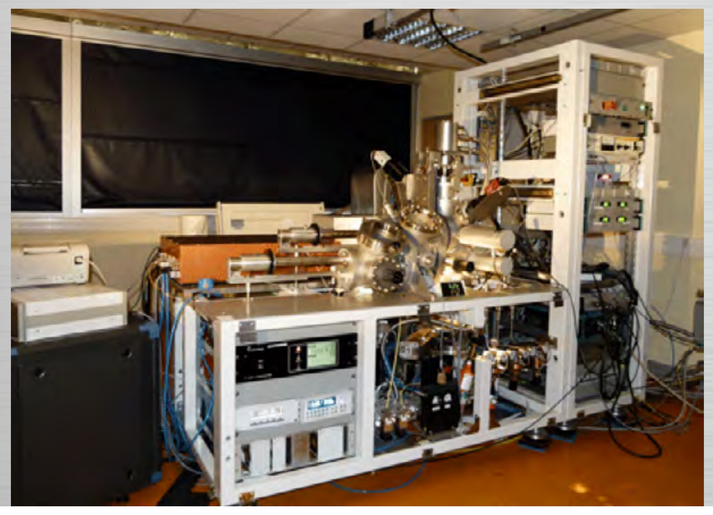
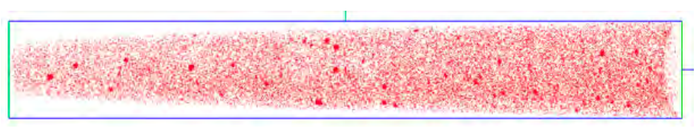
RPV INTEGRITY

Reactor Pressure Vessel Integrity

The vessel lifetime is a decisive topic for long term operation of nuclear power plants. One of the key issues concerning RPV Integrity project is the radiation effect on the Reactor Pressure Vessel (RPV) steel in the core zones. The vessel steel becomes more brittle in the Reactor Pressure Vessel core region where radiation is high. Margins have been included at design and manufacturing stages taking into account the irradiation embrittlement of the materials. Moreover, operating measures have been taken to manage ageing of Reactor Pressure Vessel. The challenge is to preserve margins and to provide the safety studies supporting these margins. In this context, the project objective is to provide tools and data for the demonstration of the safe operation of the vessel significantly beyond 40 years.

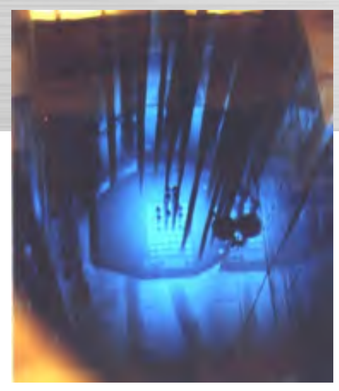


Rouen University's APT



Aspect of Cu clustering

Kurchatov Institut : Atom probe tomograph ***Cameca LEAP 4000 HR***



Kurchatov Institute : experimental reactor IR8

Specimens for testing

Transmission electron microscope ***FEI Titan 80-300***

Scanning electron microscope ***Merlin***

The project is focused on the understanding of thermal and irradiation induced embrittlement and the modelling of mechanical behaviour. It includes different benchmarks (atom probe benchmark) and materials investigation (experimental programs to assess the impact of the irradiation and the thermal ageing on nanostructure features and mechanical properties) carried out by several MAI partners.

Atom probe tomography (APT): This technique is quite commonly used to characterize the irradiation microstructure of RPV steels. A benchmark allowed to show common trends and consistencies of the results provided by each laboratory and to identify the differences.

Thermal ageing of low copper PWR materials: For low copper materials, the potential mechanism of embrittlement is phosphorus segregation to grain boundaries.

A set of typical PWR or PWR-like pressure boundary materials has been submitted to an experimental program of thermal ageing at 300 and 350 °C up to 80 000 h. The obtained data allow to propose predictions of thermal ageing embrittlements for PWR materials with low copper contents.

Development of an annealing procedure: For the quantitative assessment of the contribution from various hardening mechanisms, the annealing temperature and exposure time that lead to dissolution of radiation-induced hardening elements (radiation defects and radiation-induced precipitates) and reduction of grain boundary segregations accumulated under long-term exposure (~200 000 h) under reactor irradiation have been established by Kurchatov Institute. Annealing efficiency was confirmed by a complex of microstructural studies and mechanical tests.