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Evaluation of mechanical properties of TIG welding joint of stainless steel 304

Dr.Vellingiri Suresh[1], K.P.Raghavendra[2], V.Mallikarjuna[3]

[1] Professor, Department of Mechanical Engineering, Holy Mary Institute of Technology and Science, Telangana

[2]M.Tech Student, Department of Mechanical Engineering (Machine Design), Holy Mary Institute of Technology and Science, Telangana

[3]Assistant Professor, Department of Mechanical Engineering, Holy Mary Institute of Technology and Science, Telangana

ABSTRACT

This paper investigated the mechanical properties like Hardness and tensile test of 304 stainless steel joints by tungsten inert gas (TIG) welding. Tensile tests and Hardness were performed and the fracture surfaces were analyzed. The results showed that the joint by TIG welding had highest tensile strength and smallest dendrite size in all joints, while the joint by had lowest tensile strength, biggest dendrite size.

Keywords: Welding, Tensile test, hardness, SS 304

INTRODUCTION

SAE 304 stainless steel is the most common stainless steel. The steel contains both chromium (between 15% and 20%) and nickel (between 2% and 10.5%) [1] metals as the main non-iron constituents. It is an austenitic stainless steel. It is less electrically and thermally conductive than carbon steel and is essentially non-magnetic. It has a higher corrosion resistance than regular steel and is widely used because of the ease in which it is formed into various shapes. [1]

304 stainless steel has excellent resistance to a wide range of atmospheric environments and many corrosive media. It is subject to pitting and crevice corrosion in warm chloride environments and to stress corrosion cracking above about 60 °C. It is considered resistant to pitting corrosion in water with up to about 400 mg/L chlorides at ambient temperatures, reducing to about 150 mg/L at 60 °C [2].

304 stainless steel is also very sensitive at room temperature to the thiosulfate anions released by the oxidation of pyrite (as encountered in acid mine drainage) and can undergo severe pitting corrosion problems when in close contact with pyrite- or sulfide-rich clay materials exposed to oxidation.

For more severe corrosion conditions, when 304 stainless steel is too sensitive to pitting or crevice corrosion by chlorides or general corrosion in acidic applications, it is commonly replaced by 316 stainless steel.

304 stainless steel is used for a variety of household and industrial applications such as food handling and processing equipment, screws, [2] machinery parts, and car headers. 304 stainless steel is also used in the architectural field for exterior accents such as water and fire features. It is also a common coil material for vaporizers[3].

Tungsten inert gas (TIG) welding became an overnight success in the 1940s for joining

Author for correspondence:
Department of Mechanical Engineering, Holy Mary Institute of Technology and Science, Telangana
Email: winsureshv2011@gmail.com

magnesium and aluminum. Using an inert gas shield instead of a slag to protect the weld pool, the process was a highly attractive replacement for gas and manual metal arc welding. TIG has played a major role in the acceptance of aluminum for high quality welding and structural applications[4-6].

In the TIG welding process the arc is formed between a pointed tungsten electrode and the work piece in an inert atmosphere of argon or helium. The small intense arc provided by the pointed electrode is ideal for high quality and precision welding. Because the electrode is not consumed during welding, the TIG welder does not have to balance the heat input from the arc as the metal is deposited from the melting electrode. When filler metal is required, it must be added separately to the weld pool [7-9].

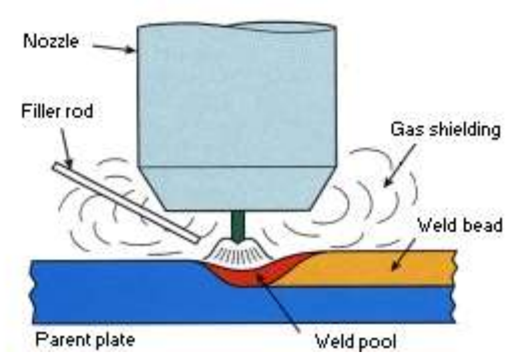

Fig 1. Working Principle of TIG Welding

MATERIAL AND METHOD

SS 304 having a density of 8 g/cc and protuberant properties like weight, toughness, heat conduction etc., be chosen as the base material due to its usage in automotive pistons. The spectroscopy analysis was carried out for SS 304 and its chemical composition, Mechanical and Physical were given in Table 1.Typical applications of SS 304 include Food processing equipment, particularly in beer brewing, milk processing & wine making, Kitchen benches, sinks, troughs, equipment and appliances, Architectural panelling, railings & trim, Chemical containers, including for transport and Heat[10].

Table 1 Chemical Composition of SS 304

Elements	C	Si	Mn	P	S	Cr	Ni
%	0.067	0.305	1.053	0.039	0.003	18.596	8.013

Mechanical Properties of SS 304

Grade	Tensile strength (MPa)min	Yield strength 0.2% Proof (MPa)min	Elongation (% in 50mm) min	Hardness Rockwell (HRB) max	Brinell (HB)max
304	515	205	40	92	201

The physical Properties of SS 304

Grade	Elastic modulus (GPa)	Thermal conductivity (W/m.k)	Specific heat 0-100 °C (J/Kg.K)	Electrical resistivity (nΩm)

		At 100 ° C	At 500 ° C		
304	193	16.2	21.5	500	720

Experimental Procedure

SS 304 material is considered and a sheet of this metal of thickness 5 mm is taken for the purpose and it is cut into four 30x30 mm plates. It is divided into two pair and each pair is TIG welded as shown in Fig. 2. These work pieces are used for testing purpose. Table 2 and Table 3 shows joint configuration and parameters of TIG welding.

Fig 2. TIG Welding Work piece

Table 2. Joint configuration of TIG Welding

JOINTS(QW-402)
Joint design: V-Groove
Root Spacing:1.5-2.0mm
Land spacing: 0.5mm
Backing (YES / NO): Yes
Backing Material (Type): Steel

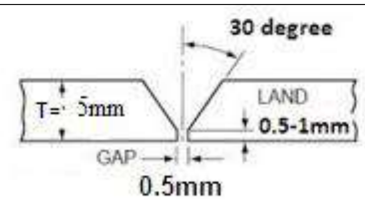

Table 3.Tig Welding Parameters

ELECTRICAL CHARACTERSTICS (QW-409)							
Weld Layer(s)	Process	Filler Metal Class	Dia (mm)	Current AC/DC	Amp Range (Amp)	Volt Range(V)	Travel Speed (cm/min)
SINGLE	GTAW (TIG)	SS304L	Ø1.2mm	DCEN	90-100	15-20	20

TIG WELDING- TESTING

Hardness Test

The **Brinell hardness test method** as used to determine Brinell hardness, is defined in ASTM E10. Most commonly it is used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. Brinell testing often use a very high-test load (3000 kgf) and a 10mm diameter indenter so that the resulting indentation averages out most surface and sub-surface inconsistencies.

The Brinell method applies a predetermined test load (F) to a carbide ball of fixed diameter (D) which is held for a predetermined time period and then removed. The resulting impression is measured with a specially designed Brinell microscope or optical system across at least two diameters – usually at right angles to each other and these results are averaged (d). Although the calculation below can be used to generate the Brinell number, most often a chart is then used to convert the averaged diameter measurement to a Brinell hardness number. Common test forces range from 500kgf often used for non-ferrous materials to 3000kgf usually used for steels and cast iron. There are other Brinell scales with load as low as 1kgf and 1mm diameter indenters but these are infrequently used.Table 4 shows brinell hardness test sample value.

Table 4. Brinell Hardness Value

BHN				
Indentation BM	Indentation HAZ	Indentation WZ	Indentation HAZ	Indentation BM
146	150	157	143	138

Tensile Test

The hardness values are converted into tensile values. Table 5 shows converted tensile values. Fig 3 shows tensile and harness values. According to ASM INTERNATIONAL 1059-9495 standard the hardness values are converted into tensile values by the flowing equation.

$$TS=3.45HB$$

Table 5. Converted Tensile Values

SL.NO	WELD PALCE	HARDNESS VALUES	CONVERTED TENSILE VALUES
1.	BM	146	503.7
2.	HAZ	150	517.5
3.	WZ	157	541.65
4.	HAZ	143	493.35
5.	BM	138	476.1

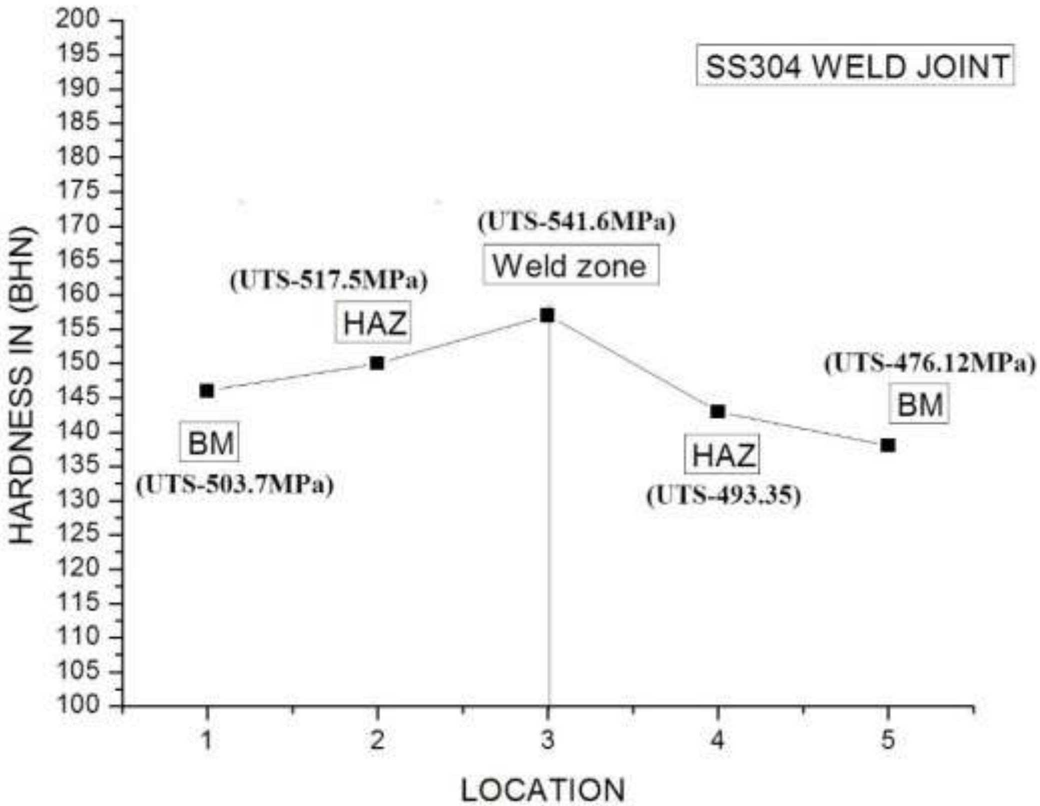

Fig 3 .Hardness Vs Tensile values

CONCLUSIONS

- It has been observed that the tensile properties of the SS304 such as tensile strength is improved after TIG Welding.
- It has been observed that the hardness properties of the SS304 such as tensile strength is improved after TIG Welding.
- TIG welding process has a very large area of application due to its many advantages like It provides a concentrated heating of the work piece.
- It provides an effective protection of the weld pool by an inert shielding gas.
- It can be independent of filler material.

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