Stainless Steel Advisory Service
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A service provided by the
British Stainless Steel Association

Welding of Stainless Steel

Introduction

The '300 series' austenitic stainless steels are readily welded with or without filler wire They are by far the most common types used in fabrications.

Superaustenitic, ferritic, superferritic, martensitic and ferritic-austenitic (duplex/super duplex) material types require more control when being welded and may involve post weld heat treatment or special welding consumables.

The prime objectives when producing a welded joint are: -

1. To ensure sound welds which match the corrosion and mechanical properties of the parent material.
2. To choose a welding process that meets productivity requirements, but which will result in as little distortion as possible and need a minimum of post weld dressing.

Considerations to be taken when choosing a Welding Process are: -

- Joint type and material thickness
- Welding position and working environment e.g. fabrication shop or on-site
- Manual or mechanised methods to increase productivity and repeatable quality
- Availability of suitable filler materials which are often over-alloyed to enhance the corrosion resistance of the weld deposit, and may be essential in the prevention of weld bead cracking.

The most popular welding processes used on stainless steels are: -

Gas Tungsten Arc Welding (GTAW or TIG)

This is the most widely used process due to its versatility, high quality and aesthetic appearance of the finished weld. The ability to weld at low current, and hence low heat input, plus the ability to add filler wire when required, make it ideal for thin materials and root runs in one sided welding of thicker plate and pipe. The process is easily mechanised and the ability to weld with or without the addition of filler wire (autogenous welding) make it the process for orbital welding of fixed pipe. Pure argon is the most popular shielding gas, but argon rich mixtures with the addition of hydrogen, helium or nitrogen are also employed for specific purposes. Inert backing gas protection of the weld under bead is employed with single sided welding to prevent oxidation and the loss of corrosion resistance.

Plasma Arc Welding (PAW)

A derivative of the TIG process involving a constructed nozzle system to produce a narrow concentrated transferred plasma arc with deep penetration characteristics. Mainly used in a mechanised system where high speed, high productivity autogenous welding of square edged butt joints up to 8mm thick is required. With thicker square edged butt joints, a combination of PAW/TIG and filler wire becomes necessary to ensure a full profile weld surface. Thickneses greater than 10mm employ a partial v-preparation, PAW root weld followed by multi-pass joint filling. Argon backing gas protection is necessary to maintain the corrosion resistance of the under bead.

Shielded Metal Arc Welding (SMAW or MMA)

Manual in operation and the oldest of the arc processes, MMA electrodes are in common use due to their flexibility in accommodating the wide range of materials to be welded. Electrode coating types are produced to give performance characteristics, which lend themselves suitable for differing welding applications. The most widely used, acid rutile coated electrodes produce a spray arc type metal transfer, self-releasing slag and a finely rippled aesthetic weld profile. These electrodes are designed to produce a spray arc type transfer of the weld metal, a self-releasing slag, a fine rippled bead and an aesthetic looking weld. Minimal post weld dressing will be required. They are primarily used in the down hand position when producing fillet and butt welds. Electrodes with this coating type can be used in position but are limited in application and size i.e. 3.2mm maximum.

Basic coated electrodes produce weld metal of higher integrity, with slag micro-inclusions and gas pores, and are extremely useful for fixed pipe weldments. Slag removal and weld profiles are not as attractive as with the acid rutile types. Special coated electrodes are produced for specific applications; e.g. vertical-down and high recovery downhand welding. Electrodes are manufactured in sizes ranging from 2.5 to 5.0mm in diameter (308L,347 and 316Ltypesalso in 1.6 and 2mm diameters)

Gas Metal Arc Welding (GMAW or MIG/MAG)

This semi-automatic welding process, which can be used manually or automated, involves a continuous consumable solid wire electrode and an argon rich shielding gas. It is employed for its high productivity features when welding thin material using ‘short-circuit’ metal transfer mode, or ‘spray arc’ transfer with thicker material. Power sources, which produce a pulsed current supply have been developed to provide improved weld metal quality when positional welding, and cleaner weld appearance. Gas mixtures, with the addition of oxygen, helium, carbon dioxide etc have been developed to improve arc stability and weld bead ‘wetting’ characteristics.

Flux Cored Arc Welding (FCAW or FCW)

A version of the MIG/MAG process where the solid wire consumable is replaced with a flux (FCW) or metal powder (MCW) filled tubular wire and can be used with equipment of the same type. Two variants of wire are produced, one to provide all positional capabilities and one for higher deposition down hand welding applications. Higher rates of weld deposition and weld metal overlaying are possible than with the MMA or MIG/MAG process. Significant reduction in post weld cleaning and dressing is possible.

Submerged Arc Welding (SAW)

A fully mechanised wire and flux powder shielded arc process capable of high deposition rate, fast travel speed and weld quality. Applications include continuous down hand fillet and butt welds in thicker section plate, pipe and vessels and also stainless steel cladding of mild steel components, particularly where long seams or extended runs are involved. An electroslag process, employing a strip electrode, is also available for overlaying, having some characteristics which are superior to SAW.

Electric Resistance Welding (ERW)

Resistance spot and seam welding is generally confined to mass production welding of thinner material, where the overlap joint type of weld configuration, and the resultant crevice will not detract from any corrosion resistance expected during service.

Laser Welding

The energy concentration reached in the focused spot of a laser beam is very intense and is capable of producing deep penetration welds in thick section stainless steel, with minimal component distortion. The process employs high capital cost equipment and its use is reserved for mass production manufacturing.

General Guidelines

- Avoid excessive heat input and high weld interpass temperature. Austenitic grades have a high coefficient of thermal expansion and low conductivity. High heat input will result in excessive distortion and residual stress.

- Design criteria and/or metallurgical transformation due to welding may necessitate the selection of a non matching welding consumable, to achieve toughness levels at cryogenic temperatures or increased weld metal corrosion resistance

- It is important, where possible, to reserve a fabrication facility exclusively for stainless steels. In addition, use protective handling equipment and tools which are dedicated to stainless steel fabrication, to avoid contamination from contact with carbon steels.

- If in doubt about welding and fabrication techniques then consultation of the parent material or welding consumable supplier / manufacturer is recommended

- When shielding gas is required consult your supplier for updated information on recommended gas compositions

- When new grades of materials are to be welded, especially ferritic, martensitic and duplex alloys, contact your consumable manufacturer for weld procedure information and filler material recommendations

- Post weld dressing may require the use of pickling pastes or other corrosive substances. Consult your material supplier before use.

Health and Safety Information

Welding Manufacturers Association Publication No. 236, 1994 HAZARDS FROM WELDING FUME states:

It is advised that where stainless steel welding takes place in a building or a confined space, the provision of adequate fume extraction is especially important. Ask your welding consumables supplier for information and recommendations.

Relevant Standards

BS7475:1991 – Specification for fusion welding of austenitic stainless steels

BS EN 1600:1997 – Covered electrodes for manual metal arc welding of stainless and heat resisting steels – Classification

EN 12072 – Wire electrodes, wires and rods for arc welding of stainless and heat resisting steels – Classification

BS EN 12073 – Tubular cored electrodes for metal arc welding, with or without a gas shield, of stainless and heat resisting steels – Classification.

BS EN 760 – Fluxes for submerged arc welding - classification

BS EN 287: Pt 1: 1992 – Approved testing of welders for fusion welding

BS EN 288: Pt3: 1992 – Welding procedure tests for the arc welding of steels

Before commencing any task ensure that you have received the appropriate health and safety literature from the supplier and fully understand it. If in doubt seek advice.

This Information Sheet is an update of BSSA Information Sheet No.6