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Role of hierarchical martensitic microstructure on localized deformation and fracture of 9Cr-1Mo steel under impact loading at different temperatures

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Abstract

Blocks from a modified 9Cr-1Mo steel plate used for fast breeder reactor application under normalized and tempered condition were hot-rolled at different temperatures (1050-875°C) applying same amount of deformation, normalized using different austenitizing temperatures (1100-950°C) and finally tempered at 750°C. These samples having tempered martensitic microstructures were impact tested over the temperature range of +80°C to -196°C. The effect of hierarchical martensitic microstructure with different structural units of varying length scales (i.e. lath, sub-block, block, packet and prior-austenite grain) on the micro-mechanisms of deformation and fracture have been elucidated by studying the propagation of cleavage cracks and the formation of shear cracks within the samples using electron back-scattered diffraction (EBSD) technique and Visco-plastic self-consistent (VPSC) polycrystalline plasticity model. The study indicates strong influence of certain crystallographic variants on the cleavage crack propagation and the 'martensitic block' is found to be the 'effective grain' controlling the impact toughness at low temperatures. Dynamic fracture at high temperatures was dictated by cracking along the shear bands, evolution of which depend on the size and distribution of prior-austenite grains.

Keywords: Dynamic fracture (A), Crack propagation and arrest (A), Martensitic steel (B), Crystal plasticity (B), Impact testing (C).

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