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The mechanisms of arc coupling and rotation in cable-type welding wire CO_2 welding

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ABSTRACT In the cable-type welding wire CO_2 welding process, the arc coupling and rotation behaviors are greatly different from those in typical single-wire CO_2 welding. A deflection length model is proposed to explain the phenomenon of arc shape interaction and coupling, which is considered to be caused by a concentration of forces at the central wire resulting from the electromagnetic forces generated by the currents running through the individual wires. The arc rotation is influenced by the compositional characteristics of the cable-type welding wire as the wire is fed, resulting in self-rotation as the wire melts. The arc stability, the droplet transfer behavior and the weld pool are affected by the balance of the forces during the welding process and cause the arcs from the cable-type welding wire to couple together, resulting in a stable arc and stable droplet transfer. The combined forces acting on the weld pool are beneficial for the transfer of arc heat and droplet heat to the side and bottom of the molten pool, affecting the weld pool and weld formation.
Keywords: GMAW, Cable-type welding wire, Arc coupling and rotating, Droplet transfer, Arc mechanism, Weld formation

1. Introduction

Four special gases have been used in the welding process to achieve stable rotating spray transfer and overcome the limit on the welding current, as reported by Lahnsteiner et al. (1992). In this process, Ar, He, CO_2 and O_2 play different roles in determining arc contraction, increasing the arc voltage, shielding, establishing an electric potential gradient and ensuring stability. Tandem welding is one of the most popular methods for improving productivity in gas-shielded metal arc welding (GMAW). Sproesser et al. (2016) suggested that tandem GMAW can substantially increase welding efficiency and cost-effectiveness. The electricity consumption is reduced in this high-power tandem GMAW process. For the case of double-electrode GMAW (DE-GMAW), Li et al. (2007) investigated bypass GMAW using a non-consumable tungsten electrode to change the melting current in the base metal during the GMAW process. This change in the melting current increased the welding speed and productivity by allowing the base-metal current to be controlled via the bypass arc. Fang et al. (2016) established an indirect welding system with three wires and two power sources (TW-GIA). The combination of a pulsed direct current with a direct current resulted in a stable process capable of a high wire-melting rate, a low dilution rate and a low penetration depth. Goecke et al. (2001) improved welding productivity using the tandem GMAW-P method. This method allowed the heat distribution in the weld pool to be varied under the same heat input, making it possible to maintain a suitable force balance during high-speed welding. Meng et al. (2014) suggested a hybrid TIG-MAG arc welding process to achieve high-speed welding, in which the balance between the TIG-MAG welding current and the probe wire-electrode distance was the key factor in stabilizing the welding process. Some researchers have incorporated the use of a laser beam into the GMAW welding process to improve the welding speed. Choi et al. (2006) used a laser beam

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