Thermal Behavior of Advanced UO_2 Fuel at High Burnup

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To improve the fuel performance, advanced UO_2 fuels are developed to reduce significantly Pellet-Cladding Interaction and Fission Gas Release to increase high burn-up safety margins on Light Water Reactors. To achieve the expected improvements, doping elements are currently used, to produce large grain viscoplastic UO_2 fuel microstructures. In that scope, AREVA NP is conducting the qualification of a new UO_2 fuel pellet obtained by optimum chromium oxide doping.

To assess the fuel thermal performance, especially the fuel conductivity degradation with increasing burnup and also the kinetics of fission gas release under transient operating conditions, the instrumented REMORA experiment has been developed by the CEA.

One segment base irradiated for five cycles in a French EDF commercial PWR (~ 62 GWj/tM) was consequently re-instrumented with a fuel centreline thermocouple (uncertainty of 9°C at 1000°C) and an advanced pressure sensor. The design of this specific sensor is based on the counter-pressure principle and avoids any drift phenomenon due to nuclear irradiation and so allows very accurate measurement (uncertainty of $\pm$ 0,5 bar at 2σ). This rodlet was then irradiated in the GRIFFONOS rig of the OSIRIS experimental reactor at CEA Saclay. This device, located in the periphery of the core, is designed to perform test under the conditions prevailing in PWR reactor by providing the required neutronic and thermohydraulic conditions (pressure loop ~ 130 bars and coolant temperature ranging of 35 to 240°C). Power variations are carried out by translating the device relatively to the core. Self - powered neutron detectors are positioned in the loop in order to monitor the power the whole time of the irradiation.

The re-irradiation of the REMORA experiment consisted of a stepped ramp to power in order to point out a potential degradation of the fuel thermal conductivity with increasing burnup. During the first part of the irradiation, most of the measurements were performed at low power in order to take into account the irradiation effects on UO_2 thermal conductivity at high burnup in low range of temperature. The second part of the irradiation consisted in power cycling with one steady–state at several powers (290 W/cm and 360 W/cm) to assess both the thermal conductivity at higher temperature (until 1600°C) and the fission gas release kinetic.

This paper summarizes and discusses the main results acquired on this advanced UO_2 fuel.

- The thermal performances indicate that the fuel thermal conductivity is similar to the one of the standard UO_2 fuel type. The thermal conductivity damage under irradiation can be modelling alike.
- The test results show low fission gas release in comparison with UO2 standard fuel fission gas release in this test compared with the standard uranium fuel experimental and only slight pressure increase have been observed during the steady state periods.