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**Names and affiliations of applicants** (* indicates experimentalists):

***P J Webster, *D J Hughes, *G Mills, *H Sitepu**

Institute for Materials Research, University of Salford, Manchester, M5 4WT, UK
FaME38 at ILL-ESRF, 38042, Grenoble, France

**G Xu**

Structural Integrity Group, TWI Ltd, Great Abington, Cambridge, CB1 6AL, UK


## Report:

How to treat residual stresses is a key aspect in defect assessment of welded structures. It is generally accepted practice that uniform tensile residual stresses of magnitude equal to the yield stress of the material should be assumed when residual stress profiles are not available for the geometry in question. The unfused land in fillet welded joints is one of the geometry features which is not covered in residual stress profile compendiums in defect assessment standards and procedures such as BS 7910 [1]. In a loading carrying fillet welded T-joint the unfused land acts as an inherent flaw, the length of which may be considered to be equal to the main plate thickness which can be in the range 30-150 mm. To the knowledge of the proposers there are, up to now, no published residual stress/strain measurement data for the unfused land. Engineering critical assessments carried out recently at TWI and elsewhere for offshore and building structures encountered situations where the acceptability of the unfused land flaws by analysis depended critically on the assumption of residual stresses. The TWI assessments adopted innovative techniques, combining expert opinion, computer modelling and physical measurement to assess the appropriateness of the yield magnitude residual stress assumption. The evaluation of residual stresses in long welds centred on the use of thin section specimens. Residual stresses in the unfused land were shown to be low or compressive by both modelling and centre-hole measurement. Those findings have played an important role in preparation of the safety case, which has huge financial and operational implications for offshore structures and fillet welded joints. However, they were not sufficient to be formally recognised by authoritative defect assessment standards such as BS 7910.

In this investigation, validatory synchrotron X-ray measurements, and further finite element modelling, were performed in order to establish guidelines on the treatment of residual stresses in the unfused land so that the benefits of innovative procedures for residual stress evaluation in long welds can be maximised. The principal objectives were to:

- Validate procedures using thin section specimens for evaluation of residual stresses in long welds.
- Develop guidelines on the treatment of residual stresses in the unfused land.

Synchrotron X-ray measurements were made on 5 mm thick transverse section samples from two T-joints provided by TWI. The T-sections were fillet welded from two ferritic steel plates 50 mm and 65 mm thick. The measurements were made in transmission through the 5 mm thickness of the plate section in the Y (parallel to the unfused land) and Z (perpendicular to the unfused land) directions The Fe 112 reflection was used at an X-ray energy of 58.29 KeV.

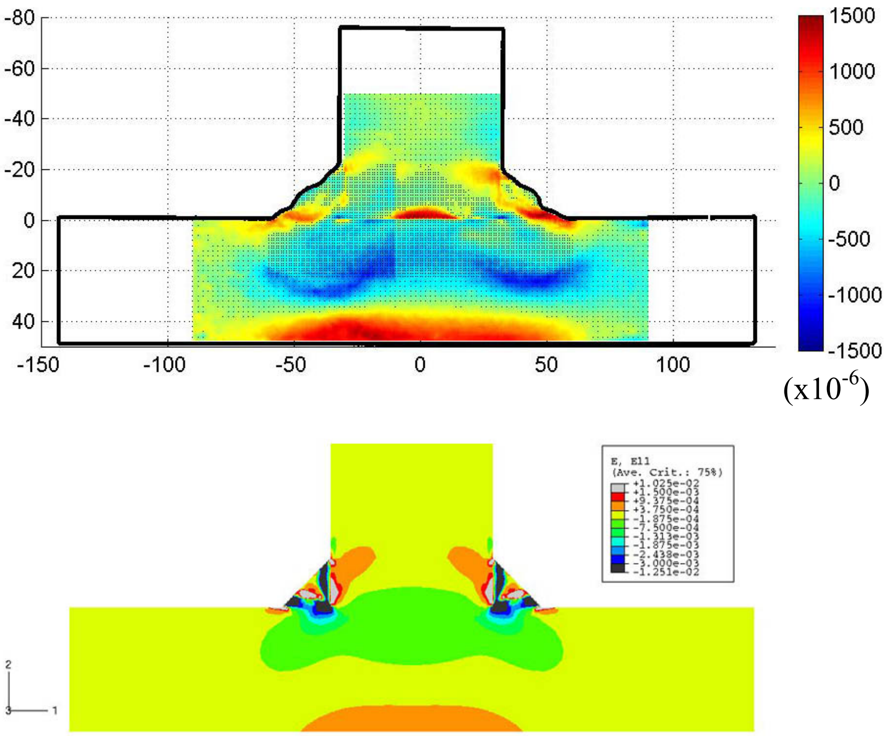


*Figure 1. Measured (TOP) and predicted(BOTTOM) residual strain map for the Y direction*

Representative residual strain results (calculated using a single estimated strain-free reference) for measurements made in the Y direction over an area close to the weld and unfused land (which extends from z = 0, -32 < y < 32) are shown in figure 1 (top). Finite element analyses were carried out to generate residual strain/stress data for the same T-welded joint and the comparative map is also shown in figure 1 (bottom). The measured and calculated maps show the same general features but differ in detail. Particularly interesting is the unpredicted region of tensile strain in the centre of the unfused land.

It became apparent however, during the data analysis that there are discontinuities in the experimental data related to a storage beam refill and further analysis revealed a further drift in scattering angle with time. This problem is highlighted by the visible step in strain at y = -10 (for positive values of z) which coincided with a refill. Investigations are being made by beam-line staff in conjuction with the experimental team to ascertain the causes, to perform remedial action for future strain/stress experiments and to determine whether corrections can be made so that the data can accurately validate the Finite Element model.

## Reference

[1] BS 7910:1999 – Guide on methods for assessing the acceptability of flaws in metallic structures. British Standards Institution, ISBN 0 580 33 081 8.