The hybrid laser beam welding process combines the traditional GMAW process with laser beam processing. (Photo courtesy of Craig Bratt, Fraunhofer USA.)

Make yourself more competitive globally through improved shielding gas selections

Two divergent forces are hard at work in today's business world: one is the constant updating of the latest and greatest technology, and the second is the ongoing political rhetoric about outsourcing jobs to lower-wage-paying countries.

Inverter technology, for example, offers better power efficiency and, in some cases, more stable arc characteristics. International competition, however, utilizes simpler technology coupled with lower overhead costs to put pressure on manufacturing jobs in the United States.

Being pressured into making a capital investment of tens of thousands of dollars that may only achieve incremental cost savings over current optimized prac-

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Welding machine manufacturers have developed both fixed and variable slope welding power supplies to control the output voltage with increasing amperage. This limits the maximum energy available to separate the wire from the pool. If there is too much energy, the result is excessive spatter, which lowers the deposition efficiency; with too little energy, the wire piles up, resulting in incomplete fusion and poor weld quality.

Secondly, welding equipment manufacturers have developed both fixed and variable inductance to control the rate of the current rise as illustrated by the current curve sequence A-B in Fig. 2. As inductance is increased, the amount of arcing time also increases as illustrated by the voltage curve sequence E-H in Fig. 2. The additional arc-on time produces a more fluid weld pool, which yields a flatter weld bead with better wetting at the edges. In turn, this affects the cosmetics and load-bearing capacity of the joint.

The proper selection of shielding gas will drastically affect the energy transfer and deposition efficiency of the GMAW short-circuit transfer mode. Carbon dioxide was the first shielding gas used because of its availability and cost. The arc plasma has a narrow inner core and a low outer temperature envelope resulting from its low thermal conductivity that produces narrow and deep penetration. This presents problems for thin materials.

More expensive GMAW wire containing higher amounts of deoxidizing elements is typically needed to balance the oxidizing nature of carbon dioxide. Also, because of centerline crowning and excessive spatter that result in 85 to 95% deposition efficiencies, manufacturers developed binary mixtures of argon and carbon dioxide.

Additions of up to 80% argon (with the balance being carbon dioxide) will produce less crowning, better edge tie-in, and 94 to 98% deposition efficiencies. Argon additions offer better arc ignition and stability based on argon’s low ionization potential. Argon has a low thermal conductivity that yields similar arc constriction but a shallower penetration profile than carbon dioxide. Plus, argon-carbon dioxide mixtures yield higher deposition rates with less spatter, which is ideal for all-position welding and thin materials.

As additional welding current is applied, the end of the welding wire becomes overheated and balls up 1.5 to 3 times the wire diameter. This establishes a longer arc length as illustrated in sequence E-H of Fig. 2. Gravity facilitates the metal transfer, which creates instability and excessive spatter. Deposition efficiency tends to fall between 80 and 90% depending on gas selection and processing parameters. For this reason and welding position limitations, it is wise to stay outside the globular transition range of 160 to 185 A for 0.035 wire, and 200 to 220 A for 0.045 wire.

Depending on the gas selection, the minimum transition current for spray transfer occurs between 155 and 195 A for 0.035 wire, and 220 and 250 A for 0.045 wire. Above this transfer range, the end of the wire electrode develops a taper that emits fine droplets of metal across the arc with virtually no spatter, yielding 97 to 99% deposition efficiencies. The spray transfer yields higher travel speeds and deposition rates because of the superior arc stability and high droplet rate. However, the high heat input limits the weldment to the flat position.

Choosing the optimal shielding gas for spray transfer takes some forethought to understand the application and effects each gas component will contribute to the
deposition efficiency and cost, environmental, and mechanical properties.

Pure argon produces higher arc voltage and subsequent longer arc lengths, which create arc instability and excessive undercut at the edge of the welds. For this reason, 5 to 20% carbon dioxide is added to create an argon mixture that stabilizes the spray transfer. It is well documented that the lower the amount of carbon dioxide concentration, the lower the minimum spray transfer current and subsequent fume generation rates.

It should also be noted that 8 to 15% carbon dioxide mixtures are flexible enough to facilitate both spray and short-circuit transfer modes. In some cases, 1 to 5% oxygen may be added to argon to achieve superior arc stability and better wet-in (wetting) at the weld edge. Oxygen tends to provide a wider but shallower penetration profile, as compared to carbon dioxide mixtures, because of its lower ionization and higher thermal conductivity properties. Oxygen additions tend to yield better toughness and strength because of the absence of carbon retention associated with carbon dioxide mixtures.

Shielding gas development has led manufacturers to design three-component gas blends that offer the benefits of both carbon dioxide and oxygen additions to argon-based mild steel gas metal arc applications.

As mentioned previously, each company must evaluate the incremental benefits of three-component mixtures as compared to two. In most cases, attention to quality and continually training personnel to meet the basic processing parameters will yield the greatest return with minimal investment.

For example, assume that the weldment is a ½-in. mild steel, 12-in. fillet weld requiring 0.106 lb/ft of welding wire. Current practice calls for a 0.045-in.-diameter wire using 75% argon balance carbon dioxide. It is assumed that the wire costs $0.80 per pound on a 33-lb spool, and the typical labor and overhead rate is $40/h. There is a total of ten weld stations each using a single “T-size” (330 ft³) high-pressure bottle. The company uses eight bottles per week at a cost of $18 each. The manual welding is performed utilizing conventional short-circuit parameters set at 20 V/200 A, yielding a deposition rate of 5.5 lb/h at 96% efficiency.

In today's market, it is also safe to assume that the company is receiving pricing pressure from international competitors. Utilizing existing equipment and providing the required training, the procedure is changed to a spray transfer with the following parameters listed below.

The shielding gas is changed to 92% argon, balance carbon dioxide. The welding machine parameters are 29 V/300 A, which provide a deposition rate of 9.7 lb/h with a 98% efficiency. The economic results displayed in Table 1 show that a 38% cost reduction per foot of weld is achievable because of the higher deposition rate and efficiency of a spray transfer. As well, Table 1 illustrates that an additional 6% in cost savings can be realized by mixing the argon-carbon dioxide shielding gas on-site.

Simple blending systems as illustrated in Fig. 3 enable the company to realize additional duty cycle or productivity savings by eliminating daily cylinder handling.

Finally, the on-site blending system enables the company to adjust the ratio of carbon dioxide in the shielding gas, which will have a positive effect on the weldment's mechanical properties and work environment.

With American business facing so much competitive pressure today, it is necessary to look for the "lowest hanging fruit" to reduce production costs and enhance the quality of products. Getting back to the basics will further enhance the incremental cost savings of future investment in technology. To achieve such results, solutions as simple as evaluating the mode of transfer for a gas metal arc weld and the gas delivery system are important in the highly competitive market-place.

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