ISSN 2250-3153

Investigation on Property Relationship in Various Austenitic Stainless Steel 304L Welds

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Abstract- In the present work an investigation was made on property relationship of SS 304L austenitic stainless steel welds. Shielded metal arc welding (SMAW), gas metal arc welding (GMAW) and gas tungsten arc welding (GTAW) methods were used to make welds. Tensile test was used to measure the yield strength and ultimate tensile strength of the welds. Impact test was used to measure the toughness of the welds. Experimental results clearly revealed that these properties of GTAW was superior compared to the other two welds. This was due to more weld penetration at lower heat input into the base metal. The disadvantage of SMAW and GMAW is that the slag must be chipped off of the weld after it cools and can sometimes infiltrate the weld causing weakness.

Index Terms- 304L austenitic stainless steel; shielded metal arc welding; gas metal arc welding; gas tungsten arc welding; material properties;

I. INTRODUCTION

Carbon steel on cooling transforms from austenite to a mixture of ferrite and cementite. With austenitic stainless steel, the high chrome and nickel content suppress this transformation keeping the material fully austenite on cooling. Austenitic stainless steels have high ductility, low yield stress and relatively high ultimate tensile strength, when compared to typical carbon steel. Austenitic stainless steels are commonly used in the fabrication of piping systems, automotive exhaust gas systems and in a variety of equipment associated with the chemical and nuclear power industries. The type 304L austenitic stainless steel is an extra low-carbon variation of type 304 with a 0.03% maximum carbon content that eliminates carbide precipitation due to welding. As a result, it can be used in severe corrosive conditions. It often eliminates the necessity of annealing weldments except for applications specifying stress relief. Since 304L stainless steel weldments are frequently subjected to dynamic loading conditions in their service environments, it is essential to optimize the welding process. The present study aims to investigate the effect of Shielded metal arc welding (SMAW), gas metal arc welding (GMAW) and gas tungsten arc welding (GTAW) on the mechanical properties of weldments, Specifically on the material behavior under forces and toughness properties.

II. WELDABIILITY

The austenitic class of stainless steel is generally considered to be weldable by the common fusion and resistance techniques. Special consideration is required to avoid weld “hot cracking” by assuring formation of ferrite in the weld deposit. Type 304L is generally considered to be the most common alloys of this stainless class. When weld filler is need, AWS E/ER 308, 308L, 304L or 347 are most often specified.

Shielded metal arc welding

Shielded metal arc welding (SMAW) is also known as manual metal arc welding or flux shielded arc welding or informally as stick welding, is a manual arc welding process that uses a consumable electrode coated in flux to lay the weld. An electric current, in the form of either alternating current or direct current from a welding power supply is used to form an electric arc between the electrode and the metals to be joined.

Gas metal arc welding

Gas metal arc welding (GMAW), also called metal inert gas (MIG) welding, and extrudes a metal wire electrode from a gun held by the welder. Power is applied to the gun by a power supply that attempts to regulate voltage at a preset level set by the operator. The gun also carries a shielding gas to the nozzle of the gun. Current flows down the gun through the arc and back to the power supply via the ground clamp.

Gas tungsten arc welding

Gas tungsten arc welding (GTAW), also called tungsten inert gas (TIG) welding uses a non-consumable tungsten electrode which must be shielded with an inert gas. The arc is initiated between the tip of the electrode and work to melt the metal being welded, as well as the filler metal, when used. A gas shield protects the electrode and the molten weld pool.

Present work is aimed at comparisons of yield strength, ultimate tensile strength and toughness of SMAW, GMAW and GTAW of SS 304L austenitic stainless steel.

III. EXPERIMENTAL PROCEDURE

Material

The parent metal employed in this work is SS 304L austenitic stainless steel having 10mm thickness. The chemical composition is given in **Table 1.** The mechanical property of the steel is given in **Table 2.**

ISSN 2250-3153

Table 1: Chemical composition of base metal

	C	Mn	Si	N	P	S	Cr	Ni
min	-	-	-	-	-	-	18.00	8.00
max	0.030	2.000	0.750	0.10	0.045	0.030	20.00	12.0

Table 2: Mechanical properties of base metal

STEEL GRADE	0.2% Yield strength (MPa)	Ultimate tensile strength (MPa)	Hardness Rockwell (RB)	Elongation % 50.8 mm
SS-304L	170	485	201 (92)	40

Edge preparation of parent metal

The edge preparation is done for plate specimen as per ASME B16.25 standard as shown in **Fig.1.**

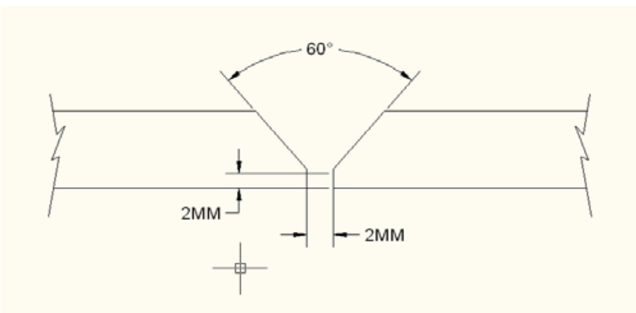

Fig.1: Dimension for Edge preparation process of plate specimen

Welding process

- Direct current Shielded metal arc welding (SMAW) process with electrode of AWS A5.4 E308L-16 of 3mm diameter was used to weld steel plates in square-butt joint configuration. SMAW welding parameters of current 80A, voltage 20V were used. The image of this weld metal is shown in **Fig. 2.**
- Direct current Gas metal arc welding (DC-GMAW) process with electrode of AWS A5.9 ER 308L of 1.2mm diameter and argon-carbon dioxide shielding gas at 20^0C and 0.15 MPa was employed to weld steel plates in square-butt joint configuration. GMAW welding parameters of current 200A, voltage 20V were used. The image of this weld metal is shown in **Fig. 3.**
- Direct current Gas tungsten arc welding (DC-GTAW) process with throated tungsten electrode of 2.4mm diameter and argon shielding gas was employed to weld steel plates in square-butt joint configuration. GTAW parameters of current 120A, voltage 20V were used. The image of this weld metal is shown in **Fig. 4**.

Fig.2: Fabricated Shielded metal arc weld (SMAW) metal

Fig.3: Fabricated Gas metal arc weld (GMAW) metal

Fig.4: Fabricated Gas tungsten arc weld (GTAW) metal

ISSN 2250-3153

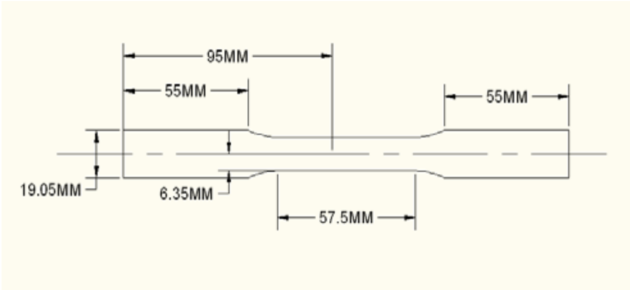

Fig.5: Dimension of Tensile test specimen

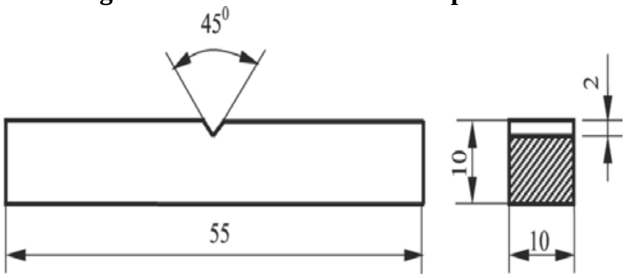

Fig.6: Dimension of Impact test specimen

Tensile test

Longitudinal weld tensile test samples were machined for both plates and rods, as per the standard ASTM-E8 as shown in **Fig.5**. Tensile test was conducted on Instron 1185 Universal testing Machine at a cross head speed of 0.05 mm/min and values were noted.

Impact test

Charpy V-notch Impact test samples were machined for both plates and rods as per the standard ASTM-E23 as shown in **Fig.6**. The impact test was conducted on pendulum impact tester, Model IT-30 and values were noted.

IV. RESULTS AND DISCUSSION

Tensile and toughness properties

The **Fig.7a** and **Fig.7b** shows tensile test and impact test specimens. The results of tensile test and impact test are shown in **Table 3.** The fracture specimens in tensile test and impact test are shown in **Fig.8** and **Fig.9** respectively.

As mentioned earlier, these were determined from longitudinal all-weld specimens taken from weld zone. The tensile data and impact data for each condition are an average of measurement made from six specimens.

Fig.7a

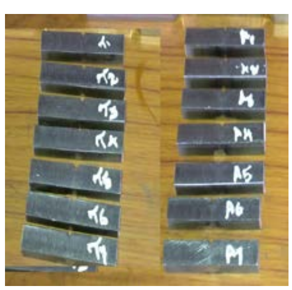

Fig.7b

Fig.7: Fabricated specimens

Fig.8: Fracture specimens in tensile test

Fig.9: Fracture specimens in impact test

Table 3: Material properties of welds

Type of Weld	Material Properties		
	Toughness (MPa)	0.2% Yield strength (MPa)	Ultimate tensile strength (MPa)
GTAW	32.9	9.80	460
GMAW	30.42	7.60	422
SMAW	26.86	6.60	406

V. CONCLUSIONS

From the above experimental data, it is clear that gas tungsten arc welded (GTAW) joint SS-304L gives the better ultimate tensile strength, yield strength and toughness properties nearer to the base metal properties than Shielded metal arc welds (SMAW) and gas metal arc welds (GMAW).

REFERENCES

[1] U. Kamachi Mudali , B.M. Ananda Rao , K. Shanmugam, R. Natarajan, Baldev Raj, 'Corrosion and microstructural aspects of dissimilar joints of titanium and type 304L stainless steel', Journal of Nuclear Materials 321 (2003) 40–48 20 March 2003.

[2] Kenji Krzywosz , 'NDE for Type 304L Stainless Steel Material Characterization', Buenos Aires – Octubre 2007.

[3] K. Abdel Ghany ∗, M. Newishy ,'Cutting of 1.2mm thick austenitic stainless steel sheet using pulsed and CW Nd:YAG laser', Journal of Materials Processing Technology 168 (2005) 438–447, 2 February 2005.

[4] H. Y. Han and Z. Sun, 'Development of Welding Wire for High-Purity Austenitic Stainless Steels', WELDING RESEARCH SUPPLEMENT-February 1999.

[5] Y. Cao, F. Ernst ∗, G.M. Michal, 'Colossal carbon super saturation in austenitic stainless steels carburized at low temperature', Acta Materialia 51 (2003) 4171–4181-26 April 2003.

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