Towards a novel thermal criterion for form defects prediction in Wire Arc Additive Manufacturing: Finite element modelling and validation (Sim-AM 2019)

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ABSTRACT

Wire arc additive manufacturing (WAAM) enables the production of metallic parts by depositing beads of weld metal, layer-by-layer, using arc-welding technologies. Combined of an electrical arc as a heat source and a wire as feedstock, this technology has the ability to manufacture large parts at a high deposition rate. However, the quality of parts produced by WAAM is greatly affected by the various thermal phenomena present during the manufacturing process. Numerical simulation remains an effective tool for studying such phenomena. In this work, a finite element model is built in order to investigate the thermal behavior in WAAM, based on a novel metal deposition technique. This latter allows to gradually construct the mesh representing the deposited regions along the deposition path. The heat source model proposed by Goldak is adapted and combined with the proposed element deposition technique taking into account the energy distribution between filler material and the molten pool. Furthermore, a novel thermal criterion is developed based on the proposed finite element model, allowing a better prediction of cracking and defects in the fabricated parts. The effectiveness of both the proposed model and the thermal criterion is validated by series of experiments carried out using a WAAM system that integrates Fronuis cold metal transfer (CMT) welding equipment, and a six-axis robot. Different thin-walled components are fabricated according to different deposition strategies, and the temperature curves measured during the manufacturing process are compared to the FE-results in order to verify the accuracy of the model. The geometrical defects in the different fabricated parts are also analyzed and explained using the proposed thermal criterion, showing the impact of the deposition strategy on the quality of parts produced by WAAM.