly mechanical test facility is now ready to use. Since the fuel assembly hydraulic tester will also be completed during this year, it is certain that the level of LWR fuel development technology in Korea is to be further upgraded. These facilities will be used for the performance verification of a fuel which will be developed in Korea without any assistance from foreign countries.

4. Acknowledgement

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REFERENCES

[1] Vishay Measurements Group Inc., 2001, “StrainSmart® User's Manual,” CT, USA.

[2] Structural Dynamics Research Corporation, 2002, "I-DEAS Master Series 9.0," OH, USA.