NUCLEAR FUEL PERFORMANCE AND IRRADIATION DAMAGE OF STRUCTURAL MATERIALS

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Fuel degradation

Efforts are being made by Fuel Engineering Group to understand the mechanisms involved in the fuel degradation subsequent to primary failure. Large local hydriding is believed to be the main cause of such degradation. R&D activity have been carried out aiming the development and validation of analysis models of reaction kinetics of fuel and cladding oxidation and hydriding of LWR fuel rods after primary failure getting coolant into UO2-Zircaloy fuel rod during reactor stationary regime and operational transients. Controlling the degradation process is extremely important to avoid large radioactivity levels in the plant and unscheduled shutdowns for removing the leaking assembly.

Irradiation damage of structural materials

It is a know fact that radiation damage of PWR structures is a time limiting factor on its operation, the study of detrimental radiation effects on materials structures is one of the objects of research at IPEN. The R&D activities are basically performed in two fields:

1) Establishment of an experimental infrastructure, by designing and fabricating the materials irradiation device CIMAT (Materials Irradiation Capsule), with controlled atmosphere and temperature (from 25 to 700^{o}C) allowing for in-pile irradiation and on-line acquisition of parameters of interest. Priority is given to post irradiation evaluation to be performed by means of mechanical methods: creep, hardness, micro hardness, strain-stress, etc., at fluence of 10^{19} nvt, which represents a critical dose for the reactor pressure vessel (RPV) steels. Operational tests of CIMAT have been completed and a modified device is under construction. Another device CIMAT 2 is under completion.

2) Pre-irradiation characterization has been performed on samples of RPV steel AS 508 cl.3, of two origins: one from ELETROMETAL (Brazil AE) and the other from VITKOVICE (Czech AV), in as delivered condition. The samples were studied by means of metalography, TEM, SEM, hardness, internal friction and X-ray diffraction. The samples show martensitic (AE) and bainitic (AV) structures, due mainly to different heat treatments. Rockwell (60 fkg) and Vickers (1 fkg/mm^2) hardness data provide a maximum toughness of 600-630 MPa, which is in good agreement with the suppliers information. This characterization will be repeated after an annealing at 300^{o}C, corresponding to the time internal of irradiation of the samples at 300^{o}C (approx. 300 h), to equalize the thermal state of the material.

Participation in the IAEA BRA/4/052 extension for 2003-2004 development of design, performance and safety criteria for UO2-Gd2O3 fuel for NPP

INB is obtaining the technology to fabricate UO2-Gd2O3 fuel pellets with the help of CTMSP and UEM through the AIEA TC Project BRA/4/052. In this project extension, CTMSP and the Nuclear Engineering Centre of IPEN have been gathering further data including neutronic tests, performance calculations and measurements of fuel thermophysical properties. The final result is to provide INB with the technical data necessary for the development of design, safety and performance criteria for the use of these UO2-Gd2O3 fuel elements in the Angra I and Angra II power stations.

Irradiation performance of U-Mo fuels

The goal of this research is to study the irradiation performance of the U-Mo alloy dispersion fuels and generate the technical specification for fabrication of U-Mo/Al dispersion fuel to be irradiated in the IEA-R1 Reactor. By the end of 2004 was generated the technical specifications for fabrication of miniplates of U-Mo/Al fuel with uranium density of 5 gU/cm^3 to be irradiated in IEA-R1 Reactor.