Mechanical test of spent fuel at KAERI-PIEF

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Introduction

The PIEF in KAERI has been facilitating a wide range of research on the nuclear fuels irradiated at commercial nuclear power plants to evaluate the fuel integrity through hot cells and pool examination for more than twenty years. The PIEF consists of six hot cells to examine the spent fuel rods and to prepare mechanical test specimens, as well as hot laboratories to investigate the mechanical properties of spent fuel rod cladding and a spacer grid. In this paper, the mechanical tests for spent fuel conducted in the PIEF are introduced.

Mechanical test of irradiated cladding

To predict the behaviour of the fuel rod cladding during storage, particularly in interim dry storage, various types of tests, such as creep, hydride reorientation, fatigue, and compression, have been conducted. Prior to the cladding tests, the spent fuel pellet in the segment of a fuel rod is removed by the mechanical defueling and chemical dissolution. Furthermore, oxide layers on both ends of the cladding, to which the high-pressure fittings are connected, are removed completely to prevent a leakage of the internal pressure (Figure P40).

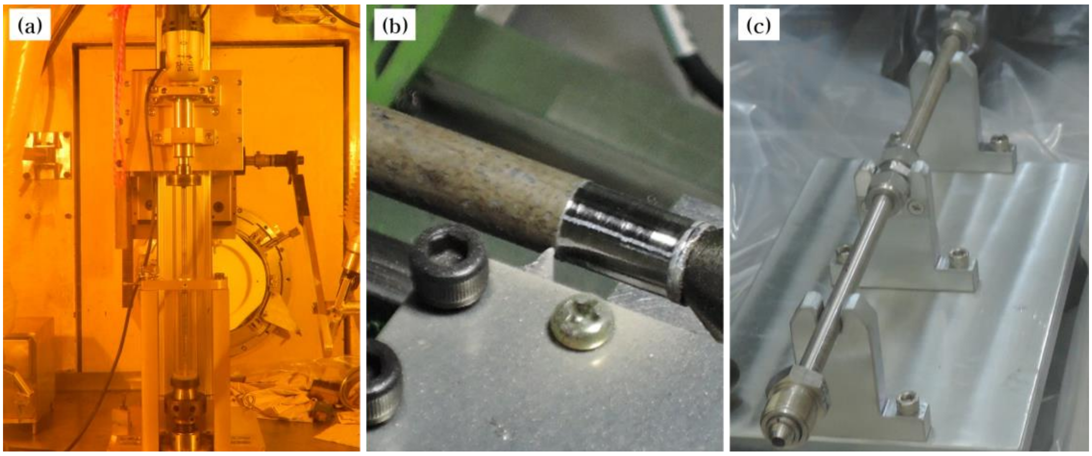

Figure P40: Test specimen preparation: (a) fuel removal, (b) oxide layer removal, (c) test specimen

The creep and hydride reorientation tests are performed with 150-mm-long specimens under internal gas pressurization. In each test, the temperature and hoop stress are set considering the conditions in dry storage. In particular, in the hydride reorientation test, the cooling rate and thermal cycling condition are also considered as major variables. The test equipment and one of the hydride reorientation test results are shown in Figures P41 (a) and P41 (b).

To evaluate the effect of creep and hydride reorientation on the mechanical property of irradiated cladding, a ring compression test is conducted. The test specimens are prepared to 10 mm in length from creep and hydride reorientation test specimens, and the ring specimens are heated to the target temperature and compressed in the radial direction at a rate of 1 mm/min. Figure P41 (c) shows the specimen after the ring compression test.

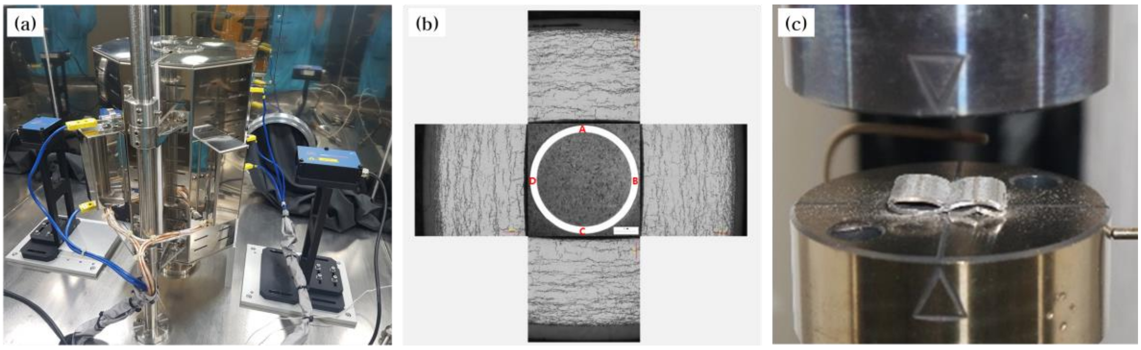

Figure P41: (a) Creep and hydride reorientation system, (b) metallography of irradiated cladding after hydride reorientation, and (c) ring specimen after ring compression test

Mechanical test of irradiated spacer grid

A spacer grid has a critical role in protecting the fuel assembly from the external impact load under severe accident conditions. Thus, it is essential to investigate the structural integrity of an irradiated spacer grid. A crush test, which is accomplished through the pendulum movement of the hammer to impact on the side of the spacer grid, has been performed to produce various buckling characteristic data, such as the impact strength and buckling mode. Figure P42 shows the crush test system and one of the test results.

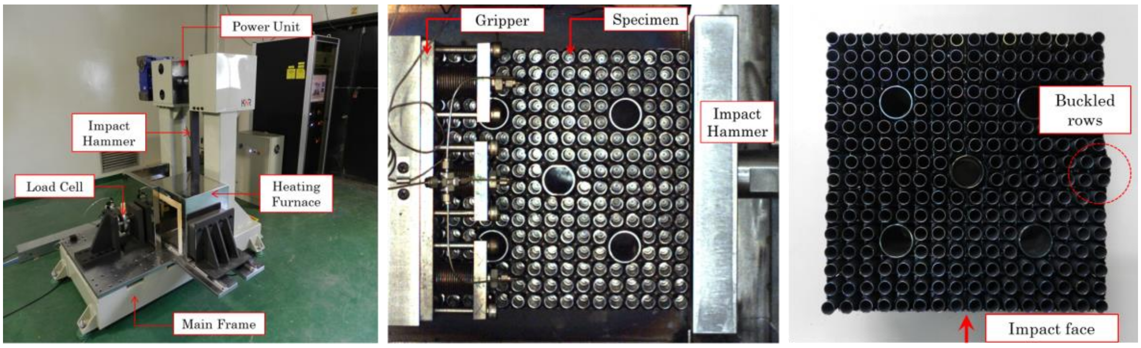

Figure P42. Crush test system for spacer grid and buckling mode shape of mid-spacer grid