Modeling of Solidified Surface Profile in GTA Welded Butt and Fillet Joints,
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Introduction

Structurally sound welds of desirable chemical composition often contain geometric features that are detrimental to their mechanical properties. Weld bead morphology (free surface profile) have considerable effect on crack initiation, propagation and growth. Although applications of transport phenomena has lead to significant advances in our understanding of the weld metal geometry based on scientific principles, they have not been focused on understanding and controlling bead morphology. Several investigations on the free surface deformation of liquid weld pool during welding have been reported. However, in most studies, the transient nature of the free surface geometry during cooling was ignored. Therefore, the results were not useful to understand the post-solidification surface morphology of the solidified weld bead that is responsible for weld mechanical properties. Furthermore, much of the previous research was limited to simple rectangular butt welds and, in most cases, did not consider filler metal additions.

The research we seek to present addresses development of bead morphology in the GTA welds of both simple, rectangular butt joints as well as fillet joints with or without filler metal additions. Apart from these features, the research to be presented considers changes of free surface profile due to solidification of the weld pool.

Approach

A new three dimensional numerical model has been developed to investigate heat transfer and fluid flow in the weld pool considering free surface deformation in complex geometry such as the fillet welds. The model considers addition of filler metal. The free surface has been calculated by minimizing the total energy of the surface which includes the surface energy for the change in the area of the pool surface, the potential energy in the gravitational field, and the arc pressure displacing the pool surface. The equations of conservation of mass, momentum and energy are solved numerically using a deformed Cartesian co-ordinate system where the free curved surface is approximated by a set of planer segments. The grid is regenerated periodically to consider changes of the free surface location. The area and volume of the non-rectangular elements at the surface are also recalculated to account for the deformation of the free surface.

Results and conclusions

A model has been developed for the calculation of weld bead shape, size and free surface profile in butt and fillet welds. The weld pool depth, width and shape were in good agreement with the corresponding experimental values for both types of joints. Consideration of weld metal convection, filler metal addition and latent heat effects resulted in more accurate prediction of the size and shape of the weld pool than the results obtained ignoring either the convection in the weld pool or the filler metal addition. The depression of the weld pool surface was investigated

for different welding conditions during GTA welding. The variables investigated were welding speed and power. The depression at the center of the pool surface was more pronounced with higher welding current and lower welding speed. The extent of depression was considerably reduced during solidification of the fusion zone.