Welding Knowledge

WP - 311

part 3

Smaller Diameter Tube Welding

Making butt welds in small diameter metal tubes presents problems not experienced with other applications. Control over consistency of deposit, particularly with diameters less than 15 mm, is difficult even when using a mechanised process. Perhaps more significantly the issue of adequate internal weld purging with inert gas can become a real headache.

As tube diameters increase, manual welding can be used with more confidence but the need to purge effectively to avoid oxidation at the weld root is crucial. This can lead to significant loss of corrosion resistance (refs 1 to 5) if critical elements such as chromium are present in the metal and since the majority of small tubes are destined for applications in aerospace, food and drink this can be serious.

The solution to the purging problem is to seal the tube on both sides of the joint, have a small entry hole for the gas at one end and a suitable exit hole at the far end for the unwanted gas to pass out, and then fill the interspace with inert gas. A whole host of approaches have been tried over the years: these include using screwed up paper, plastic foam and carboard as sealants, but these ae prone to leak and even burst into flames during the welding process. The only truly effective method is to use thermally resistant expandable plugs through which inert gas can be passed. Even then, because of the possibility of turbulence and feeder tube leaks, it is advisable to employ oxygen monitoring instrumentation to measure and control any residual oxygen content close to the joint to well below 100 ppm.

1.Welding Techniques

Because of the necessity to maintain close control over the weld pool GTAW is used almost exclusively. Virtually all the metal alloys employed in industrial sectors employing tubes can be welded and since the process is carried out in an inert atmosphere it produces results that are extremely clean, oxide free and without spatter.

Integrated into orbital welding equipment this is the most reliable method of creating fusion welds capable of meeting the many stringent quality demands made for applications in the aerospace, food, electronics and petrochemical industries. Here, inconsistency and the presence of even minor imperfections must be eliminated to avoid rejection.

Automatic orbital welding equipment can be expensive and for small batch production may not be acceptable. Recourse then has to be made to manual welding but skilled operators are essential if weld quality is to be maintained.

For full control over the weld pool, a good balance must be maintained between gravitational force and surface tension at every position of the torch. With automated welding, a computer-controlled welding process runs completely independently, without the need for any intervention from the operator.

Argon is the most commonly used purge gas but helium, nitrogen and hydrogen also offer protection as inert gases during root protection. On a cautionary note however there are limitations with regard to hydrogen- and nitrogen-containing backing gases. These are unsuitable for use with materials such as titanium that are sensitive to gas uptake, since this can lead to embrittlement and/or porosity formation. Nor should such mixtures be used with most fine-grain structural steels.

2. Protecting the weld from contamination using inert gas purging

The smallest expandable purging systems are in the region of 15 mm diameter and are typified by the Argweld® Weld Purge Plugs™ (Fig 1) manufactured by Huntingdon Fusion Techniques (HFT) (ref 6). These accommodate pipe diameters from 15 mm and offer some flexibility either side of the nominal size. HFT® is currently developing purge systems as small as 5 mm diameter.

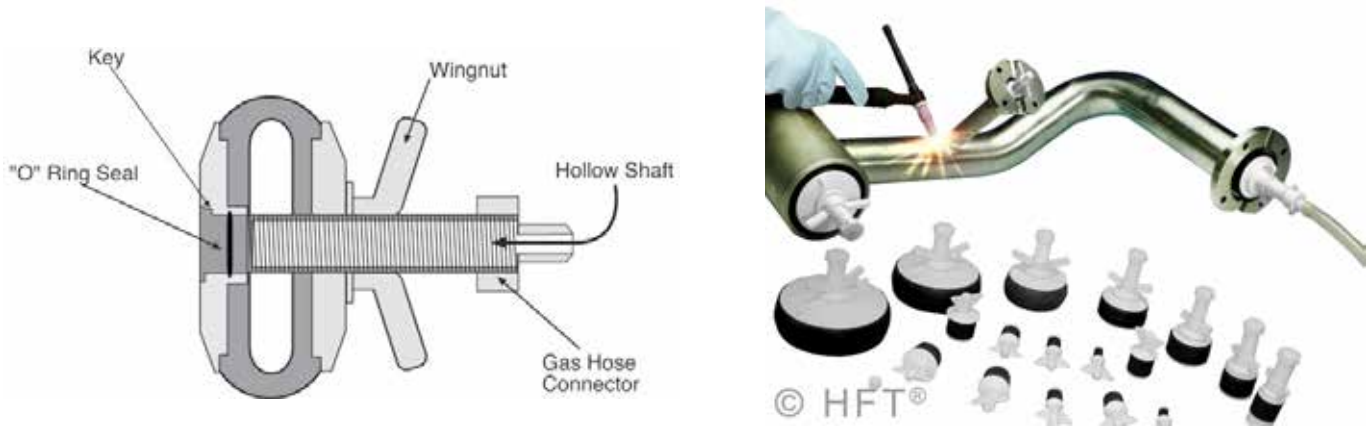

Fig 1 Tube diameters from 15 mm can be purged effectively using this type of engineered plug. Inert gas passed in at one end can be analysed for oxygen level at the exit.

The Argweld purge plugs can be used up to 75ºC continuously and 105ºC intermittently. Optional high temperature seals are available for use continuously up to 120ºC. A low-friction acetal copolymer thrust washer inserted between the top plate and wing nut provides easy expansion and release.

For tube diameters between 25 and the upper size for small tubes, considered to be 40 mm, there are fully integrated inflatable systems such as the Argweld® PurgElite® range (Fig 2).

These systems have a pair of inflatable dams connected by an armoured heat-resistant spinal tube. Once ready to start purging, the system is inserted into the bore with one purge dam either side of the weld joint. The spinal tube carries the gas to inflate the purge dams and the gas flow is then controlled automatically to release gas without causing turbulence. Only one gas connection is therefore required for both dam inflation and purging. The connecting spinal tube can be shortened or lengthened to accommodate special requirements.

Fig 2 A family of integrated purge systems is available covering all tube diameters from 25 mm. These offer total protection against oxidation during welding by providing a purge gas oxygen content as low as 10 ppm

Heat resistant covers with a rating up to 300ºC are available as accessories to protect the inflatable dams. These are attached with ties sewn into the covers.

Some currently available purge systems incorporate advanced control elements that include for example;

- IntaCal® technology to eliminate standard control valves and thus preclude any need for pre-setting.
- RootGlo® luminescent central bands that allow the operator to locate the purge system quickly and accurately by viewing through the weld root gap.
- PurgeGate® to prevent the dams from bursting due to excess pressure or flow.

3. Monitoring the purge gas oxygen content

The fact that even very small amounts of oxygen in the purge gas can cause discolouration around the weld underbead makes it desirable that sensitive instruments be employed to measure residual oxygen. Resorting to ‘do it yourself’ solutions such as the use of a flame at the exhaust end of the purged volume are prone to serious errors. They may be unsafe and only provide information about exit gas - nothing at all about the oxygen level at the weld root.

Two essential characteristics of a suitable instrument are that it must have an adequate measuring range and it must sample the gas inside the purge volume. The sensitivity should be such that an oxygen level as low as 10 ppm can be detected. Instruments that only display down to 1000 ppm (0.1%) are totally unsuitable.

A typical high sensitivity instrument will include a sampling tube, gas extraction facility and sensing electronics that are reliable and repeatable. It should be robust enough for site application and offer a calibration function.

Although many commercial monitoring systems are available these are generally not sensitive enough to meet the requirements for quality welding of sensitive alloys such as stainless steels and titanium where the presence of oxygen levels as low as 50 ppm are essential if loss of corrosion resistance (ref 2) and changes in reduction in mechanical properties are to be avoided. Typical of advances monitoring systems is the PurgEye (ref 6) family of instruments.

These specially designed instruments (Fig 3) can be used to continuously monitor oxygen level and if required interrupt the welding operation if levels increase above a pre-set limit. They are also useful as quality control tools and records can be stored using an optional data logging software interface.

Fig 3 Providing a sealed volume below the joint and purging with inert gas goes a long way to preventing oxidation. However, the purge gas itself need to be continuously monitored to ensure that a low oxygen content is maintained. This can be undertaken by using a monitor capable of detecting very low levels of oxygen. Advanced instruments such as the PurgEye range from Huntingdon Fusion Techniques meet these requirements.

4. Conclusions

Welding techniques and filler materials have been developed to accommodate the singular requirements for making fusion joints in small diameter tubes.

Advanced inert gas purging systems are available to provide excellent protection against oxidation for tubes as small as 25 mm diameter. Research is being undertaken to develop devices for diameters down to 5 mm.

In conjunction with purging equipment it is essential that continuous monitoring of the purge gas in the region of the joint is undertaken if oxidation is to be prevented.

For quality control purposes it is recommended that the whole sequence of the welding operation, but especially the purge gas oxygen level, is recorded.

References

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