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VEQTER

Residual Stress Experts

VEQTER is an engineering company providing excellence in the measurement, analysis and management of residual stresses. We are world leaders in our field and offer expertise on any aspect related to residual stresses in engineering components and structures.

Case Study: Submarine Structure

During the manufacture of this submarine a number of circular hull sections are welded together to form the complete hull. Each hull section is comprised of a number of curved metal sheets welded together and reinforced internally by T-section rings welded at regular intervals. The T-section rings are manufactured from a number of web and flange plates, plastically bent to form the correct curvature and again welded together.

For this investigation, the manufacturer was interested in the residual stresses generated by the welds that attach the T-section rings to the hull inner surface. Therefore a small, straight, mock-up T-section was supplied by the manufacturer for the measurement of residual stresses using the Deep-Hole Drilling technique. Furthermore, upon the successful completion of the initial laboratory measurement the manufacturer requested an "on-site" measurement be carried out on a full-scale submarine hull section.

To find out how VEQTER can help you please contact us on *+44 (0) 117 992 7970* or using *experts@veqter.co.uk*

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Component design:

The mock-up component consisted of a web and a flange plate (i.e. excluding the hull plate) fillet welded together to form a T-section 1000mm long, 255mm high and 140mm wide, see Figure 1. The mock-up was manufactured to represent a section of the reinforcement rings welded to the inner surface of the hull.

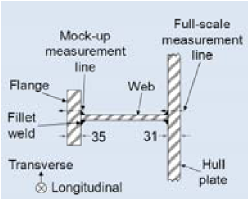

Fig. 1: Cross-section through hull plate and attached T-section

The full-scale component consisted of a circular hull section with dimensions 2360mm long, 6600mm outer diameter and average wall thickness 31mm, see Figure 2. Welded to the inner surface of the hull section were four T-section rings. The final weight of the component was 17 tonnes.

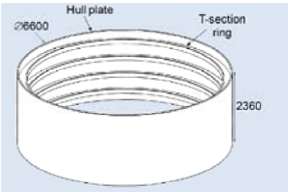

Fig. 2: Full-scale hull section

Measurement location:

For both the mock-up and full-scale applications the measurement lines were through the flange and hull plate respectively, at the toe of the fillet weld, see Figure. These locations were chosen in order to measure the residual stresses generated in the heat-affected zone of the flange and hull material.

Results:

The residual stresses measured in the mock-up T-section and full-scale hull section are presented in Figures 3 and 4 respectively. The residual stresses are shown for the directions longitudinal and transverse to the fillet weld axis. The residual stresses are shown as functions of depth through the flange/hull plate from the toe of the fillet weld.

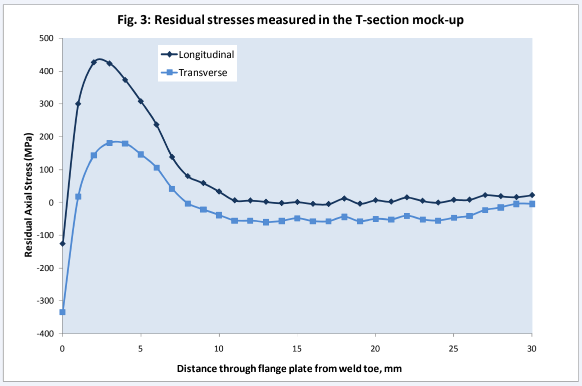

Fig. 3: Residual stresses measured in the T-section mock-up

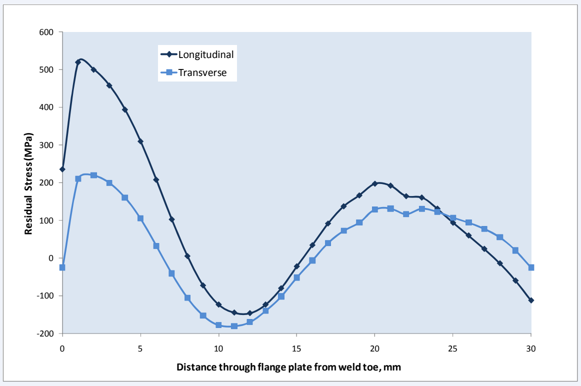

Fig. 4: Residual stresses measured in the full-scale section

Discusion:

When comparing the residual stress distributions from the two components it can be seen that they both display peak longitudinal and transverse tensile residual stresses close to the weld toe. The differences between the residual stresses (longitudinal and transverse) in the mock-up T-section and the full-scale hull section are shown in Figure 5.

The “difference” residual stress distributions are 180° rotationally symmetric about mid-depth. The symmetric, oscillatory distributions are consistent with the residual stresses generated by plastically bending the hull plate to the correct curvature to form the circular hull section. Consequently, the residual stress distributions presented in Figure 4 are a combination of welding residual stresses and plastic bending residual stresses.

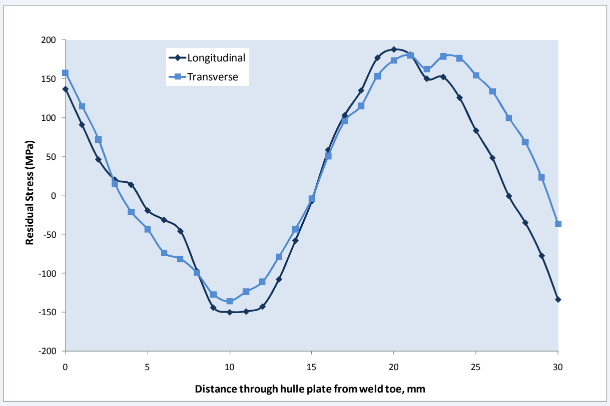

Fig. 5: Estimated residual stresses arising from bending the hull plate