SAGBO EFFECT ON CREEP CRACK GROWTH OF INCONEL 718 SUPERALLOY AT ELEVATED TEMPERATURES

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Abstract

A serious and significant brittle fracture problem in high strength superalloys is known as "stress accelerated grain boundary oxygen (SAGBO) embrittlement" where, for a notched structure under load at elevated temperature, brittle oxide layers are formed at grain boundaries at the notch tip region and eventually cause intergranular brittle failure. The formation of the brittle oxide layers is due to oxygen diffusion along notch-tip grain boundaries where it reacts with alloy elements (such as Nb, Al, Mo or Si) to form the oxide layers. In this research, the SAGBO effect on the creep crack growth behavior of fatigue pre-cracked single edge-notched (SEN) Inconel 718 specimens tested in air and oxygen-free (vacuum) environments is investigated. High temperature moire interferometry (HTMI) was applied to obtain in-situ near-field crack tip displacement fields of the test specimens at 650 ^{o}C under various creep loading conditions (from 0.25 K_{IC} to 0.6 K_{IC} loads). Elastic crack growth was observed for specimens tested in air and no crack growth was observed for specimens tested in vacuum with applied loads under 0.25 K_{IC} - indicating the presence of a SAGBO effect. As for specimens tested in vacuum with applied loads larger than 0.25 K_{IC}, elastic-plastic crack growth was observed. Based on the near-tip moire fringes, crack-tip plastic yield zone sizes for all the test cases were determined, and C* (for the elastic-plastic creep crack growth cases) and the K-R curve (for the elastic crack growth cases) were evaluated. Furthermore, results from extensive post-mortem crack tip microstructural analyses showed that the brittle oxide layers along the crack tip grain boundaries may be Nb oxide. It is postulated that the presence of oxygen at grain boundaries may promote the migration of Nb elements to the surfaces of grain boundaries and form the large concentration of Nb oxide layers, as observed in our test results. Further investigation is underway to verify this assertion.

Superalloys 718, 625, 706 and Various Derivatives
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