International Conference on Management of Spent Fuel from Nuclear Power Reactors: An Integrated Approach to the Back End of the Fuel Cycle

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Hydride effect on cladding behaviour for spent fuel storage and transport conditions

In Spain, the fuel is stored in the spent fuel pools and in on-site interim dry storage facilities when the pool capacity is reached. Additionally, a centralized temporary storage facility to dry store spent fuel assemblies, based in a vault system, is under construction.

Fuel conditions (internal and external pressure, temperature, etc) differs from pool to dry storage. The morphology and distribution of the hydrogen picked-up during in-reactor operation could evolve due to the evolution of these conditions. The dissolution and re-precipitation of the hydrides in the radial direction could affect the mechanical behaviour of the fuel rods as the clad could become brittle. The clad behaviour during spent fuel interim storage and subsequent transport is a key factor to assure the fuel safety functions, taking into account that the transport will be performed after years of storage and cladding ductility will decrease as temperature decreases.

Spanish organizations CSN, ENRESA and ENUSA have carried out research and development programs to characterize the behaviour of spent fuel under transport conditions.

Fresh cladding material has been electrochemically charged at different Hydrogen concentrations from 150 to 2000 ppm. The mechanical and fracture behaviour has been studied using Ring Compression Tests (RCT) to simulate the pinch forces generated in the contact between the cladding and the spacer grid under hypothetical transport accident conditions. The tests have been performed at different strain rates (0.008, 1.7, 17 mm/s and 3000 mm/s) and different temperatures (20, 135 and 300℃) representatives of dry storage and transport conditions. Micro and macro fracture mechanisms have been analysed.

Additionally a finite element model, based on the experimental RCT load vs. displacement curves has been developed to calculate the fracture energy as a function of the hydrogen concentration.

Pre-hydrided samples with homogeneous and circumferential hydrogen distribution, do not present brittle behaviour. Rupture is produced at displacements higher than 3 mm, even for 2000 ppm hydrogen, the lowest temperature (20℃) and the highest strain rates.
For radial hydride reoriented samples brittle fracture are obtained for low displacement values at 20℃ and 135℃.

Country/ int. organization

spain

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