Quantification of Residual Stresses in External Attachment Welding Applications

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It is uncertain whether postweld heat treatment (PWHT) should be required for external attachment welds in petrochemical industry applications where stress corrosion cracking (SCC) is a possibility. An industrial criterion established by NACE SP0472 indicates that PWHT is not required if residual stresses don't extend through the entire thickness. To investigate this problem, a finite-element analysis (FEA) software, Sysweld™, was utilized to analyze the extent and level of residual stresses of such welds through the thickness of the pressure vessel shell. The study also used the gas metal arc welding (GMAW) process to deposit single beadonplate welds with ER70S6 wire on ASTM516 grade 70 pressure vessel steel plates of 6.3, 12.7, and 19 mm thicknesses.

Microstructural analysis, temperature, and distortion measurements of weldments were performed to qualify the FEA modeling results. In addition, the holedrilling method was used for residual stress measurement on the bottom surfaces. Following the through-thickness direction, the maximum tensile residual stresses were invariably observed in the subcritical and intercritical heat-affected zones (HAZ). Maximum tensile stresses at 86 to 104% of the yield strength existed in the bottom surface of the 6.3mm-thick plates, whereas the maximum tensile stresses only reached 26 to 35% of the yield strength in the 19mm-thick plates. This conclusion indicates that, for single-pass welding, the 6.3-mm-thickness application demands PWHT. The 19-mm-thick plates were found with safe conditions where PWHT can either be optional or waived, depending on loading conditions.

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