TOPTIG offers TIG quality with MIG productivity

This article – extracted from a paper by T Opderbecke, and S Guiheux of Air Liquide C.T.A.S, the welding division of Air Liquide, which was recently acquired by The Lincoln Electric Company – introduces TOPTIG, which incorporates an integrated wire feeder and a novel torch design to enable welding speeds associated with MIG/MAG welding to be achieved while retaining the end weld quality associated with TIG welding.

TOPTIG is a robotic tungsten inert gas (TIG) welding process developed to combine the quality of TIG with the productivity of metal inert gas/metal active gas (MIG/MAG) welding. Key to the technology is an original torch design that incorporates the wire feed into the gas shroud of the torch at an ideal fixed angle relative to the tungsten electrode.

As well as reducing overall dimensions for enhanced accessibility for robotic welding, this torch design removes the need for separate wire feed and torch control, which simplifies programming and liberates one axis from the controller.

Several technical features are associated with TOPTIG, including an automatic electrode changer, a double flow gas nozzle, and a push pull and pulsed wire feeder. Applications have been developed in partnership with the automotive industry for spatter-free weld-brazing of galvanised steel with CuSi3 wire, for example, while other applications can be found in welding stainless steel or aluminium in the food industry or for manufacturing high quality metal furniture.

The TOPTIG process targets three key aims: high welding speeds for improved productivity; compact torches for robotic welding without the manipulation constraints associated with conventional TIG or plasma torches; and an automatic electrode changing capability.

The key innovation in the system is a patented welding torch with integrated wire feeding. The wire feed passes through the gas nozzle at an angle of about 20° to the electrode, parallel to the cone-angle of the electrode tip. This causes the wire to pass through the hottest region of the arc, which promotes high deposition rates.

This configuration enables the TOPTIG torch to be used on robot arms as a direct substitute for MIG/MAG torches. The distance between the electrode and the work piece also becomes less sensitive, because the wire tip is always aimed into the weld pool and, because the wire tip is permanently attached to the gas nozzle, its position cannot change.

Also, because no current flows through it, the wire is melted under arc heating to form either a liquid metal stream or discrete metal droplets, neither of which is associated with spatter and deposition rates can be varied independently of the arc current.

The liquid stream transfer mode involves the continuous flow of filler metal into the weld pool at the edge of the arc cone. This results in high deposition rates, a very regular weld seam and a significantly reduced risk of the filler wire coming into contact with the tungsten electrode. This transfer mode can be obtained for all common welding and weld-brazing wires, as well as those for stainless steel and aluminium.

The droplet transfer metal mode is similar to short-arc MIG/MAG metal transfer. Contact of the molten weld tip starts a necking process in the liquid wire. The liquid droplet grows before detaching under gravity and surface tension and entering the weld pool. This continuous cycle helps to stir the weld pool and can, for example, help to prevent porosity or lack of fusion.

The two transfer modes can be obtained by varying the welding parameters, most notably, the welding current and the wire feed rate.

Another design feature of the TOPTIG torch is an optional gas nozzle, which Induces dual flow. This provides higher flow velocities in the centre of the tungsten arc, which causes the arc to

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constrict, raising the energy density and improving penetration. Furthermore, it helps to more effectively protect the tungsten electrode.

Using a dual flow nozzle, for example, full-penetration butt welds on 3.0 mm stainless steel plate can be produced without the need for joint preparation. Another application involves using the constricted gas jet to force copper filler material deep into the gap of an inner flange joint.

Test results and applications

The TOPTIG process can be implemented on all applications on thin sheets from 0.5 to 3.0 mm thick, particularly in those that demand high-quality, productivity and reasonable costs.

Welding speeds: In all the applications tested, the most interesting result is the welding speed. Contrary to the classical GTA process, the welding speeds achieved are similar to those obtained with MIG/MAG processes. For example, a welding speed of 1.0 m/min can be easily achieved for lap weld brazing of 1.0 mm galvanised sheet.

In the test laboratory, speeds up to 3.5 m/min were reached on electro-galvanised sheet, while for conventional single wire MAG brazing, maximum speeds of 1.5 m/min can typically be achieved.

Weld bead appearance: Another advantage of TOPTIG is excellent weld bead appearance. The use of this process with non-oxidising shielding gases results in 'brilliant' beads with very low levels of surface oxidation, most notably for weld brazing and stainless steels joints. Furthermore, the liquid stream transfer mode leads to a smooth bead surface free of solidification waves.

Spatter: There is a complete absence of spatter during normal arc welding using TOPTIG as no current passes through the wire. However, when welding coated or galvanised steels some of the surface coating can vaporise which gives the appearance of spatter. Also this vaporised material will have an adverse effect on tungsten lifetime and hence arc re-striking.

For these reasons, TOPTIG arc welding of galvanised materials is not recommended, but braze welding applications, where the lower heat input avoids such vaporising phenomenon has been successfully implemented.

Distortion: The independence of welding current and the wire speed rate allows the energy/heat input into the joint to be widely varied and well controlled to minimise distortion. This is particularly advantageous for the welding of thin stainless steel parts.

Control and flexibility of the process: The TOPTIG process is easy to implement. The welding path is determined


TOPTIG is ideal for robotic brazing of car body parts.

by the position of wire tip, with an ideal standoff distance between the electrode tip and the sheet of 3.0 mm and one wire diameter separating the wire and the cone of the tungsten electrode.

Integrated wire feeding and the fact that the wire melts near the point of highest arc temperature means that the orientation of the wire is insensitive to the welding direction, giving more freedom when welding complex structures using a 6-axis robot.

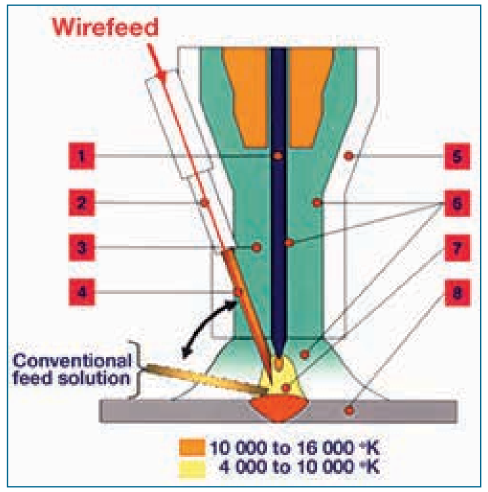
Moreover, this process is able to better bridge poor gap tolerances, with gaps of up to a wire diameter presenting no problems – and the use of weaving can be applied to overcome larger gaps.

Above all, TOPTIG has been developed for automotive applications involving weld brazing on thin-coated steel sheets. Most of these applications are lap joints on 0.8 mm to 1.5 mm thick galvanised sheet. The use of TOPTIG allows welding speeds of about 1.0 m/min to be achieved on these joints and the process produces excellent weld bead appearance.

For welding stainless steels, the use of TOPTIG is also very exciting, because of the achievable welding speeds and deposition rates (about 3.0 kg/h). Possible applications include, for example, the food industry and for metallic furniture where TOPTIG excels due to its excellent bead appearance.

The torch is mounted to the robot arm via a quick connector to a push pull wire drive. The torch is internally water-cooled and additional water-cooling of the gas nozzle can be used in cases where high currents or confined assembly situations cause excessive heat build-up.

The wire guide tip is easily removable from the gas nozzle when worn or when changing the wire diameter. The gas nozzle can be removed easily from the torch without affecting the water circuit. The electrode is clamped into the central electrode holder that can be



A schematic of the TOPTIG welding torch. 1: tungsten electrode; 2: wire feed; 3: dual gas (optional); 4: integrated wire feed; 5: nozzle; 6: shielding gas; 7: constricted arc; 8: workpiece.

removed automatically.

The current limit of the torch is 220 A dc current, which is suitable for wire diameters of between 0.8 to 1.2 mm.

The torch is associated with a complete welding solution, including: a dedicated 220 A 100% duty cycle dc power source with remote control; the harness and a wire-feed unit capable of feeding wire at a rate of up to 10 m/min. The equipment is also HF protected via full isolation between the robot, the wire feeder and the opto-coupled signal interface.

The optional electrode changer is pneumatically driven with an onboard PLC control that can be connected to all common robots. It offers a stock of seven electrode holders on a tool-changing platform. The control of the stock is automatic and the cycle time of an electrode change is about 15 seconds.

Conclusions

TOPTIG is a new variant of the conventional TIG process adapted for robotic fabrication. The torch design offers simple and reliable setup and very good accessibility, even when welding complex parts. For increased productivity, an automatic tungsten electrode changer, a quick torch to robot connector and a pulsed wire drive are also available.

The achievable welding or brazing speeds are similar or sometimes higher than those obtained using single wire MIG/MAG/MIG/MAG processes, but weld quality is significantly improved.

The process is ideal for thin sheet joints of up to 3.0 mm, most notably when excellent weld quality is required for visible or semi-visible areas of products.