Waveform Control in Welding Power Supplies

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Welding, the fusion of metal parts by applying heat or pressure, is a ubiquitous part of the modern manufacturing process. One of the most common sources of heat for welding is an electric arc. Although arc welding technology has been used since the 1880s, welding equipment manufacturers continue to improve the control of this process.

In gas metal arc welding (GMAW) the arc is created by applying a voltage between a wire electrode and the workpiece, which consists of two pieces of metal that are to be joined. If the voltage is high enough and the distance between the electrode and the workpiece is small enough, an arc is created. The electrode itself is consumable filler material, which melts due to the heat of the arc and is transferred to the weld area in droplets. The wire is automatically fed to replace the melted material.

Until recently, GMAW power supplies regulated their output (usually ac) to achieve either a constant-amplitude current or voltage. However, the welding arc plays many different roles. The arc must provide sufficient heat to melt the electrode at the desired rate, while ensuring proper fusion and microstructure of the solidified weld. In addition, electrical forces in the arc plasma interact with the melting material of the electrode; this interaction can affect the size of the droplets and the velocity at which the droplets hit the workpiece. The convergence of advanced power electronics and fast computation has enabled welding power supply control to become more sophisticated, with power and voltage controlled by means of feedback to follow prescribed periodic waveforms that achieve different requirements at different times.

An example of periodic excitation is the proprietary surface tension transfer (STT) process developed by Lincoln Electric. In this process, the melting electrode material contacts the weld pool on the workpiece before detaching, creating a periodic short. At the start of the cycle (T1 in Figure 1) the heat from an arc melts the material at the end of the electrode. Note that the voltage and current amplitudes are constant, implying a fairly constant heat source. After enough of the electrode material has melted, the droplet is large enough to touch the workpiece, causing a short. The power supply control immediately reduces the current, allowing surface tension forces to draw the droplet downward. After a short period of time (T2), a large current pulse accelerates the droplet movement, resulting in a thinning neck. By monitoring the increasing electrode impedance, the current is reduced before the droplet separates (T3), and the metal is transferred to the workpiece with very little splatter. The arc is then reestablished (T4). A second current pulse (T5–T6) is introduced to increase arc length and heat a wide area of the workpiece to promote fusion. A lower level of current is then applied, which serves as a fine heat control. Typical waveform cycle periods are 1/120 s.

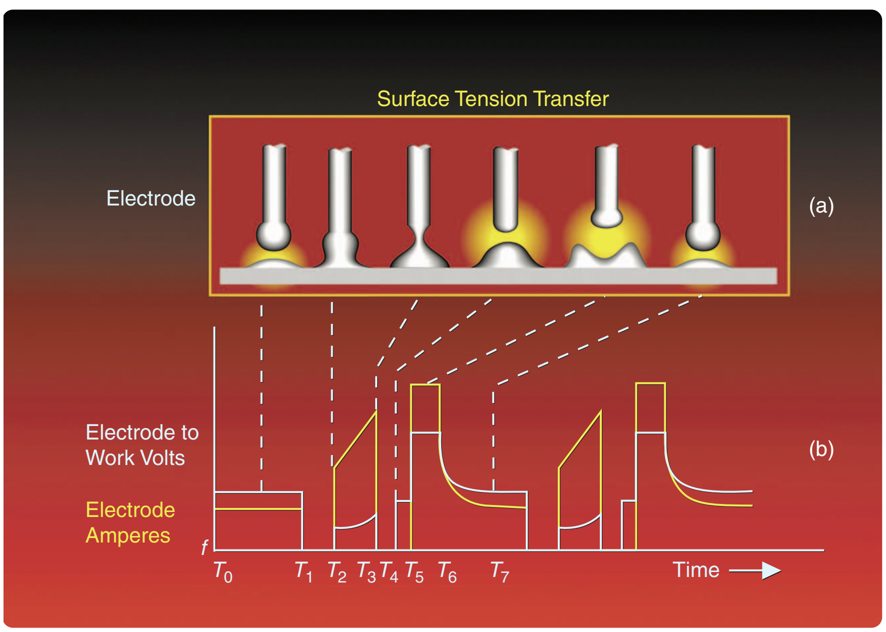

FIGURE 1 Electrode behavior during the welding process. (a) The different stages of droplet deposition, from initial droplet formation to contact and eventual transfer to the workpiece. (b) The voltage between the electrode and workpiece (white) and current through the electrode (yellow) are plotted versus time. The dotted lines indicate at what time the droplet formation images occur relative to the voltage and current waveforms. (Figure used with permission of Lincoln Electric Company, Cleveland, Ohio.)

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According to [2], the major benefits of the STT process are substantially reduced spatter, ease of welding, lower arc radiation, reduced fume generation, and lower heat input on thin-gauge material.

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The wonderful sights of Seville, Spain, are a delight to the tourist. Perhaps only an attendee of the CDC/ECC, however, might take special note of the Sevillian manhole covers. At first glance, one might think that the city of Seville had made an extraordinary effort to welcome attendees affiliated with the Society of Instrumentation and Control Engineers, one of the leading professional organizations in the field of control. A report on the CDC/ECC appeared in the June 2006 issue of this magazine.

D. BERNSTEIN

Reflex and Cortex

Helmholtz once made disparaging remarks about the human eye and suggested specific mechanical improvements: but no machine in existence is anything but a clumsy fake, no more lifelike except for motion, than a mummy, in comparison with any living vertebrate. This holds more particularly true for the higher human functions, in which sensitivity, imagination, emotional responsiveness, feeling, sexual passion, love, with all their associated symbols, provide an otherwise unattainable enrichment that no machine can even feebly utilize or duplicate.

Above all, only organisms that can reproduce and renew themselves have stood the test of time, maintaining continuity, exhibiting creativity, and temporarily reversing entropy. As for automation and cybernation, which technologists now boast of as the highest product of their art—what are they but the most ancient of organic devices, rather than the most modern: equivalent to the reflexes, not the cerebral cortex. In this evolutionary sense automation, if treated as a goal of human development, would be a backward step—as in some areas it already is.

—L. Mumford, The Myth of the Machine: The Pentagon of Power. *New York: Harcourt, Brace, Jovanovich, 1970, pp. 394—395.*