

Theoretical model and experimental investigation of current density boundary condition for welding arc study

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Abstract: This paper presents results of theoretical and experimental investigation of the welding arc in Gas Tungsten Arc Welding (GTAW) and Gas Metal Arc Welding (GMAW) processes. A theoretical model consisting in simultaneous resolution of the set of conservation equations for mass, momentum, energy and current, Ohm's law and Maxwell equation is used to predict temperatures and current density distribution in argon welding arcs. A current density profile had to be assumed over the surface of the cathode as a boundary condition in order to make the theoretical calculations possible. In stationary GTAW process, this assumption leads to fair agreement with experimental results reported in literature with maximum arc temperatures of $\sim 21\,000$ K. In contrast to the GTAW process, in GMAW process, the electrode is consumable and non-thermionic, and a realistic boundary condition of the current density is lacking. For establishing this crucial boundary condition which is the current density in the anode melting electrode, an original method is setup to enable the current density to be determined experimentally. High-speed camera (3000 images/s) is used to get geometrical dimensions of the welding wire used as anode. The total area of the melting anode covered by the arc plasma being determined, the current density at the anode surface can be calculated. For a 330 A arc, the current density at the melting anode surface is found to be of $5 \times 10^7 \text{ Am}^{-2}$ for a 1.2 mm diameter welding electrode.

Keywords : Gas Tungsten Arc Welding, GTAW, Gas Metal Arc Welding, GMAW, spectroscopie