Metal Transfer in Double-Electrode Gas Metal Arc Welding

---Desired Transfer Achieved with Minimal Base Metal Heat Input

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Introduction

The Double-Electrode GMAW or DE-GMAW has been developed to increase the melting current independently from the base metal heat input, thus the welding productivity. A series of experiments have been conducted to uncover its fundamental characteristics. The emphasis has been placed on its effects on the melting rate and metal transfer. Results obtained from analyses of high speed image sequences and recorded current signals suggest that the use of DE-GMAW does not change the melting rate but lowers the critical current, shifts the droplet trajectory, reduces the diameter of the droplet, and increases the droplet moving speed and generation rate.

Technical Approach

Several experiments were conducted using different wire feed speeds. In each experiment, the conventional GMAW ran for 10 seconds first, and then the bypass arc was introduced to conduct DE-GMAW. The high speed camera recorded the last and first 2 second period of the conventional GMAW and DE-GMAW, respectively. The wire feed speed was fixed in each experiment so that the total current remain unchanged for conventional GMAW and DE-GMAW. The value of the resistance in the bypass loop was set differently according to the bypass current needed in different experiments.

Results and Discussion

Analysis of recorded current signals shows that the bypass arc does not change the total current when the wire feed speed is given.

The bypass arc changes the trajectory of the droplet and pushes the droplet away from the bypass electrode. This phenomenon can be observed in different transfer modes: globular, (drop) spray and stream spray. It is believed that this phenomenon is due to the presence of the bypass arc pressure.

When the total current is high enough, the droplet forms a stream which bridges the electrode wire and the weld pool and allows part of current to flow from the electrode wire to the workpiece. However, the current path from the tip of the solid end of the electrode wire to the workpiece still exists because of the existence of the main arc. In addition to the shift away from the bypass electrode, the stream as a current carrier is subjected to the electromagnetic force.

The bypass arc has a significant effect on the metal transfer of the droplet. When the current is below the critical current, conventional GMAW produces globular transfer or short-

circuiting. An introduction of the bypass arc may reduce the diameter of the droplets or change the transfer model from globular to spray.

The metal transfer mode is determined also by the total current. The bypass arc can change the transfer mode from globular to spray only when the total current exceeds a certain level. This minimal total current is actually the critical current in DE-GMAW, above which the spray transfer may occur. Experimental studies suggest that the critical current in DE-GMAW is reduced 25amps approximately from its value in conventional GMAW.

Conclusion

The DE-GMAW makes it possible to achieve the spray transfer with a total current 25amps below the critical current. More importantly, the base metal current, which differs from the total current melting the wire in DE-GMAW, can be as low as 65amps to obtain the spray transfer without pulsing the currents. The heat input and arc pressure for base metal/weld pool can thus be greatly reduced while the desired spray transfer is still achieved.