EDF R&D
MATERIALS AND MECHANICS OF COMPONENTS
DEPARTMENT

COLLABORATION

MASTER PROPOSAL
6 MONTHES

CHARACTERIZATION AND MODELING OF MECHANICAL EVOLUTION OF ZIRCONIUM ALLOYS DURING HIGH TEMPERATURE TRANSIENT

In the framework of accidental conditions, LOCA (Loss of coolant accident) and RIA (Reactivity Insertion Accident), EDF is continuously improving its capacity to model the behaviour of fuel rods.

LOCA is an hypothetical accident which imposes stringent restrictions on the core management. As such it is very important to model it to be able to estimate these restrictions with the less uncertainty. A LOCA can be roughly divided into 3 stages. During the first stages, temperature increases very fast (10 to 100°C/s) because loss of coolant and residual power of the core. Gas release and pellet dilatation induce a ballooning of the rod. It is followed by a more or less constant temperature stage during which the cladding oxidizes. At the end of the accident reflooding of the core occurs and the rod is quenched.. The temperature range of a LOCA is typically the range of phase change occurring in zirconium alloys. Constitutive laws coupling the metallurgical evolution and the mechanical behaviour have been developed to model the ballooning phase of LOCA. They are phenomenological and do not rely on the physical understanding of the microstructure and deformation mechanisms of zirconium alloys. RIA is also an hypothetical accident: a control rod is abruptly suppressed from the core producing an intense energy pulse. It generates an interaction between the pellet and the cladding, a departure of nucleate boiling and a ballooning of the rod.

It is a long-term objective to model LOCA and RIA (Reactivity Insertion Accident) using one unique constitutive law for one alloy.

The objective of the Master is to reproduce the anisotropic mechanical response of the material using an homogenization approach. In order to achieve this task a self-consistent approach will be used with a single crystal constitutive law. Nevertheless, several modelling are available in this context and must be compared by the student during this work. The implementation of these different models are available in different software (Code_aster, VPSC, MAP). The experimental data, required as a reference for this work, will come from the work of different PhD thesis supervised at EDF.

Work will done in collaboration with Westinghouse and Manchester University. The trainee will be located at EDF-Les Renardières. The work is financially supported by EDF.

This training period could give access to a PhD contract which is planned in the same framework.

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