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Development of a crack arrest toughness measurement techniques using small specimens to evaluate the fracture behavior in the ductile-brittle transition region of “ferritic” steel.

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Neutron embrittlement of nuclear reactor vessels made of ferritic steels is one of a key parameter limiting the life of power plants. Owing to the small volume of available irradiation facilities and the limited number of neutron-irradiated surveillance specimens, techniques to measure initiation fracture toughness with small specimens have been developed over the years. Although arrest toughness is of equal importance regarding safety assessment, the emphasis has been put on the effect of specimen size on initiation toughness and practically no small specimen test technique is to be found for arrest toughness measurements. Thus, the objective of the current work was to develop experimental techniques for measuring the initiation and arrest toughness of ferritic steels with miniaturized specimens. Small specimens were produced with a brittle thin layer, which enables crack initiation, was created by surface laser treatment. The cracks were arrested in the more ductile ferritic matrix. The dimension of the specimens was optimized both experimentally and computationally. The test fixture was modified with the guidance of numerical simulation results. Series of successful tests were carried out on tempered martensitic steel (Eurofer97) cantilever beams from -125 °C to room temperature with different types of microstructures. The mechanical tests showed that brittle fracture could be triggered over a temperature range of more than 100 °C for different kinds of specimens and the running cracks arrested occurred in the ductile part of the specimen.

Keywords: Fracture arrest toughness, miniaturized specimens, Ductile to brittle transition region, test technique.