EVALUATION OF MECHANICAL PROPERTIES OF SS 316 L WELDMENTS USING TUNGSTEN INERT GAS WELDING

C. BALAJI[1]

mechbalajisjce@yahoo.in

S.V. ABINESH KUMAR[2]

abinesh.071890@gmail.com

S. ASHWIN KUMAR[3]

st_arasi2008@yahoo.com

R. SATHISH[4]

sai_27r123@rediff.com

[1, 2, 3]Under Graduate students

[4]Assistant Professor

[1,2,3,4] St. Joseph's College of Engineering

Chennai, Tamil Nadu

India – 600119

Abstract:

This work aims at joining of similar grades of stainless steel by TIG welding with the various parameters like current, bevel angle and gas flow rate. The SS 316L is selected over other grades due to its lesser carbon content it is used in pressure vessels for corrosive liquids etc. The rod of SS 316L of 25 mm diameter and 75 mm length was used as the base material for this experiment. The rod was machined in accordance to ASTM-A-370 standards for finding the mechanical behaviour like Tensile strength, micro hardness and micro structure. Higher tensile strength achieved with a current of 110A, bevel angle of 60^0 and a gas flow rate of 0.7 LPM. Non-destructive tests like radiographic tests were performed to find the defects in the joints. The defect incurred was lack of penetration and it was observed in the sample D and sample G.

KEYWORDS: Tensile strength; Bevel angle; Radiography tests; lack of penetration.

1. Introduction:

Gas Tungsten Arc Welding (GTAW), also known as tungsten inert gas (TIG) welding is a process that produces an electric arc maintained between a non-consumable tungsten electrode and the part to be welded. The Heat-Affected Zone, the molten metal and the tungsten electrode are all shielded from atmospheric contamination by a blanket of inert gas fed through the GTAW torch. Inert gas (usually Argon) is inactive or deficient in active chemical properties. The shielding gas serves to blanket the weld and exclude the active properties in the surrounding air. Inert gases such as Argon and Helium do not chemically react or combine with other gases.

2. Material selection:

The material SS 316 L is selected because the material contains low carbon and it has a good weld ability factor. The increase of carbon in steel may result in decrease in the ductility of steel, increase in the tensile strength of steel, increases in the hardness of steel, decrease in the ease with which steel can be machined, lowering the melting point of steel and increases the difficulty of welding steels [2]. Thus the stainless steel with low carbon content is selected in order to have the better parameters in welding. SS 304L and SS 316L both have the same carbon content but the effect of chromium is more in the case of 304L plays a major role. The addition of chromium causes the steel to increase corrosion resistance and oxidation resistance which is good but there is a proportional increase in the harden ability as well as high-temperature strength. As a hardening element, chromium is frequently used with a toughening element such as nickel to produce superior mechanical properties. At higher temperatures, chromium contributes to increased strength. So the addition of chromium results is in more time consumption in welding because of its nature. Thus the hardness reduces the weld ability nature of the material, so the SS316L was selected for this work. The other considerable fact is that SS 316L has the addition of Molybdenum which causes the material to increase its creep strength at elevated temperatures. The material SS 316L is selected based on the above mentioned features and the base metal compositions are shown in Table 1. The tensile strength of the base metal is found to be 539.69 N/mm^2.

Table 1: Chemical Composition of 316L

Elements	C	Si	Mn	P	S	Cr	Mo	Ni
Wt %	0.03	0.29	1.58	0.027	0.003	16.25	2.27	11.90

3. Experimental procedure:

The parameters which are required for welding is being arranged by means of Taguchi's table and the Taguchi's orthogonal array is constructed to know the parameters which is required for this welding experiment with our own sample range[3]. The table shows the three levels and the three parameters which we have employed for the welding the samples. The filler metal used is SS304L.The Table 2 shows the parameters for welding the samples. The machining of sample is done in accordance to the ASTM-A-370 standards. The machining is done in order to perform the tensile test on the samples.

Table: 2 Parameters and Factors

LEVELS	CURRENT(AMPS)	BEVEL ANGLE (^{0})	GAS VOLUME(LPM)
LEVEL A	90	60	1.1
LEVEL B	100	70	0.9
LEVEL C	110	80	0.7

4. Results and discussions:

4.1 Tensile strength

The result of tensile strength is discussed in the Table 3, the sample D gives low tensile strength, sample G gives the high tensile strength and the sample I shows the medium tensile strength. From the table it is clearly shows that Maximum tensile strength was obtained with Maximum Current followed by low bevel angle and with medium gas flow rate.

Table 3: Tensile Strength (UTM)

Sample ID	Current (Amps)	Bevel angle (Degrees)	Gas volume (LPM)	Tensile strength (Mpa)
Sample A	90	60	1.1	554.74
Sample B	90	70	0.9	535.04
Sample C	90	80	0.7	553.47
Sample D	100	60	0.9	526.29
Sample E	100	70	0.7	562.30
Sample F	100	80	1.1	549.44
Sample G	110	60	0.7	575.57
Sample H	110	70	1.1	557.97
Sample I	110	80	0.9	551.20

4.2 Micro hardness

The micro hardness experimentation was done in order to compare the characteristics of ductility Vs micro hardness in the weldment. The hardness results are taken for all the nine samples and the average value is taken to compare the values with that of tensile strength. The table 4 shows that the sample with low hardness offered less tensile strength and the one with higher tensile strength had the neutral average hardness value. The table also clearly illustrates how the tensile strength is varied with respect to hardness.

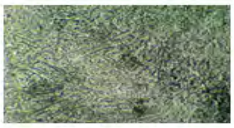
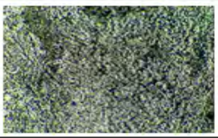
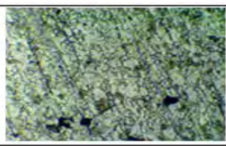
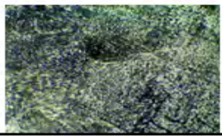
Table4: Vickers Hardness Number

Sample ID	Tensile strength (Mpa)	Micro hardness (VHN)		
		Weldment	Heat affected zone	Base metal
Sample A	554.74	262.27	245.8	233.67
Sample B	535.04	248.53	232.2	211.77
Sample C	553.47	250.33	240.37	229.77
Sample D	526.29	240.03	216.5	204.37
Sample E	562.3	242.6	230.67	212.7
Sample F	549.44	240.6	221.53	206.7
Sample G	575.57	247.67	231.13	212.5
Sample H	557.97	240.1	219.06	205.27
Sample I	551.2	253.33	231.5	210.6

4.3 Microstructure

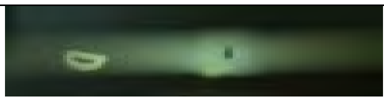
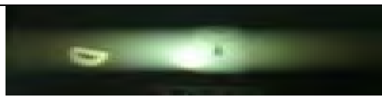
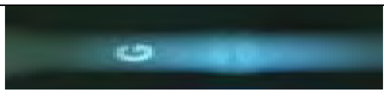
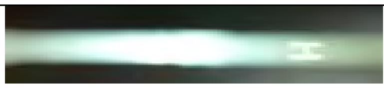
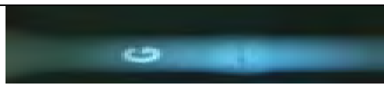
The microstructure is taken to determine the grain growth in the Weldment, Heat Affected Zone and the base metal in order to find the impact, it was taken and compared to all the nine samples with the three level of operation. The microstructure of all the samples were taken during this work with reference to that the samples which showed low, medium and high tensile strength are shown in the table 5. The microstructures with inclusions of the filler metal proved to show a lot of variations in the tensile strength, the sample G with the finer grains of austenite with the inclusions in the heat affected zone showed the maximum tensile strength and the coarser grains of austenite in the heat affected zone of the sample D made the sample to fracture faster [4].

Table 5: Microstructure on Weld, Base metal, HAZ

Sample ID	Weldment	Base metal	Heat affected zone
Sample D			
Sample G			
Sample H			

4.4 Radiography

Table 6: Images inferred in Radiography test

Sample ID	"A" Side Result	"B" Side Result
Sample D		
Sample G		
Sample I		

This test was performed to find the weld defects in a more detailed and simpler ways [5]. The radiography images are shown in table 6.The radiography tests were observed in the samples which showed low, medium and high tensile strength. The defect incurred was lack of penetration. Lack of penetration (LOP) occurs when the weld metal fails to penetrate the joint. It is one of the most non objectionable weld discontinuities [6]. Lack of penetration allows a natural stress riser from which a crack may propagate. The appearance on a radiograph is a dark area with well-defined, straight edges that follows the land or root face down the centre of the weldments. Incomplete penetration forms channels and crevices in the root of the weld. This defect is one of the non-objectionable defects but on major cases this lack of penetration defect can cause lamellar cracks [7]. Here are some causes of lack of penetration in welding. Improper joints design, root gap too small, too small bevel angle, less Arc current, wrong electrode manipulation, faster arc travel speed and incorrect torch angle.

5. Conclusions

All the experimental steps were carried out under precautionary measures in order to keep the error factor low and to increase the reliability of the results. In spite of these measures taken, the result prone to deviations and it was subjected due to the uncontrolled conditions and factors which were not taken into considerations during the scope of this work.

- The tensile test has showed that the Current of 110A, Bevel Angle of 60^0 and a gas flow of 0.7 LPM offers the maximum tensile strength of 575.57 MPa.
- The tensile test has also showed that the Current of 100A, Bevel Angle of 60^0 and a gas flow of 0.9 LPM offers the minimum tensile strength of 526.29 MPa.
- The micro hardness has showed that the sample with the minimal tensile strength has the maximum micro hardness, which concludes that, the increase in micro hardness results in the decrease of the tensile strength.
- The micro structure showed that the heat affected zone with inclusions has an impact in the tensile strength, so this concludes that the tensile strength is impacted when inclusions take place.
- The radiography results showed the defect of lack of penetration, thus the result concludes that the defect does not create a major impact.

6. Acknowledgements

The authors are sincerely thankful to our College Director and the Department of mechanical engineering of St. Joseph's college of engineering, Chennai-119 for extending their support in carrying out this work.

7. References

[1] Gourd .L. M. “Principles of welding technology third edition”, the Welding Institute, Auckland pg160-161

[2] Weiss .B. and Stickler .R. “Metallurgical and materials transactions” B,Volume 3, Number 4, 851-866, DOI: 10.1007/BF02647659, “Phase instabilities during high temperature exposure of 316 austenitic stainless steel”.

[3] Gadewar et. al. P. “Experimental investigations of weld characteristics for a single pass TIG welding with ss316L”. / International Journal of Engineering Science and Technology Vol. 2(8), 2010, 3676-3686.

[4] Norström, L.A. (1977), “The influence of nitrogen and grain size on yield strength in Type AISI 316L austenitic stainless steel”, Metal Science, Volume 11, Number 6, J, pp. 208-212(5)

[5] Engenho de Dentro, Rio de Janeiro, Rua José Dos Reis “Estimated accuracy of classification of detected in welded joints by radiographic” tests[a] 299 Casa 4, CEP 20770-050, Brazil, NDT & E International Volume 38, Issue 5, July 2005, Pages 335–343.

[6] “Weld defects and quality control”, pg 199-215.

[7] Tapany Udomphol. “Weld assesments and properties” Suranaree University of TechnologySep-Dec2007