Time-Dependent Crack Growth Mechanisms in Alloy 617 at 800°C for Next Generation Nuclear Applications

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Abstract

Materials enabling the construction of the Next Generation Nuclear Plant (NGNP) require rigorous study to ensure their reliability over a 60 year design life at extreme temperatures (>$0.6T_m$). Alloy 617 is a solid solution strengthened nickel based superalloy slated for use in the intermediate heat exchanger (IHX) of the NGNP. In this work, time-dependent crack growth mechanisms in Alloy 617 at 800°C were studied in a worst-case-scenario assessment of creep-fatigue crack growth in the NGNP. Compact tension samples were cracked at temperature using an induction furnace and a servo-hydraulic load frame. Crack growth rates were mapped against relevant crack tip parameters in order to better understand the material's viscoplastic response to representative loading waveforms. Fracture surfaces and crack tip profiles were examined to discover germane relationships between transgranular cracking, void growth and coalescence, and the role of oxygen embrittlement. A comparison of results obtained in this work to existing literature reveals a significant blind spot in the application of linear elastic fracture mechanics. Finally, as a result of this work, Alloy 617 is further qualified for use in the NGNP.

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