FRACTURE TOUGHNESS CHARACTERIZATION OF INCONEL 718, 304L, AND 316L AUSTENITIC STAINLESS STEELS AFTER IRRADIATION IN A HIGH-ENERGY, MIXED PROTON/NEUTRON SPECTRUM

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ABSTRACT

This paper describes the fracture toughness characterization of precipitation hardened Inconel 718 alloy and annealed 304L and 316L stainless steels, performed at the Oak Ridge National Laboratory as a part of experimental design and development for the Accelerator Production of Tritium (APT) target and blanket. Materials were irradiated at 25 to 200EC by high-energy protons and neutrons from an 800-MeV, 1-mA proton beam at the Los Alamos Neutron Science Center (LANSCE). The proton flux produced in LANSCE is nearly prototypic of anticipated conditions for significant portions of the APT target/blanket system. The objective of this testing program was to determine the change in J_{Ic} of candidate APT materials from irradiation at prototypic APT temperatures and proton and neutron fluxes. The J-integral-resistance (J-R) curve toughness tests were conducted in general accordance with the American Society for Testing and Materials Standard Test Method for J-Integral Characterization of Fracture Toughness, E 1737-96, with a computer-controlled test and data acquisition system. J-R curves were obtained from subsize disk-shaped compact tension specimens (12.5 mm in diameter) with thicknesses of 4 or 2 mm. Irradiation up to 12 dpa significantly reduced the fracture toughness of these materials. Inconel 718 had the lowest fracture toughness in both the unirradiated and irradiated conditions. All irradiated specimens of Inconel 718 alloy failed by sudden unstable crack extension regardless of dose or test temperature. Type 304L and 316L stainless steels had a high level of fracture toughness in the unirradiated condition and exhibited reduction in fracture toughness to the saturation levels of 50 to 100 MPa/m. Resistance to crack extension (the tearing modulus) of both stainless steels was more sensitive to irradiation than J_{Ic}. The present reduction in fracture toughness is similar to changes reported from fission reactor studies. However, the currently observed losses in toughness appear to saturate at doses slightly lower than the dose required for saturation in reactor-irradiated steels. This difference might be attributed to

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