ESSENTIAL VARIABLES FOR MIG WELDING ALUMINUM

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Influencing factors in the MIG-welding of aluminium

The high quality MIG-welding of aluminum is a much more sensitive operation than the welding of some other more common materials, mainly due to aluminum having very different physical characteristics, such as its thermal conductivity. To achieve necessary levels of repeatability, all variables in the process must be carefully considered.

An everyday analogy would be the production of high quality photographs, where type of camera, lens used, filters attached, film speed and make, type of lighting, subject composition, camera settings, depth of field, and processing, can all make a profound difference to the end result of a photograph.

A change in anyone of the MIG-welding variables, when transferring established data, may produce an adverse effect on the finished weld characteristics and quality.

WELDING POWER SOURCE

Many different types of power sources may be encountered, and the assumption could be made that they should all provide the same results as the power source used to establish the initial welding data. This assumption may be incorrect. Welding parameters established with one type of power source may not necessarily provide the same welding characteristics with another.

The range of power sources can include DC rectifiers, constant voltage or constant current, DC inverters, pulsed self-created programmed systems, and pulsed synergic systems preprogrammed by the manufacturer. Another area of concern is that voltage and current meters installed on the power source equipment are, often, not calibrated. This may result in misleading data being provided.

WIRE FEEDERS

If digital read-out values of the wire feed rate is provided as part of the equipment, it may be advisable to verify their accuracy, as large variances have been recorded on some equipment when using calibrated external reading devices for verification. This situation strongly suggests the need for using external calibrated equipment in order to verify the wire feed rate, as even small differences in this variable, can produce changes in the welding characteristics that are unacceptable for aluminum welding.

Fig 1. *The author MIG welding a thick 6xxx series (Al/Mg/Si) extrusion using a 5356 (5%Mg) filler alloy and high current spray transfer settings.*

Another area of concern relating to wire feeders is the equipment's ability to consistently feed the spooled aluminium welding wire when MIG welding, without interruption, during the welding process. Feeding is a far more significant issue with aluminum than steel and is probably the most common problem experienced when moving to MIG welding of aluminum. This is primarily due to the difference in the mechanical properties of the materials. Steel welding wire is comparatively rigid and can withstand far more mechanical abuse. Aluminum is softer, more susceptible to being deformed or shaved during the feeding operation, and, consequently, requires far more attention when selecting and setting up a feeding system for MIG welding.

Feeding problems often express themselves in the forms of irregular wire feed or as burn-backs (the fusion of the welding wire to the inside of the contact tip). In order to prevent excessive problems of this nature, it is important to understand the entire feeding system and its effect on aluminum welding wire.

Starting with the spool end of the feeding system, the brake settings should be considered, first. Brake setting tension is required to be backed off to a minimum. Only sufficient brake pressure to prevent the spool from freewheeling, when stopping welding, is required. Inlet and outlet guides, as well as liners, which are typically made from metallic material for steel welding, must be made from a non-metallic material such as Teflon or nylon to prevent abrasion and shaving of the aluminum wire.

Drive rolls should have a proper U-type contour with edges that are chamfered not sharp, be smooth, aligned, and have correct drive roll pressure. Excessive drive roll pressure can deform the aluminum wire and increase friction drag through the liner and contact tip.

WELDING GUNS

Length of gun cable assemblies can produce a voltage drop. Contact tip internal diameter and quality are of great importance. If the internal diameter is too large, and there is too much clearance between the wire and the contact tip, arcing can occur. Continuous arcing inside the contact tip can cause a buildup of particles on the inside surface of the tip, which increases drag and produces burn-backs. Contact tip design can affect electrical conductivity and resulting arc characteristics.

SHIELDING GAS SUPPLY

Back pressure values need to be taken into account when supply lines are run over long distances. Differences with these values can have an effect on arc characteristics, especially with respect to aluminum-silicon filler alloys A1Si. If the shielding gas is supplied through bulk liquid delivery systems, then all conditions are basically similar. However, this is not necessarily true with cylinder supply of argon gas.

ALUMINUM FILLER ALLOY

Surface condition should be free of slivers, tears, cracks, seams and laps that are able to entrap impurities. These surface conditions can introduce impurities during welding, which in turn can change the arc characteristics and result in remarkably different weld results. Also, actual wire diameter can vary from spool to spool depending on the manufacturers production system. A change in wire diameter, even within the manufacturing specification allowable range, can produce very significant differences in wire cross-sectional area. These differences in wire diameter can relate to extremely different welding characteristics and the potential for major welding discontinuities. This problem is most serious on robotic or mechanized applications. Wire cast and helix can also have an effect on arc conditions.

BASE MATERIAL SURFACE CONDITION

Oxide thickness can vary from part to part depending on method of storage or heat treatment. Areas of a work piece that have had direct and lengthy exposure to water and that show a white staining will produce an erratic arc when welded. Aluminum oxide should be removed prior to welding in order to prevent its interference during the welding process and its potential for causing weld discontinuities.

ARC LENGTH

Due to the high thermal conductivity of aluminium materials, additional energy is gained from the velocity or kinetic energy produced by the force of the droplets impacting the weld pool and base material. Although these distances may appear very short, slight changes will have a significant effect on heat input that may produce lack of fusion or lack of root penetration discontinuities. The usually recommended distance of 12 to 15 mm is a reasonable degree of tolerance. By increasing this distance, the focal area on the base material that is being impacted by the droplets is increased, and the distance that the droplet travels will increase with a consequent reduced velocity and final energy being delivered to the weld pool. Care must be taken when changing gun angles or changing the position of the gun on the circumference of rotated tube, pipe or tank fabrication as this can significantly affect the actual arc length employed.

Fig 2. *The author welding a thin heat exchanger made of 3xxx series (aluminum/ manganese) with pulse spray and 4047 (12% Silicon) filler alloy... a very different welding procedure than that used in Fig 1.*

Aluminum welding requires that the contact tip is recessed into the gas nozzle. A recess in the range of 3 mm to 8 mm, depending on the voltage in use, is reasonable, *i.e.,* low voltage work requires a short recess (17 to 21 volts), conversely high voltage work, (22 to 30 volts) requires a long recess. It is, therefore, important to monitor and record this variable as this will affect the arc length and the energy being delivered to the base material.

For example, if procedure data is developed with a contact tip recess of 3 mm and actual production work is using a 8 mm recess, one would expect a different result.

ALLOY TYPE

Weld data developed on one alloy may not apply for another. This is due to the great differences of thermal conductivity values for the different materials. An example of the range is as follows:

AA 1100 1540 BTU AA 5083 810 BTU
AA 3003 1340 BTU AA 6063 1510 BTU

It can be seen for example that AA6063 would require very different weld parameters than AA5083 with the former requiring far greater heat input. When welding dissimilar grades to one another this needs to be taken into consideration.

HEAT SINK VALUE AFFECTING WELD CONDITIONS

Weld data on one set of geometry will not necessarily work for another even if they may appear to be similar. When welding different section thickness, the thicker aluminum sections require significantly more heat to effectively weld. Applying procedures designed for thin materials can result in weld discontinuities if applied to thicker sections. Special care is required when designing welding procedures for joints between sections having large differences in sections.

LOCAL ENVIRONMENT AND BASE MATERIAL TEMPERATURE

For the robotic and mechanized welding of production components, the base material temperature can have an effect on the start of the weld. Conditions developed at a local workshop temperature of 22°C could be different to that if the temperature was 12°C, for example. On large complex components requiring significant welding time, the base material may see a gradual increase in temperature. As the part gets hotter, welding conditions may require a change to accommodate this increase.

ABOUT THE AUTHOR

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