ABSTRACT

Heat sources such as arc, in fusion welding processes, generate a transient temperature field that has profound influence on the material being welded. The parent microstructure of the material close to the arc movement is modified through one or more of processes such as solidification, annealing and phase transformations. The ultimate physical and mechanical properties in the solidified welded zone (WZ) as well as in the contiguous heat affected zone (HAZ) are in turn controlled by the resulting microstructure. Thus, a reliable computation of transient thermal behaviour forms a critical first step in the analysis of physico-mechanical behaviour of welded materials.

Initial attempts on heat flow analysis used essentially empirical equations. Subsequently rigorous analytical models were developed - particularly that by Rosenthal remains the pioneering work in the field. These models however yield inaccurate results close to the heat source. Numerical models such as FDM and FEM have been successfully applied and are amenable to computation. However they consume extensive computer time if the model were to be applied over the entire plate being welded.

In the present investigation, welding of steel plates using TIG process was considered. A unique mixed boundary condition (Neumann at the axi-symmetry and Rosenthal away from the heat source) was developed for simulating the transient conduction behaviour due to a moving heat source. This mixed boundary model(MBM) was evaluated using two-dimensional, five-point explicit FDM in which temperature dependence of material properties were considered. In addition, more conventional FDM and FEM techniques have also been used to compare the temperature predictions. Further, extensive microstructural observations have been used along with IT and CCT diagrams in order to validate the model predictions. The correlation appears very satisfactory, particularly in the crucial HAZ of the welded plate. The new methodology is thus expected to serve well in evaluating the ultimate physico-mechanical properties of the material through the prediction of microstructure.

KEY WORDS

Computer Modelling, Thin plate TIG welding, Two-dimensional Transient Heat Flow, Analytical (Rosenthal) Solution, Numerical Techniques, FDM, FEM, Mixed Boundary Model, HAZ Thickness prediction, IT - CCT Diagrams, Microstructure and Hardness Predictions.