Experimental determination of residual stresses around hydride blisters in ZrNb pressure tubes.

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In CANDU nuclear power reactors, pressure tubes of cold-worked Zr-2.5Nb material are used in the reactor core at temperatures of ~300^{o}C. Appearance of hydride blisters due to unexpected contact of the tube with other reactor components are a possible mechanism for failure. The morphology of the precipitated hydrides and the propagation of cracks along the tube depend strongly on the stress field within the blister, and on the tube material around it.

We have measured strain and stress fields around a hydride blister grown on a section of a pressure tube of a CANDU nuclear reactor using synchrotron X-ray diffraction.

The blister was produced by the creation of a small cold spot (~200^{o}C) on the surface of a section of a pressure tube previously charged with a homogeneous hydrogen concentration of 300 ppm in weight. The tube sections were kept at bulk temperatures between 300^{o}C and 365 ^{o}C, over periods ranging from 430 hours to 3300 hours.

The experiments were performed on the wiggler beam line ID15 at the European Synchrotron Radiation Facility (ESRF), using polychromatic beam of high-energy X-rays between 60 keV and 300 keV. In these experiments the scattering angle fixed and the diffracted beam is discriminated on the basis of the photon energy.

For a specimen grown at 338^{o}C over 1000 hours we have determined the full stress tensor for a line passing through the centre of the blister and crossing the thickness of the tube, with a spatial resolution of ~100 μm. In the ZrNb matrix , the maximum macroscopic stress was (80±40)MPa at a distance ~0.4 mm away from the blister/matrix interface. 2D maps of the residual strain distribution around the blister along the radial, hoop and axial directions of the pressure tube have also been measured.

The present results are compared with finite elements simulations of the problem found in the literature.