B. Characterization of Adaptive Arc Length Controls for Pulsed Gas Metal Arc Welding

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Introduction

In gas metal arc welding, control of the arc length is an important parameter since it affects heat distribution and weld quality. Adaptive arc length controls are used to modify the GMAW-Pulse current waveform in response to disturbances (such as contact-tip-to-work and wire feed variations), thus adjusting the burn-off rate of the electrode to control the arc length. Several methods of adaptive arc length control have been developed and implemented in commercial power supplies. The performance of adaptive arc length controls have not been extensively quantified through experimental testing. A methodology was developed for testing adaptive arc length controls that can be used for evaluating power supplies for use in both manual and automated welding applications.

Technical Approach

An apparatus was specially designed to rapidly increase the CTWD of the GMA torch by 0.25 inches during welding. It was named the Transient CTWD, or T-CTWD test, since it allowed the transient response of the arc length to be observed. High-speed video and data acquisition were used to measure the arc length, metal transfer behavior, and pulse parameters during the T-CTWD tests. Three commercial pulsing power supplies with differing methods of adaptive arc length control were studied over a range of wire feed speeds on carbon steel. One of the power supplies was tested in its conventional constant voltage mode. To eliminate variability in the results due to power supply electrical design, the observed waveforms of each power supply and their respective methods of adaptive arc length control were subsequently reproduced on one power supply and subjected to the T-CTWD test. The influence of different pulse waveform shapes on arc length control performance was also investigated.

Results and Discussion

It was found that the tested adaptive arc length controls employed by the various power supplies had different methods of modifying the current waveform. Depending on the type of adaptive arc length control, up to three different pulse parameters are changed in order to regulate the arc length when the CTWD is increased. Arc length control performance was measured from the response of the arc length and related electrical parameters. It was found that different adaptive arc length controls employed by varying manufacturers accounted for a difference in performance of controlling the arc length and in the time of regulation of the arc length over a range of testing conditions when subjected to the CTWD increase. Weld bead shapes were found to mostly decrease in penetration and base metal dilution when the CTWD increased for the adaptive arc length controls. When the CTWD increased, very little bead shape differences were observed between different adaptive arc length control strategies. However, less change in heat input during the CTWD increase helped maintain constant penetration and dilution at low wire feed speeds, but it was not the case at medium to high wire feed speeds. Longer arc lengths after the CTWD increase resulted in significantly less penetration and dilution, and also produced undercut of the weld bead. Additional research found that the particular strategy of modifying the pulse current waveform to control the arc length was found to have a significant impact on the performance of the adaptive arc length controls. Pulse parameter waveform differences were also seen to have an impact on arc length regulation performance.

Conculsions

The T-CTWD test method effectively characterized the strategy and performance of the adaptive arc length controls used in the selected modern waveform controlled power supplies. In terms of dynamic performance of the power supplies with adaptive arc length controls, some were seen to have faster speeds of arc length correction that enable higher bandwidths of CTWD oscillation (up to 1.5 Hz difference for given test conditions). Evaluation of steady state performance revealed that arc length changes after the CTWD increase varied from no change to 0.1-inch increase for a given power supply and test conditions. At low to medium WFS, the adaptive arc length controls were viewed to result in a more controlled arc length response and have better control of metal transfer conditions than the self-regulation process with CV when the CTWD increased. At higher WFS, the self-regulation process was determined to give better arc length control performance than the adaptive arc length controls.