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FATIGUE CRACK PROPAGATION OF AEROSPACE ALUMINUM ALLOY 7075-T651 IN HIGH ALTITUDE ENVIRONMENTS

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ABSTRACT

Fracture mechanics fatigue testing of 7075-T651 in environmental conditions pertinent to high altitute airframe operation established the fatigue crack growth behavior over a wide range of stress intensity range (ΔK). Two distinct methods were used to control the environmental severity parameter of water vapor pressure over frequency (P_{H2O}/f): (1) at 23°C the P_{H2O} value was controlled by an ultra-high vacuum system into which purified water was leaked, and (2) the testing temperature was decreased to temperatures as low as -65°C allowing an equilibrium P_{H2O} over ice at a given temperature to be maintained. Decreasing P_{H2O} at 23°C (at a constant f) results in a drastic reduction in the fatigue behavior, strongly suggesting that the reduction in moisture is a primary mechanism controlling the retarded fatigue crack growth behavior observed at low termperatures. Additionally, studies conducted at a constant P_{H2O}/f with various testing temperatures down to -15°C show that fatigue crack growth rate (FGCR) behavior is consistent with data generated at 23°C. However, at temperatures below -30°C, low T tests exhibit crack growth rates below the 23°C results despite a constant P_{H2O}/f value. This suggests that the strong role of environmental moisture reduction is augmented by a separate temperature dependent effect on either the inherent dislocation behavior and/or a separate aspect of the Hydrogen Environment Embrittlement (HEE) process. Mechanisms based purely on temperature dependent dislocation behavior fail to fully describe the experimental observations. Temperature dependent impacts on the HEE process (apart from the reduction of the P_{H2O}) via influencing the surface reaction process to generate atomic H at the crack tip or the diffusion of the H within the crack tip process zone do not adequately describe the observed experimental data. Furthermore, a dip in the crack growth rate at -30°C suggest that molecular flow of H_2O from the bulk to the crack tip is in part responsible for the temperature dependent behavior. Such behavior is hypothesized to be caused by the preferential onset of a rough crack wake morphology (likely slip band cracking) at low temperatures, that impedes molecular