RESIDUAL STRESSES IN WELDED TUBULAR T-JOINTS

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Abstract

An extensive experimental and theoretical investigation has been conducted to determine detailed residual stress distributions in welded tubular T-joints. Experimental test specimens were continuously welded using robotics to allow precise control of the welding parameters. A fully destructive sectioning method, to determine stresses experimentally through the material, was developed to allow for the complex geometry at the pipe intersection. The finite element package PAFEC, modified to deal with multipass welding residual stress analyses was used to study axisymmetric configurations to best model the stresses found in a tubular T-joint. Good agreement was obtained between the experimental results and the numerical analysis pip-on-sphere geometries.

Particular attention has been focused on the transverse stresses through the chord below the weld toe as this is an important area for fatigue crack growth. Conservative transverse stress predictions show the weld toe have been derived; namely yield tension on the outer surface of the chord, moving to one fifth yield compression at a depth of about 10 mm from the outer surface, moving to two fifths yield tension on the inner surface of the chord (these predictions being based on chords with a wall thickness in the range 22mm → 36mm). The effect of increasing wall thickness is to reduce the stresses through the thickness of the chord; an example of a thicker chord wall (11mm) has been given.

The stresses at the weld root have been investigated and it has shown that for the thinner chords (≈ 22mm) the transverse and through-thickness stresses at the root are compressive. However, as chord wall thickness increases, the root stresses become tensile and approach yield tension for the thickest specimens studied (100mm).

A qualitative explanation of the build-up of the residual stresses has been proposed. This description identifies the section stiffness as an important parameter and confirms

previous observations that the longitudinal direction is effectively ‘fully’ restrained. Hence the final stresses depend primarily on the stiffness of the section in the transverse plane.