



Images of a Steel Electrode in Ar-2%O₂ Shielding during Constant Current Gas Metal Arc Welding

A set of clear images gives a visual representation of transfer modes in GMAW

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ABSTRACT. A collection of well-specified, clear images is presented that illustrates the condition of a steel gas metal arc welding electrode in Ar-2%O₂ shielding gas over a wide range of constant welding currents. The images show that the transition from globular to spray transfer mode occurs over a narrow current range. The transition from spray mode to streaming mode is not evident.

Introduction

In gas metal arc welding (GMAW), a low-voltage electric arc plasma is maintained between a workpiece and a wire electrode, both of which are melted by the arc. When Ar-2%O₂ is used for the shielding gas, drops of molten metal detach from the wire electrode in a uniform manner. At low welding currents, the drops are large compared to the electrode and assume classic pendant drop shapes determined by surface-tension and gravitational forces. As the welding current is increased, the drops become smaller and more frequent, and magnetic forces accelerate the drops off of the end of the electrode. If the current is in-

creased further, a taper forms on the end of the electrode, and the drops become small relative to the diameter of the electrode. At high currents, a short column of molten metal streams off of the end of the electrode taper, and small drops are formed by the breakup of this column. Finally, at very high currents, asymmetric magnetic forces become significant compared to the inertial forces in the streaming column of metal and the column spirals about the electrode axis.

Such a description of metal transfer in Ar-2%O₂-shielded GMAW is commonly found in the literature and the various transfer conditions have been classified into metal transfer modes (Ref. 1). The large drops at low currents are commonly referred to as the globular transfer mode. Metal transfer at mid-range currents, typically after an electrode taper has formed, is known as the spray transfer mode. At high currents, drops formed by column breakup are known as the

streaming transfer mode, and at very high currents, the spiraling column is known as the rotating transfer mode.

Only a limited number of experimental images of these modes is available in the literature. For example, images of globular transfer at unspecified currents may be found in Ref. 2 (Fig. 17), Ref. 3 (Fig. 4A) and Ref. 4 (Fig. 19). More carefully specified images may be found in Ref. 5 (Fig. 1) and Ref. 6 (Figs. 22 and 24). Unclear images of spray transfer may be found in Ref. 7 (Fig. 5) and images of spray transfer at unspecified currents may be found in Ref. 3 (Figs. 4B and 8). More carefully specified images of spray transfer may be found in Ref. 6 (Fig. 26). Finally, an unspecified image of rotating transfer may be found in Ref. 1 (Fig. 7.14).

Not available in the literature is a carefully specified set of images showing the transition from globular to rotating transfer using the same electrode and shielding gas. Such a set is presented in the Appendix. This gallery of clear images illustrates the condition of a steel GMAW electrode in a Ar-2%O₂ shielding gas over a wide range of currents. The experimental conditions in effect when the images were collected are described in the next section, followed by a discussion of the images.

Description of Experiments

The images in the Appendix are of bead-on-plate gas metal arc welding operated in constant current mode, that is,

KEY WORDS

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Argon

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paper was extracted from Appendix A of the first author's doctoral thesis in the Department of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology (Ref. 11).

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Appendix

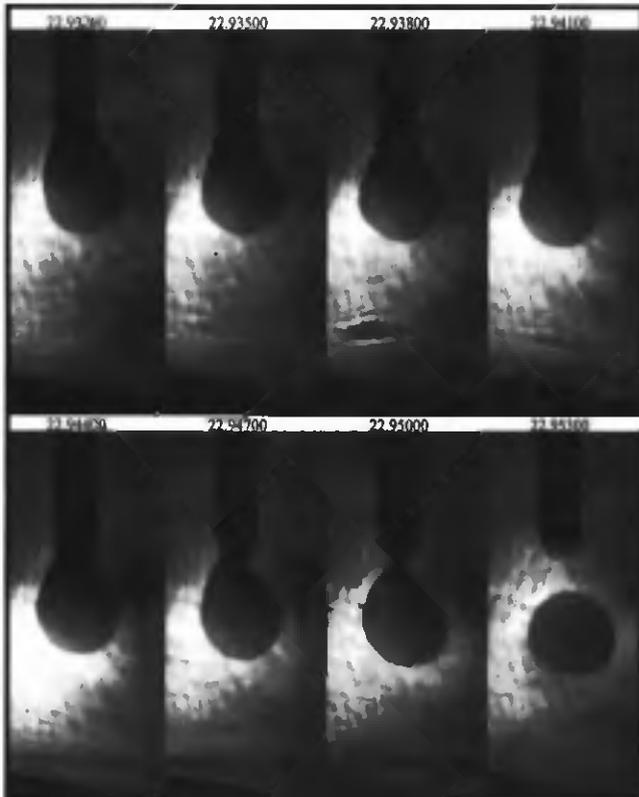


Fig. A1 — Constant current GMAW at 180 A and 27 V in Ar-2%O₂.

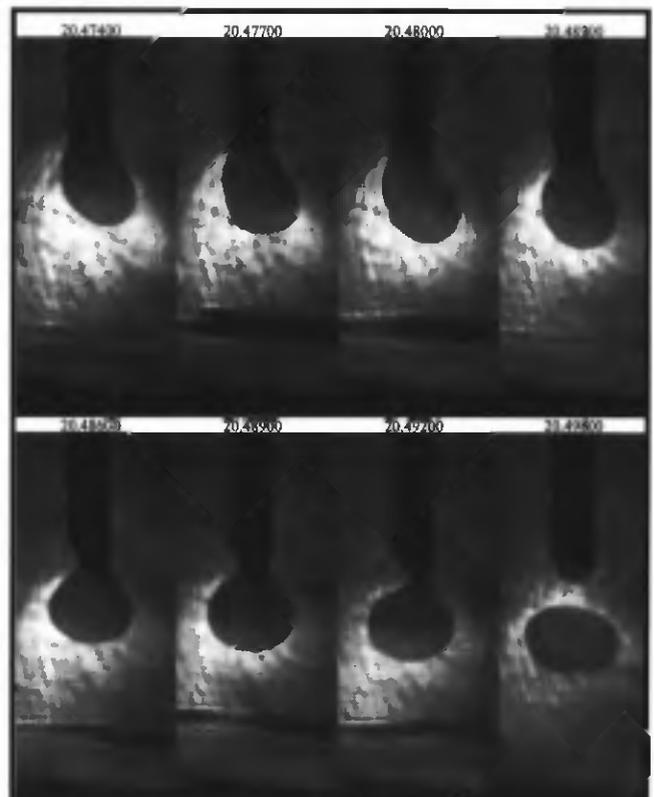


Fig. A2 — Constant current GMAW at 200 A and 27 V in Ar-2%O₂.

