Getting the Most Out of Tandem GMAW: For the Fearful and the Frustrated

Marc Purslow, Applications Engineer
EWI

Tandem GMAW History: The Slow Adoption of a Fast Process

Tandem gas metal arc welding (GMAW) is not a new technology. Although it boasts a number of enticing benefits over single-wire GMAW such as significantly higher travel speeds, doubled deposition rates, and reduced heat inputs, few manufacturers have implemented and taken full advantage of this process. What's more, many first adopters faced frustrations that led them to abandon their tandem GMAW systems to the depths of their plants to die slow, dust-covered deaths.

In some cases, the demise of these Ferraris of the arc-welding world was due to the finicky nature of early tandem equipment. Tandem GMAW systems built in the 1950s employed a common-potential contact tip with a single power supply. The arc interference caused by the close proximity of the two electrodes created a highly unstable process with excessive spatter production. Later systems were improved by using two independently controlled power supplies and two electrically isolated arcs, allowing operators to choose different currents, voltages, and operating modes. Arguably, the most significant innovation in tandem GMAW technology has been to operate both electrodes in pulsed mode while synchronizing the waveforms of the two arcs out-of-phase. This technique ensures that while one arc is in the peak portion of its current waveform, the other is in the background portion of its own waveform. This reduces arc interference and allows stable parameters to be developed, resulting in significant spatter reduction

Figure 1: Application of high-speed tandem GMAW to tailor-welded blanks.

Figure 2: 3/16-in fillet weld made at 80 ipm.

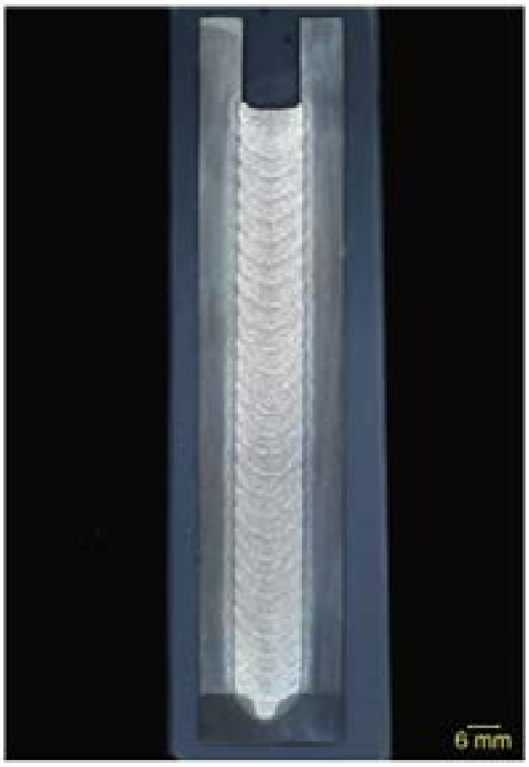

Figure 3: 5-inch thick joint welded using EWI's patented narrow-groove tandem GMAW process.

and allowing further increases in achievable deposition rates and travel speeds.

The Challenge of Tandem GMAW Parameter Development

Even with these improvements, many manufacturers have a difficult time taking advantage of tandem GMAW's full potential. At EWI, we've demonstrated the impressive versatility of this process, welding at 180 inches per minute (ipm) on sheet metal (Figure 1), optimizing the toe angles of high-speed fillet welds (Figure 2), welding out of position on two-inch thick sections, and joining 5-in. thick plate using our patented narrow-groove tandem GMAW torch (Figure 3).

Our research hasn't been limited to steel. As part of an internally funded project, we've also developed tandem GMAW fillet weld parameters to joint 6061 aluminum in T-joint and lap-joint configurations (Figure 4), achieving travels speeds of 60 ipm.

Based on these results, the question is not whether tandem GMAW is a process capable of significant productivity gains, but is rather: Why are so many manufacturers shying away from something that could so drastically increase their through-put? The answer is that two electrodes operated in close proximity are more than twice as complex as a single electrode. While operating in asynchronous pulse/pulse mode will certainly minimize electrical arc interference, many other interactive factors will influence the resulting weld quality. The most significant of these is the electrode spacing, as it directly affects the flow of the molten puddle, which in turn affects arc stability and the maximum achievable travel speed. In addition to the fact that electrode spacing is often the limiting/enabling factor, determining the ideal spacing is somewhat counterintuitive until you understand the nuances of the molten tandem GMAW puddle.

Figure 4: 6061 lap joint welded at 60 ipm using Tandem GMAW.

Ideal Tandem GMAW Electrode Spacing

Most people think that increasing the electrode spacing will stabilize an unstable tandem GMAW process. This makes some sense; if the arcs are interacting and negatively affecting the process, then moving them farther apart to decrease this interaction will result in increased stability. The problem with this logic is that it doesn't take into account the influence of the molten puddle. Indeed, the best way to judge the stability of a set of tandem GMAW parameters is to carefully observe the puddle, specifically the area between the two arcs. When we examine this area, we see that molten material flows backwards from the leading arc and around the trailing arc. When the space between the two electrodes is too large, a wave is formed as the arc force from the trail has a damming effect. When this wave is large, it often becomes unstable and causes puddle interference in both arcs. This instability leads to excessive spatter, reduces penetration, and ultimately limits the maximum travel speed that can be achieved. In extreme cases, the interference can become so severe that the equipment cannot compensate and welding has to be stopped.

This leads us to our surprising solution. The key to increasing the stability and resultant overall performance of tandem GMAW is to move the arcs closer together. This effectively suppresses the wave of molten metal and increases overall process stability. There is, of course, a limit to how far we can go before we run into a number of other problems. That said, research conducted by EWI has shown that the correct electrode spacing can essentially eliminate the undesirable wave of molten metal without causing electrical arc interference. We've observed that this ideal spacing is effective regardless of the travel speed, joint configuration, and deposition rates used. With this optimized electrode spacing, we have produced our most notable tandem GMAW results to date. Interestingly, the newest tandem GMAW torches all employ this ideal spacing, indicating some agreement among manufacturers regarding what configuration results in the most stable process under a variety of welding conditions.

A Better Understanding of the Tandem GMAW Process

While torch configuration standardization is good news for manufacturers looking to implement tandem GMAW, electrode spacing isn't all there is to consider. At EWI, we have developed an in-depth understanding of what other factors will contribute to the overall success of tandem GMAW implementation and utilization. We know that the individual arc lengths of each electrode can affect penetration, wetting, spatter levels, and maximum travel speed, as can the travel angle used. We've developed effective rules of thumb for welding in joint configurations ranging from clad layers to narrow grooves, as well as optimal current ratios for welding at different travel speeds. Our innovative tandem GMAW work with sheet metal has included using silicon bronze electrodes at travel speeds in excess of 180 ipm to significantly reduce the deterioration of galvanealed coatings (Figure 5). We've also completed work showing the viability of tandem GMAW as an alternative to narrow-groove submerged arc welding (SAW), demonstrating increased productivity and improved mechanical properties.

While the innovative tandem GMAW process development described above requires a thorough understanding of the nuances of the process, implementation is far less complicated. Provided that operators understand which factors will influence overall weld quality, producing consistent results on the production floor should be only marginally more complicated than for commonly employed single-wire arc welding process variations.

Figure 5: Galvannealed sheet metal joining using silicon bronze electrodes.

How EWI Can Help

Whether you're looking to increase the performance of your currently owned system, or to implement tandem GMAW in your production line, our significant experience allows us to effectively troubleshoot challenges on your factory floor or quickly optimize this process for new applications.

Marc Purslow *has more than a decade of experience in manufacturing research and development, conducting high-impact projects for commercial and government clients. With significant experience leading multi-disciplinary engineering teams, Marc has designed and successfully executed innovative multi-year projects funded by commercial clients, the United States Navy, and the United States Federal Railroad Administration. In additional to his in-depth knowledge of arc-based welding processes, such as gas metal arc welding (GMAW), submerged arc welding (SAW), and gas tungsten arc welding (GTAW), Marc is recognized as a leading expert on tandem GMAW and has conducted high-speed, narrow-groove, and out-of-position welding research that has redefined what is possible with the process.*