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A study of mechanical properties of gas tungsten arc welded 316L stainless steel joints

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ABSTRACT

The aim of this work is to study mechanical properties of gas tungsten arc welded 316L stainless steel joints using 308L stainless steel filler metal. Yield strength, ultimate tensile strength and percentage elongation of the welded joints across the weld interface has been reported. The integrity of the joints has been investigated using optical microscopy and load Vs displacement curves.

Keywords: Austenitic stainless steel, mechanical properties, microstructure.

1. INTRODUCTION

Stainless steel is particularly suitable for the production of everyday households and commercial products especially for alimentary use because of rust-resisting. Many researchers and technicians on weldability of stainless steel is still going on because of wide spread use of stainless steel and their importance in critical industrial technologies (Metals, 1990). Austenitic stainless steel (ASS) such as type 316L is usually preferred over other austenitic varieties as a structural material due to its higher corrosion resistance and superior mechanical properties both at low and high temperatures. Micro structural changes due to welding have been reported by several researchers (Brookes et al.1991: Samanta et al. 2006) investigated the effect of rare earth elements on microstructure and oxidation behaviour in GTA weldments of AISI 316L SS and observed that it improves the oxidation resistance as well as oxide scale adherence to a great extent. Prasad reddy et al., (2008) investigated high temperature low cycle fatigue properties of 316(N)weld metal and 316L(N)/316(N) welded joints and observed that 316(N) weld metal shows a higher cycle stress response than 316L(N)/316(N) welded joints. (Rafal et al. 2009) investigated measurement of mechanical properties in a 316L stainless steel welded joint and found that the highest mechanical properties are revealed in the material taken from the heat affected zone than the weld material. GTAW process suitable for the fabrication process involves the joining of stainless steel components. However, the thermal effects associated with the welding process cause a structure to fail at its welded joints, and consequently a number of researchers have investigated the relative influences of the welding structure, the welding parameters, the nitrogen content, the number of welding passes and

Figure 1
Welded specimen of S1

Figure 2
Welded specimen of S2

Figure 3
Welded specimen of S3

Figure 4
Welded specimen of S4

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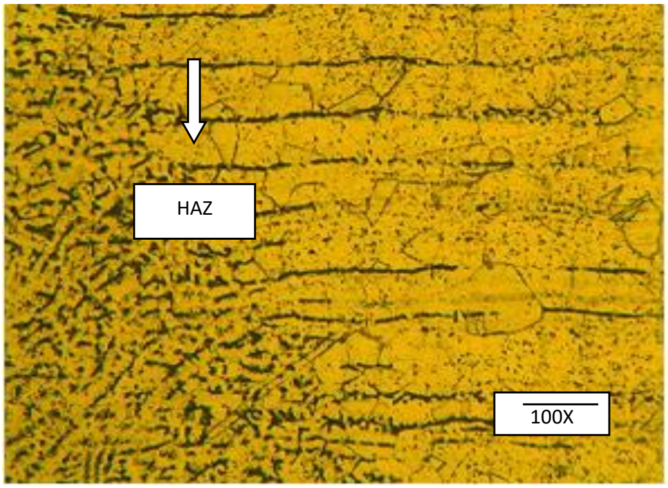


Figure 5

GTAW 316L-308L PM HAZ WM

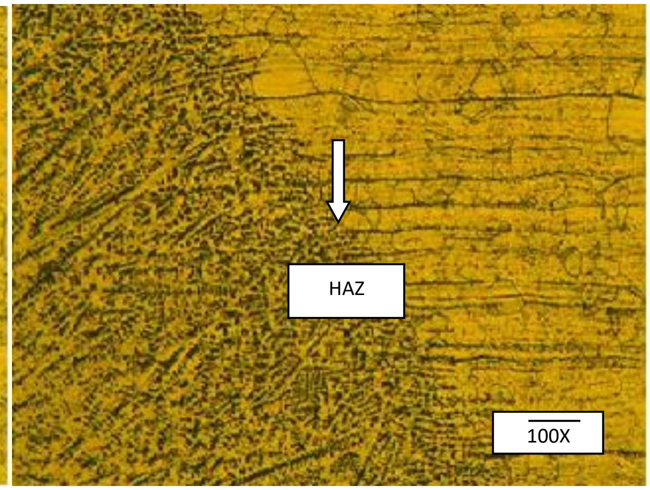
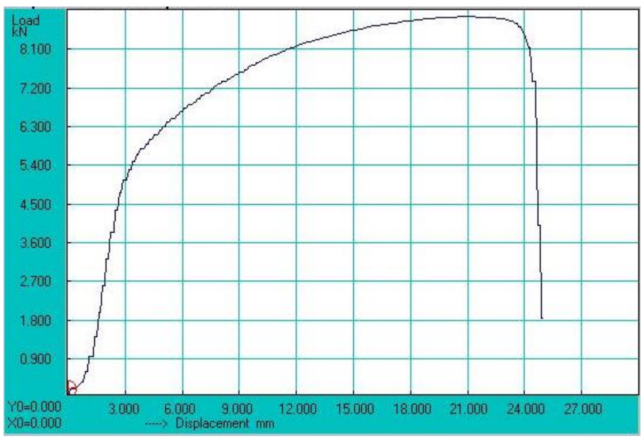
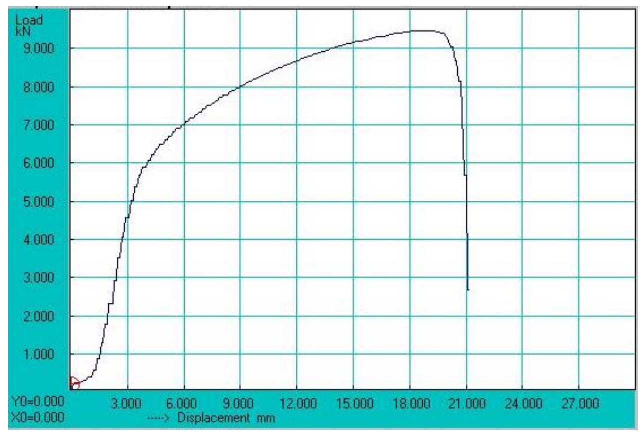


Figure 6

GTAW 316L-308L PM HAZ WM

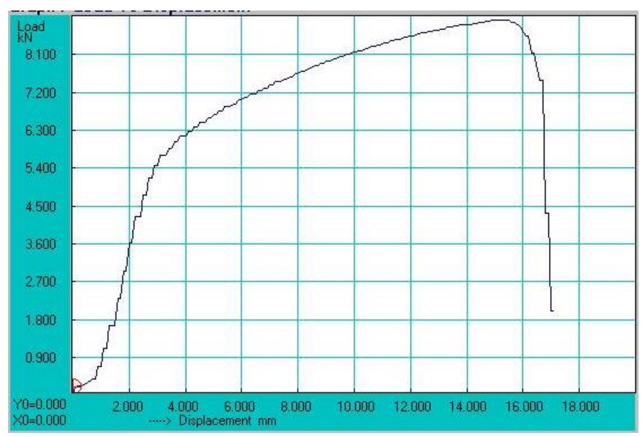


a) Load Vs Displacement curve of S1



b) Load Vs Displacement curve of S2

c) Load Vs Displacement curve of S3



(d) Load Vs Displacement curve of S4

Figure 8

Load Vs Displacement curve for all the 4 specimens

the solidification morphology on the mechanical properties of welded austenitic stainless steel joints (Yuri et al. 2000). Most of the reported literature focused on different types of welding methods, heat input and welds bead, etc., Hence the present investigation is carried out to study the effect of austenitic stainless steel filler metal on mechanical properties and microstructure of GTA welded austenitic stainless steel joints.

2. MATERIAL AND EXPERIMENTAL PROCEDURE

2.1. Samples of experiment

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In this study, AISI 316L stainless steel plate with 3 mm thickness in annealed condition was used. The chemical composition (wt.%) of stainless steel was C 0.022, Mn 1.410, P 0.029, S 0.003, Si 0.374, Cr 16.69, Ni 9.80, Ti 0.004, Mo 2.04, Cu 0.49 and Fe as the balance.

Table 1 Mechanical properties of weld

Specimen No.	Yield strength (Mpa)	Tensile strength (Mpa)	Elongation (%)
S1-GTAASS(308L)	351	492	45.636
S2-GTAASS(308L)	404	526	38.727
S3-GTAASS(308L)	404	526	39.636
S4-GTAASS(308L)	361	496	31.273

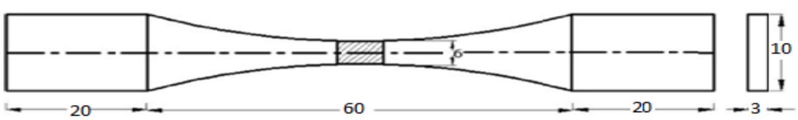
2.2. Welding process

Gas tungsten arc welding (GTAW) was employed to join the plates together. The welding processes were performed with AISI 308L stainless steel filler metal and form a single V butt joint. The initial joint configuration was obtained by securing the plates in position using tack welding. Necessary care was taken to avoid joint distortion and the joints were made with applying clamping devices. Selective parameters were voltage (V) 14, current (A) 90, welding speed (mm/sec) 1.4, heat input (J/mm) 900, gas flow (lit/min) 10, electrode diameter (mm) 2.0 and shielding gas (%) argon 99.99, basis of thickness of plate, type of alloy and type of welding process.

3. RESULTS AND DISCUSSION

3.1. Macro examination

Visual examination of the welded specimens showed uniform and good welded joints. The flash obtained was also symmetric and even which indicates plastic deformation on both base metal and weld metal. Figs. 1-4 show the macrographs of the four specimens welded under same welding conditions.



Sub-size tensile specimen

Figure 7

3.2. Optical microscopy

Optical micrographs were taken with a metallurgical microscope model LEITZ, West Germany. The etchant used was 2% Nital and the microstructures were observed at a magnification of 100x and 200x in the heat affected zone (HAZ) region. Optical microscopy of the interface micro examination of the longitudinal section of the welded sample did not reveal any lack of fusion and cracks. The joint fabricated by ASS filler metal contains solidified dendrite structure of austenitic (Fig.5 & 6).

3.3. Tensile test results

Tensile testing was done on an electro-mechanical controlled UTM of 100KN capacity. The tests were carried out according to ASTM E8M-06 standards, the geometry of the sub sized tensile test specimen as shown in Fig.7. Tensile strengths varied from 492 to 526 Mpa depending upon the GTA welding conditions used. Mechanical properties of the weld are shown in Table 1. The tensile strength values reported in the current study are comparable to the values reported in the literature. The mechanical property data show that the entire gas tungsten arc welding specimens, strength of the weld is good. The stress vs. displacement curves for S1-S4 as shown in Fig.8. The yield strength and ultimate tensile strength of GTAW (using ASS filler metal) specimen S1 values are 351 and 492Mpa, but in specimen S2 and S3 values are the same 404 and 526 Mpa respectively. The specimen S4 values are 361 and 496 Mpa. The variation in the values depends on mainly the welding speed and filler metal ratio. Hence, the specimen S2 and S3 exhibits more tensile strength compared to S1 and S4.

4. CONCLUSIONS

Strength of the joints obtained was good and ductility was reasonable. Chemical composition of the stainless steels used for welding play an important role in deciding the properties of the weld. From this investigation, following important conclusions are derived.

- Of the four specimens, GTAASS-2 and GTAASS-3 shows higher yield strength, and tensile strength compared to the joints GTAASS-1 and GTAASS-4, respectively.
- Further studies are needed to study the mechanical properties such as impact, hardness and fatigue.

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