NEUTRON DARK-FIELD IMAGING OF HYDROGEN-FATIGUED PRESSURE VESSEL STEEL

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One of the leading proposed mechanisms of hydrogen embrittlement is the Nano-Void Coalescence Mechanism (NVC). In NVC, hydrogen is predicted to lead to the stabilization and promotion of vacancy (“nano-scale void”) agglomeration. To date, evidence for the NVC mechanism is primarily found through SEM imaging of dimples on the fracture surface. However, relaxation processes at the fracture surface complicate the interpretation of these dimples as necessarily arising from nano-scale voids. Measurements in the bulk material are required to further support the NVC mechanism. Neutrons readily penetrate a few centimeters of steel, and neutron dark field imaging, using a far field interferometer, enables measuring the pair correlation function over a length scale range from about 1 nm to about 1 μm. A two-dimensional detector provides spatial resolution at the pixel level, or about 50 micrometers. We used neutron dark field imaging to measure the pore structure of AISI 4130 steel. The steel posts were fatigued in fully-reversed strain-controlled loading until failure over a range of applied strain amplitudes, in air and in hydrogen environments. For all strain amplitudes, the hydrogen environment strongly reduced the number of cycles required to reach failure. We combine the dark field analysis with SAXS data to develop a correlation between strain amplitude and pore structure with the aim of furthering the understanding of the NVC mechanism of hydrogen assisted failure.