Reducing Post-Processing and Allowing Free Complexity in Metal Additive Manufacturing

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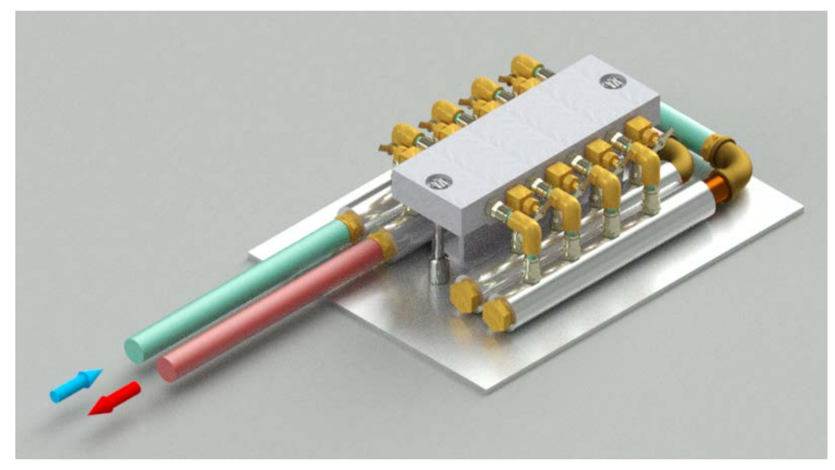


William House's CAD Model

Abstract

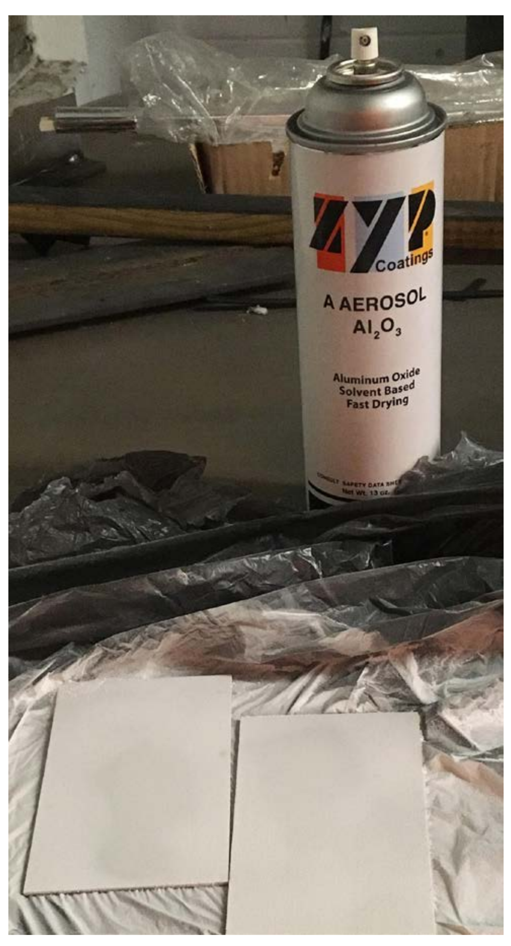
Wire Arc Additive Manufacturing (WAAM) is a Near-Net-Shape additive manufacturing (AM) economical process technology. Based on a 3D CAD description of geometry, layers of welding passes are deposited on a substrate forming a part, and usually a wire electrical discharge machine (EDM) is used to detach the part from the substrate. EDM detaching is the main deterrent companies have against WAAM.

This project's main goal is to increase feasibility of WAAM in manufacturing by shortening lead-time, a problem common in AM due to post processing, with the ability to build complex bottom geometries by characterizing relationships between welding materials, ceramics, cooling methods, and process parameters.

The approach used in this project is to apply different ceramic coatings between the AM part and the substrate. The ceramic coatings tried in this are aluminum oxide, yttrium oxide, zirconium oxide, boron nitride, etc. A special cooling system was designed to provide a heat sink under the substrate to avoid/minimize the fusion of the interface layer of the AM parts to the substrate. The success of this novel technology is determined by the ability to separate the AM from the substrate with a small shearing force using a tool like a hammer.

Initial Ideas

- Ceramic Coating Layer
  - Aluminum Oxide
  - Boron Nitride
- Cooling Methods
  - Refrigerated Block
  - Cooling Bed
- Removal Methods
  - Impact Tester
  - Hammer
  - Hand Removal



Coating Layer

- Prevents penetration of weld to substrate
- Tested aluminum oxide
- Worked on small scale

Repeatability

- Need automation for experimental integrity and production simulation
- Build CNC-controlled gantry-operated robotic welder
- Fabricate fixture for welding gun
- Use Spindle On/Spindle Off for Feed On/Feed Off

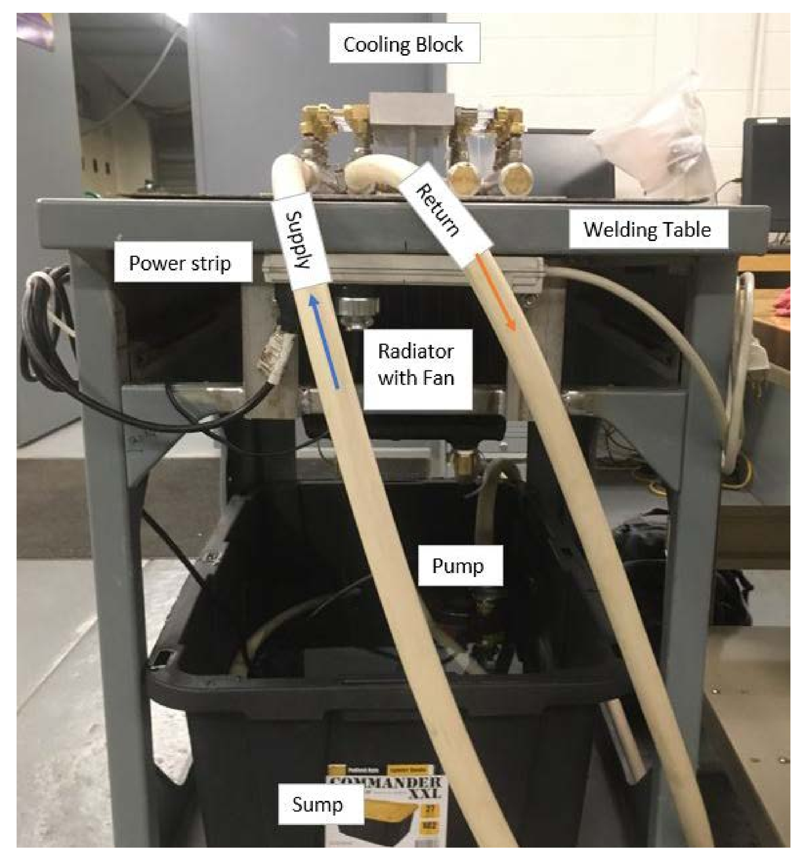
CNC Router Parts

Cooling Bed

- Acts as heat sink to cool substrate
- Prevents penetration of weld into substrate by protecting the coating
- Variable cfm minimizes warping due to residual heat stress

Cooling Bed Operation

1. Water pumped to block
2. Water fills block, flow controlled by needle valves on return side
3. Hot water flows into radiator, cooled by fan
4. Water returns to sump



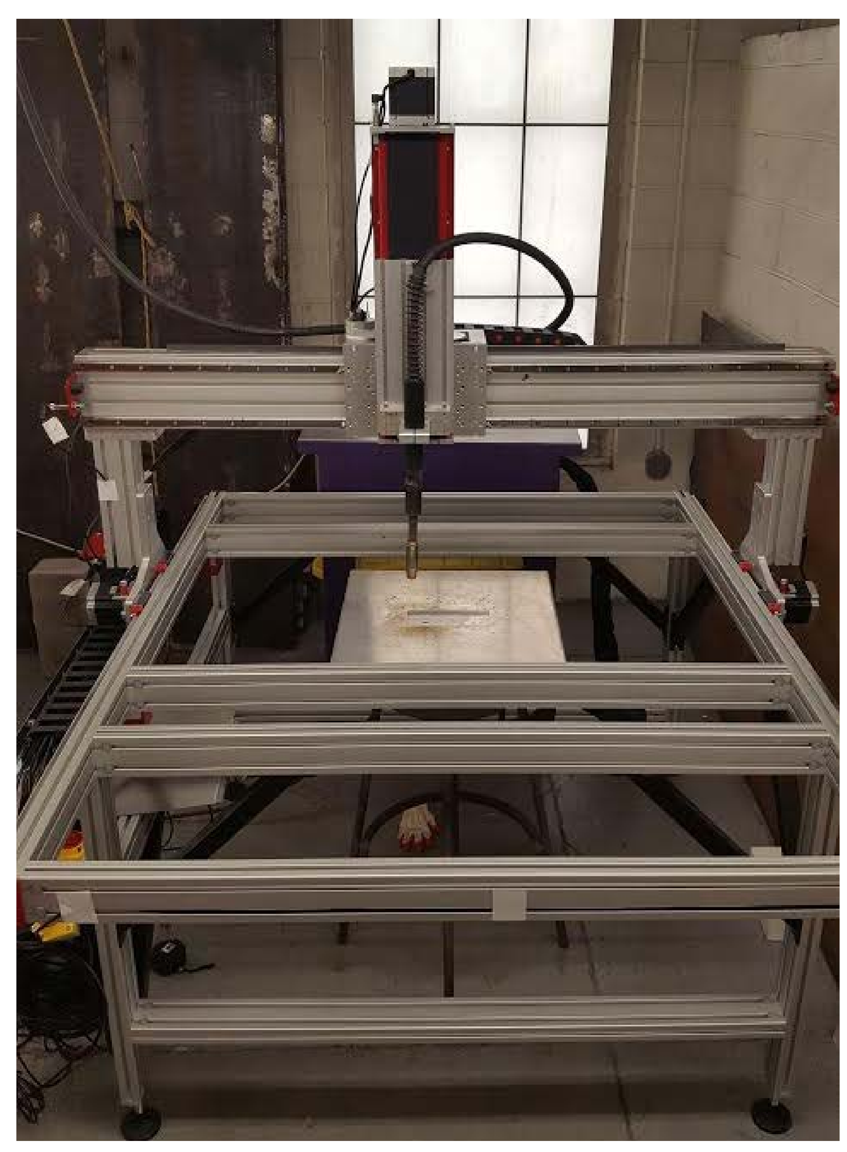
Testing Cooling Bed

- 1/8" Steel Substrate
- Warmed in oven to 216˚
- Control cooled on 1 1/8" aluminum flat bar as with cooling bed block
- Temperature measured with infrared thermometer
- Shows faster cooling rate with water cooled block

Seconds	0	30	60	90	120	150	180	210	240	270	300
Control (°F)	216	170	144	123	108	104	100	93	85	85	85
Cooling Bed (°F)	216	109	86	77	76	75	75	75	75	75	75

Tying Things Together

1. Substrate is coated in ceramic
2. Substrate is loaded onto cooling bed
3. Gantry robotic welder deposits molten metal onto coated substrate
4. Impact tester determines energy required to remove part



Future Work

- Testing parameters (feed, speed, voltage) by running beads
- Depositing aluminum parts
- Change cooling bed material to copper and add electronics
- Research better coolant
- Further complexity research

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