Making short work of small welds

Precision welding lights the path to miniaturization in medical, aerospace, instrumentation, and other industries.

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Precision welding is a key step in the manufacture of light bulb filaments, sensors, solenoids, switches, thermocouples, batteries, metal bellows, hermetically sealed components, and other products. Here, a welding process must reliably maintain tight operational tolerances and not interfere with product aesthetics or function.

Four fusion welding methods are available for such jobs: laser, electron beam, micro-TIG or gas-tungsten arc welding (GTAW), and micro-plasma. Laser welding uses heat from a focused coherent light (laser) beam to fuse materials. In general, laser welding is appropriate when the weld joint can be accurately positioned without gaps or mismatch. For less-precise work, the beam may be defocused.

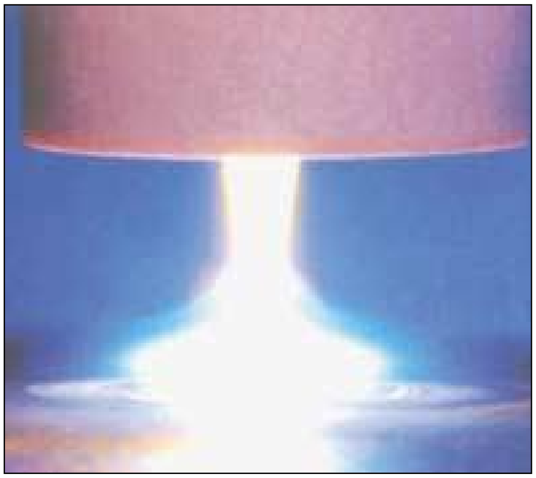
Electron beam welding focuses a high-velocity stream of electrons at the surface to be welded. The resultant welds are deep and narrow with low heat input. Because the process takes place in a vacuum chamber, it tends to be expensive and requires longer setup times.

Micro-TIG and micro-plasma welding are probably the two most commonly used methods for precision joining. Recent advances in power supplies and process controls (current control to 0.10 A and weld duration to 0.01 sec) promote extremely accurate welds with relatively low heat input. Both methods can be a low-cost alternative to electron beam and laser welding.

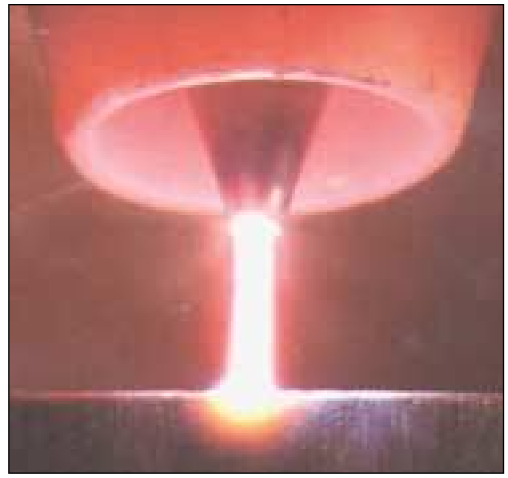
In the micro-TIG welding process, a high-voltage, high-frequency pulse starts an

The Dual Arc 80 from Pro-Fusion supports both Micro-TIG and Micro-Plasma processes.

Lathe welding systems accommodate round parts.



TIG



PLASMA

TIG versus plasma

TIG	PLASMA
Simple setup and operation.	Extremely short weld duration possible (0.01 sec).
Electrode can extend for improved weld joint access.	Gentle arc transfer.
Excellent gas shielding.	More stable, stiffer arc reduces arc wander.
Softer TIG arc can more easily fill weld joint gaps.	Arc standoff distance not as critical as with TIG.
No high-frequency arc starting noise.	
Higher weld speeds possible.	
Protected electrode makes more welds before being contaminated.	

electric arc between a tungsten electrode and the part to be welded. The arc's intense heat fuses the materials with or without filler metal. An inert shield gas provides a conductive (ionized) path to the part surface and protects the tungsten electrode and molten material from oxidation. Shield gases include argon, hydrogen-argon mix, or helium, and are selected based on the material type being welded.

Plasma welding dates back to 1964 when it was introduced as a way to improve arc control with lower current ranges. A plasma-welding torch locates a tungsten electrode within a copper nozzle containing a small opening at the tip. A pilot arc initiates between the tungsten electrode and the inside of the nozzle tip. Similar to TIG, plasma arc uses this plasma to transfer an electric arc to the workpiece. Argon is typically the plasma gas, while the torch uses a secondary gas such as argon, argon/hydrogen, or helium, to help shield the molten weld puddle from oxidation.

A variation on micro-TIG and micro-plasma welding called pulsed micro-arc helps join thin metals near fragile materials such as glass or polymer. Here, a combination of rapid-response power supplies and weld process controllers rapidly increase and decrease arc current. The result is a seam weld made from overlapping spot welds. This reduces overall heat input to the joined parts and increases weld speed.

Pluses and minuses

Plasma welding has several advantages over TIG. For one, the copper nozzle orifice tends to constrict the arc passing through it, boosting arc power density. This makes for smaller welds, faster welding rates, and less heat distortion of joined parts. The protected plasma torch electrode is less prone to contamination and lasts longer, important for high-production work and when materials being welded outgas. The "stiffer" plasma arc also reduces arc wander so weld tooling can be in closer proximity to a joint for better heat sinking. Arc standoff distance is not as critical compared with TIG which improves weld consistency. And no electronic arc-gap control is required for most applications, even those using wire feed.

The pilot arc also gives a gentle, consistent welding arc start for short-duration (0.01-sec) welds, especially important for accurate spot welding of fine wires, needles, filaments, and tube endings. Gentler arc transfer also eases welding of thin sheet and miniature components. The more harsh TIG arc start, in contrast, may damage these smaller, finer parts. Moreover, the high-frequency pulse that starts each TIG weld can disrupt NC controls. Plasma arc requires only one start pulse to “light” the pilot arc, so it is more compatible with NC controls.

However, micro-TIG has some advantages over micro-plasma welding, most notably simplicity. TIG is one of the more common, well-understood welding processes. Most welders capable of setting up a TIG system can also run micro-TIGs. Micro-TIG torches are physically smaller than comparable micro-plasma torches for improved access in tight spots. And the micro-TIG tungsten electrode can extend to reach inside corners and crevices for applications such as tool, die, and mold repair.

Better gas shielding is another advantage of TIG. The micro-plasma torch’s additional copper nozzle surrounding the tungsten electrode consumes some space inside the torch and slightly impedes the flow of inert shield gas. For some applications, a micro-TIG can produce cleaner welds than a comparable micro-plasma rig. TIG can also help accommodate bad weld joint fit-up. The “softer” TIG arc lets the molten metal more easily flow together at the weld joint than the higher-current-density plasma arc.

Automation considerations

A well-engineered, automated welding system can help manufacturers boost quality, productivity, and profitability. Automated welding has two basic categories: semiautomatic and fully automatic. In semiautomatic welding an operator loads the parts into a fixture. A weld controller then guides the torch/component motions and sets welding parameters to ensure a quality, repeatable weld. The operator removes the welded part and the process repeats.

Fully automatic welding systems load the work piece, index it or the torch into position, weld, monitor quality control, and unload the finished product. Additional “part in place” and product functionality checks may be built into the machine. Depending on the system requirements, a machine operator may or may not be needed. Applications that benefit most from automation typically involve quality or critical-function welds, repetitive welds on identical parts, or parts with significant accumulated value prior to welding

In general, the more automated a welding system becomes, the closer a supplier and customer must work together. Spreadsheets available from welding automation suppliers can help manufacturing engineers determine break-even points for such investments. ■

WHAT AFFECTS WELD SIZE, SHAPE AND QUALITY.

- Welding physics — arc starting, arc voltage, weld current, and heat input (watt-sec).
- Weld joint design, joint fit-up requirements, and heat balance.
- Tooling design including materials and geometry.
- Arc pulsing.
- Weld speed.
- Arc length.
- Welding electrode material and tip shape on weld shape as well as available electrode materials and electrode tip grinding requirements.
- Shield gas type, purity, mixture.

Information on these and other topics pertaining to precision welding, including weld-parameter-selection software and streaming videos of parts being welded, can be found at the Pro Fusion web site: www.pro-fusiononline.com

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