RESIDUAL STRESSES IN GIRTH BUTT WELDED STRUCTURES

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Abstract

A finite-difference computational model has been developed for predicting residual stresses and deformations in girth butt welded pipes, with emphasis on through-thickness distributions in the weld itself. Due account is taken of heat losses, latent heat effects and the temperature dependence of yield stress.

Through-thickness distributions of residual stress have been determined by sectioning in three girth butt welded Grade 50D structural steel pips specimens (9.1, 15.0 and 19.5 mm thick x 1m diameter). The technique involves removing and subsequently layering a number of strain-gauged blocks in the region of the weld. For comparison, surface stress measurements have been made by air-abrasive centre-hole drilling. In addition, deformations in the vicinity of the joint have been recorded by a demountable extensometer. The experimental methods are entirely independent, but complement each other and yield results which are self consistent.

Good agreement it also achieved between theory and experiment. Theoretical extrapolations beyond the range of experimental data have therefore been made. It is found that axial stresses depend primarily on the heat input per pass relative to the wall thickness, i.e. (Q/v)/t. For (Q/v)t > 90J/mm^2, the through-thickness distributions are virtually linear and display tension-compression from the inner surface outwards. For (Q/v)t< 50 J/mm^2, they are S-shaped and display repeated tension compression from the inner surface outwards. For (Q/v)/t between 50 and 90 J/mm^{2,} they are sensitive to the ratio of pipe radius to thickness (R/t): for low (R/t) (= 10) they are S-shaped and for high (R/t) (= 50) they are virtually linear. For very thick pipes welded with low heat inputs, i..e. (Q/v)/t → 0. the restraint may be sufficient for a simpler inner compression – outer tension distributions to develop.

The results of the present work suggest that, for (Q/v)/t < 90 Jmm^2 , there is a strong case for abandoning the conventional assumption of tensile yield residual stress at the weld root in critical fracture assessment of defects.