Surface residual stresses in multi-pass welds produced using low transformation temperature filler alloys

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Tensile residual stresses at the surface of welded components are known to compromise fatigue resistance through the acceleration of crack propagation, especially at the weld toe. Inducement of compression in these regions is a common technique employed to enhance fatigue performance [1]. Transformation plasticity has been established as a viable method to control residual stresses in steel welds and exploits the phase transformation in welding filler alloys, which transform at low temperature to compensate for accumulated thermal contraction strains [2]. In this work, neutron diffraction has been used to measure surface stress profiles across plates welded with low transformation temperature (LTT) welding alloys with a particular focus on the stress at the fusion boundary, where compressive longitudinal stresses have been recorded in the weld metal.

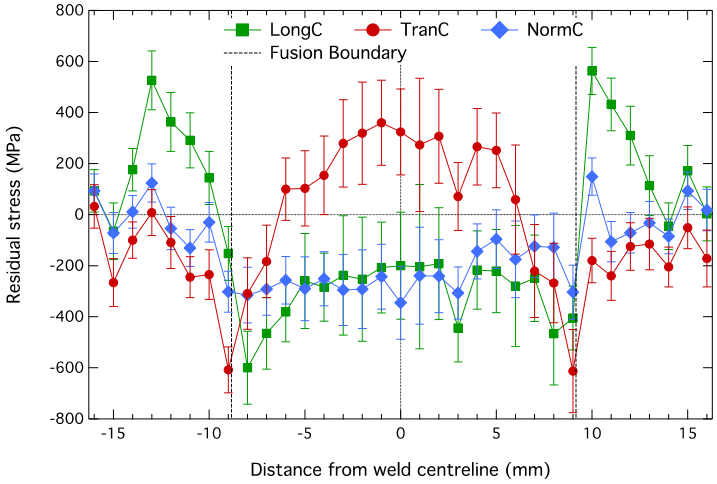

Figure 1 Surface residual stress measured by neutron diffraction for an LTT welding alloy.

The surface residual stresses measured in three orientations by neutron diffraction are presented in Fig. 1. The stress distribution at the fusion boundary (usual site of fatigue failure) is compressive and contributes to longevity of the welded component. Conversely, the stress distribution in the same region for the specimen welded with a standard filler shows tensile stresses, which are deleterious to fatigue performance.

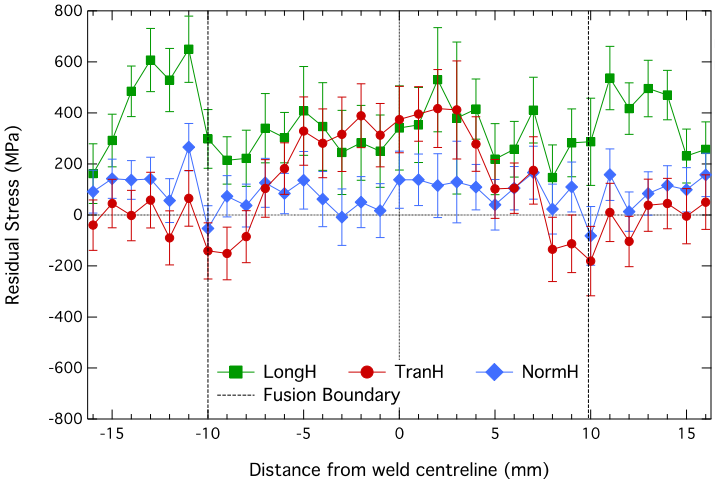

Figure 2 Surface residual stress measured by neutron diffraction for a standard welding alloy.

The adoption of a small gauge volume has allowed stress measurements at the sample surface and is the first instance in which these types of alloys have been investigated using this technique. Thus revealing the mechanism of fatigue improvement.

References

[1] H. E. Coules, Materials Science and Technology, 2013, 29, 4–18
[2] J. A. Francis, et al., Materials Science and Technology, 2007, 23(9), 1009– 1020