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EFFECTS OF WELDING PARAMETERS ON THE TENSILE STRENGTH OF GAS TUNGSTEN ARC (GTAW) WELDED PLATE

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Abstract

The increasing demand for high quality welds have given rise to the use of gas tungsten arc welding (GTAW) process, which is also known as tungsten inert gas welding (TIG). This research work focuses on the use of the conventional common approach utilized by many engineers in manufacturing companies, which is the one-variable-at-a-time (OVAT) to study the effect of input parameters on the tensile strength of a mild steel weld. Coupons of 50mmx100mmx10mm mild steel plate were welded using the GTAW process with the following input process parameters arc voltage, current and gas flow rate and argon gas as the shielding gas. From results obtained, the input parameters have a great effect on the response- tensile strength, as so much variation was recorded as the parameters were increased and decreased. The results obtained showed that the experiment recorded an optimum value of 496.5Mpa for the Tensile Strength at an input parameter of 170A current, 20V Voltage and 20L/min Gas Flow Rate.

1.0 Introduction

Welding is the process of joining two pieces of metal, alloys or plastics by intense heating with or without the application of pressure or by the application of pressure alone and with or without the use of filler material [1]. It is different from other forms of mechanical connections, such as riveting or bolting, which involves friction or mechanical interlocking, or brazing and soldering, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces. During welding, the work-pieces to be joined are melted at the interface and after solidification a permanent joint can be achieved. The Weldability of a material depends on several factors ranging from the metallurgical changes occurring during welding, tendency of crack formation in the joint position, changes in hardness in weld zone caused by rapid solidification, and oxidation caused by reaction of materials with atmospheric oxygen.

Among the various welding processes in existence, arc welding is the most popular; it's widely used for welding different types of materials irrespective of thickness. Gas Tungsten Arc Welding (GTAW) also known as Tungsten Inert Gas (TIG) is an arc welding process which uses a non consumable tungsten electrode to produce the weld. The weld area is protected from atmosphere with a shielding gas generally Argon or Helium or sometimes mixture of Argon and Helium. A filler metal may also feed manually for proper welding. With the development of TIG welding process, materials such as Aluminum and Magnesium which were nearly impossible to weld are now been welded. The use of TIG today has spread to a variety of metals like stainless steel, mild steel and high tensile steels, Al alloy, Titanium alloy. Generally, the quality of a weld joint, in terms of different features, is directly influenced by welding input parameters during the welding process; therefore, welding can be considered as a multi-input, multi-output process. Therefore it has become necessary to investigate the weld input parameters for welded product to obtain a welded joint with the required specifications.

Mechanical properties, some of which are hardness, impact strength (toughness), yield strength, ultimate tensile strength, percentage elongation, resistance to wear and corrosion etc., are important characteristics of the weldment that must conform to the application feasibility as well as functional requirement of the welded joint. They are greatly dependent on the weld microstructure, which in turn is related to cooling condition, composition of base metal, wire electrode as well as flux. The best value of current, voltage, speed of welding and external magnetic field to produce the best quality of weld in respect of depth of penetration has been investigated using the artificial neutral network [2]. Result obtained showed that a strong joint of mild steel is found to be produced in the work using SMAW as amperage, arc voltage and travel speed varied inversely to the depth of penetration. The effect of process parameters for welding of AA 6351 using TIG welding has been analyzed [3]. Several control factors were found to predominantly influence weld quality. The % contributions from each parameter were

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computed through which optimal parameters were identified. ANOVA method was used to check the adequacy of data obtained. The experiment revealed that low current values have created lack of penetration and high travel speed has caused lack of fusion in welding AA6351. The depth of penetration for 6mm mild steel plate for MIG welding process has been investigated using the following process parameters current, voltage and welding speed [4]. The depth of penetration was measured for each specimen after the welding operation for closed butt joint. The voltage higher than 26.5 v and current higher than 150 amp causes abrupt rise in penetration depth but welding speed higher than 0.16 mm/min decreases the depth of penetration. The effect of welding parameters on the weld quality to develop guidelines for a selection of suitable parameter ranges for micro plasma welding has been investigated [5]. A series of experiments was conducted to explore how changes of welding parameters affect the strength of the weld for the thin stainless steel most often used in the industry. The experiment results show that work piece exposure height must be above a minimum limit in order to prevent undesired joining. The strength increases as the current increases with fluctuations, but still in the sufficient range. The minimum sufficient current for quality welds increases, while the minimum sufficient heat input decreases, as the travel speed increases.

2.0 METHODOLOGY

Problem Formulation

This procedure was observed in carrying out the experiment; (i). Selection of material. (ii). Identification of process parameters and their levels. (iii). Development of design matrix. (iv). Conducting experiments as per design matrix. (v). Testing and recording of the response.

Material Selection

Mild steel plate of 10mm thick was selected as the material used for the experiment. In order to produce weld specimens, a joint consisting of two mild steel coupons each cut to dimensions of 50mm x 100mm with the aid of a power hack saw and grinded at the edges to smoothen the surfaces to be welded were prepared. TIG welding process was used with Alternate Current (AC) to perform the experiments as it concentrates the heat in the welding area [6], using 100% argon gas as the shielding gas. At the completion of the welding process, each specimen was cut at the cross section for the tensile strength testing.

Identification of factors and responses and their range.

Input Parameters: There are quite a number of input parameters relevant to welding, but for this study, we decided to limit our focus to a few which from literature has been proven to have more effects. In this present work the following input parameters within the stated levels were studied and their effects analyzed. Welding current (240-200Amp), Welding Voltage (15-25volts), Gas flow rate (20-24L/min). **Output Parameters**: • Tensile Strength.

Experimental Procedure

Mild steel plate of 10mm was selected as material used for the experiment. The mild steel plate was cut to dimension of 50mm x 100mm using a power hack saw and grinded at the edges to smoothen the surfaces to be joined. The surfaces of the coupon were polished with emery paper, thereafter they were fixed on a work table with a flexible clamp in preparation to be welded. The one variable at a time approach was used in generating the design matrix as shown in table 1 below:

Table 1; Design Matrix

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)
1	140	15	20
2	140	20	22
3	140	25	24
4	170	15	24
5	170	20	20
6	170	25	22
7	200	15	22
8	200	20	24
9	200	25	20

A TIG welding process was used with Alternate Current (AC) to perform the experiments as it concentrates the heat in the welding area, using 100% argon gas as the shielding gas. In its simplest form, the standard equipments required for tungsten inert gas welding comprises of a source for power supply, a welding torch, the welding leads or cables for connection, shielding gas supplying source and hoses for gas supplies. In TIG welding the tungsten electrode is non-consumable whereas shielding gas and filler wires are major consumables. The diagrams in figure 1, below shows the Tungsten Inert gas welding machine and the gas regulators.


Figure 1: Welding Setup showing the touch, gas head regulator & meter.

Welding of Specimens

The experiment was carried out 9 (Nine) times, producing a 9 (Nine) welded joints, with all necessary precautions observed. At the end of the welding process, the specimens were the pieces were cooled naturally in open air, cleaned and each cut at the cross section for tensile strength testing.

Tensile Testing of the Welded Specimen

The basic test for determination of material behavior is the tensile test. Tensile test specimen has enlarged ends or shoulders for gripping. The important part of the specimen is the gauge section. The cross sectional area of the gauge section is reduced relative to that of the remainder of the specimen so that deformation and failure will be localized in this region. The tensile test was performed on all nine (9) specimens. The shape and size of the specimen chosen was in accordance with ASTM specification E8/E8M-11 as shown in figure 2.

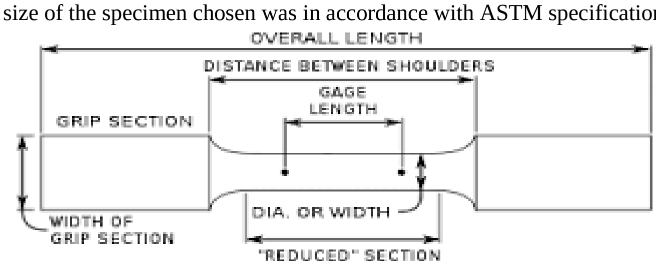

Figure 2: Tensile Test Specification

PRESENTATION OF RESULTS AND DISCUSSION

And at the end of the welding process, the output parameter the tensile Strength was tested on welded specimens, measured and recorded as shown in table 2 below.

Table 2: Tensile Strength Results from Experiment

Exp No	**Current (Amp)**	**Voltage (Volt)**	**Gas flow Rate (L/min)**	**Tensile Strength (Mpa)**
1	140	15	20	468.7
2	140	20	22	469.8
3	140	25	24	486.4
4	170	15	24	473.4
5	170	20	20	496.5
6	170	25	22	483.4
7	200	15	22	482.1
8	200	20	24	489.9
9	200	25	20	475.7

The results obtained have been analyzed with one parameters held constant and the others varied within their limits.

Table 3 Tensile strength at a constant current of 140A

Exp No	**Current (Amp)**	**Voltage (Volt)**	**Gas flow Rate (L/min)**	**Tensile Strength (Mpa)**
1	140	15	20	468.7
2	140	20	22	469.8
3	140	25	24	486.4
				474.97

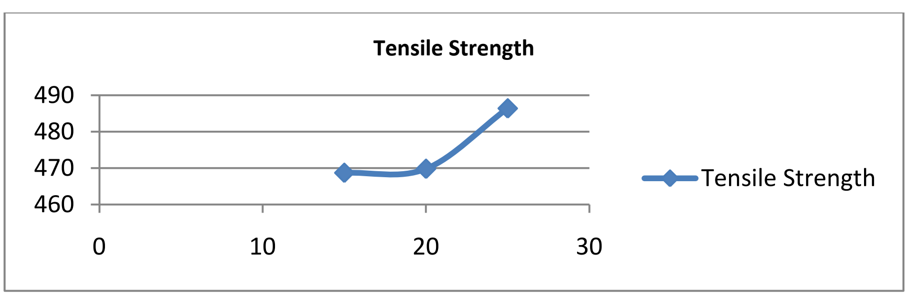

Figure 3: Graph showing tensile strength at a constant current of 140A

Table 4: Tensile strength at a constant current of 170A

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)	Tensile Strength (Mpa)
1	170	15	24	473.4
2	170	20	20	496.5
3	170	25	22	483.4
				484.4

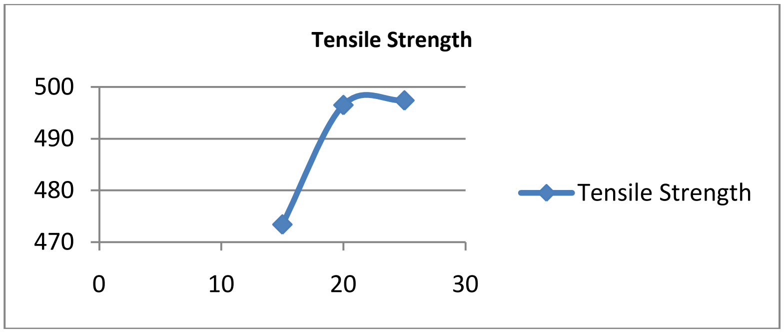

Figure 4: Graph showing tensile strength at a constant current of 170A

Table 5: Tensile strength at a constant current of 200A

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)	Tensile Strength (Mpa)
1	200	15	22	482.1
2	200	20	24	489.9
3	200	25	20	475.7
				482.4

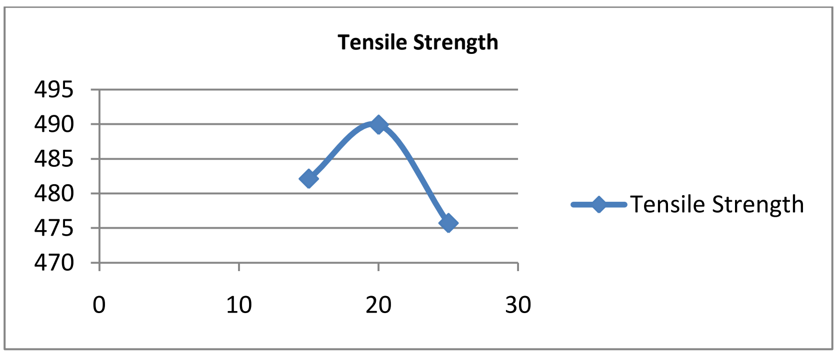

Figure 5: Graph showing tensile strength at a constant current of 200A

Table 6: Tensile strength at a constant Voltage of 15V

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)	Tensile Strength (Mpa)
1	140	15	20	468.7
2	170	15	24	473.4
3	200	15	22	482.1
				474.7

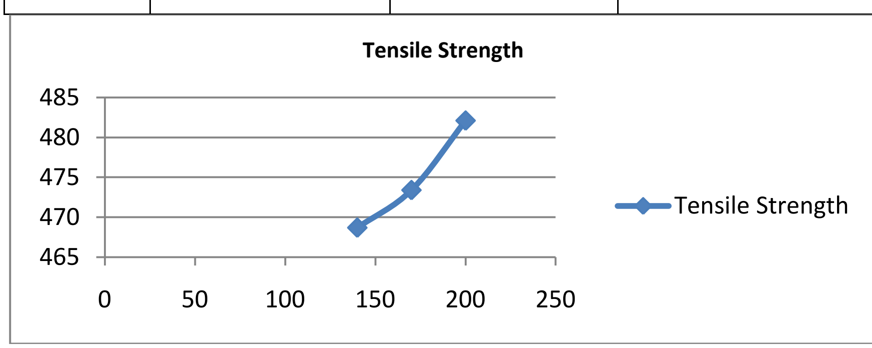

Figure 6: Graph showing tensile strength at a constant Voltage of 15V

Table 7: Tensile strength at a constant Voltage of 20V

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)	Tensile Strength (Mpa)
1	140	20	22	469.8
2	170	20	20	496.5
3	200	20	24	489.9
				485.4

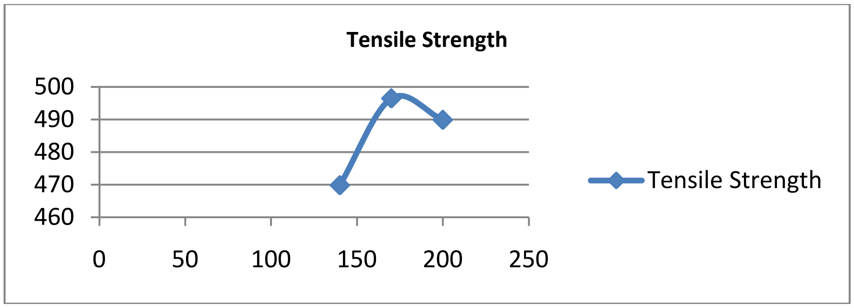

Figure 7: Tensile strength at a constant Voltage of 20V

Table 8: Tensile strength at a constant Voltage of 25V

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)	Tensile Strength (Mpa)
1	140	25	24	486.4
2	170	25	22	483.4
3	200	25	20	475.7
				481.8

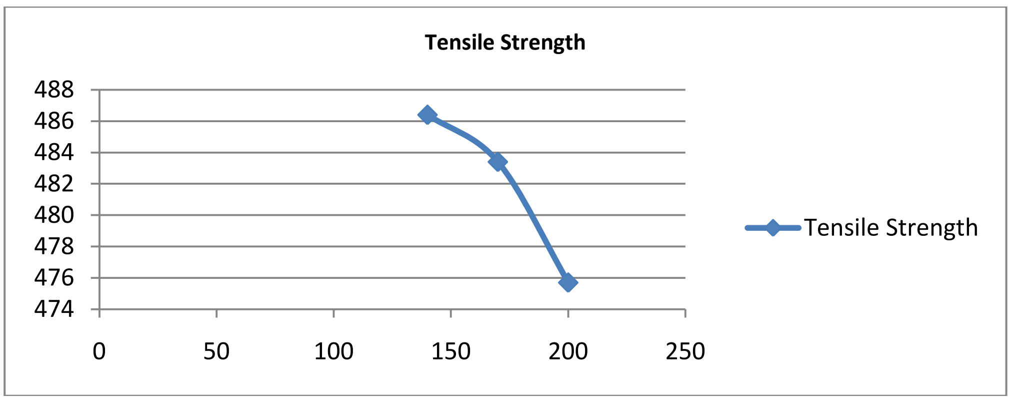

Figure 8: Tensile strength at a constant Voltage of 25V

Table 9: Tensile strength at a constant Gas Flow Rate of 20 L/min

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)	Tensile Strength (Mpa)
1	140	15	20	468.7
2	170	15	20	473.4
3	200	25	20	475.7
				472.6

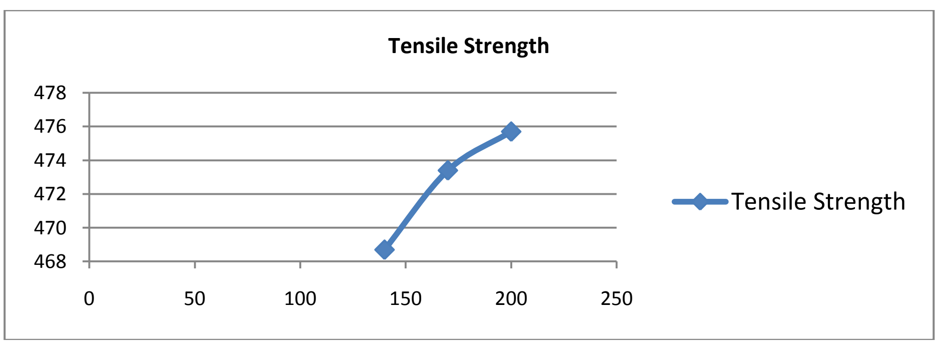

Figure 9: Tensile strength at a constant Gas Flow Rate of 20 L/min

Table 10: Tensile strength at a constant Gas Flow Rate of 22 L/min

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)	Tensile Strength (Mpa)
1	140	20	22	469.8
2	170	25	22	483.4
3	200	15	22	482.1
				478.4

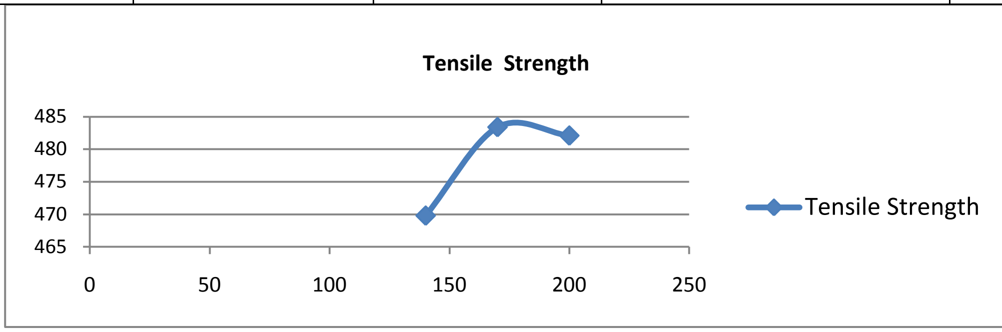

Figure 10: Tensile strength at a constant Gas Flow Rate of 22 L/min

Table 11: Tensile strength at a constant Gas Flow Rate of 24 L/min

Exp No	Current (Amp)	Voltage (Volt)	Gas flow Rate (L/min)	Tensile Strength (Mpa)
1	140	25	24	486.4
2	170	15	24	473.4
3	200	20	24	489.9
Mean				483.2

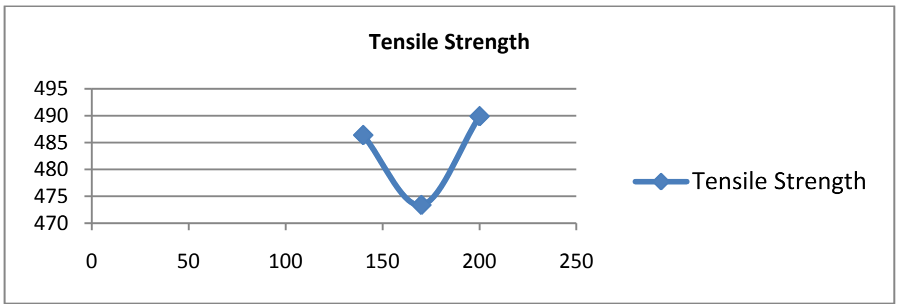

Figure 11: Tensile strength at a constant Gas Flow Rate of 24 L/min.

From figure 3, the tensile strength displayed a steady increase at a constant current of 140A. The tensile strength maintained its rise at a further increase of the current to 170A, (Figure 4) but at an additional increase of current to 200A (Figure 5), the tensile strength maintained a steady rise but latter began to decrease. An indication that a further increase in current signifies a drop in the tensile strength.

From Figure 6, the voltage seemed to have had a positive effect on the tensile strength as it displayed a steady increase at a constant voltage of 15V. The tensile strength maintained its rise at a further increase of the voltage to 20V (Figure 7) but at an additional increase of voltage to 25V (Figure 8), the tensile displayed a totally negative effect on the tensile strength. As the response displayed a total decrease.

From Figure 9, at a constant gas flow rate of 20l/min, the tensile strength displayed a steady increase. But at a flow rate of 22l/min (Figure 10) the tensile strength indicated a sudden decrease after an initial rise. At a flow rate of 24l/min, (Figure 11), the tensile strength indicated a sharp decrease but later began to rise.

CONCLUSION

The welding process using Gas Tungsten Arc Welding on mild steel plate was done successfully and the response (Tensile Strength) was measured and recorded as well. From the experiment the following conclusion can be made.

i. Welding parameters has a great influence on the weld strength of the welded joint.
ii. The response (Tensile Strength), showed variation at a further increase of the parameters.
iii. The experiment recorded an optimum value of 496.5Mpa for the Tensile Strength at an input parameter of 170A current, 20V Voltage and 20L/min Gas Flow Rate.

REFERENCES

[1] American Welding Society. Welding handbook. vol. 2. 9th edition. Welding processes part 1.

[2] Singh R.P, Gupta R.C and Sarkar S.C (2012): "The Effect of Process Parameters on Penetration of Shielded Metal Arc Welding under Magnetic Field using Artificial Neutral Networks," *Int. J. of Application or Innovation in Eng. and Management*, vol. 1, Issue 4.

[3] Kishore K, Gopal Krishna P.V., Veladri K., Kiran Kumar G. (2010), "Analysis of defects in Gas Shielded Arc welding of AA 6351 using Taguchi methods", *International Journal of Applied Engineering Research*, Vol.5, pp.393-399.

[4] Das, B., Debbarma, B., Rai, R.N. and Saha, S.C. (2013), "Influence of Process Parameters on Depth of Penetration of Welded Joint in MIG Welding Process", *International Journal of Research in Engineering and Technology*, Vol. 2, Issue 10, pp. 220–224.

[5] Kueng-Hueng Tseng , Min Jou , Yun Chang , Her-Yueh Huang , 2008a, "Influence of process parameters on joining strength in microplasma arc welding", *International Journal of Manufacturing Technology and Management*, pp. 265-279.

[6] Asibeluo I.S, Emifoniye E. (2015) Effect of Arc Welding Current on the Mechanical Properties of A36 Carbon Steel Weld Joints. SSRG *Int. J. of Mech. Eng*. vol. 2 Issue 9.