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Effect of Welding Current and Filler Metal Types on Percent Elongation of GTAW Austenitic Stainless Steel Weld Joints

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ABSTRACT: *This work is on the study of the effect of welding current and filler metal types on the percent elongation of 3mm thick austenitic steel (304L grade) welded joint. Five welding currents in the range of 91-95 amperes at 1 ampere interval and three filler metal types (ER308L, ER309L and ER316L) were used to produce square butt weld joints. The percent elongation was determined by carrying out tensile test using standard equipment and ASTM standard procedure. The results show that the percent elongation for all filler metal types increased with increase in welding current but were generally lower than that of the base metal.*

KEYWORDS: Percent Elongation, Gas Tungsten Arc Welding, Shielding Gas, Austenitic Stainless Steel.

INTRODUCTION

In the process industry welding is very widely used by metal workers in fabrication, maintenance and repairs of parts and structures. Welding is the most convenient, economical, efficient and rapid way of joining two or more metals together to form a monolithic structure (1). Its advantages over other metal joining processes is in its flexibility, low fabrication cost, simple set up and production of very efficient joints (2).

A welded joint is produced when two clean metal surfaces are brought into contact with each other and either heat or pressure or both is applied to obtain a metallic bond. The various welding processes include shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), gas metal arc welding (GMAW) and submerged arc welding (SAW). Among the several arc welding processes GTAW has been considered very suitable for the welding of stainless steel. It enhances good penetration, enables maintenance of very stable arc and grants the operator greater control over the weld than other competing processes, thereby allowing for stronger higher quality welds. However in GTAW the selection of the filler metal is important to ensure production of good quality weld joints.

Percent elongation is a mechanical property of a metal that indicates the degree to which a metal may be bent, stretched or compressed before it ruptures. It is a measure of ductility, which provides the confidence that metal can be formed without cracking or fracturing. It is also a measure of toughness of a metal. Therefore percent elongation, especially at fracture, is of engineering importance not only as a measure of ductility but also as an index of the quality of the metal. It is one of the essential mechanical properties for weld joints (frepd.com, 2010) and can be affected by welding parameters (3, 4). It is usually determined by carrying out tensile tests and expressed as

$$\%\text{Elongation} = \frac{\text{increase in length}}{\text{original length}} \text{x}100$$

In GTAW process while some work has been done to investigate the effect of welding parameters on the strength of welded joints (5, 6, 7) very limited attempt has been made on the effects of these parameters on percent elongation especially on austenitic stainless steel weld joints but no investigations have been recorded on the effect of filler metals types (8).

Effect of Welding Current on percent Elongation

Some scholars, (9) and (10), while working on magnesium alloy AZ31 established that increase in welding current results in decrease in relative elongation. The work of (11) on pure titanium agrees with this result.

Therefore this work is concerned with the effect of welding current and filler metal types on the percent elongation of austenitic stainless steel weld joints.

EXPERIMENTAL PROCEDURE

Materials

The materials used for this investigation include 304L austenitic stainless steel sheet metal, 3mm thick as base metal; 308L (2mm), 309L (2mm) and 316L (2.4mm) filler rods, in accordance with AISI Standard, 2% thoriated non-consumable tungsten electrode for carrying current to the arc and high purity argon gas as shielding gas.

The chemical compositions of the base and filler metals are shown in Table 1.

Procedure

Prior to welding the edges of the base metal pieces to be joined, measuring 400mmx50mmx3mm, were prepared by grinding filing and cleaning in accordance with AISI SS Standard to ensure good quality weld joint. Also to minimize distortion the specimens were held in position by clamping devices. The initial joint configuration was obtained by tack-welding to secure the specimens in position and a backing slate was attached to the tacked pieces to create a vacuum that will ensure effective gas purging of the underside of the weld joint for good penetration.

The welding process was carried out with a manually operated, air-cooled welding machine (Precision TIG 225) and consisted of two runs, the root and cap, in the down-hand (1G) welding position to produce a square butt weld joint. Five welding currents were employed ranging from 91-95 amperes at 1 ampere interval. During welding heat input was varied by varying the welding current while other parameters were held constant according to the following equation

$$H = \frac{60EI}{1000S}$$

Where,

H = heat input (KJ/mm)

E = arc voltage (volts)

S = welding speed

I = welding current

The shielding gas flow rates were maintained at 12 litres/min and 7.5 litres/min for welding and purging respectively. When welding was completed the shielding gas flowed for 10 minutes after the arc was stopped to protect the weld until it was no longer subject to contamination. The welded joints were then air-cooled, examined for defects and prepared for tensile test.

Tensile test

The welded specimen were cut to size (230mmx25mm) using power saw and then subjected to longitudinal tensile test according to ASTM E8 standard procedure using a tensile testing machine, model 316Q with a maximum load of 300KN. The specimens were fitted into the jaws of the testing machine and subjected to tensile loading until they fractured. The results are given in Table 2 and Figures 1 and 2.

RESULTS AND DISCUSSIONS

The chemical compositions of the base metal and filler metals are shown in Table 1.

Table 4.1. Composition of Base Metal and Filler Metals

Material	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	V	Al	SN	N	Ti
Base metal	0.02	0.42	0.05	0.031	0.001	18.80	7.18	0.008	0.029	0.079	0.013	0.004	0.042	0.005
Filler Metal Type														
ER308L	0.013	0.43	1.86	0.023	0.002	19.85	9.95	0.05	0.07					
ER309L	0.016	0.41	1.84	0.019	0.002	23.28	13.68	0.03	0.04					
ER316L	0.014	0.41	1.74	0.023	0.002	19.22	12.29	2.19	0.11					

Table 2: Percent Elongation

Current (A)	Filler Metal Type	%Elongation
91	308L	27.388
	309L	23.048
	316L	25.224
	308L	27.684
92	309L	26 532
	316L	25.439
	308L	28.729
93	309L	28.261
	316L	25.654
	308L	29.084
94	309L	28.697
	316L	25.798
	308L	30.436
95	309L	29.133
	316L	26.085
control	-	30.436

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Percent Elongation

Effect of welding current on percent elongation

It can be observed from Figure 1 that the higher the welding current the higher the percent elongation. This contradicts the observations of Zou et al (2004), Quan et al (2008) and Karaman et al (2010). This could be attributed to the poor thermal conductivity of the base material resulting in grain growth with its softening effect.

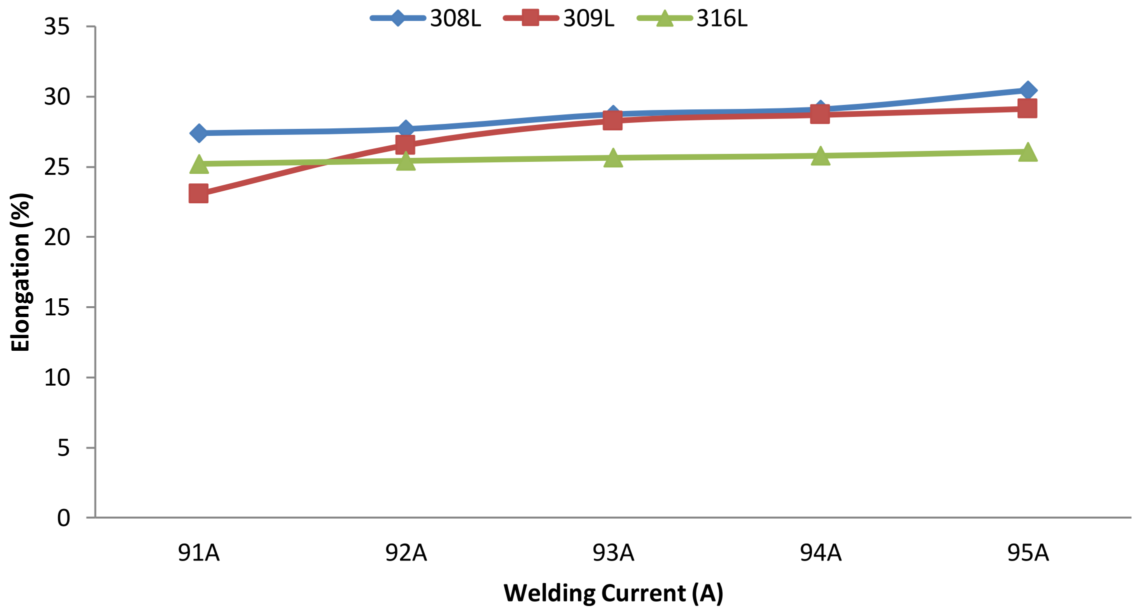

Figure 1. Effect of Welding Current on %Elongation of Welded Join

Effect of filler metal type on percent elongation

From Figure 2 it can be seen that 308L filler metal produced higher percent elongation values than the other filler metals for all welding currents. This may be attributed to the fact that it has the lowest values of carbon and nickel contents.

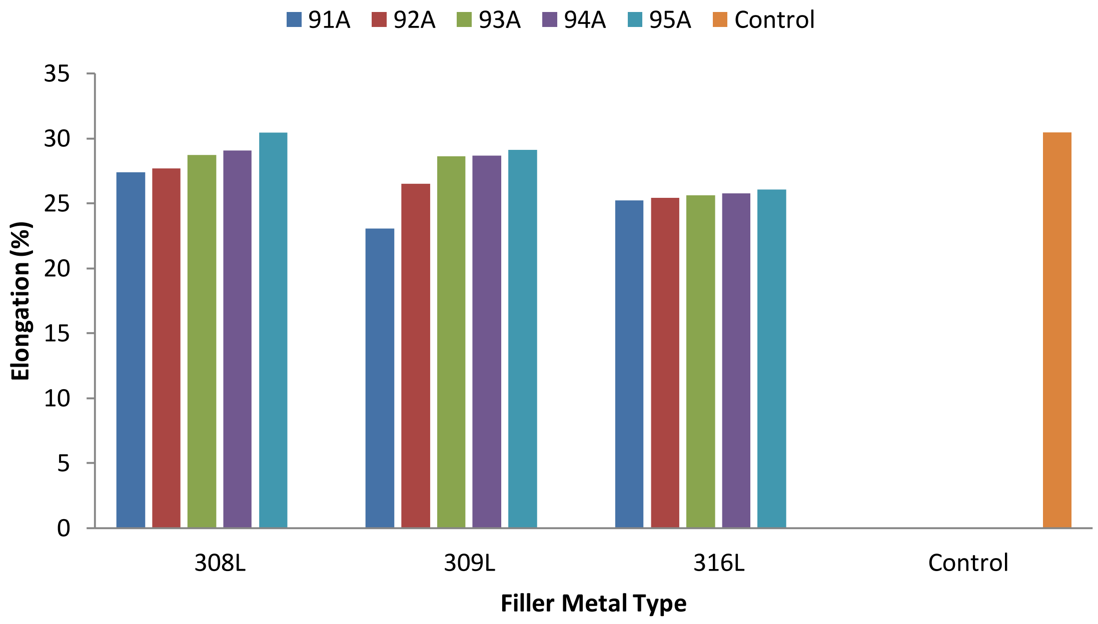

Figure 2. Effect of Filler Metal Type on % Elongation of welded Joint

CONCLUSION

The effect of welding current and filler metal type on percent elongation of 304L austenitic stainless steel using ER308L, ER309L and ER316L filler metal types as well as welding current ranging from 91- 95 amperes was studied. After a review of the results obtained from the experiment the following conclusions were made. The percent elongation values were generally lower for all currents and filler metal types than that of the base metal. However the values increased with increase in welding current for all filler metal types. The ER308L filler metal recorded the highest values for all welding current.

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