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REFINING PARAMETERS AND PROCEDURES FOR PRODUCING COMPONENTS WITH A WIRE ARC ADDITIVE MANUFACTURING (WAAM) SYSTEM

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ABSTRACT

Wire Arc Additive Manufacturing (WAAM) is a process with the potential to supply industries with large form-factor prints, at a deposition rate far greater than that of powder bed sintering, that uses standard welding consumables to print solid metal parts with properties comparable to conventionally manufactured components. WAAM applies technology from Gas Metal Arc Welding (GMAW) that uses an arc to melt a metal wire consumable (that is also used as the electrode) and deposit it on a surface/structure, making it a subset of Directed Energy Deposition (DED). Cold Metal Transfer (CMT) is a GMAW program that advances and retracts the wire at a high frequency and briefly short circuits the wire with the build surface. This allows for far higher material deposition rates whilst allowing the thermal input to be reduced, and hence was used in the WAAM system. The CMT welding torch was controlled by a 6-axis robot arm in conjunction with a 2-axis positioner to create 3D prints.

A common low carbon mild steel consumable, ER70S-6, was initially deposited in walls one bead thick and 10 layers high. The fundamental process parameters (Wire Feed Speed (WFS), torch travel speed, and layer height) were adjusted to observe the effects on the bead/wall geometry, and a database of compatible parameters and the resulting bead geometries was compiled. Leading on from this, more complicated geometries were printed, such as cubes, hemispheres, and pyramids, and the bead geometry database was expanded by investigating the effect of CMT specific parameters such as Arc Length Correction and Dynamic Correction.

One significant limiting factor in the speed of printing that also presents complications with the microstructure of the final part was thermal accumulation during the print. Apparatus consisting of a finned heat sink base, thermoelectric modules, and an air blower was designed, and its effectiveness at removing thermal energy from the print, both passively and actively, was investigated. Additionally, a specialised program, CMT Cycle Step, was used to experiment with printing single droplets stacked vertically, and once dialled in, these successful parameter combinations were added to the system repertoire.

Samples were cut, polished, and etched to observe the present phases/microstructures and understand how the welding parameters affected the resulting deposited alloy. Once all results had been collated, a complex part was designed and, utilising the bead geometry database and other findings, the model was printed.

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