The key to quality

Meeting hygienic security specifications with automated orbital welding equipment

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The design of production lines and equipment for processing, filling and packaging food, chemical and pharmaceutical products must exclude any contamination. The installations consist mainly of thin-walled pipes with less than 3.5 mm wall thickness, constructed with commonly used materials such as stainless steel or nickel-base alloys like AISI 304, AISI 316 and 904L. Installation critical zones include connections between pipes and joints between pipes and bends or other components. Consequently, reducing the potential for contamination means reducing the number of these connections to a strict minimum.

Welded joints are generally assumed to be the origin of a wide variety of imperfections, including geometry (concavity or convexity, regularity of the weld), surface (roughness, porosity, cracks), material composition (metallurgical and structural changes, colourisation), and fusion (lack of fusion, burn through, crevasses), to name a few. In general, a certain number of weld imperfections exclude the obtained joints from being acceptable. However, for practical and economic reasons, 'perfect' welded joints are impossible to realise. To overcome this, obligatory limits have been specified for all acceptable weld imperfections.

To get satisfactory results, welding operations must be preceded by an extensive planning process, which begins with the conception of the installation. A manual welder needs free access to the tubes to be joined. Very narrow distances between tubes or other obstacles make the welder's work difficult or even impossible. As such, the pipe material has to be chosen with regard to sufficient weldability. Notably, the sulphur content of the alloys is limited between a minimum and a maximum. In addition, the sulphur content of the parts to be welded must not differ too much, and therefore it is strongly recommended parts are manufactured using alloys that are created at the same temperature.

Other concerns associated with ensuring that pipes are suitable include very tight tolerances of geometry and wall thickness, as well as the quality of the pipe end preparation. If machined on-site, the burr-free rectangular preparation without chamfer only can be obtained if proper facing machines are used. Finally, the pipes have to be positioned in a manner that avoids misalignment and gaps between the pipe extremities (Figure 1).

Figure 1. Installation in a food and beverage plant with an orbital welding head. The workpieces must be properly positioned to avoid misalignment.

Automated orbital TIG welding technology is strongly recommended

Recommendations, standards and regulations on surface finishes that will come into contact with food, beverages or medicines define the required quality of stainless steel welded connections. In addition to conforming to both European and American laws, the most important stipulations are specified in the European Hygienic Engineering & Design Group (EHEDG) Guideline Docs. 9 and 35, which address stainless steel welding.[1,2] These guidelines state that an essential prerequisite to successfully welded joints is the control of the welding process at all stages and, although manual welding is not expressly excluded, automated welding is preferred for its repeatability and consistency. In both the standards of the US Food and Drug Administration (FDA) and in the book "Hygiene in Food Processing," which has a focus on hygienic equipment design, the use of automatic orbital TIG welding for pipework is strongly recommended.[3]

A well-trained manual welder can, of course, produce quality welds; however, an automated orbital welding machine guarantees constant results together with sustained consistency. Automated orbital welding delivers smooth weld seams that allow adequate cleaning. The seam roots end flush with the internal pipe wall and the minimised and controlled heat input causes the lowest level of oxidation, which, if really necessary, can be removed by etching.

Independent of the chosen welding method – manual or automated welding – adequate equipment and consumables must be made available. Top-class welding gear leads to first-rate results. In manual welding, the craftsmanship of the welder is another important factor, but in automated welding as well, only a well-trained operator who is proficient in his or her tasks will get the desired results in a reliable way.

Tungsten electrode products from well-known brands should be preferred. If closed orbital welding heads are the tools of choice, customer-specific prepared electrodes can be purchased. The adequate length and shape of the electrodes enable the operator to change them whenever necessary without worry about machining small pieces, dust release, or similar challenges while working on-site.

Meticulous attention must be paid to the inert gas, which can be supplied by cylinders or a central gas tank. The purity of the inert gas in the cylinder or tank may meet the specifications, but any contamination from tubes, hoses, valves, connections from the distribution system also needs to be reliably excluded (Figure 2). Furthermore, if the devices are subject to changing temperatures, unwanted humidity can be generated.

Poor shielding gas quality is discovered in most cases during the welding process or through an external visual inspection. However, insufficient inerting inside the pipes to be welded is very difficult or impossible to detect, especially when the roots are not accessible. To ensure sufficient root protection, the oxygen content of the outstreaming backing gas has to be monitored, since welding can only be executed if the required low values are reached.

Figure 2. The hygienic, aseptic, sterile and particle-free design of the weld seam surface is smooth and clean, enabling thorough cleaning because product residue cannot adhere and bacteria cannot settle. These are properties that typically are met by using automated TIG orbital welding.

Orbital TIG welding – when quality is the primary concern

When high quality welds are required, orbital TIG welding is the recommended technology for tube-to-tube or tube-to-bend welding applications. Fusion welding without additional filler wire is a stable, reliable process that can be used on steel, stainless steel, titanium, nickel, aluminium and their alloys. In the course of the development of appropriate welding parameters, a provisional welding instruction (pWPS) can be created, its final transformation to a weld procedure specification (WPS), a so-called welding program, guarantees the constantly high-quality weld level through automation. The welding cycle can be repeated as often as necessary, always leading to the same result. Once memorised, the welding parameters can be checked at any moment and compiled into a printable protocol for consistent traceability.

Figure 3. A guaranteed reproducible welding result, which displays the mechanical parameters for tube-end preparation as documented by a state-of-the-art system.

Enhanced efficiency of automatic equipment is achieved due to its precise programming facility. Unlike power sources of the previous generation, the latest units allow the operator to find matching weld programs by means of a touchscreen or personal computer (Figure 3). The operator inputs fundamental data relating to the size and material of the tubes to be joined. The system consults its built-in database to find similar applications, or suggests weld parameters determined by progressive calculation. The proposed welding procedure can be optimised by an expert help menu.

State-of-the-art orbital welding equipment is designed for real-time monitoring of the key weld parameters; a complete weld protocol can be generated and stored or output as a printed document.

Figure 4. Orbital welding equipment on stainless steel tube.

Fusion welds are carried out using portable inverter power sources, combined with closed orbital welding heads (Figure 4). These closed chamber welding heads are especially designed to meet the requirements of hygienic applications (Figure 5). The weld zone is completely covered by the shielding gas inside the closed chamber of the welding head (Figure 6). Thus, all welds are oxidation-free, complying with hygiene requirements.

Figure 5. High-quality welding results – work on tubes and fittings is carried out primarily using closed welding heads.

Conclusion

There are many benefits to using automated orbital TIG welding for pipework joints, especially when the manufacturer requires hygienic application on the production line. The required quality level, in accordance with the common stipulations for all TIG welding processes on steels, titanium and alloys, is constant and reliable. Automated orbital TIG welding has a positive impact on quality, because it creates the smooth weld seams required for comprehensive cleaning, together with a weld seam sealed flush with internal pipe walls, which are essential factors for the bacteria-free production of drinks, food and pharmaceuticals.

Figure 6. Orbital welding equipment on stainless steel tube with backing gas for the oxidation-free welds.

References

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