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Experimental investigation of the effect of welding current, voltage and gas flow rate on welding characteristics of TIG welded S31603 material

Jeya Jeevahan*, G.Britto Joseph, G.Mageshwaran, N.Manikandan
Department of Mechanical Engineering, Sathyabama University, Chennai, India
***Corresponding author: E-Mail: jeya.jeevahan@gmail.com**

ABSTRACT

In this work, the welding characteristics of TIG welded stainless steel S31603 are investigated by varying welding current, welding voltage and gas flow rate. Specimens of three factors and three levels are considered for the investigation. Tensile test, hardness test and impact test are performed on the specimens. The test results are obtained and discussed. The results shows that the welding characteristics may be improved by suitably selecting welding current, welding voltage and gas flow rate in a TIG welding machine.

KEY WORDS: Welding characteristics, TIG welding, S316 Material, Welding current, Effect of welding current, Welding strength.

1. INTRODUCTION

Austenitic Stainless Steel S31603 is a low carbon variety of S316 and is generally used for welding applications of over about 6 mm thickness. When it is necessary to weld stainless steel, austenitic stainless steel becomes the most preferred filler material.

Ahmed (2010) explained how welding speed could influence tensile properties of a welded joint in TIG welding process. (Arun Narayanan, 2013) had showed how the welding parameters could influence in Aluminium 5083 alloy. Atma Raj and Joy (2014) determined the distortion during TIG welding of low carbon steel plate. (Dhruval, 2014) conducted a parametric analysis of weld characteristics for improving the fabricating properties. (Dinesh Kumar, 2014) optimised the weld parameters of of 304L butt joint. (Halil Ibrahim and Ramazan Samur, 2013) studied about tensile strength and hardness of TIG welded 304 stainless steel. (Harish Kumar, 2012) showed the advantage of using S31603 in corrosive environments. (Kuang and Chih, 2011) studied about the welding characteristics of TIG welded 5083 Al-Alloy. (Lakshman Singh, 2014) showed how different graded electrodes Influenced the tensile strength of TIG welded 5083 alloy. (Parvinder Singh and Rajinder Singh, 2014) investigated on the deposition rate in TIG welded 304 Stainless Steel. (Raveendra, 2014) studied the effect of welding parameters on TIG welded 5052 aluminium alloy. (Sathish, 2012) studied about optimization of the process parameter of dissimilar pipe joints using GTAW.

There have been a number of studies conducted on austenitic stainless steel. They focused on particular application, different grades of material and optimizing welding parameters. No such focus was given to S31603 material when both base metal and filler material are same. Also, the influence of welding current and welding voltage was not studied. In this work, the welding characteristics of TIG welded S31603 material are investigated. The work piece thickness, wire rod diameter and welding speed are considered to be constant parameters. The filler rod metal used is Stainless Steel ERS31603 grade of 1.60 mm diameter. The welding characteristics are investigated by varying welding current, voltage and gas flow rate. Thus, the factors considered are welding current, welding voltage and gas flow rate with three levels as shown in the table 1.

Table.1. Factors and their Levels

Factors	1st Level	2nd Level	3rd Level
Welding Current	160 A	180 A	200 A
Welding Voltage	40 V	50 V	60 V
Gas Flow Rate	4.0 l/m	4.5 l/m	5.0 l/m

2. SPECIMEN PREPARATION

Specimens of dimensions 200 mm × 100 mm× 10 mm are prepared from S31603 material. The edges of the specimen are prepared using a wire cutting machine and the debris are removed from the edges using a wire brush. Then, the specimens are butt-welded using a TIG welding machine under constant speed and wire diameter. A gap, of 1 mm to 2 mm, is maintained between the edges to ensure proper penetration of the weld. The welded specimens with specimen numbers are shown in the following figure (Figure 1). The details of the specimens are shown in table 2 in the previous section.

Figure.1. Welded specimens

Table.2. Specimens for the experimentation

Specimen No.	Welding Current (A)	Welding Voltage (V)	Gas Flow Rate (l/m)
T1	160	40	4.0
T2	160	50	4.5
T3	160	60	5.0
T4	180	40	4.5
T5	180	50	5.0
T6	180	60	4.0
T7	200	40	5.0
T8	200	50	4.0
T9	200	60	4.5

3. RESULTS & DISCUSSION

After the specimens were prepared as per the orthogonal arrays, the tensile test and hardness test were conducted at XL Engineering Test Services, Thiruchirapalli and Impact test at Vinayaka Metallurgical Laboratory, Thiruchirapalli. The test results are discussed below.

To obtain the tensile strength of weld joints, the specimens were first machined according to ASTM-E8 standard and the tensile strength of each welded specimen was measured in universal testing machine. The results are recorded as shown in table 3. The same is represented in the graph (Figure 3).

Table.3. Experimental observations of tensile test

Specimen No.	Welding Current (A)	Welding Voltage (V)	Gas Flow Rate (l/m)	Tensile Load (N)	Tensile Stress (N/mm^2)
T1	160	40	4	83.55	422.61
T2	160	50	4.5	59.31	311.34
T3	160	60	5	71.91	360.32
T4	180	40	4.5	74.49	400.59
T5	180	50	5	84.6	425.98
T6	180	60	4	67.87	355.38
T7	200	40	5	78.99	402.83
T8	200	50	4	83.46	420.45
T9	200	60	4.5	71.49	368.09

The tensile test results of the S31603 material jointed by TIG welding were given in Table 3. From this table T1, T5, T8 will give maximum value of tensile stress. The failure was occurred in weld metal zone. Microhardness test was performed by using Rockwell hardness tester. The hardness of the weld specimens is measured and shown in the Table 4. The same is represented in the graph below (Figure 2).

Figure.2. Rockwell Hardnesses of different Specimens

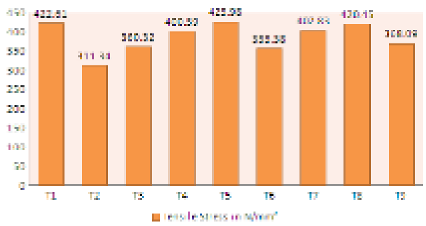

Figure.3. Tensile Strength of different Specimens

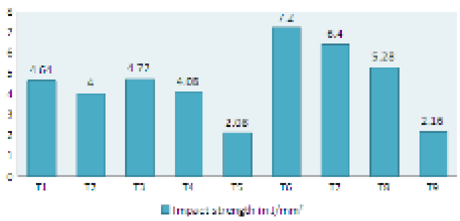

Figure.4. Impact Strength of different Specimens

Table.4. Experimental observations of Rockwell hardness test

Specimen No.	Welding Current (A)	Welding Voltage (V)	Gas Flow Rate (l/m)	Rockwell Hardness Number in HRB
T1	160	40	4	61.33
T2	160	50	4.5	67.67
T3	160	60	5	66.67
T4	180	40	4.5	69.67
T5	180	50	5	76.33
T6	180	60	4	57.33
T7	200	40	5	65.67
T8	200	50	4	63.00
T9	200	60	4.5	67.67

Impact strength is obtained using Charpy Impact Test. The specimens are machined according to ASTM-E23 standards. The impact strength of the S31603 welded joints are measured in Charpy impact testing machine and the results are found as shown in table 5. This is shown in the figure 3.

Table.5. Experimental observations of Charpy Impact test

Specimen No.	Welding Current (A)	Welding Voltage (V)	Gas Flow Rate (l/m)	Energy absorbed (J)	Impact strength (J/mm²)
T1	160	40	4	116	4.64
T2	160	50	4.5	100	4.00
T3	160	60	5	118	4.72
T4	180	40	4.5	102	4.08
T5	180	50	5	52	2.08
T6	180	60	4	180	7.20
T7	200	40	5	160	6.40
T8	200	50	4	132	5.28
T9	200	60	4.5	54	2.16

From the results of Tensile test, Hardness test and impact test, the following effects on welding charecteristics are observed.

- 160-200 Amps, 40-50 Volt and 4-5 lpm shows higher tensile strength.
- 180 Amps, 50 Volt and 5 lpm shows higher hardness strength.
- 180 Amps, 60 Volt and 4 lpm shows higher Impact strength.

These results shows that the welding charecteristics may be improved by appropriately selecting the welding conditions such as welding current, welding voltage and gas flow rate in a TIG welding process.

4. CONCLUSION

In this work, an experimental investigation was performed to study whether welding characteristics may be improved by varying welding current, voltage and gas flow rate in a TIG welding process. Specimens of S31603 material was considered for this investigation by changing the welding parameters and tested to determine the hardness, tensile strength and impact strength. From the results, it is concluded that the effect of changing welding current, welding voltage and gas flow rate improve the welding characteristics.

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