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A Study on Structural Strength of Irradiated Spacer Grid for PWR Fuel

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1. Introduction

The mechanical properties of a fuel assembly structure, which is a long and flexible structure, are of great importance for fuel operation reliability in the extended fuel burnup and duration of the fuel life. A fuel assembly consists of an array of fuel rods, spacer grids, guide thimbles, instrumentation tubes, and top and bottom nozzles. In PWR (Pressurized light Water Reactor) fuel assemblies, the spacer grids support the fuel rods by the friction forces between the fuel rods and springs/dimples. Under irradiation, the spacer grids supporting the fuel rods absorb vibration impacts due to the reactor coolant flow, and also bear static and dynamic loads during operation inside the nuclear reactor and transportation for spent fuel storage [1-3]. Thus, it is important to understand the characteristics of deformation behavior and the change in structural strength of an irradiated spacer grid [4,5].

In the present study, the static compression test of a spacer grid was conducted to investigate the structural strength of the irradiated spacer grid in a hot cell at IMEF (Irradiated Materials Examination Facility) of KAERI.

2. Experimental

The irradiated fuel assembly after a 3-cycle operation in the PWR was transferred from the nuclear power plant to PIEF (Post Irradiation Examination Facility) of KAERI for an assessment of the structural integrity.

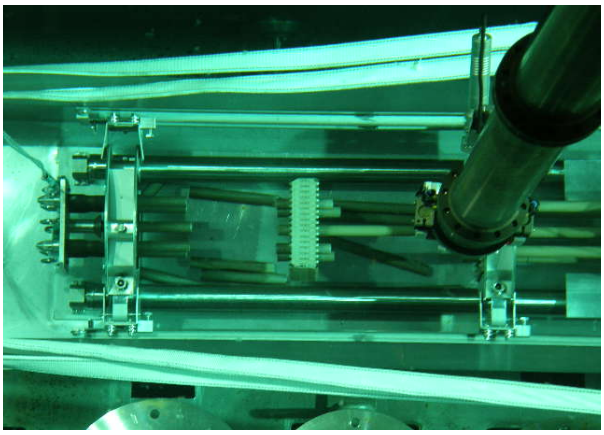

Fig. 1. Cutting machine used to cut the guide thimbles and instrumentation tubes simultaneously at both sides of a grid using abrasive wheels.

For the preparation of a spacer grid without any damage, the fuel assembly was dismantled and cut by the underwater cutting machine at PIEF of KAERI, as shown in Fig. 1, and the irradiated spacer grid was obtained for the compression test in a hot cell, as shown in Fig. 2.

As the grid of a nuclear fuel bundle is irradiated by neutrons in the core of a reactor, it can be a highly radioactive substance during operation. Therefore, the examination and measurement apparatus must be designed to control it remotely from the operation area of the hot cell facility.

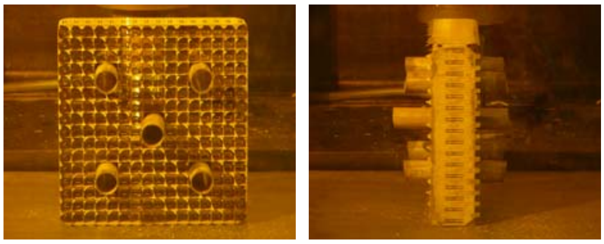

Fig. 2. Irradiated spacer grid obtained for the compression test in a hot cell.

Fig. 3. The compression test device composed of lower and upper plates with a spherical bearing.

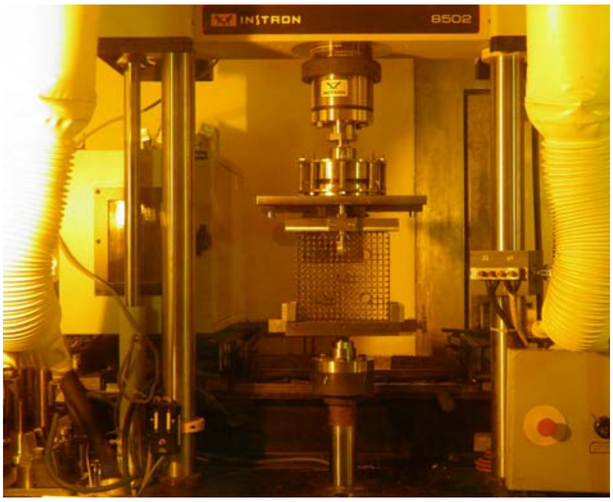

Fig. 4. Experimental set-up for the measurement of the compression strength of the spacer grid in a hot cell.

As shown in Fig. 3, the compression test device is composed of lower and upper plates with a spherical bearing. The spherically seated head is designed to ensure a uniform seating by tilting freely as the upper plate contacts with the top of the spacer grid.

Fig. 4 shows the experimental set-up for the compression test with an irradiated grid in a M5b hot cell of IMEF. Experiments were carried out using a universal testing machine (Instron 8502) with a 50 kN load cell at room temperature. The initial load was -0.5 kN, and the constant velocity of the crosshead used was 0.5 mm/min. The data acquisition system associated with the control system of the universal testing machine records the load and the displacement during the compression of a spacer grid.

3. Results

Fig. 5 compares the load-deflection curves of the unirradiated and irradiated spacer grids obtained during the static compression tests.

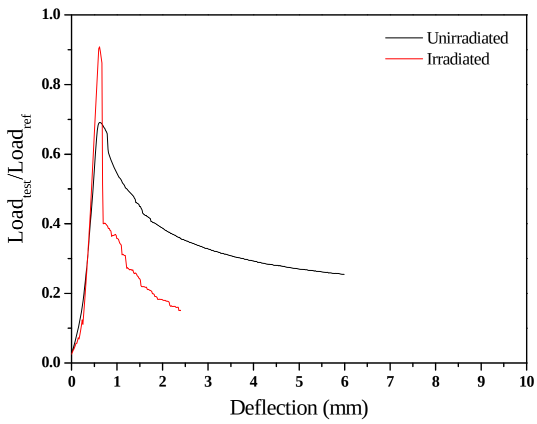

Fig. 5. Load-deflection curves obtained from the compression test of the spacer grid in a hot cell.

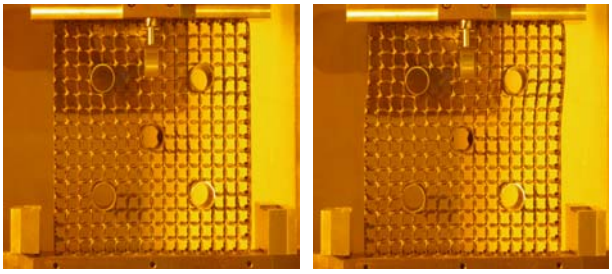

Fig. 6. Deformation behavior of the irradiated spacer grid during the compression test.

These curves show that the compression strength of the spacer grid increased and the ductility decreased due to the irradiation effect.

Fig. 6 shows the deformation behavior of the irradiated spacer grid during the compression test. It can be seen that the spacer grid presents a higher deformation cell line and the region is close to the guide tube in the middle of the spacer grid.

4. Conclusions

To evaluate the structural strength of an irradiated spacer grid, hot cell tests were carried out at IMEF of KAERI. The fuel assembly was dismantled and the irradiated spacer grid was obtained for the compression test. The apparatus for measuring the compression strength of the irradiated spacer grid was developed and installed successfully in the hot cell. The spacer grid presents a higher deformation cell line and the region is close to the guide tube in the middle of the spacer grid. It was shown that the compression strength of the spacer grid increased and the ductility decreased due to the irradiation effect.

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