A Novel Control Approach for the Droplet Detachment in Rapid Prototyping by 3D Welding

Bing Zheng
Harbin Institute of Technology,
Harbin 150001, P. R. China

Radovan Kovacevic
Southern Methodist University,
Dallas, TX 75275

Gas metal arc welding (GMAW) of steel in argon-rich shielding usually features free-metal transfer and short-circuiting metal transfer. Projected spray transfer in one droplet per pulse (ODPP) mode in combination with the droplet detachment feedback control is one of the most effective approaches to guarantee high weld quality. This paper explores new methods for controlling mass and heat transfer based on droplet detachment behavior in rapid prototyping by 3D welding. Three groups of experiments are performed based on the different welding current wave forms: pure square wave, square wave combined with sine wave (combined wave), and pure sine wave. Compared with the pure square wave form, the combined wave form can generate a weld bead with a more narrow and shallow penetration profile (the width and depth are 3.04 mm and 0.22 mm, respectively). When a pure sine wave form is used, the droplet is forced to oscillate once at the wire tip (the oscillation cycle equals the pulse cycle) and then detaches smoothly; the droplet is accompanied by a characteristically harmonious sound. Recorded images show that the droplet in a square or combined wave form can be forced to oscillate twice (the oscillation cycle equals half of the pulsed cycle) before it detaches. Careful selection of parameters is required to generate multiple oscillations for the droplet before it detaches. Photos of a weld cross section reveal that the penetration profile can be greatly improved using a combined wave form. The results achieved are not only effective for mass and heat control in rapid prototyping by 3D welding, but also are beneficial for further investigation of the droplet detachment behavior in GMAW. [DOI: 10.1115/1.1345730]