The Effect of Torch Angle on the Heat Transfer, Fluid Flow and Weld Pool Geometry During GTA Welding of AISI 1020 Steel

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Abstract

The effect of torch angle on the geometry of AISI 1020 steel welds was investigated during gas tungsten arc (GTA) welding experimentally and numerically. A mathematical model has been developed to understand the effect of torch angle taking into account the convective flow of liquid metal driven by a combination of electromagnetic, Marangoni and buoyancy forces. The changes in the heat distribution pattern at the weld pool surface and the electromagnetic force field within the weld pool owing to torch angle changes were taken into account in the model. The model numerically calculates temperature and velocity fields and the geometry of the fusion zone. To validate the theoretically predicted results, a set of carefully controlled experiments were also conducted, in which identical plates of AISI 1020 low carbon steel were GTA welded for various torch angles, then the geometry of these welds were determined. The experimentally determined geometry was compared with that obtained from the numerical calculations. Both experimental and theoretical results showed a strong effect of torch angle on the fusion zone geometry. It was found that the penetration depth increased significantly as the torch angle changed from 0˚ to 45˚. The proposed mathematical model could correctly predict the weld pool geometry for various torch angles. The calculation of fluid flow and heat transfer showed that the changes in penetration were mainly caused by the combined effect of changes in power density distribution and the fluid flow pattern which was driven by electromagnetic and Marangoni forces.