Shop sheet 105

Welding parameters for duplex stainless steels

Virtually all welding processes used on austenitic stainless steels are applicable to duplex stainless steels. This includes Gas Tungsten Arc Welding (GTAW, TIG), Gas Metal Arc Welding (GMAW, MIG), Shielded Metal Arc Welding (SMAW, "stick"), Flux Core Wire Welding (FCW), Submerged Arc Welding (SAW), and Plasma Arc Welding (PAW). Oxyacetylene welding should not be used because of the associated carbon contamination of the weld.

Filler metals

Most filler metals for duplex stainless steel welding are described as "matching", but typically they are overalloyed in nickel with respect to the wrought products that they are said to match. Usually there is about 2–4% more nickel than in the wrought product. The nitrogen content is typically slightly lower in the filler metal than in the base metal. It is generally accepted that the more highly alloyed duplex stainless steel weld fillers are suitable for welding the lower alloyed duplex stainless steel products. The "matching" fillers have been reported to give acceptable results when joining duplex stainless steels to austenitic stainless steels or to carbon and alloy steels.

Preheating

As a general rule, preheating is not recommended because it may be detrimental. It should not be a part of a procedure unless there is a specific justification. Preheating may be beneficial when used to eliminate moisture from the steel as may occur in cold ambient conditions or from overnight condensation. When preheating to deal with moisture, the steel should be heated to about 100°C (210°F) uniformly and only after the weld preparation has been cleaned.

Heat input and interpass temperature

Duplex stainless steels can tolerate relatively high heat inputs. The duplex solidification structure of the weld metal is resistant to hot cracking, much more so than that of austenitic weld metals. Duplex stainless steels, with higher thermal conductivity and lower coefficient of thermal expansion, do not have the same high intensity of local thermal stresses at the welds as austenitic stainless steels. While it is necessary to limit the severity of restraint on the weld, hot cracking is not a common problem.

Table 1: Typical gas metal arc welding (GMAW) parameters for short-circuiting arc transfer and for spray arc transfer for welding duplex stainless steels with various wire sizes.

Short-circuiting arc transfer			
Weld wire diameter		Current	Voltage
mm	Inch	A	V
1.0	0.035	90–120	19–21
1.2	0.045	110–140	20–22
Spray arc transfer			
1.0	0.035	170–200	25–28
1.2	0.045	210–280	26–29
1.6	0.063	270–330	27–30

Source: Avesta Welding

Exceedingly low heat input may result in fusion zones and heat-affected zones that are excessively ferritic with a corresponding loss of toughness and corrosion resistance. Exceedingly high heat input increases the danger of forming intermetallic phases. To avoid problems in the heat-affected zone, the weld procedure should allow rapid cooling of this region after welding. The temperature of the work piece is important, because it provides the largest effect on cooling of the heat-affected zone.

As a general guideline, the maximum interpass temperature is limited to 150°C (300°F) for lean and standard duplex stainless steels and 100°C (210°F) for superduplex stainless steels. Electronic temperature probes and thermocouples are the preferred instruments for monitoring the interpass temperature. When a large amount of welding is to be performed, planning the welding so there is enough time for cooling between passes is good, economical practice.

Postweld heat treatment

Postweld stress relief is not needed for duplex stainless steels and is likely to be harmful because the heat treatment may precipitate intermetallic phases (700–1000°C/1300–1830°F) or alpha prime (475°C/885°F), causing a loss of toughness and corrosion resistance. Postweld heat treating temperatures in excess of 315˚C (600˚F) can adversely affect the toughness and corrosion resistance of duplex stainless steels.

Any postweld heat treatment should include full solution annealing followed by water quenching. Full solution annealing should also be considered after autogenous welding, since the weld microstructure will be highly ferritic if an overalloyed filler metal is not used during welding.

Table 2: Typical shielded metal arc welding (SMAW) parameters for welding duplex stainless steels with various size electrodes.

Electrode diameter			
Weld wire diameter		Current	Voltage
mm	Inch	A	V
2.0	0.078	35–60	22–28
2.5	0.094	60–80	22–28
3.25	0.125	80–120	22–28
4.0	0.156	100–160	22–28

Source: Outokumpu

Table 3: Typical submerged arc welding (SAW) parameters for welding duplex stainless steels with various size wire.

Weld wire diameter		Current	Voltage
mm	Inch	A	V
2.5	0.094	250–450	28–32
3.25	0.125	300–500	29–34
4.0	0.156	400–600	30–35
5.0	0.203	500–700	30–35

Note: Travel Speed is typically 30–60 cm/minute

Source: Outokumpu