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Combined welding of Austenitic and Ferritic Stainless steel

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Abstract: *This paper contains experiences in the welding of Austenitic and Ferritic stainless steel with combination of welding process GTAW and SMAW. This investigation characterized the mechanical and chemical properties of weld metal in the Austenitic and Ferritic stainless steel. The selection of filler metal for welding the Austenitic and Ferritic stainless steel is based on the composition of the base metal (SA240 UNS S32304). For root welding GTAW processes ER2209 filler wire and subsequent layer SMAW processes with electrode with basic flux E2209-17selected for this investigation. These investigations are complains with ASME boiler pressure vessels codes. The principal goal of this presentation was to provide the solution for combined welding of Austenitic and Ferritic stainless steel to the application of fabrication of desalination tank and ship building.*

Keywords: *ER2209-Filler wire, E2209-17-Electrode with basic flux, GTAW-Gas Tungsten Arc Welding, SMAW -Shield Metal Arc Welding*

I. Introduction

The austenitic stainless steels contains a combined total Cr, Ni and Mn content 24 % of more with Cr content generally above 16 % and Ni often above 7 %. The Cr provides oxidation resistance and resistance to corrosion while Ni and Mn stabilize the austenitic phase sufficiently to resist most or all it when the steel is cooled rapidly to room temperature. Austenitic stainless steel is usually the most corrosion resistant of all the stainless steels and they find wide use in chemical plants. The microstructure of the austenitic stainless steels is either all austenitic or ferritic in a matrix of austenite. These steels are grouped into AISI 200 and AISI 300 series. The basic grade is type 302 which contains 18% Cr and 8% Ni. These steels are not hardenable by heat treatment. The austenitic stainless steels generally have low yield strength and ultimate tensile strength that is why they are often ductile. They have excellent properties at cryogenic temperatures and have higher strength at 540^{o}C than the 400 series.

Ferritic stainless steels are the non-hardenable grades of AISI 400 series that contain from about 14 to 27% Cr and no Ni. These steels have such a chromium-to-carbon ratio that does not allow the formation of austenite so they remain ferritic throughout their normal operating range. These are magnetic in all conditions. The basic alloy of this group is type AISI 430. Some of the ferrite stainless steel not only have good corrosion resistance but also have good resistance to high temperature environment. Furnace parts are therefore often made from these steels. Other principal applications of ferritic stainless steel are automotive and appliance firm and mufflers, chemical processing equipment and industrial equipment requiring a low material with good corrosion resistance built with limited welding requirements.

Duplex stainless steels are a family of grades combining good corrosion resistance with high strength and ease of fabrication. Their physical properties of the austenitic and ferritic stainless steels but tend to closer to those of the ferritics and to carbon steel. The chloride pitting and crevice corrosion resistance of the duplex stainless steel is a function of chromium, molybdenum, tungsten and nitrogen content. It may similar to that of type 316 or range above that of the sea water stainless steels such as the 6% Mo austenitic stainless steels. All the duplex stainless steels have chloride stress corrosion cracking resistance significantly greater than that of the 300-series austenitic stainless steels. They all provide significantly greater strength than the austenitic grades while exhibiting good ductility and toughness. There are many similarities in the fabrication of austenitic and duplex stainless steels but there are important differences. The high alloy content and the high strength of the duplex grades require some changes in fabrication practice. This presentation is for fabricators and for end users with fabrication responsibility. It presents, in a single source, practical information of duplex stainless steels.

II. Experimental Procedure

They are many grades available in duplex stainless steels family. In this experiment, solution annealed duplex stainless steels (SA240 UNS S32304) has been chosen. Base metal used in this experiment 6 mm thick 300 mm width 450 mm long hot rolled plate. Chemical composition of this metal as shown in table 1.1

1.1 Table

Chemical properties
SA240 UNS S32304
EN No. 1.4362

Fe	Composition (%)
C	0.03
Cr	21.5 – 24.5
Ni	3.0 – 5.5
Mo	0.05 – 0.6
N	0.05 – 0.20
Mn	2.50
Cu	0.05 - 066

And also mechanical properties of lean duplex stainless steels SA240 UNS S32304 as shown in table 1.2

1.2 Table

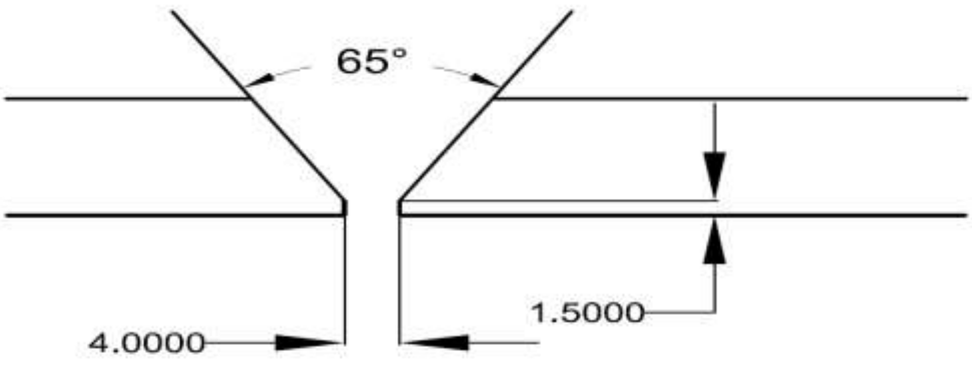
Mechanical properties
SA240 UNS S32304

Steel grades	P
Yield strength	400Mpa
Tensile strength	630MPa
Elongation (%)	25
Impact strength	
+200C	100J
-400C	80 J

When welding of duplex stainless steels, the edge preparation and correct joint types are important for good results. Because of the weld pool's slightly poorer penetration and fluidity the joint must be correctly designed to give full penetration without the risk of burn through. The groove angle must be sufficiently wide to allow the welder full control of the arc, weld pool and slag. A groove angle of around 350 is to be recommended for manual welding.

For plate thickness approximately 6 mm single V joint is advantages. In single sided welding a root gap of 2-3 mm and a straight edge of about 0-1 mm are recommended for manual welding. Ceramic backing should be used for duplex stainless steels welding.

Joint preparations are done for this experiment as shown in figure 1.



Joint type 2
V Joint, t = 4 – 16 mm
α = 62º
C = 0.5 – 1.5 mm
D = 2 – 3 mm (4 mm against backing)
Single sided with ceramic backing.

Workpieces are fixed with suitable fixtures to reduce the distortion during welding. And the root weld area covered with proper ceramic backing.

To avoid shrinkage during welding, precise tack welding is extremely important. For metal thickness up to 6 mm, tack length should be 10 – 15 mm. In single sided welding, the entire tack must be ground away before welding. A common alternative in single sided welding in the use of bridges or distance pieces. These must be made of and tacked with duplex steel. Filler wire and electrodes for welding the duplex stainless steels selected based on the equivalent chemical and mechanical properties of base metals for GTAW filler wire is exact matching with SA240 UNS S32304 is ER2209. And also SMAW electrode is E2209-17 complaints with ASME section II part – C.

The root and tack welding, the welding parameters are shown in table 1.3.

1.3 Table

Welding parameters	Specification
AWS specification	ER 2209
Filler wire size	Diameter 2.4 mm (solid wire)
Position of groove	1G
Preheat	300 – 500C
Interpass temperature	1500C
Shielding gas	Argon
Gas flow rate	8 – 10 lit/min
Root weld bead	String bead
Orifice or gas pipe size	6 mm
Polarity	DC IN
Tungsten electrode	Diameter 2.4 mm & 2 % Thoriated.
Current	120 Ampere.
Voltage	12 Volts
Travel speed	75 mm/min
Weld deposit thickness	2 mm maximum.

Subsequent welding layers of duplex stainless steels are carried by SMAW with electrode E2209-17. The welding parameters of SMAW process are shown in table 1.4.

1.4 Table

Welding parameters	Specification
AWS specification	E 2209-17
Filler metal	Diameter 3.25 mm

After completion of welding, the plate shall be gone through Non Destructive Test (Radiographic test) to verify the weld soundness. After completion of Non Destructive Test, the results are verified against ASME codes and standards,

After completion of Non Destructive Test, the test specimens are prepared as per ASME section – 9. The test specimens are tensile and bend prepared and tested in NABL approved laboratory. Those results are complaints with ASME boiler pressure vessels codes and standards.

III. Results and discussions

The tensile result of the test specimen i.e., the Austenitic and Ferritic stainless steel with combination of welding process GTAW and SMAW showed 784 N/mm2 which specimen has the width 19.27 mm and thickness of 5.55mm.In that fracture occurred at the parent material side only. This result of this tensile test has been satisfied as per the ASME boiler pressure vessels code and standards.

The bend test of the Austenitic and Ferritic stainless steel with combination of welding process GTAW and SMAW showed that, no open discontinuity in the weld and HAZ (Heat affected zone). The result compared with ASME boiler pressure vessels code and standards, and find as satisfied results.

The radiographic test (Non Destructive Test) results showed the test specimen that no indication and indentation as per the ASME boiler pressure vessels code and standards, and find as satisfied results.

IV. Conclusions

The growing demand of the Austenitic and Ferritic steels has increased for suitable welding consumables.

The following conclusions were drawn from the work

For root welding GTAW process ER2209 filler wire and subsequent layer SMAW process with electrode with basic flux E2209-17 provides sufficient strength as per the ASME requirements.

The matching of Austenitic and Ferritic steel and filler of ER2209 for GTAW and E2209-17 for SMAW have been shown the tensile strength of 784 N/mm2. This result satisfied the ASME code.

The matching of Austenitic and Ferritic steel and filler of ER2209 for GTAW and E2209-17 for SMAW have been shown the no defect in radiographic test.

Applications of this Austenitic and Ferritic stainless steel fabrication of desalination tank and ship building.

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