Member report number: 1086/2017

Industrial Member Report Summary – Key Findings for Industry

Material Models for Improved Finite Element Predictions of Residual Stresses in Ferritic Steels

TWI Core Research Programme

Author: Nicholas O'Meara

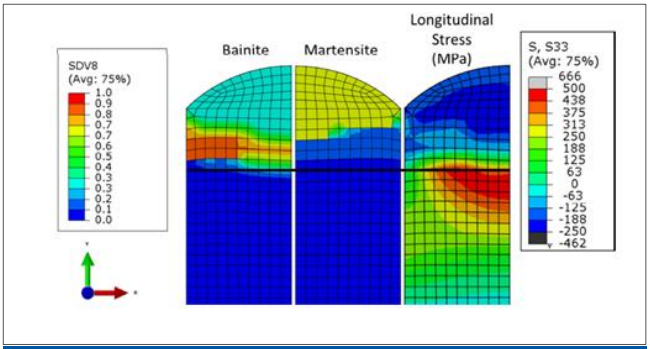
Industrial need

Knowledge of welding residual stress is required to ensure welded structures are able to operate with sufficient resistance to certain failure mechanisms. In light of the difficulties associated with measuring residual stresses, finite element simulation can be used to predict stress evolution during welding processes. Solid state phase transformations, as experienced by ferritic steels, can affect residual stress evolution and should be accounted for in modelling approaches in certain cases. In this report, models to incorporate these effects using a widely used finite element modelling package are presented.

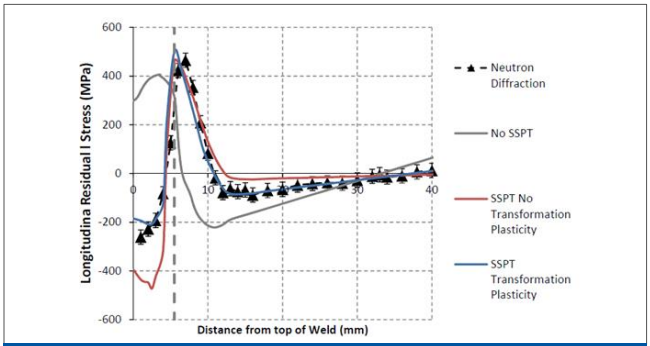
Key Findings

Predictions of microstructure and residual stress in a ferritic benchmark weld were made and compared with published measurements for this specimen.

- Flexible user subroutines can be written that allow phase transformation behaviour to be accurately simulated in ABAQUS;
- Low alloy steel phase transformations can significantly affect welding residual stresses;
- Beneficial compressive stresses in the HAZ of ferritic welds, induced by low temperature phase transformations have been simulated;
- It is possible to accurately predict the micro hardness distribution in the weld using calibrated phase transformation models.



Predicted phase and longitudinal stress distributions in an autogenous GTAW edge weld.



Comparison of measured and predicted longitudinal residual stress for a number of simulation cases: no solid-state phase transformation (no SSPT); SSPT with no transformation plasticity; and SSPT including transformation plasticity.

How to benefit from this work:

- As an Industrial Member of TWI, you have free access to the full report
- If you are not an Industrial Member of TWI, find out how your company could benefit from Membership www.twi-global.com/membership
- Read more: [http://www.tandfonline.com/doi/full/10.1080/02670836.2015.1132529]
- Contact us to learn more