FRACTURE TOUGHNESS CHARACTERIZATION OF A HIGHLY EMBRITTLED RPV WELD*

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ABSTRACT

The Heavy-Section Steel Irradiation (HSSI) Program at Oak Ridge National Laboratory includes a task to investigate the shape of the fracture toughness master curve for reactor pressure vessel steel highly embrittled as a consequence of irradiation exposure. A radiation-sensitive reactor pressure vessel (RPV) weld, designated KS-01, is characterized in terms of static initiation (K_{Ic}, K_{Jc}) and Charpy impact toughness in the unirradiated and irradiated conditions. The objective of this project is to investigate the ability of highly embrittled material to maintain the shape of the unirradiated transition fracture toughness curve, as well as to examine the ability of the Charpy 41-J shift to predict the fracture toughness shift at such high level of embrittlement. Irradiation of this weld was performed at the University of Michigan Ford Reactor in the new HSSI irradiation-anneal-reirradiation (IAR) facility. This reusable facility allows the irradiation of either virgin or previously irradiated material in a well-controlled temperature regime, including the ability to perform in-situ annealing. Specimens of KS-01 weld were irradiated up to about 8×10^{18} n/cm^2 at 288EC. Selection of this target fluence was based on previously available Charpy shift data for this weld, which suggested a Charpy shift at this fluence of $150EC. It was estimated that this shift would result in a fracture toughness transition temperature (at 100 MPa%m) in the irradiated condition near or slightly above the pressurized thermal shock screening criterion for weld metals, an RT_{PTS} of 300EF (149EC) according to the *Code of Federal Regulations, Title 10, Part 50* (10CFR50). This was determined in terms of the master curve transition temperature T_{oPTS} = 129EC using the American Society of Mechanical Engineers Code Case N-629 which allows RT_{NDT} to be replaced by $RT_{To} = T_o + 35EF$ (-20EC). The fracture toughness characterization of KS-01 weld in the unirradiated and irradiated conditions is mainly performed by testing 1T C(T), although some amount of 0.5T C(T) and precracked Charpy specimens are used in this study.

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