BR2 REACTOR: IRRADIATION OF FUELS

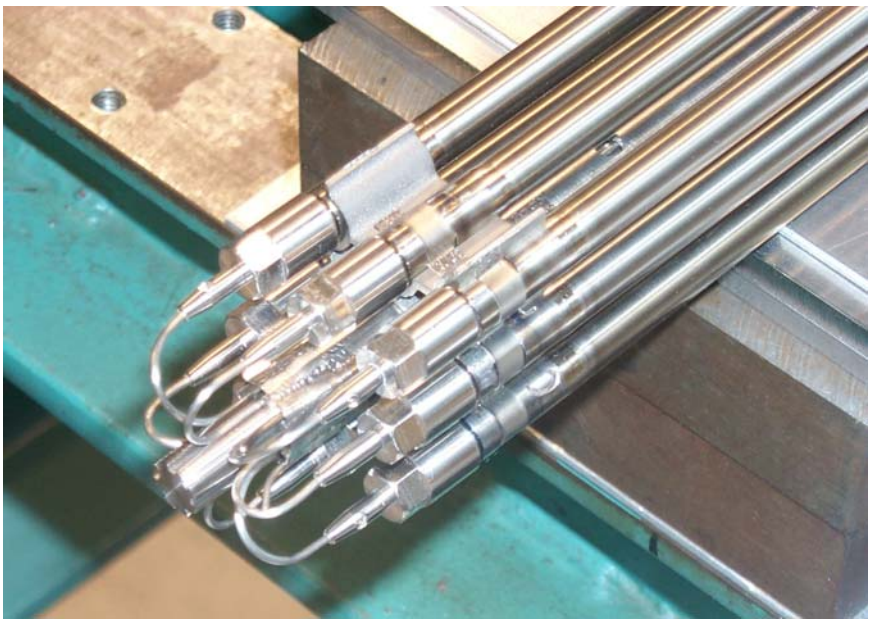
Background

Safe, reliable and economical operation of reactor fuels, both UO_2 and MOX types, requires in-pile testing and qualification up to high target burn-up levels. In-pile testing of advanced fuels for improved performance is also mandatory.

Objectives

- Neutron irradiation of LWR (Light Water Reactor) fuels in the BR2 reactor under relevant operating and monitoring conditions, as specified by the experimenter's requirements.
- Improvement of the on-line measurements on the fuel rods themselves

Principal results

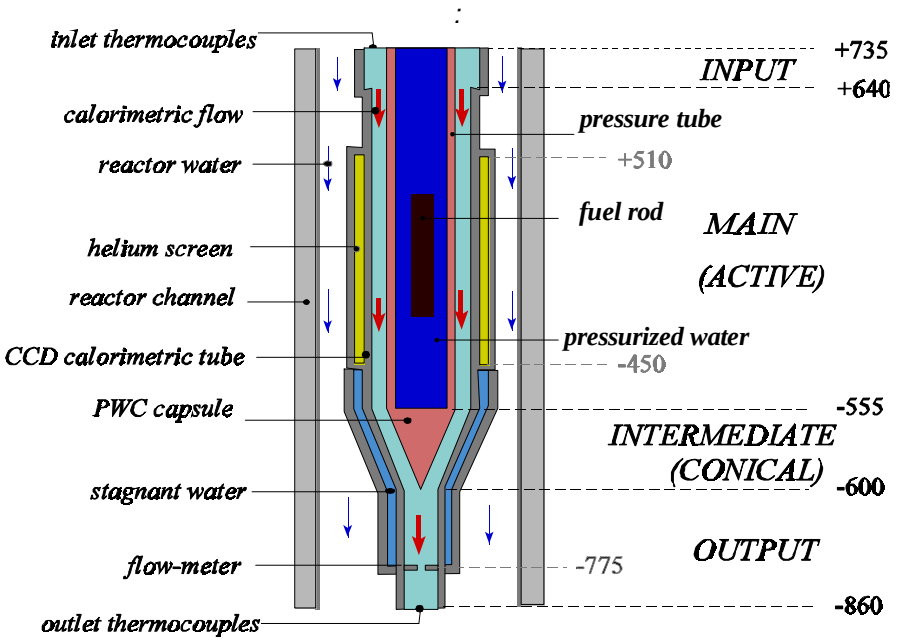


Bottom of the OMICO instrumented fuel bundle. All pins are equipped with a central high temperature thermocouple connected via the lower end plug and a pressure transducer connected via the upper end plug

- In 2004 further development work was done for preparing the long term irradiation of LWR fuel in the high-pressure facility CALLISTO in the BR2 reactor. The irradiation of this experiment was started in November.
  Detail design work for the OMICO (Oxide fuels: MIcrostructure and COmposition Variations)-MIMAS-PV (MIMAS Process Variation) program has continued. A twin bundle consisting of 8 instrumented- and 8 non-instrumented fuel pins is being tested in the high-pressure high-temperature loop CALLISTO under typical PWR-conditions (155 bar, 300°C, controlled PWR water chemistry). The bundle comprises UO_2, $(U,Pu)O_2$ as well as $(Th,Pu)O_2$ pins. Each of the pins in the upper part of the twin bundle is provided with a gas pressure transducer connected via the upper end plug and a high temperature thermocouple type W5/W26 connected via the lower end plug. A total number of 40 instrumentation wires are installed on the pins and in the upstream and downstream section of the fuel bundle. The lower basket containing the 8 non-instrumented pins can be removed for hot-cell examinations and coupled again to the upper basket. The irradiation can then be resumed with both the instrumented and the non-instrumented bundles. The picture shows a detail of the instrumented bundle.

  Special attention has been given to an accurate measurement of the power generated by the pins. Fourteen thermocouples are distributed along the twin-bundle for that purpose. MCNP calculations have been made and qualified by the irradiation in the CALLISTO loop of a mock-up of the experiment. This irradiation also allowed the determination of the heat generated by gammas as well as the heat losses of the in-pile section to the BR2 water. The leak rate via the coupling between non-instrumented and instrumented bundle has been determined in a water test.
  The out-of-pile equipment has been complemented by a system that enables the operators to take water samples even after a possible rupture of some pins. Such a failure can cause a considerable contamination of the cooling water of the CALLISTO loop.

Further details on the experimental program are reported in the chapter "Reactor Safety" of this report.



*Power Ramping - Scheme of the PWC/CCD device (Pressurized Water Capsule/ **C**alibration and **C**ycling **D**evice) with axial reactor coordinates in mm ('0' being the centre of the 76 mm high BR2 core).*

- In 2003 four power ramps have been done on BWR fuel segments in an in-pile pressurized water capsule. After the irradiation of the segments and their removal from the reactor, gamma spectroscopy measurements have been performed. The measured activity of certain isotopes of suitable half-life (e.g. ^{140}Ba, ^{140}La), taking into account the relevant part of the irradiation history, provides data on the time-averaged fission rate during a certain period or on the instantaneous fission rate for a certain reference reactor power. The average linear rod power assessed via this technique is in very good agreement with the values based on the thermal balance as calculated on-line during the execution of the test in the reactor (linear power from gamma spectro/linear power from thermal balance = 99.4 to 105.4%).

Future Developments

It is foreseen to irradiate the OMICO twin fuel bundle for achieving a burn-up of about 25 GWd/tM and 2-5% fission gas release. After the first irradiation cycle the set of non-instrumented rods will be unloaded to study critical fuel performance indicators (cladding corrosion, creep, fuel swelling) as well as to perform an independent experimental control of the power generated in the fuel rods by gamma spectrometry. These measurements will then be repeated after every irradiation period of 5 reactor cycles (21 days each).

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