Influence of argon shielding gas flow rate on the cooling and solidification of AA5087 aluminum alloy during wire arc additive manufacturing

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Wire Arc Additive Manufacturing based on Metal Inert Gas welding (WAAM-MIG) has emerged as a cost-effective technique for fabricating large-scale aluminum alloy components [1-4]. However, the deposition process is strongly influenced by process parameters that govern thermal behavior and layer formation. Among these parameters, the argon shielding gas flow rate plays a critical role - not only in controlling cooling and solidification rates, but also in stabilizing the arc, thereby influencing the geometry of individual layers [5-6].

This study investigates the combined effects of argon flow on thermal gradients, bead morphology, and dimensional stability during WAAM-MIG production of an AA5087 aluminum alloy component, using both numerical simulation in ANSYS software and experimental validation. The deposition process of ESAB OK Autrod 5087 filler wire, with a diameter of 1.2 mm, onto the surface of an AW5083 aluminum plate with a thickness of 4 mm was carried out using a Fronius TPS600i welding power source, with a welding current of 65 A and a voltage of 16.1 V. Argon shielding gas at flow rates ranging from 6 L.min^{-1} to 14 L.min^{-1} was applied, along with a constant travel speed of 5 mm.s^{-1} and a wire feed speed of 4 m.min^{-1}. The produced weld bead had a length of 100 mm.

At lower argon flow rates, insufficient shielding leads to broader, flatter layers due to extended melt pool spreading. In contrast, excessive flow can disturb the molten pool, resulting in irregular and elevated beads. The obtained results show that an optimal gas flow rate enhances convective heat extraction, promoting refined microstructures and consistent bead geometry. The findings demonstrate that argon gas flow rate directly affects bead height, width, and surface uniformity, with significant implications for geometric accuracy and mechanical properties of the final components. This work underscores the importance of optimizing shielding gas dynamics to achieve both desirable microstructural characteristics and dimensional precision in WAAM-fabricated AA5087 parts.

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