

Welding the nickel superalloys

Independent consultant Michael Fletcher, a qualified metallurgist with extensive experience in welding and non-destructive testing, talks about the requirements for welding the new high-temperature creep- and corrosion-resistant nickel-based superalloys such as Inconel 740H, with particular regard for careful purging and gas purity monitoring during gas tungsten arc welding (GTAW).

Significant recent developments have been made that have resulted in the introduction of new nickel alloys that offer major improvements in mechanical properties.

Not least is Inconel 740H [1], a nickel-based, precipitation hardenable superalloy that offers a unique combination of high strength and creep resistance at elevated temperatures, along with resistance to coal ash corrosion. The alloy was originally used for A-USC boiler tubes in the superheater sections of power plants but has been adapted for use in steam headers. A-USC boiler tubes are typically sized at between 38 and 76 mm in diameter, while main steam header pipes can have outer diameters of 305 mm and wall thicknesses exceeding 38 mm. Seamless reheat piping with diameters of up to 760 mm is also now a target for the Inconel 740H alloy.

Whilst new materials such as these help to expand the use of nickel-based alloys in areas where mechanical properties and corrosion resistance at elevated temperatures are mandatory, the need to maintain strict control during welding is imperative in order to preserve these characteristics.

Inconel 740H has a higher chromium content than other alloys in this class of materials and consequently offers

significant high-temperature corrosion resistance. All the nickel-based alloys and particularly Inconel 740H, however, are prone to loss of chromium through oxidation during welding [2] unless some form of shielding is provided [3].

With respect to pipework and boilers, failure to purge or failure to purge properly will result in a heavily oxidised surface on the weld root inside the cavity, with substantially lower corrosion resistance. Even after the completion of the root weld, the weld purge should be continued for several passes to avoid heat tint, the discolouration caused by oxidation inside the tube or pipe.

When using the GTAW process, direct protection of the upper weld deposit can be achieved through the inert gas shroud with the additional use of a trailing gas shield. The weld root, however, remains fully exposed to the atmosphere and oxidation will take place.

An essential requirement when making butt joints, therefore, is to provide interior inert gas purging, typically with argon or helium [4]. With very small tubes this can usually be achieved through careful continuous gas flow through the inside of the tube, but this technique is prone to erratic coverage



Figure 2: These examples from the QuickPurge® range are representative of proven purge systems. They cover the pipe size range 152 to 2 235 mm in diameter.

because of turbulence.

Isolating the section to be welded by inserting dams on either side of the joint and filling the volume with inert gas is a much better solution. For economic reasons, attempts have been made to provide dams using paper, card, timber or even polystyrene plugs, but success is erratic, sealing is difficult, contamination is inevitable and effective removal of the debris following

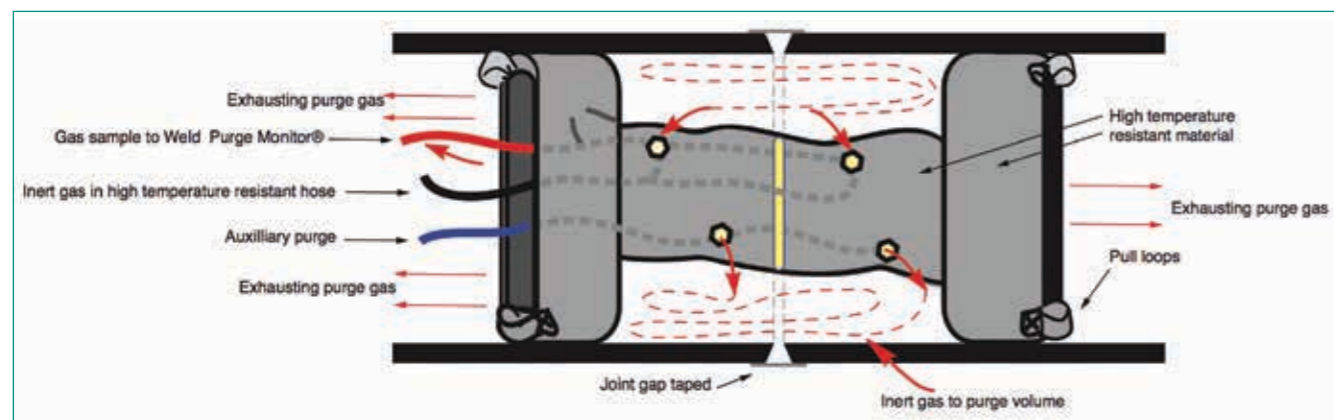


Figure 1: The use of an inflatable purge system for high temperature pipe welding with heat resistant material, hoses and fittings.



Figure 3: PurgEye monitors include full colour touch screen control. The instruments support data logging and weld certification. Readings are accurate down to 10 ppm (0.001%).

welding becomes an issue.

The best solution, and the one now adopted globally by leading fabricators, is to employ commercially available integrated inflatable purging systems.

For adequate protection of nickel alloys during welding the internal purge atmosphere should have the oxygen level reduced to 50 ppm (0.005%) or less in order to obtain a root surface with little or no oxide. Control of purge gas oxygen content during welding is clearly an important aspect. Recent development in monitoring instruments (Figure 3) have led to the introduction of equipment that measures oxygen level accurately and provides facilities for continuous recording. These systems can even over-ride the joining process if oxygen levels exceed those pre-set by the operator.

Techniques for measuring oxygen content have been available for decades but only recently have instruments been developed specifically for welding applications. Users increasingly demand complete absence from discolouration and no loss of corrosion resistance and this requires purge gas oxygen content to be as low as 20 ppm

(0.002%). Very few oxygen purge monitors are capable of meeting this sensitivity, but the PurgEye® instruments (Figure 3) cover all of these requirements.

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THERMASPRAY Launches Laser Cladding Services

Laser cladding is a process which applies a metallic overlay material to primarily metallic substrates, offering properties similar to traditional welding methods, such as hardness and impact resistance. It does however also offer the benefits such as low dilution, a small heat-affected zone, and minimal heat input into the substrate.

Precise application of localised refurbishment and superior metallurgical properties make laser cladding the perfect solution for heat-sensitive components that are exposed to harsh erosive, corrosive or abrasive environments.

- Benefits of Laser Cladding:**
- Full metallurgical bond to the base material
 - Non-porous overlays
 - Small heat-affected zone
 - Little to no thermal distortion
 - Less than 5% dilution between substrate and overlay
 - Overlays between 0.5 - 5mm
 - Precise overlay thickness control
 - Unlimited clad thickness
 - High repeatability and process stability
 - High deposition rates
 - Greatly extended part lifespans
 - Excellent impact resistance

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