

Understanding the structure of aged Ni-Cr based alloys

EDF (Electricity of France) is a major electricity utility company which operates all the nuclear power plants in France.

THE PROBLEM TO SOLVE:

The integrity of some Pressurized Water Reactor (PWR - Fig. 1) components can be affected by thermal ageing. EDF aims to identify this Ni-alloy ageing in the early stages.

A STEP TOWARDS THE SOLUTION

Quantitative evaluation of the degree of order (at the atomic level) within the Ni-alloy samples is important to identify thermal ageing. Neutron diffraction is the only technique that provides quantitative analysis by measuring the intensity and width of super-lattice peaks in the alloys. This technique is non-destructive and does not add further thermal effects during the measurement.

A senior Engineer and a PhD student from EDF visited the Institut Laue-Langevin in France with samples of different ageing profiles. Diffraction spectra of each sample were obtained using a neutron diffractometer instrument.

THE RESULT

Test measurements showed that neutron diffraction could identify a new structured phase even at mid-term ageing of the material (Fig. 2) These results will contribute to the understanding, detection and modeling of ordered phases during ageing.

“Neutron diffraction measurements were decisive in understanding the phenomenon of ageing. It is the combination of these data with other advanced analysis that allowed us to determine precisely the nature of the phases involved.”

Frederic Delabrouille, Senior Material Scientist, EDF

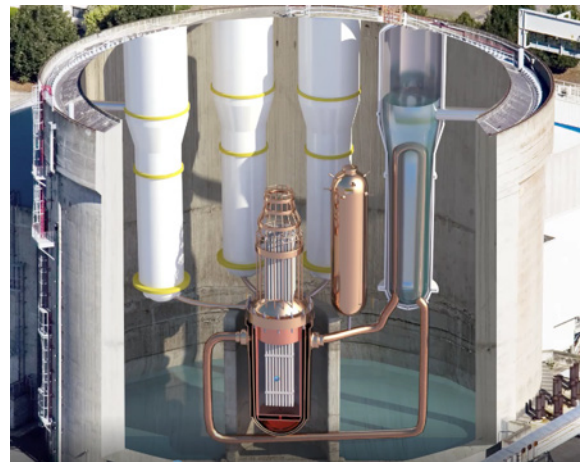


Fig. 1 Design of a pressurized water reactor. The nuclear core is visible at the center of the image. Credit: EDF.

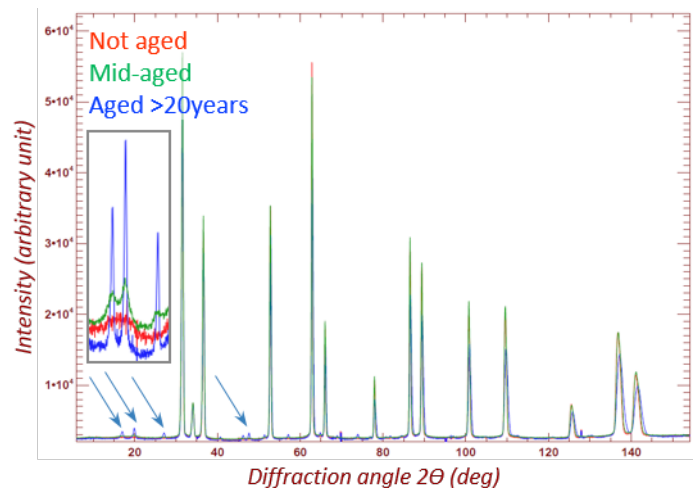


Fig.2 Neutron diffraction patterns of the three Ni-alloy samples: not aged (red), mid-aged (green) and aged (blue).

The blue spectrum (aged sample) reveals an onset of an additional phase.

The insert shows a detail of the spectra that reveals a particular signature with sharp and strong additional peaks from the new phase (aged sample in blue), obviously better crystallised compared to the mid-aged sample (green).

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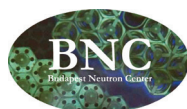
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