Solutions for automated tube-to-tubesheet welding

In tube-to-tubesheet welding, historically manual welding was the only option for joining metals and alloys. GTAW (Gas Tungsten Arc Welding) or, as it is commonly referred to, TIG (Tungsten Inert Gas) welding has become a well-established method. Most tube-to-tubesheet connections can be accomplished by manual welding. However, since the introduction of automatic welding, greater production opportunities have been made available to manufacturers. The development of mechanised TIG welding equipment provides for the production of large quantities of identical welds, unrivalled weld quality, and exceptional TIG process stability, allowing for the modification of weld parameters within a wide range and the almost unique feature of controlling the addition of filler metal independent of weld current intensity.

Although, there is still often a choice between manual and automated welding, in some applications manual welding is simply not possible. Polysoude is one of the companies that has been developing solutions for applications where automated welding of tube-to-tubesheet is the only, or preferred, option. The company has designed welding tools and torches, specifically to complete single or multi-pass welds in situations where the accessibility of joints is problematic.

Its standard TIG torch is equipped with a non-consumable tungsten electrode, which is centred in a gas lens and surrounded by a ceramic nozzle. A continuous electrical discharge, between the electrode and the workpiece, the 'electric arc', releases heat, creating a pool of molten metal. The gas lens maintains a laminar flow of shielding gas to protect the hot electrode, the weld pool, and the heated zone of the workpiece, from the oxygen in the atmosphere. The arc is very stable and regular, no welding fumes or splatter are released from the TIG process. This standard design can be adapted, wherever necessary, to complete the various operations required in the welding of tube-to-tubesheet.

In the case of air cooled heat exchangers, for example, the joints are inaccessible for a manual welder. Generally, in air cooled heat exchangers, a hot medium passes through the heat exchanger along a number of tubes. The tubes at both ends are connected to the walls of two rectangular boxes, which are called headers. They are recessed ready for connection at the inside of the back tube plate; the only way to access the welding of joints is through the front plug sheet of the header box.

Using automated orbital tube welding, the company's specially adapted TIG torch, or 'lance', can be used for such welds, at the inner edge of the rear tube plate. A range of distances between the front sheets and back plates of header boxes (usually up to 300 mm) can be covered, as the scope of the lance, can be reduced by the use of spacers to 100 mm, where necessary. Filler wire is integrated within the body of this torch and the torch angle has been specifically designed for optimum accessibility. The lance is controlled by AVC, an essential prerequisite, as this dispenses with the need for manual adjustment.

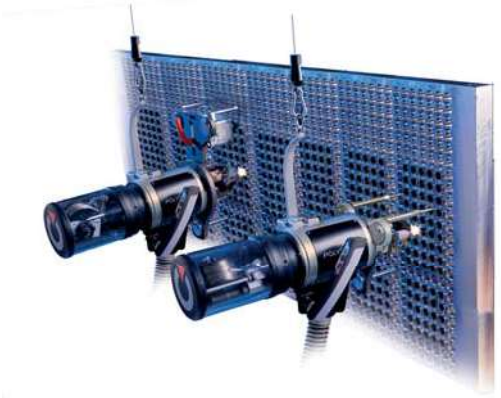


Fig.1. Orbital tube-to-tubesheet welding heads.

For tube-to-tubesheet applications, which require the welding of thin-walled Tubesheet (up to a thickness of 30 mm), where the tube is connected at the rear, Polysoude has developed a special open orbital welding head, known as the TIG 20/160, with a special torch, to carry out gapless welds from the front face. This is equipped with special clamping units, which are not centred within the tube to be joined, but instead make use of other bores located around it. For this kind of joint, full penetration is required and generally filler wire is added. As the access to the weld zone is quite restricted, correct adjustment of the distance between the electrode and the workpiece, for a proper setup of the welding head, is again taken over by the AVC function. During the weld cycle, the operator has only a limited visual field to watch the process, so the uniform arc length is ensured by the AVC system as well. A second slide is installed to move the torch perpendicularly to the welding direction. The operator can centre the electrode precisely above the joint, via remote control pendant. During the welding operation, an alternating movement of this slide can be programed, so that instead of the stringer bead technique, the torch oscillation forms a wider weld seam. If the inner diameter of the tubes is large enough to introduce a TIG welding torch, connections at the rear of tubesheets with bigger wall thicknesses can be welded using Polysoude's customised tooling, to create autogenous welds or with the addition of filler wire, depending on the application.

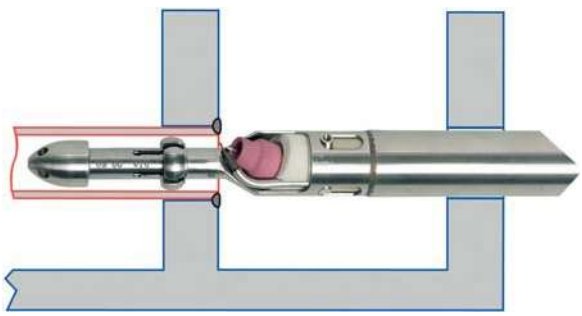
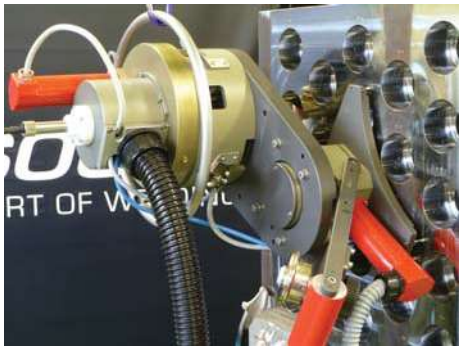


Fig.2a + 2b. Welding of header boxes.



» *Fig.3a + 3b. Welding head for heavy wall multilayer applications.*

» *Fig.4. Internal bore welding.*

A third application, in which automated welding is the sole solution, is the welding of gapless joints at the rear of tubesheets with wall thicknesses of up to 600 mm and tubes with small inner diameters; this process is known as internal bore welding. The closeness of the tubes prevents joining from the shell side, as there is not enough space to position even the slimmest orbital welding head. Internal bore welding is carried out from the front face of the tubesheet by means of a welding lance, which is introduced into the individual tube.

Very close workpiece tolerances must be adhered to, the joint preparation of the tubesheet has to be carried out on a CNC machining centre, the ends of the quality tubes must be cut square by means of adequate facing machines, and the assembly must be expertly carried out. Only state-of-the-art orbital welding equipment with excellent repeatability can be used and the consumables, such as shielding gas and electrodes must also be of outstanding quality.

For every application of this type, an individually designed matching welding lance is required as the small diameter of the tubes is insufficient to provide enough space for wire feeding. By the same token, the integration of an AVC device is normally impossible as well. The correct setup of the welding head is vital, in particular, the correct projection of the electrode. The TIG torch or lance is modified to a ceramic sleeve with a hole to allow the tiny electrode to pass through.

More information can be found in the brand new handbook 'Orbital TIG welding of industrial heat exchangers' which is available at www.polysoude.com via the documentation request form.