REMTEC Case Study

Low Carbon Energy - Manufacturing Technology Centre

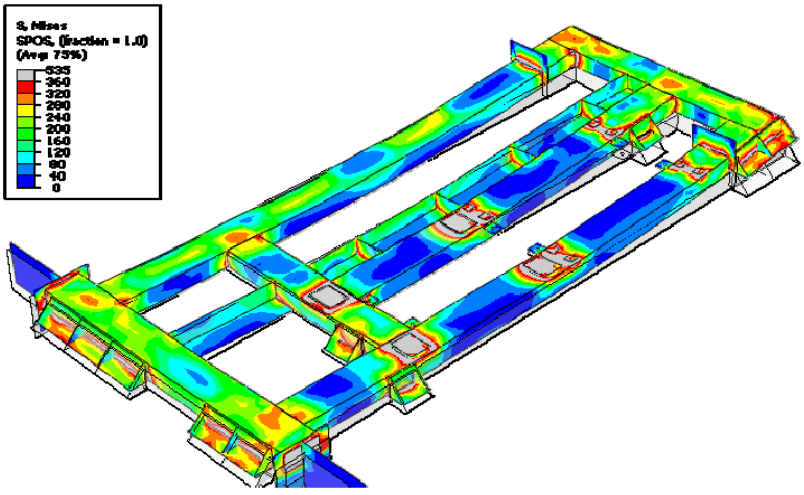
Delivered by

TWI WORLD CENTRE FOR MATERIALS JOINING TECHNOLOGY

Staying in shape

When one of the UK's leading train manufacturers needed help in developing a fabrication procedure, specifically aimed at predicting and controlling weld distortion, TWI was there to help. TWI's feasibility study was carried out under the REMTEC regional technology transfer programme.

The task facing Turbo Power Systems and Tharsus Engineering involved developing a fabrication procedure for a welded hanger that supports heavy electrical equipment underneath a train. The structure, which measures a metre and a half long and half a metre wide, was being fabricated with 130 welds. But the dimensional accuracy of the structure was critical. The fit-up tolerances were tight, between a millimetre and two millimetres between key dimensions. During fabrication however, welding caused distortion well beyond the acceptable tolerances, up to six millimetres along the length of the hanger.



Residual stresses in hanger from welding using the original fabrication procedure. The model predicted a maximum out of plane distortion of 6.1mm (units in MPa, magnification x10 for visual aid).

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Expert advice and in-depth assistance from TWI

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So how did TWI approach the problem?

Finite element (FE) weld modelling tools were used to predict the distortion in the hanger using the current fabrication procedure. The model was then validated with distortion measurements and used to investigate several means of mitigating the unwelcome distortion.

The hanger was fabricated using manual MIG welding. The first 90 welds were carried out with the job clamped in a stiff 10mm thick steel jig. The remainder were performed out of the jig so allowing access to the underside of the structure.

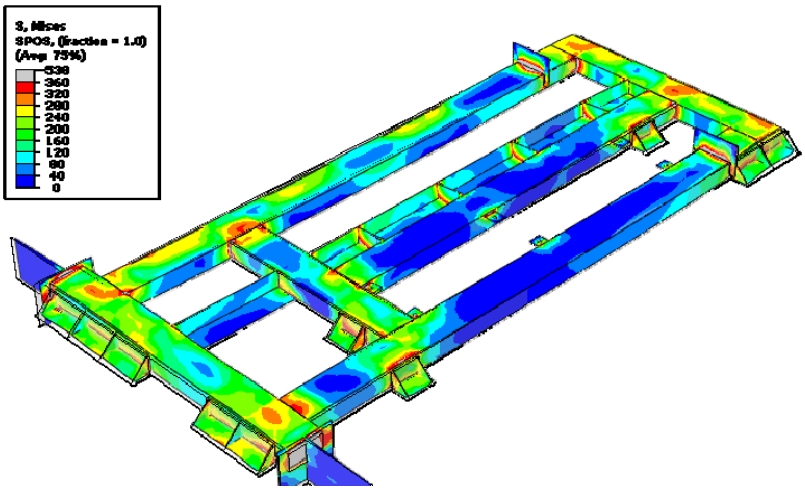
A modelling procedure was developed at TWI to predict residual stresses and distortion in large and complex structures. It used general purpose FE code, known as ABAQUS, involving a thermal model that predicts the temperature distribution from welding. This is then used in a mechanical model as a thermal load to predict the residual stresses and distortions.

Suitable boundary conditions were applied to the model to simulate clamping during welding when the hanger was in the jig.

Two models were used to validate the modelling procedure. The first involved simulating the original fabrication procedure and welding conditions. The second model of the hanger was partially welded using lower heat input settings.

Distortion measurements were carried out on a second hanger, fabricated using lower heat input welding settings. The measured amount of out-of-plane distortion along the length of the hanger was 1.4mm, which was comparable with the model predictions. This was much less distortion than that measured using the original fabrication procedure, where the plates and bolts were also welded using higher heat input welding conditions.

As a direct result of working with TWI, both Turbo Power Systems and Tharsus Engineering were able to conclude first, that the FE model of the hanger was validated with two fabricated hangers. Second, results of the model that omitted welding of the plates and bolts, but used the correct heat input conditions, showed a significant reduction of distortion, up to 2mm. And third, that further improvement of the fabrication procedure could be achieved by changing the welding sequence. This mitigated build-up of heat in one structural region and balanced weld shrinkage on the topside and underside of the hanger during jig welding.



Residual stresses in hanger from welding using a fabrication procedure that avoided welding the bolts and plates on the top surface and used a modified welding sequence. The predicted maximum out of plane distortion was less than 1.2mm (units in MPa, magnification x10 for visual aid).

REMTEC is part-financed by the European Union's ERDF Competitiveness Programme 2007-13, securing £1.7m ERDF investment through regional development agency One North East. The ERDF programme is bringing over £250m into the North East to support innovation, enterprise and business support across the region. Further information at www.onenortheast.co.uk/erdf

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