Progress Report: Effect of Tritium on Cracking Threshold in Aluminum 7075

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Michael Morgan and Andrew Duncan
Savannah River National Laboratory, SRS, Aiken SC, 29801
michael.morgan@srnl.doe.gov and andrew.duncan@srnl.doe.gov

The effect of long-term exposure to tritium gas on the cracking threshold of 7075 Aluminum Alloy is being investigated. The alloy is the material of construction for a cell used to contain tritium in an accelerator designed for inelastic scattering experiments on nucleons. This report and the attached slide presentation is a summary of the work at SRNL to date.

Background

Research on tritium effects on high strength aluminum alloys is limited. Aluminum alloys should be resistant to embrittlement by hydrogen isotopes because of their passive oxide layer which should act as a barrier to disassociation of the hydrogen molecule. However, embrittlement has been observed in 7075 Aluminum in moist air, apparently because freely diffusing hydrogen atoms are released from the water molecule when it reacts with the aluminum oxide surface. In this accelerator application, tritium is dissociated for on-beam conditions. Tritium that diffuses into the aluminum could lower the threshold for cracking leading to failure by slow crack growth.

Preliminary Results

Experiments are underway designed to measure the effect of tritium gas on the cracking threshold of 7075 Aluminum specimens supplied by Jefferson Laboratories. Twenty-eight specimens were fatigue pre-cracked and bolt-loaded to different stress intensity levels according to ASTM E1681. The stress intensity values ranged between 45% and 80% of the fracture toughness value (KIc). The stressed samples were than placed in a pressure vessel and are being held in 1.7MPa of tritium gas for up to twelve months. To date, four-month exposure specimens have been removed from tritium exposure and are being examined for crack growth. The remaining specimens are being held in tritium gas for examinations at a later date. Optical microscopy examinations indicate that the four-month exposure specimens show little or no crack growth at any of the stress intensity values.

Stress intensity levels in the tritium cell were estimated from the geometry of the cell and its operating pressure. The stress intensity values were estimated for a variety of assumed flaw sizes and shapes for the cylindrical and spherical sections of the cell for operating pressures and higher. The stress intensity levels in the cell at operating pressure were estimated to be less than 2 MPA-m^1/2. To date, little or no crack growth was observed in eight specimens for stress intensities between 12 and 20 MPa-m^1/2. Since no crack growth has been seen so far, no crack growth is expected in the Jefferson Lab tritium cell unless there is a significant effect tritium penetration or helium from tritium decay on cracking threshold.

Examinations will be conducted on eight-month and twelve month exposures later this year. These subsequent examinations are designed to determine if the depth of tritium penetration or decay helium will significantly reduce cracking threshold values. The four-month exposure specimens will be fractured in a mechanical testing machine and fractography conducted to confirm that cracking has not occurred. If tritium off-gassing rates are low enough, tritium autoradiography will be conducted to qualitatively determine the depth of tritium penetration. Eight-month examinations are planned for 7/16 and Twelve-month examinations for 11/16. A final report will be completed in 12/16.