FABRICATING TECHNIQUES

Setting up an aluminum welding operation requires some investment and a slightly different perspective.

A long- reach spoolgun especially made for aluminum welding allows the welder access to seem without moving the weldement. (Photo courtesy of Lincoln Electric Co.)

Welding Aluminum: Different but Not Difficult

By John Campbell

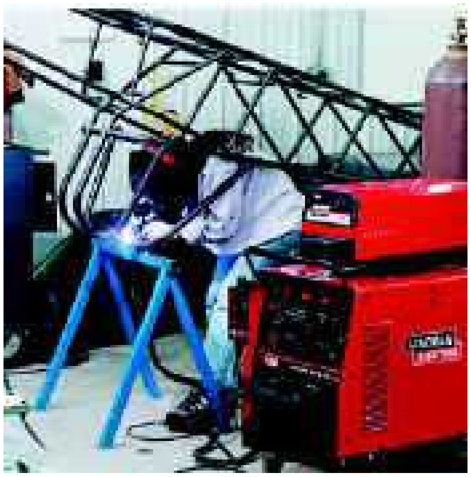
"Welding aluminum is not difficult," says John Uebele, who teaches welding and performs weld-certification tests at Waukesha County Technical College in Pewaukee , WI . "It's just different than welding steel. Someone familiar with welding techniques should be able to pick it up in 20 to 25 hours. The key is cleanliness. I'd advise keeping it separate from steel fabrication. The investment? Other than training, maybe three thousand dollars."

No matter what position the weld is in, thin sheet metal containers are easily welded with the pulsing feature of an industrial TIG welding machine. (Photo courtesy of Lincoln Electric Co.)

Uebele, who serves the American Welding Society on their structural committee for sheet steel and aluminum certifications, also works companies on a contract basis, a service faculty members at state funded technical schools provided to industries in Wisconsin.

Welding aluminum is done using two preferred methods, both of which employ inert gases, pure argon, or a mix of argon with helium. Any contamination of these gases causes oxidation of the weld, as Uebele inadvertently demonstrated trying to repair a mag-wheel.

“Mag-wheels are not magnesium, you know. They’re aluminum,” Uebele said. “I knew that, of course, but the weld kept turning black on me. Finally, I checked the gas supply and discovered I was using an argon-carbon dioxide mix. We use carbon dioxide for welding carbon steel. To weld aluminum you’ve got to use pure argon. We don’t use helium here. It’s too expensive. But they do mix argon and helium to increase welding temperatures for thicker sections.” Argon is about ten times the cost of carbon dioxide, commonly used to weld carbon steel. Helium costs another $12 per cubic feet than argon.



A TIG is used to assemble an aluminum frame. The unit shown is a Square Wave TIG 275. (Photo courtesy of Lincoln Electric Co.)

Like the game of gold, there’s no substitute for practicing in welding a torch and weld rod. The resources for learning are available. Most state funded technical schools and junior colleges have programs to teach welding. Alco-Tec, manufacturers of aluminum welding wire in Traverse, MI, and several producers of welding equipment offer courses in aluminum weld technology. Some technical courses are not specifically designed to teach welding skills, and you should inquire about the courses before sending an employee for training.

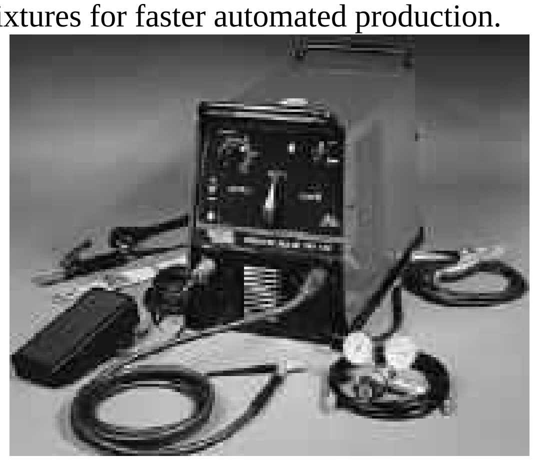
Prior to the 1940s manufacturers and repair shops welded aluminum with an oxyacetylene torch, a special flux, and the appropriate alloy filler rod. Welds often absorbed hydrogen gas and trapped oxide inclusions. If the flux used wasn’t thoroughly neutralized with sulfuric acid, corrosion occurred around the welds. The acid cleaner presented a hazard to the welder’s lungs and his clothing. Such welds were satisfactory, but they wouldn’t qualify for applications where your life depended on them.

During WW II, TIG welding was developed. Old timers also called this process heliarc welding. The word heliarc was a trademark of Linde Air Products. Like many known trade marks the name became generic for TIG welding. The Linde Air name was sold to the German subsidiary for $60 million, and Linde became known as Praxair in the U.S.

The Square Wave 175 can be used for TIG or stick welding. (Photo courtesy of Lincoln Electric Co.)

Today, TIG and MIG welding are the two recommended options for welding aluminum. TIG means tungsten-inert-gas, a shorter acronym for gas-tungsten-arc-welding (GTAW). The process uses a hand torch with a non-consumable tungsten or tungsten alloy electrode to strike an arc. Pure argon and/or helium, both non-flammable inert gases, provide the shield around the weld to prevent weld contamination from oxides and hydrogen absorption. A filler rod of aluminum is fed into the molten weld, wherever filler is necessary.

High frequency alternating current, the preferred electrical source for manual welding is controlled by either a torch trigger or foot controlled rheostat. An alternating current gives the arc a cleaning action and divides the heat evenly between the tungsten electrode and the weld pool. TIG is slower than MIG welding, but it allows for more welder manipulation without the fixtures for faster automated production.



The Square Wave 175 can be used for TIG or stick welding. (Photo courtesy of Lincoln Electric Co.)

MIG welding, an acronym for gas-metal-arc-welding (GMAW), uses a consumable electrode, aluminum alloy wire fed through the torch along with the inert gas. Torches may be water-cooled, especially when amperages exceed 200 for welding plate (over 1/4-

inch thick), where deeper penetration of the weld is required. MIG welding, the preferred automated process uses a direct current power source, electrode positive (DCFP). Unlike TIG welding, MIG occupies one hand.

Aluminum has characteristics that make welding its alloys different than welding steel, which is the reason many fabricators "job-out" their aluminum work to fabricators specializing in the process. One-third the weight of steel, aluminum thermal conductivity is six times greater. The rapid heat transfer makes the weld solidify faster than steel. Steel melts at 2,800 degrees Fahrenheit, while pure aluminum melts at 1,220 degrees Fahrenheit. However, surface oxides, one of aluminum's natural barriers against corrosion, melt at much higher temperatures, around 3,725 degrees Fahrenheit, almost 1,000 degrees over the melting point of steel. Unless these oxides, which can be four billionths of an inch thick (5 rim, angstroms), are removed prior to welding, sound metal fusion doesn't occur. This is the major reason why weld preparation and cleanliness are vital concerns in welding aluminum as compared to steel. Protective oils and grease are cleaned off with non-chlorinated solvents like toluene. Chlorinated solvents emit toxic fumes during welding, a chemistry similar to mustard gas. As with all types of welding, you should have adequate ventilation of the workstation. Before welding, it’s extremely important to remove surface oxides. A clean stainless steel wire brush is recommended for brightening the weld area.

When heated, aluminum doesn’t show color, which is another characteristic that makes the lightweight metal tricky to weld. An inexperienced welder may not recognize the silvery sheen under the blue hue of the arc as molten metal. When the weight of the puddle exceeds the surface tension of the molten metal the spot sags and drops, leaving an embarrassing, ugly hole in the weld surface.

Aluminum oxide abrasives are common grit materials in most shops because aluminum oxide is one of the hardest substances known, second only to diamonds. These same oxides are heavier than aluminum, and their presence destroys expensive milling cutters if the oxides are trapped in welds where finish machining has been done. Another phenomenon that makes welding aluminum different than joining steel is the alloys' affinity for hydrogen gas. Aluminum sucks up hydrogen when molten and emits it more slowly as the metal solidifies. Gas entrapment occurs with tell tale porosity in the welds.

In many facilities, raw materials are stored in unheated space. Cold metal seats when it’s brought into a warmer workstation. Unless aluminum is gradually raised to ambient temperature, weldements pick up hydrogen gas from the condensation. Fabricators recommend storing aluminum in the vertical position for this reason. Pre-heating to 150° Fahrenheit removes surface moisture and allows for better penetration of welds, especially with plates heavier than ½ inch thick.

Dozens of aluminum alloys can be obtained in wrought forms such as rolled bar stock, sheet, plate, extrusions, and pipe. Some aluminum alloys respond to heat treatment. The nomenclature for both cast and wrought alloyed aluminum chemistries is established by the Aluminum Association of America. Currently, in wrought shapes there are eight series of four digit numbers 1XXX to 8XXX. The 1XXX series is high purity aluminum with a little iron and silicon added. In the 2XXX series, the major alloying ingredient is copper. The 3,003 contains manganese, which is stronger and less ductile than 1,100 grade. The 5XXX series like the 5,052 has magnesium and chromium added for good ductility. Cold working will produce hardness. Heat treatable alloys are the 2XXX, 6XXX, and 7XXX series. The alloying ingredients of 6,053 are magnesium and silicon. All of this data, along with the corresponding filler wire, are published in tables and available from suppliers of welding supplies and wrought materials.

Cast grades of aluminum can be easily distinguished by their three-digit numbers like 206, 319. 356. The next time you stop at a red light look at the base of the traffic light and its support column. That's a common aluminum fabrication, a cast base welded to a tapered aluminum pipe.

Cast grades of aluminum, because of their higher silicon content for fluidity, do not anodize as well as wrought alloys. The two are difficult to color match, and the same is true of aluminum filler rods and the base alloy. The common filler rod for welding heat-treatable alloys like the 6XXX series is 4,043. When black anodizing a combination of 4,043 and 6,053, the welded surfaces will be a shade or two lighter than the 6,053 alloy. Color matching aluminum alloys is a problem that plagues companies striving for cosmetics on architectural hardware.

Remember, anodizing is a build-up of aluminum oxides a thousand times thicker than the natural oxides that occur on the surfaces of the metal. So, if you have to weld aluminum that has already been anodized, you have to grind and prepare the weld areas by removing all anodized finishes in the weld area.

According to statistics followed by the Aluminum Association, there has been an increase of 26 percent (13,197 to 16,664 million pounds) in usage of wrought aluminum products over the past ten years, which is a positive indicator of aluminum fabrication growth. Instead of sending your aluminum work up the street to another fabricator, you may want to do some marketing to see if there are other applications for aluminum fabrications in your product line. Like the teacher said, "It's not difficult, just different."

John Campbell is a former consultant, and is now a freelance writer and a regular contributor to Fabricator.

Reprinted from the May-June 1999 edition of Ornamental & Miscellaneous Metal Fabricator.