Equipment for aluminium welding

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In many cases, the arc welding of aluminium can be performed using methods and equipment that are similar to those used for welding steel. However, the physical properties of aluminium differ from those of steel in many respects and the equipment has to be adapted to guarantee reliable, high-quality aluminium welding.

MIG welding

An inexperienced aluminium welder will probably encounter most problems with the wire feed system. Experience of steel welding tells us that proper maintenance and the correct choice of accessory parts and dimensions are important. This also applies to aluminium welding, but there are some other rules which also have to be followed.

The wire feed system

Some types of aluminium filler material are very soft and they easily produce problems and burn-backs. So it is important to use a wire feed system that is recommended for aluminium welding. For the softest pure aluminium, the thinnest wires or the longest hoses, a push-pull wire feed system is the best choice, see Figure 1. The extra friction that builds up when the gun hose is curved is reduced by a push-pull system.

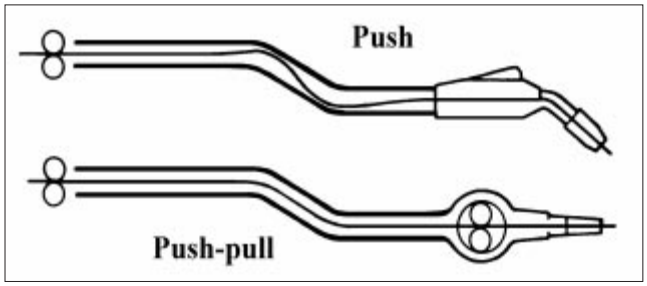

Figure 1. Difference between a push and a push-pull wire feed system.

The feed rolls that often have a V groove for hard steel electrodes should be replaced by rolls with a U groove for aluminium in order to prevent the wire deforming. Check that the size matches the wire and ensure that there are no sharp edges that will cut shavings off the wire.

Excessive feed roll pressure distorts the wire, thereby increasing friction and producing rapid wear of the liner and contact tips. It is also important to align the two rolls to avoid wire distortion.

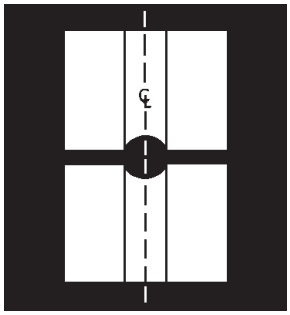

Figure 2. Align the drive rolls correctly. Misaligned rolls or excessive pressure distort the wire and cause feedability problems.

The welding gun

The contact tip is a critical factor. Use the correct inner diameter, normally 0.3-0.4 mm larger than the wire diameter, to avoid fastening and burn-backs. Replace the contact tip when it is worn out. If you notice that friction from material that builds up at the inner surface, the contact tip can be cleaned using a round section saw blade.

The liner and the inlet and outlet guides close to the feed rolls have to be made of a low-friction plastic material. Protect the wire from dust using a dust cover and clean the liner periodically, each time the electrode is changed, for example.

As aluminium welding is very sensitive to the quality of the shielding gas, it is important to check for leaks. Water or moisture may not contaminate the shielding gas. Even very small quantities result in weld metal porosity. The gas hose has to be made of a material that is specially chosen for this purpose.

Power source

A normal MIG/MAG power source can normally also be used for aluminium welding. However, an inverter for pulsed arc operation is recommended.

Power source characteristics

In Europe, a constant-voltage (slope: 2-3 V/100 A) DC power source is used for all types of MIG/MAG welding. Constant voltage produces the best arc length control. In the United States, a drooping characteristic

(slope: 10-20 V/100 A) is often recommended for aluminium welding. The reason for this is that it minimises current variations and produces more uniform penetration. A somewhat modified technique when starting may be necessary because of the lower short-circuit current.

Pulsed arc welding

Pulsed arc MIG welding is a method in which pulses from the power source control the transfer of drops from the electrode, making the arc stable and free from spatter even at low current settings.

Short arc welding, which is very common for thin sheet steel welding, is not recommended for aluminium welding. A spray arc can only be used for heavy metal welding in the horizontal position. Pulsed arc welding is a method which extends the range of the spray arc down to low currents.

Advantages of pulsed arc welding

- The opportunity to extend the spray arc range down to the lower setting range.
- The process is controlled and stable.
- No spatter generation.
- The stable arc makes it possible to use a thicker wire diameter, which will improve the wire feed properties.
- Less smoke generation due to lower drop temperature.

Power sources for pulsed arc welding

Modern inverter type power sources are as fast as needed to generate the pulses and control the arc length. They also have a database containing all the necessary information, ”Synergic lines”, about setting all the parameters. The welder simply needs to adjust the wire feed speed and the pulses are automatically adapted.

AC MIG welding of aluminium

This is something we have heard very little about in Europe and the USA, but it is more common in Japan.

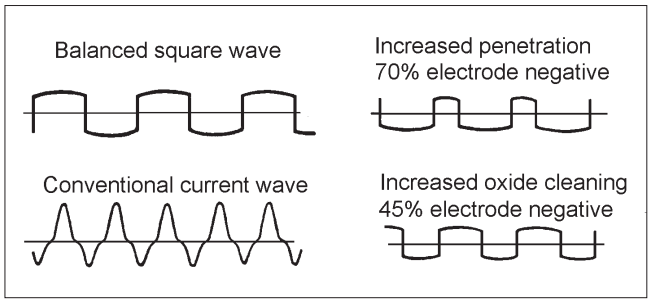

Figure 4. A square-wave power source is the best choice for the TIG welding of aluminium.

Some 700 units have been sold by different manufacturers. As many as 85% of them are used in the transportation industry, where the majority are used for welding motor cycles. AC MIG welding can be combined with pulsed arc welding and is mainly used for thin sheet metal.

During the portion of the time when the electrode is negative the melting rate of the electrode increases. This also means that, for a given wire feed speed, a lower current is necessary to melt the wire. At 50% negative polarity, the current will be reduced by 40%. The benefit is lower heat input, suitable for thin plate and with improved gap-bridging performance. A higher welding speed can be achieved without burning through. The lower heat input results in less distortion.

However, the problem that arises relates to stability, as a result of poor arc re-ignition at the zero crossings. This problem can, however, be solved using a square-wave power source where the zero crossing time is very short.

TIG welding

When it comes to TIG welding, the equipment also has to be adapted to some extent for aluminium welding. Aluminium is normally welded with an AC current. DC, with the electrode negative (EN), which is used for steel, does not produce any oxide removal and a positive electrode (EP) would generate too much heat in the electrode. AC is a compromise solution, but here,

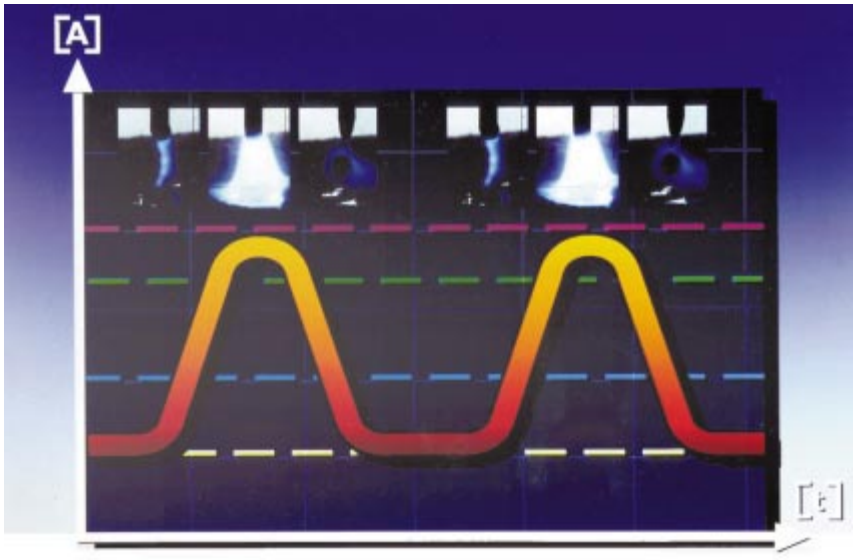

Figure 3. Principle of pulsed arc welding. Current pulses from the power source have such a high amplitude that they reach above the green line where drops can be detached from the electrode. Between pulses, there is a low background current. The mean current (blue line) and the heat input can be kept low. The pulse frequency is in the range of 50-300 Hz.

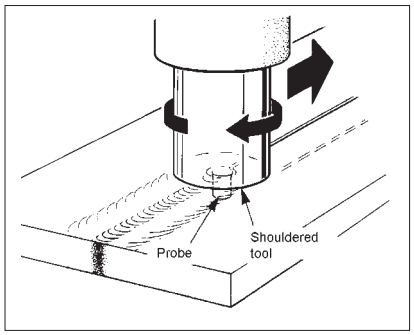

Figure 5. The principle of friction stir welding.

too, the development of modern square-wave power sources with a balance control for the percentage of positive/negative polarity has improved performance. For AC welding, the electrode should have a rounded shape not a sharp tip, as is the case for DCEN welding.

Another solution that is sometime used for welding aluminium with DCEN is to use helium as the shielding gas. However, the higher arc voltage drop in helium may necessitate a power source with high open-circuit voltage.

Friction stir welding

One interesting development when it comes to friction welding is the method involving a rotating tool, so-called Friction Stir Welding (FSW). The two parts of the workpiece are clamped in a square butt weld onto a backing bar. Together with the shouldered tool, this clamping prevents the joint metal from flowing up or the plates being moved out of position. The tool has a profiled probe that is forced through the material. Frictional heat is generated between the tool and the material in the workpieces. The joint metal is softened without reaching melting point and allows the tool to traverse the weld line. The plasticised material is transferred from the leading edge of the tool probe to the trailing one. It leaves a solid-phase bond between the two pieces.

The process can be regarded as a solid-phase keyhole welding technique, as a hole to accommodate the probe is generated and is then moved along the weld during the welding sequence.

FSW compared with other processes

- Good, reproducible weld quality. No porosity or lack of fusion.
- Energy-efficient, low heat input. This results in low levels of deformation and little impact on material strength.
- Minimum surface preparation and no need for post-weld treatment.
- No light emission, no smoke or toxic gases that are dangerous for the operator or other personnel are produced.
- No consumables are needed.

FSW in production

The ESAB SuperStirTM plant at Marine Aluminium in Norway (see Figure 6) has been designed primarily for the production of panels for ships and railway wagons, but it can also be used for other parts such as heavy profiles. The maximum panel dimensions are 16 x 6 metres. Aluminium alloys of almost every kind, from 1.6 mm up to 15 mm, can be welded in one run and the most common, 6082-T6 in 5 mm thickness, can be welded at a speed of 750-1,000 mm/min.

This machine was the very first FSW and has been in use since 1996.

The experience acquired at Marine Aluminium shows that the tool service life is 1,000–2,000 metres of welds (depending on the material used). By April 2000, the plant had produced some 200,000 m without any kind of defect.

About the author

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Figure 6. Plant for fhe friction stir welding of panels from extrusions at Marine Aluminium in Norway.