Detailing DeepTIG

How increased weld penetration can improve GTAW results

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Gas tungsten arc welding (GTAW) has found an important niche among many metal fabricators. Initially known as heliarc welding because it relied on helium to shield the arc from oxygen contamination, the basic process hasn't changed much since its inception: It uses an arc between a nonconsumable tungsten electrode and the workpiece to produce a weld pool, and it needs a shielding gas to protect the molten weld pool from contamination by oxygen in the ambient air.

While the process is essentially unchanged, the equipment and consumables have undergone updates over the decades. Alternating current welding units, water-cooled torches, alternative tungsten electrode formulations, and using argon to shield the arc (either alone or in combination with helium) have helped to improve the process. Also known as tungsten inert gas (TIG) welding, it has become an indispensable tool for manufacturers in industries as diverse as aerospace, nuclear, marine, petrochemical, and semiconductors.

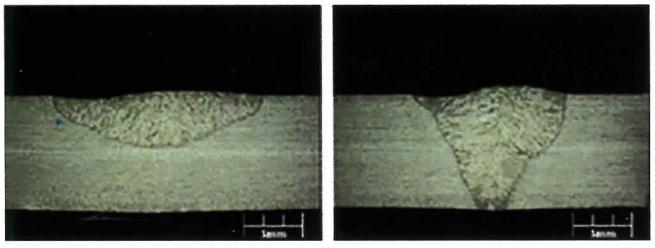

FIGURE 1

Two welds, identical except for the use of DeepTIG (right), show markedly different profiles.

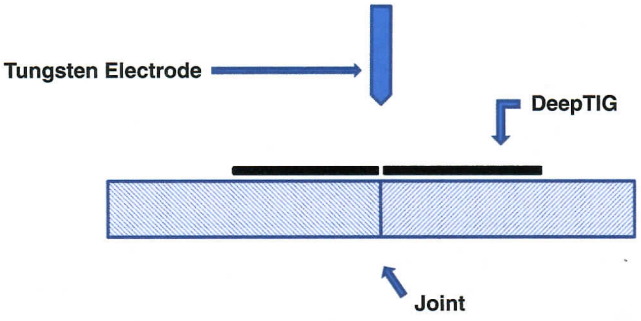

FIGURE 2

This schematic shows the process applied to a butt joint.

Deep-penetration GTAW

Recently a process called EWI DeepTIG that uses specialized metal oxides to increase weld penetration in GTAW was patented. It uses proprietary oxide formulations which, when applied to the surface of the workpieces to be joined, increase weld penetration and consequently enhance process productivity.

The process has been shown to increase weld penetration in GTAW by up to 300 percent (see **Figure 1**). In turn, increased penetration helps reduce welding time and simplify weld joint preparation—for example, by allowing substitution of a square joint for a groove joint. It also reduces weld distortion, because it provides a more symmetrical weld cross section.

Suitable for use on 300 and 400 series stainless steel, the process is advantageous to use on 409 stainless tube because it can be sped up and the electrical energy of the GTAW process can be reduced.



FIGURE 3

A photomicrograph of a single pass on a 6-mm-thick stainless steel plate shows the process's potential when applied via the filler wire's core.

How It Works

The metal oxide formulation modifies the Marangoni flow in the weld pool, which is based on the flow of fluids with dissimilar surface tensions. The modified Marangoni flow increases weld penetration. Repeated testing has proven that the material's original mechanical properties, weldability, and corrosion resistance are not adversely affected in the alloys tested.

Initially the process was available only in powder form, which turns into a slurry when a quick-drying solvent is added to it. The slurry is applied manually using a fine-bristle brush. **Figure 2** shows the process applied to a butt joint. A newer variant is available in a form similar to metal-cored wire, which opens up new possibilities (see **Figure 3**).

Maintaining a short arc length of 0.050 inch is critical to ensure maximum penetration during welding, and it is also a critical variable in the repeatability of welds made with deep-penetration GTAW. To that end, the use of automatic voltage control and mechanized equipment is recommended.

Benefits and Applications

In addition to increasing weld penetration, the process has been shown to have a positive effect on many weld characteristics and related processes:

- **Weld Quality.** It reduces heat-to-heat variation in weld penetration and reduces weld joint volume.
- **Welding Time.** It reduces welding time as much as 50 percent in most applications.
- **Manufacturing Costs.** Because it reduces heat input and weld time, it reduces power and labor requirements, thereby lowering manufacturing costs.
- **Joint Preparation Costs.** In many applications, full penetration can be achieved with a closed square butt joint, reducing joint prep and filler material costs, heat input, distortion, and welding times.

The process originally was developed for the U.S. Navy's shipboard piping systems, using mechanized and orbital welding systems to weld tube and pipe butt joints. The welding equipment used for deep-penetration GTAW is the same as that used for conventional GTAW (see **Figure 4**).

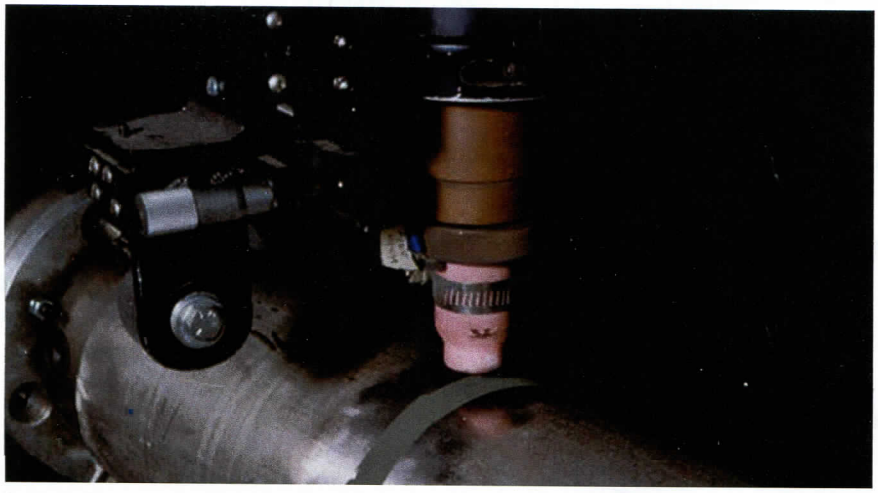

FIGURE 4

The process is suitable for mechanized GTAW, such as on this orbital butt joint. The oxides are painted onto the surface. *Photo courtesy of EWI.*

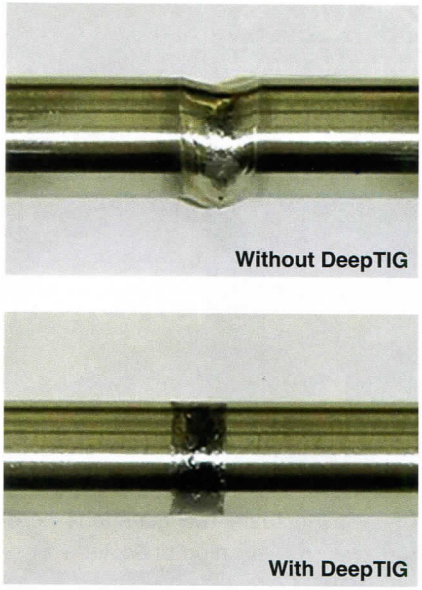

FIGURE 5

When the process is used on thin-wall duplex 2205 tubing, the oxide reduces the weld's tendency to sag, a result of the weld profile's low depth-to-width ratio.

DeepTIG has been approved for naval, commercial shipping, aerospace, and energy applications, including the fabrication of:

- Piping for Navy ships (aircraft carriers and destroyers) and commercial tankers.
- Boiler systems.
- Duplex and superduplex tubing for downhole umbilical products for oil and gas equipment.
- Center tubes, plumbing on skids (injection pumps), hydraulic control panels, and oil well Christmas trees (see **Figure 5**).
- Aerospace components.
- Thicker-wall tube and connector joints than are possible using orbital GTAW without oxide formulations.

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