WARP3D at Canadian Nuclear Laboratories

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Safety is a primary concern of the nuclear industry and assessment of the fracture behaviour of components is an on-going endeavour. A typical CANDU power generation reactor has over 300 fuel channels. The critical component in a fuel channel is the pressure tube that contains the pressurised coolant and the heat-producing fuel pins. These tubes are in a very harsh environment of radiation and temperature and are constantly monitored for any leakage. Determining the leakage and the critical crack length of the tube are important factors to ensure a safe, controlled shut-down. WARP3D has been used to determine the crack driving force of fixed-length, through-wall cracks in the pressure tubes and J_R curves of compact tension specimens extracted from the tubes. These were then used to perform stability analyses. Fracture surface images showed that the crack tunnelled in the center of these components and WARP3D was applied to determine the fracture quantities such as T/Q-stress, triaxiality, traction/separation, crack tip opening angle, etc. that would govern the tunnelling behaviour. WARP3D was instrumental in evaluating the fracture response of a weld repair to the National Research Universal (NRU) reactor and indicated that any possible lack of fusion/crack in the weld-induced residual stress field would not compromise the integrity of the vessel.