"NUMERICAL MODELLING OF WELD POOL
CONVECTION IN GAS METAL ARC WELDING"

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ABSTRACT

An investigation has been made into the development of numerical models of the Gas Metal Arc Welding (GMAW) process. Initial work focussed on furthering the understanding of fluid flow and convective heat transfer in GMA weld pools using theoretical, experimental and numerical techniques. Normalised scale analysis and simplified computational models have shown that the droplet impact forces are the dominant forces in driving weld pool flow. Induced electromagnetic forces are the next most significant, with forces due to surface tension gradients becoming unimportant at welding currents greater than 150 Amps. These results have been verified using flow visualisation experiments and parametric welding studies. The influence of droplet impact on turbulence within the pool has also been investigated and appropriate turbulence models and boundary conditions evaluated.

Further work concentrated on the development of weld pool convection models for the prediction of the weld pool shape and the near weld thermal history. This necessitated the development of 3 dimensional models that solve the Navier Stokes equations for the convection within the weld pool. These have been compared with traditional welding models which use empirically tuned heat source distributions and only consider heat transfer by conduction. This comparison demonstrated that numerical models must include the effects
of convective heat transfer within the pool if weld pool shapes and near weld thermal histories are to be accurately predicted.

Models that solve the full equations of motion within the pool are very computationally expensive and their accuracy is limited by the available turbulence and free surface models. An approximate heat-conduction only model has therefore been developed which uses enhanced thermal conductivity to simulate convection within the pool. The thermal conductivity enhancement is calculated from governing flow parameters using a semi-analytical technique, and the resulting model has been compared to traditional conduction solutions and to models which incorporate convection within the weld pool. This has shown that models using this enhanced thermal conductivity scheme predict weld pool shape and near weld thermal histories with the same level of accuracy as the full convection models and the best of the empirically tuned conduction models. However the enhanced thermal conductivity model requires several orders of magnitude less computational resources than full convection solutions and much less empirical tuning than the modified conduction solutions. As such it appears to be a valuable method for accurate practical prediction of near weld thermal behaviour.