3D Metal Printing

Team Members – Brian Andrews, Branden Driver, Cameron Tribe, Ahmad Qazi
Faculty Advisor – Marek Perkowski
Industry Sponsor – Aram Kasparov

Project and Motivation

The purpose of this project is to create an alternative to the metal casting process which can be expensive and result in long lead times. The project goal is to create a 3D metal printer that is capable of quickly creating metal components at a lower cost. The final products of this printer will be used in industrial water pumps that must be precision machined after the fact, so precision of the print is not a major concern for this project.

A MIG (metal inert gas) welder will be combined with a CNC machine, as seen in Figure 1. MIG welders feed wire out of their nozzles; this wire will be the deposition material. Building upon previous layers of deposition, a 3D object will be printed in metal.

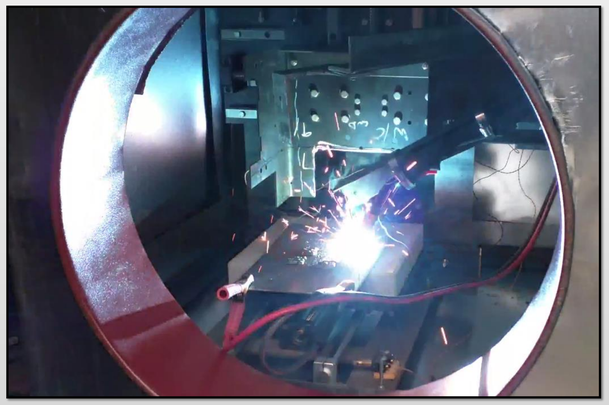

Fig 1. System in Deposition Mode

Goals

- Create a cheaper alternative to metal casting with a reduced lead time.
- Interface the MIG welder with CNC machine.
- Determine quality of deposition based on temperature and current.
- Control the MIG welder based on quality of deposition.
- Allow for future expandability

Control System

Control of the system is done using a PCI Express DAQ board from Sensoray CO Inc. The board has 48 digital I/O pins, sixteen 16-bit analog inputs, eight 16-bit analog outputs, and six counter channels. The controller receives inputs from 4 sensors that monitor the deposition. Based on these inputs, the controller will adjust wire feed speed to ensure an accurate deposition. If at any point an error occurs, the system will pause and wait for corrections to be made. Sensor descriptions are shown below.

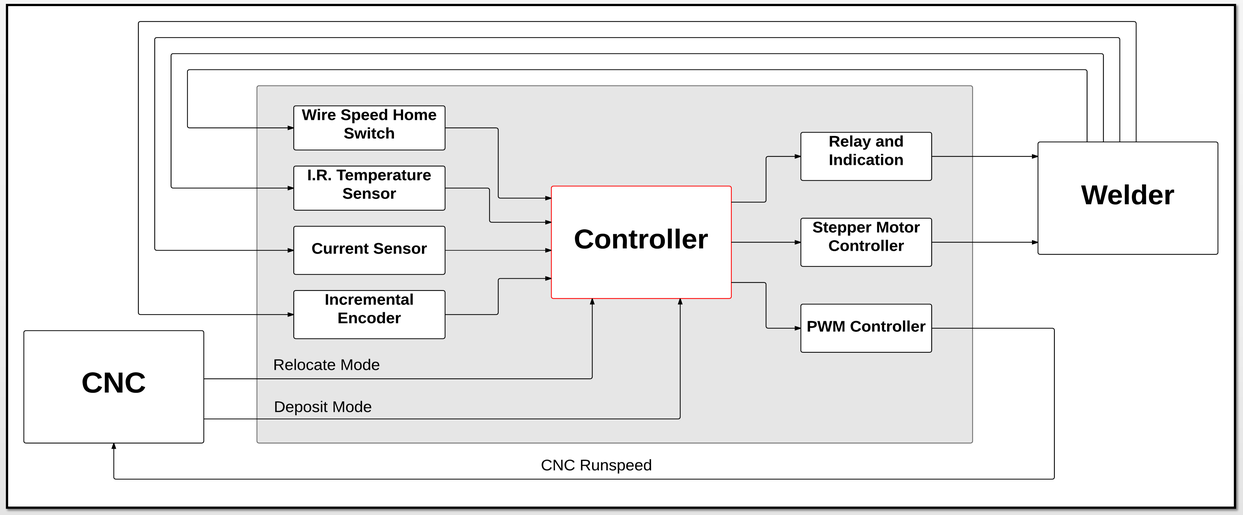

Fig 2. Block Diagram of System

Current Sensor

Data from the current sensor gives an idea of the precision of the deposition. The current sensor is placed in-line with the ground connection of the welder. When the wire of the welder completes the circuit, it melts the wire and creates a small droplet of molten metal that is shown as a spike in current. Using a peak detection algorithm, the frequency of droplets being deposited can be determined. Comparing these values to a nominal value found through testing, the wire speed knob is adjusted.

Relay and Indication:

The CNC machine has two movement modes: relocation and deposition. Each movement mode has its own digital signal, which is read by the controller. The controller uses these signals to activate or deactivate a relay, which bypasses the mechanical switch on the welder gun. This relay module also includes visual indication of the current CNC movement mode.

Incremental Encoder

Attached to the wire feed drive pulley inside the welder is an incremental encoder that is used to calculate the actual wire speed. During testing, this sensor was used to find ideal wire and CNC speed pairs. At the beginning of each print, a user inputs the CNC speed that the machine will be running at and the system sets up the appropriate initial wire speed. This is done via a process that sends the wire speed adjustment knob to a home position and measures the wire speed at that position. This provides an offset which is used in all proceeding wire speed calculations.

I.R. Temperature Sensor

An infrared temperature sensor is used to provide a reading of temperature prior to depositing material. When the temperature of the weld is outside of the allowed range, the system will pause. If it is too hot, the system waits for the deposition to cool and if it is too cold, a hand held torch is used to manually heat the part.

Project Outcomes

Through testing, the following outcomes were successfully completed:

- Selected a controller that minimized limitations of future expansion.
- Accurately measured speed of wire leaving the welder.
- Created a system that dynamically calculates and controls the wire feed rate.
- Determined welder settings in correlation with CNC settings to achieve a quality weld.
- Created a homing and calibration procedure for the welder settings.
- Controlled the temperature of the plate being welded to via feedback from the temperature sensor.

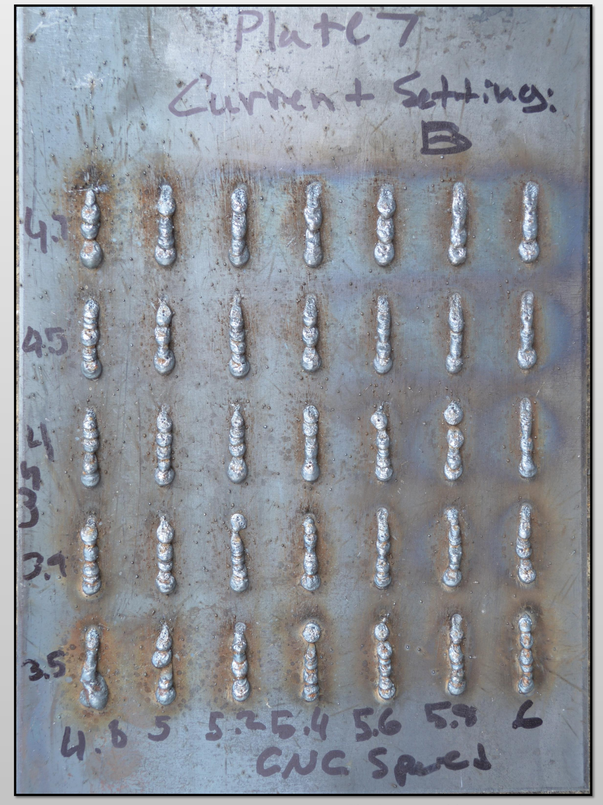

Fig 3. Deposition Testing

A special thanks to Jim Lamberson at Sensoray