Successfully Welding Sheet Metal with GNAW and GTAW

For fabricators and others with bottom line goals, welding sheet metal often means a constant battle between productivity and equipment investment vs. burn-through, warping, excessive heat affected zones (HAZ) and weld appearance. For the individual occasionally welding sheet metal, success can be as simple as learning the proper techniques.

Process Selection

When welding thin metal, the main objective is to avoid warping, burn-through and excessive heat affected zones while still ensuring the weld has sufficient mechanical strength for the application. The welding processes that provide the most control over heat are short circuit transfer GMAW ("short arc"), pulsed GMAW, GTAW and pulsed GTAW.

Process-Specific Advice

GMAW Electrode and Shielding Gas Selection

Use the smallest wire diameter feasible. A smaller wire takes less heat to melt, which in turn heats the metal less. A smaller wire also gives you more control over the weld bead and a better chance of recovering from mistakes because it has a lower deposition rate. That's why professional groups like I-CAR, the Inter-industry Conference on Auto Repair, recommend using .023 in. diameter wire for most collision repair work. For welding material 18 ga. and thicker, you may be able to use a .030 in. wire for higher deposition rates.

For welding mild steel, choose an AWS E70 wire in S-2, S-3 or S-6 classification. For shielding a shielding gas, always use a high argon-based gas, such as 75 percent argon/25 percent CO2 gas (commonly called 75/25 or C25). Argon carries less heat than pure CO2, and you'll get less spatter.

The two most popular wires for aluminum are ER4043 and ER5356. While the latter feeds more easily, choose ER4043 in .030 in. diameter to solve heat-related problems. ER4043 melts at a lower temperature and uses slower wire feed speed, often making it the superior choice in sheet metal applications. Always use 100 percent argon shielding gas.

For welding 304 stainless steel, ER308, ER308L and ER308LSI wires are compatible. For welding 316L stainless, you need a 316L wire. Use a "tri-mix" shielding gas consisting of 90 percent helium/8 percent argon/2 percent CO2. Note: Do not attempt to weld thin metal with flux cored wires. These wires use more heat because they require globular transfer. Unlike short arc, where the weld puddle cools every time the wire touches the base metal, the arc remains "on" constantly with globular transfer.

Electrode Polarity

For welding with solid wires, use electrode positive or "reverse" polarity. While EP directs more heat into the base metal than electrode negative (EN or "straight" polarity), you will obtain the best results with EP and following the guidelines provided here. If you've been using flux cored wire, be sure to change your machine's polarity from EN to EP.

GTAW Electrode Selection & Preparation

Forget the ubiquitous 1/8-in. diameter tungsten electrode and use a smaller one. They come in diameters down to .020 in. Smaller electrodes carry less heat and enable you to better focus the arc in a smaller area. For steel and stainless steel applications, keep the tungsten pointed, and be sure to grind parallel with the length.

For best results on thin aluminum, use an inverter-based power source (see GTAW power source recommendations) and forget another popular practice: welding with a pure tungsten and balling the end. Instead, select a 3/32-in. diameter tungsten with 2 percent cerium (2 percent thorium as a second choice), grind it to a point and put a small land on the end. Compared to the balled tungsten used with conventional GTAW machines, a pointed electrode provides greater arc control and enables you to direct the arc precisely at the joint, minimizing distortion.

Aluminum Preparation

Clean all metals before welding, but especially aluminum. Remove oil and dirt with a degreaser/solvent. Just prior to welding, remove oxide with a stainless steel wire brush, grinder or chemical oxide cleaner. When exposed to air, an oxide layer forms on aluminum - and aluminum oxide melts at a temperature 2,000 degrees Fahrenheit higher than plain aluminum! Any slacking in weld preparation degrades weld quality and integrity, so be diligent.

If you store aluminum in cold places (outside, unheated warehouses), bring it up to room temperature and eliminate condensation. Do not heat cold metal with an oxy-fuel torch (which is a common practice, but not a good idea). This can drive carbon into the oxide coating.

Universal Advice

Weld Technique

Direct the arc at the middle of the weld puddle. Normally, you would keep the arc on the leading edge, where the weld puddle is thinnest, to drive the arc into the work for more penetration. However, staying back enables the puddle to insulate the base metal from the arc's full force.

To prevent burn-through and warping, do not whip or weave the torch, as the more time you keep the arc in an area, the hotter it becomes. Always travel in a straight line and use the fastest travel speed possible that maintains a good bead profile.

Skip Welding

Unevenly distributed heat causes distortion and warping, which in turn wreaks havoc on parts that theoretically fit together. To minimize warping, distribute the heat as evenly as possible. You can accomplish this by using a skip welding technique.

For example, let's weld a 2 x 2 ft. piece of 18 ga. stainless steel to repair the side of a tank. Start by making a 1-in. long weld. Skip 6 in. and make another 1-in. long weld. Continue to work your way around the plate's circumference, welding 1 in. out of every 6 in. You may have heard of this as a 1" on 6" weld. After you've traveled around once, make your next 1-in. long weld 3 in. from the first weld. Continue to place the second set of welds between the ones you made on the first pass, and so on until you achieve the integrity desired.

The same technique holds true for welding linear parts. If the metal starts to warp or pull to one side, solve this by: increasing the distance skipped between welds; welding at the beginning, middle and end of the piece, then repeating the sequence; or welding on alternate sides of the joint.

Backing Bars

To dissipate heat from the weld area faster than atmospheric cooling alone, place the heat affected zone (HAZ) in contact with a "backing bar" or "chill bar." A backing bar can be as simple as a metal bar (usually copper or aluminum because they dissipate heat best) clamped to back of the weldment. This simple technique enabled one fabricator to use an all-in-one pulsed MIG power source to weld a continuous seam on .040 in. aluminum.

In higher-duty cycle applications, you may need to consider a water-cooled backing bar. Elaborate versions feature a water cooler that circulates chilled water or special coolant through holes drilled in the bar. Simple, homemade versions feature a water cooler circulating coolant through PVC pipe touching the back of the bar.

Fit-up and Joint Design

Welding thin metal demands tight fit-up. Imagine a butt weld on 20 ga. metal. If the parts fail to touch for even 1/16 in., you have just created a hole that begs for burn-through and left a gap that cannot absorb the heat. On thicker metal, the edges of the metal can support the arc, but not here. Gaps cause nothing but trouble. To avoid rework caused by burn-through, adhere to the old saying "measure twice, cut once."

If you can redesign the part with joints that can withstand more heat, do so. For example, instead of a butt weld, can you make a lap joint? If you can, you double the amount of metal available to absorb heat.

Don't Overweld

Most people, especially those without formal training, feel compelled to overweld a joint to obtain greater strength. Assuming you have sufficient heat, the leg of the joint (the long side of the triangle) does not need to be any longer than the thinnest plate. For example, when welding a 1/16-in. plate to a 1/8-in. plate in a T or lap joint, the weld only needs to be 1/16-in wide. Excessively wide welds reduce travel speed, waste time, waste filler metal and gas, may lead to unnecessary post-weld grinding, and may affect the temper of the metal.

GMAW Power Sources

When selecting a power source for short circuit GMAW, use one with good voltage control at the low end for good arc starts and arc stability.

If you plan to buy an all-in-one power source that uses 115V household current, go with one from a major manufacturer of industrial welding equipment. Machines with low-ball prices simply do not have the slope and inductance necessary for good control over the short circuit. Be sure the unit comes with a contactor and gas solenoid valve; some units designed only for flux cored welding do not.

If you plan to weld with an all-in-one power source in the 200 to 250 amp range, look for one with a spool gun that connects directly to the front panel. This eliminates a lot of hook-up headaches by letting you switch instantly between two different wires, such as .023 hard wire in the "regular" gun and .030 aluminum wire in the spool gun. To weld aluminum down to .040 in., Miller's Millermatic® Pulser provides the best value for moderate-volume fabricators because it features built-in pulsing capabilities.

For high volume work, both 200 to 300 amp all-in-one units and industrial, production type machines can weld sheet without exceeding their duty cycle. While several all-in-one units provide excellent results, they cannot compete with industrial machines for controlling spatter. If you currently spend a lot of time on post-weld cleaning and grinding spatter, you may be able to increase productivity and lower overhead costs by upgrading your power source technology. Remember that gas, wire and the power source account for less than 15 percent of a weld's total cost; 85 percent comes from labor. Far too many companies try to save pennies by cutting welding costs while obliviously wasting dollars on grinding time.

For metals in the 1/16-in. to 3/32 range, consider investing in a pulsed GMAW system when bead appearance and no spatter are factors. Pulsed GMAW is almost spatter free and provides faster travel speeds than short arc, so it can pay for itself very quickly. Pulsed GMAW may be able to replace GTAW in some applications to improve travel speeds. Again, industrial power sources with built-in pulsing controls, such as Miller's Invision™ 354MP, provide the best value.

GTAW Power Sources

GTAW power sources come in two basic categories: those with a DC output for ferrous metals and those with an AC/DC output for non-ferrous metals as well. For welding thin steel or stainless steel (and no aluminum), invest in one of the new GTAW inverters that feature pulsing controls and HF arc starts, such as Miller's Maxstar® 200 DX or Maxstar 150 STH. Pulsed GTAW, which allows the weld puddle to cool between pulses, is one of the easiest methods to prevent warping and burn-through.

For welding thin aluminum, use a GTAW machine with an adjustable squarewave output. By fine tuning its "balance control," or adjusting the EN to EP ratio, you can narrow the weld bead and take heat off the base plate.