Concept and Validation of an Active Cooling Technique to Mitigate Heat Accumulation in Metal Additive Manufacturing

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Leandro João da Silva (a), Danielle Monteiro Souza (a), Douglas Bezerra de Araújo (a), Ruham Pablo Reis (a), Américo Scotti (a,b)
(a) Federal University of Uberlândia (UFU), Laprosolda – Center for Research and Development of Welding Processes, Uberlândia, MG, Brazil
(b) Högström Väst (University West), Department of Engineering Science, Production Technology West, Division of Welding Technology, Trollhättan, Sweden

This work was aimed at introducing and exploring the potential of a novel thermal management technique, called near-immersion active cooling (NIAC), to mitigate heat accumulation in wire fed metal Additive Manufacturing processes. According to this proposed technique concept, the part is deposited inside a work tank that is filled with water, whose level rises while the metal layers are deposited. For validation of the NIAC technique, Al5Mg single-pass, multi-layer linear walls were deposited by using an arc-based deposition process under different thermal management approaches. During deposition, the temperature history of the parts was measured. Porosity was assessed as a means of analyzing the potential negative effect of the water cooling and possible water vapor in the NIAC technique. The preform geometry and mechanical properties were also assessed.

The results showed that the NIAC technique was efficient at mitigating heat accumulation in WAAM of deposited aluminum parts. The temperature of the part was kept low independently of its height. There was no measurable increase in porosity associated with the water cooling. In addition, the wall width was virtually constant, and the anisotropy of mechanical properties was reduced, characterizing an improved part quality. Thus, the NIAC technique offers an efficient and low-cost thermal management approach to mitigate heat accumulation and resulting deleterious effects of the natural cooling approach used in current wire-fed Additive Manufacturing processes.