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Neutron Radiography Studies for Detection of Hydrogen Distribution in Nuclear Fuel Claddings at Research Centre Řež

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Zirconium (Zr) based nuclear fuel claddings act as, barrier against loss of fuel particles into the coolant water during plant operation, handling and dry storage of the spent fuel rods. Claddings absorb hydrogen produced during reactor operation due to water side corrosion. Increase in the Hydrogen (H) concentration limit can lead to hydride precipitation, resulting in the reduction of cladding strength and/or mechanical failure by a process called Delayed Hydride Cracking (DHC). Mechanism DHC damage is related and dependent on the hydrogen concentration, temperature and stress level in the cladding. Therefore distribution and quantification of hydrogen in Zr based fuel claddings is an object of intensive research. The high sensitivity of neutrons for hydrogen and as a non-destructive method, makes neutron radiography a useful technique for detection metal hydrides and their distribution/location in cladding.

Un-irradiated Zr based fuel clads (Zr-1%Nb) have been investigated at neutron radiography facility of LVR-15 research reactor in Rez, Czech Republic. The samples were investigated in horizontal channel that offers an intense thermal neutron beam with a diameter of 10 cm. The facility is equipped with newest Timepix based detectors, with thin 6LiF converters for neutron detection capable of delivering high resolution. 2D radiography results have been obtained from 3 fuel cladding sections that differ in their hydrogen content. Qualitative information on hydrogen concentration locations in fuel cladding were identified. The H-distribution was revealed by image processing based on intensity histograms. Based on the neutron radiography results, quantitative evaluation of hydrides distribution was performed by classical metallographic procedure and electron microscopy. Qualitative and quantitative inspection of hydrogen distribution in fuel claddings is reported in this paper.

Country/Organization invited to participate

Czech Republic

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