RESIDUAL STRESSES IN RING STIFFENED CYLINDERS

D.M.R. Gray-Stephens

Abstract

Residual stresses which can be critical when assessing fatigue life of welded joints are investigated in welded ring stiffened cylinders.

A theoretical analysis, using a finite difference numerical model, has been developed to predict the through thickness residual stress fields due to welding a ring stiffener into a cylinder. Due account has been taken of heat losses, latent heat effects, the temperature dependence of yield stress, and the detailed build up of the joint as each weld run is completed.

An extensive experimental programme has been executed to provide data for validation of the numerical model. The investigation has determined the overall distortions and residual stresses in two cylindrical assemblies and nine unrestrained tee butt welded plates. Three material thicknesses have been considered (5, 19, and 38mm). An automatic MIG welding process was used, with the heat inputs for individual passes in the range 600 to 2400 J/mm. All the specimens were fabricated with a double sided preparation with multi-pass welds, except for the 5mm thick specimens, which were completed with a single pass. Preheat was not applied, and the specimen cooled to ambient temperature between each continuous pass.

The through thickness stress distribution near the weld toe was obtained by the two independent techniques; centre hole drilling (air abrasive), and sectioning (using the electrical discharge machine for block removal and layering). The longitudinal stress exceeded uniaxial yield tension penetrating between 5 and 8mm below the welded surface. The inferred through thickness (radial) stress in the *cylindrical specimen* approached 40% of the uniaxial yield stress on the welded surface. The transverse stress distribution is very dependent on the

restraint. In the *free tee* specimens the transverse stresses did not reach the uniaxial yield stress. However, in the *cylindrical specimen* (19mm thick) the axial moment approached the full plastic moment, with tensile yield stress penetrating 8mm below the welded surface, and compressive yield penetrating 5mm from the unwelded surface.

The theoretical and experimental results show good agreement. Geometric changes around the 19mm thick cylinder have been investigated. A simple elastic model over estimates the axial moment in ring stiffened cylinders using the results from the free tee experiments, and improvements are proposed for the model's empirical predictions.