FATIGUE CRACK GROWTH OF TYPE 304/304L STAINLESS STEEL IN PRESSURIZED HYDROGEN GAS AT ELEVATED TEMPERATURE

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The deleterious effect of hydrogen on fatigue properties of 300-series stainless steel is well known at below ambient temperatures but has not been extensively studied at elevated temperatures. The focus of the current work is to provide an initial assessment for how hydrogen may affect fatigue crack growth rates (FCGRs) of Type 304/304L stainless steel at elevated temperature and to identify potential mechanisms promoting crack growth behavior using a combined testing/characterization approach. FCGR testing was performed using compact tension specimens at elevated temperature (260°C) in air and hydrogen gas (up to ~20 MPa pressure). Initial results from a limited number of fatigue tests indicate the measured FCGRs in hydrogen are up to an order of magnitude less than those measured in air under comparable loading conditions. Post-test measurement of the compact tension specimens indicates crack mouth opening displacements are greater in hydrogen and more blunting of the crack tip is evident relative to that observed in air specimens. This suggests that the reduced FCGRs in elevated temperature hydrogen is related to a decrease in the effective stress intensity factor amplitude (ΔK). Finite element modeling indicates that the crack tip blunting may be affected by a hydrogen-based change in cyclic behavior (e.g. ratcheting, cyclic yield strength and/or cyclic hardening) occurring ahead of the fatigue crack tip. The fracture surface morphology that evolved during testing in hydrogen gas was found to be relatively flat and lacking well defined facets, but fine striations and step-like features were evident at high magnification. Evaluation of the deformed microstructure below the fracture surface formed in hydrogen gas indicates the presence of cell structures that increase in size with increasing depth below the fracture surface. Observations suggest that cracking in these specimens may occur along these cell walls in some grains.