E. PARAMETER CHARACTERIZATION OF MECHANICALLY CONTROLLED PULSED SHORT CIRCUIT GMAW

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Introduction

Short circuit GMAW is typically used for applications such as joining of thin materials due to the low heat input that is inherent with the process. While conventional short circuit GMAW may be optimal for out-of-position welds and other low heat input scenarios, it is inevitable that some arc instability and spatter will occur. Advanced GMAW control systems minimize spatter during short circuit transfer through the use of electrical sensing and inverter control algorithms. Recent advances in technology have led to the advent of Mechanically Controlled Pulsed Short Circuit (MCPSC) GMAW which exercises both electrical and mechanical control of the droplet transfer. With MCPSC-GMAW the wire is fed forward and then reversed many times per second in conjunction with adjustment to the current level. In order to achieve spatter-free metal transfer, the current level is dropped as the shorting-phase occurs, and is increased when the arcing phase occurs. One drawback of these systems is their complexity. In all, 10-20 user inputs are required to set the mechanical and electrical control parameters for particular applications. The objective of this research was to characterize the relationships between user inputs and measured outputs for a commercially available MCPSC-GMAW power source. The results of this work will allow more efficient procedure development for particular applications.

Experimental Procedure

The selected equipment had 11 user input parameters. A screening trial was performed to determine which of these parameters have the greatest influence on the following process outputs: short circuiting frequency, deposition rate, heat input, and arc length. Based on the results of the screening trials, specific parameters were selected for evaluation using a design of experiments (DOE) approach.

All of the current and wire feed speed input parameters were included in the study. A total of six current inputs need to be specified by the user in the system studied. Three of these inputs are related to the arc phase of the current cycle, while the other three are related to the short circuit phase. Figure 1 is a schematic diagram illustrating the three current inputs corresponding to the arc and short circuit phases.

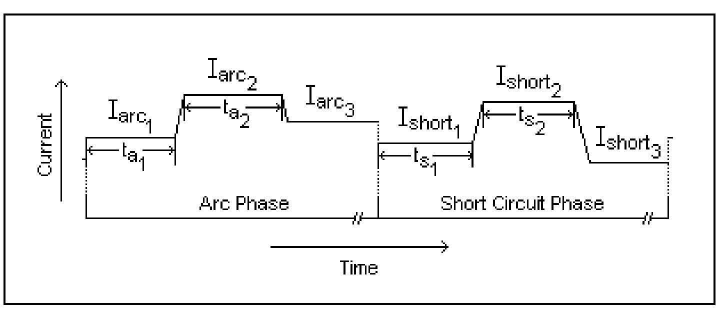

Figure 1. Schematic Diagram of the Current Cycle

Three wire feed speed inputs are required in the system studied. Two of these are the wire feed speed in the forward and reverse directions, while the third is the wire feed speed during the withdrawal of the electrode immediately following shorting.

An empirical model was developed predicting wire feed speed as a function of current input for each of three arc lengths (0mm, 1mm, 2mm). This was done by making bead-on-plate welds on mild steel using 0.045” NiCr-3 solid wire, and 100% Helium shielding gas. The wire feed speed corresponding to each current input and arc length condition was then recorded using a data acquisition system.

Deposition rate was then characterized as a function of the six current inputs, three wire feed speed inputs, the contact-tip to work distance, and the average arc current. These tasks were executed by making bead-on-plate welds on mild steel using 0.063” NiCr-3 solid wire, and 50-50 Argon-Helium shielding gas. The welds were then sectioned and metallographic analysis was used to determine the deposited cross-sectional area.

Results

As shown in Figure 1, the wire feed speed increases linearly with the current input setting. Also interesting to note is that the wire feed speed corresponding to a given current input setting increases with arc length. This difference is minimal at low current input settings but becomes increasingly noticeable as the current input setting is increased.

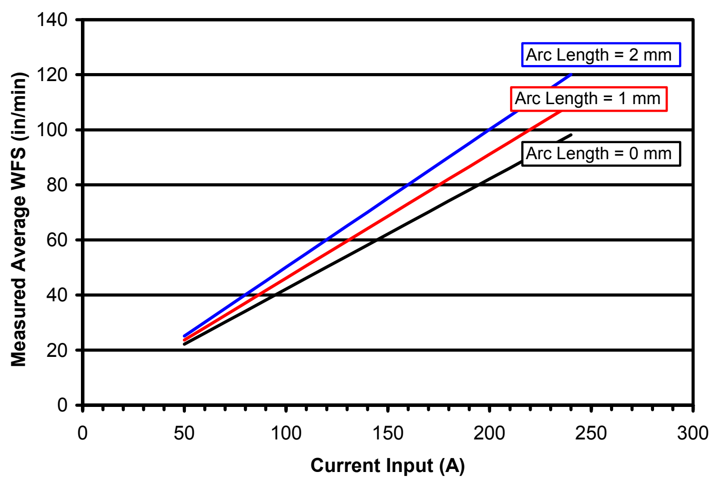

Figure2. WFS vs. Steady Current Input

The most significant electrical input in terms of deposition rate is the last current experienced during the arc phase, prior to entering into the shorting phase. When compared to the other five current inputs, changes in this input resulted in the greatest changes in the deposition rate.

Deposition rate decreased with increasing wire feed speed in the forward direction, and increased with wire feed speed in the reverse direction. The wire feed speed during the withdrawal of the electrode immediately following short circuiting had a less significant effect on the deposition rate then the two wire feed speed inputs corresponding to the forward and reverse directions. The deposition rate also increases with contact-tip to work distance, and to a much lesser degree, with steady arc current.

Conclusion

Mechanically Controlled Pulsed Short Circuit (MCPSC) GMAW is designed to reduce or eliminate spatter during short circuit transfer by exercising both mechanical and electrical control of the droplet transfer. A potential drawback of this system over conventional GMAW systems is the increased complexity that results from significantly more user inputs. The research conducted during this project provides useful insight into the input-output relationships of this system, allowing a rational selection of parameter settings for particular applications. Additional work is required to make a full characterization of this system for particular applications.