Parametric Study of Gas Tungeston Arc Welding on Mechanical Properties of Low Carbon Steel

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Abstract— In the present research work an attempt is made to understand the effect of TIG welding parameters such as welding current, gas flow rate, welding speed, weld torch angle that are influences on responsive output parameters such as weld penetration, width, fusion area, micro hardness, and tensile strength of welding. Taguchi method is used to get the optimal parameters. In Taguchi method, L9 orthogonal array is used for experimentation. The effort made to investigate optimal machining parameters and their contribution for producing better weld quality and higher Productivity. After welding test for weld penetration, weld width, fusion area, tensile test, and micro hardness have been conducted. The significance of the factors on overall output feature of the weldment has also been evaluated by analysis of variance (ANOVA).

Key words: GTAW, Hardness, Tensile Strength, Weld Geometry

I. INTRODUCTION

The use of TIG today has spread to a variety of metals like stainless mild and high tensile steels. GTAW is most commonly called TIG (Tungsten Inert Gas).

Electrode used in GTAW is non consumable tungeston and maximum thickness of plate which can be joined by GTAW is less due to low penetration. Enhancement in weld geometry has long been sought in Gas Tungsten Arc Welding. DCSP - Direct Current Straight Polarity DCRP - Direct Current Reverse PolarityAC Alternating Current can be used for TIG. Out of these alternating current is the preferred welding current for most white metals, eg aluminum and magnesium. Some researcher work for the selection of process parameters to obtained an optimal weld pool geometry in the tungsten inert gas (TIG) welding of stainless steel was presented.[6] It may be conclude that Heat affected zone decreases the strength of the weld[1] Investigated high cycle and low cycle fatigue properties of SUS304L, SUS316L steel and the effects of welding structure by GTAW welding process[25].The job of the shielding gas is to protect the weld pool contamination from air, The most dominant mechanism for increased penetration was considered to be arc constriction rather than a change in the surface tension of the molten pool.[7] . Weld torch angle have highly influence on the heat which are supply to work piece the non-consumable electrode angle influences the weld penetration depth and the weld shape The most plausible mechanism at present is that the arc or plasma was constricted by the action of the A-TIG fluxes and that the associated increase in current density results in increased forces which alter the molten pool flow to give higher penetration From literature study it can be conclude that Higher current in TIG welding can lead to splatter and work piece become damage. Again lower current setting in TIG welding lead to sticking of the filler wire. Sometimes larger heat affected area can be found for lower welding current, as high temperatures need to applied for longer periods of time to deposit the same amount of filling materials The choice of shielding gas is depends on the working metals and effects on the welding cost, weld temperature, arc stability, weld speed, splatter, electrode life etcArgon or Helium may be used successfully for TIG welding applications. For welding of extremely thin material pure argon is used. Excessive high welding speed decreases wetting action, increases tendency of undercut, porosity and uneven bead shapes while slower welding speed reduces the tendency to porosity.

The TIG welding process enjoys widespread use because of its ability to provide high quality welds with high production rate, for a wide range of ferrous and non-ferrous alloys.

II. MATERIALS AND METHODS

The chemical composition of Low carbon alloy steel is used Is shown in Table 2.1

C	Si	S	Mn	P	C equi.
0.23	0.4	0.045	1.5	.045	0.42

Table 1: Chemical Composition of Base Metal

Specimen size 200mm x 75mm x 5mm were cut from the plate which were roughly polished with 400 grit abrasive paper to remove surface impurities and then washed with acetone. Welding is done in a single pass. The input parameter were selected on the basis of a series of pilot experiments combined with the data obtained from the literature review As a result input parameter were selected as shown in Table 2.2

Input Parameter	Levels
Current (Ampere)	110-130-150
Torch Travel Speed (Mm/S)	1-1.75-2.50
Gas Flow Rate (Lit/Minute)	10-12-14
Torch Angle (Degree)	60-75-90

Table 2: Input Parameters and Their Levels

The experimental layout for the parameter, using the L_9 (3^3) orthogonal arrays is shown in Table 2.3

Sr. No	Current (Ampere)	Weld speed (m/min)	Gas flow rate (lit/min))	Torch angle (Degree)
1	110	1	10	60
2	110	1.75	12	75
3	110	2.5	14	90
4	130	1	12	90
5	130	1.75	14	60
6	130	2.5	10	75
7	150	1	14	75
8	150	1.75	10	90
9	150	2.5	12	60

Table 3: Levels of Process Parameters used in Taguchi L9

A. Orthogonal Array

After welding was done on the samples, the raw welded samples were cut using the power hack-saw machine for checking the tensile strength Smaller piece for micro hardness and weld geometry were cut by using the Meta cut abrasive cutting machine After welding, the cross-sections of the welded seams were prepared by standard metallographic procedures, such as sectioning, polishing and etching. In sectioning Samples were cut into size of 50x20mm from welded pieces to measure weld bead profile and 150mmx25mm for tensile strength now polishing was done such that One by one all emery papers of grade 160, 220, 320, 400, 600, 800, 1000 and 1200 were used in ascending order on every sample as given in above list After using abrasive paper, Velvet Cloth, Alumina Powder and Diamond Paste 5µ also used for getting reflecting surface, after using diamond paste, specimen are ready for etching operation. Etching is done to highlight the weld bead and identify microstructure feature or phases present. For detecting the weld bead border we need etching with a proper solution that attacks the metal in such a way that the specific features are made to stand out.

For etching operation require chemical mixture of HCL and HNO_3 in equal pro-portional of 10 ml. specimen was dipped into the etchant for two minutes. The exother-mic reaction takes place results in revealing the weld bead of the sample. The sample was immediately washed under running water and dried with air blower. After proper etching of the of the specimen, the weld bead will be visible. After that getting it dried by air blower all specimen are scanned with the help of scanner. These scanned images are measured for bead height, bead width and depth of penetration with the help of Adobe Acrobat Professional 11 software. These dimensions of response are analyzed in design expert 7.0.0 software

III. RESULTS AND DISCUSSION

Etched samples were analysis for weld geometry and micro hardness .Tensile test was conducted separately

A. Analysis and Result for Weld Geometry

Three sets of test were performed and average value was taken.*Result for weld geometry is shown in Table 3.1*

Sr. No.	Penetration (mm)	Width (mm)	Area (mm^2)
1	2.98	4.2	9.13
2	2.21	3.9	8.14
3	1.80	2.94	3.84
4	3.50	6.86	13.97
5	2.80	4.48	10.48
6	1.32	5.20	5.00
7	4.56	6.88	18.76
8	3.09	7.78	12.91
9	1.88	4.70	7.81

Table 4: Dimension of Weld Geometry

It was found that maximum penetration was 4.56 mm for sample number operated on 150 ampere current, 1 m/min weld speed 14 lit/min gas flow rate and 75 degree torch angle and minimum weld width and weld area were for sample number operated on 110 ampere current 2.5 m/min weld speed 14 lit/min gas flow rate and 90 degree torch angle

B. Analysis and Result for Tensile Strength

Tensile test of the welded joint was performed with universal tensile testing machine with maximum load capacity 600 kN

Sample No.	Load (kN)	Ultimate Tensile Strength (Mpa)
1	66.45	265.8
2	50.32	201.3
3	40.78	163.1
4	81.6	326.4
5	58.7	234.8
6	35.7	142.8
7	88.9	355.6
8	67.4	269.8
9	40.8	163.2

Table 5: Experimental result for tensile strength

Table 3.2 shows the tensile strength value for all the welded joints produced at different welding speed and current setting. It was found that maximum tensile strength was 355.6 Mpa which is lower than the tensile strength of the parent metal UTS of 448 Mpa for sample operated on 150 ampere current, 1 m/min weld speed 14 lit/min gas flow rate and 75 degree torch

C. Analysis and Result for Micro Hardness

Micro hardness test were performed on Vicker hardness machine which generated diamond shape indentation. Seven readings of each piece one at the mid of weld bead, three in left hand side and three in right hand from the mid of weld bead were taken. The result were shown graphically for each work piece separately.

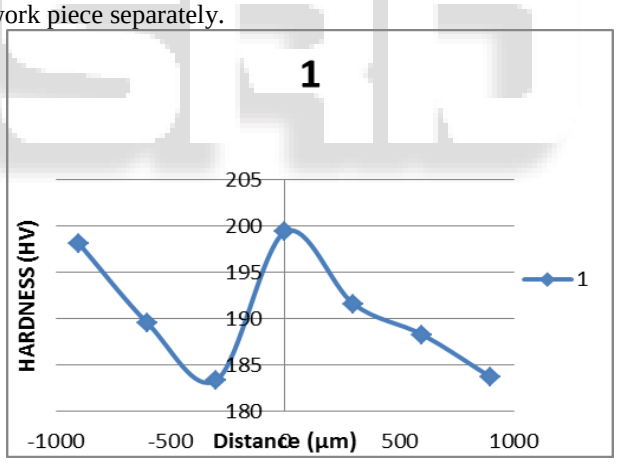

Fig. 1: Hardness Graph For Sample No -1

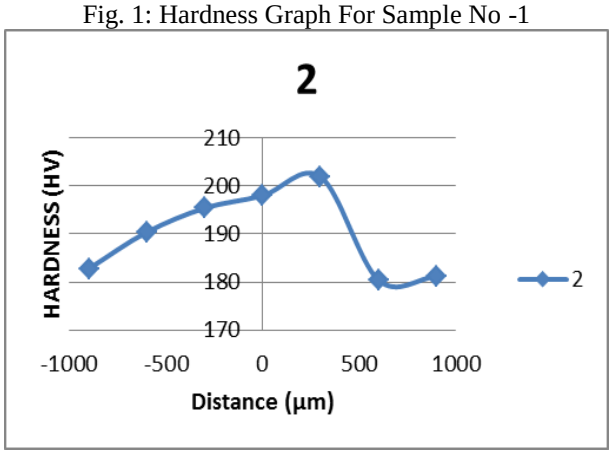

Fig. 2: Hardness Graph For Sample No -1

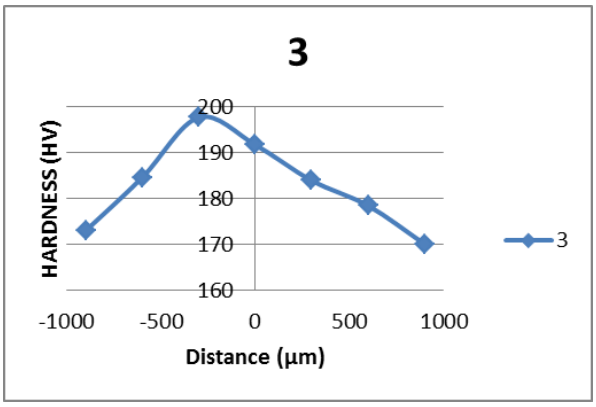

Fig. 3: Hardness Graph For Sample No -1

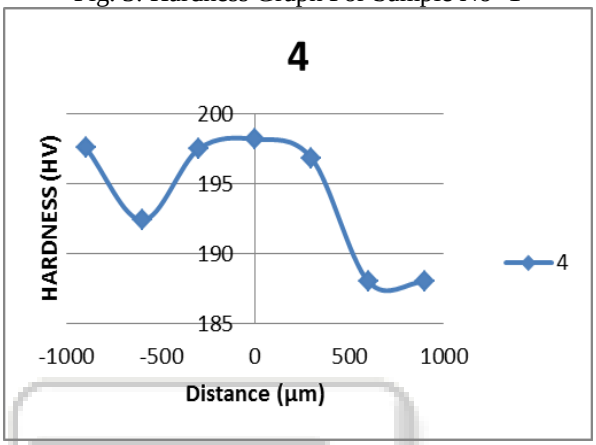

Fig. 4: Hardness Graph For Sample No -1

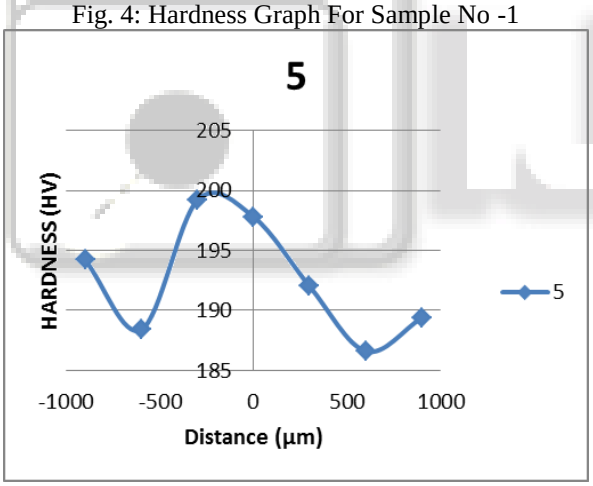

Fig. 5: Hardness Graph For Sample No -1

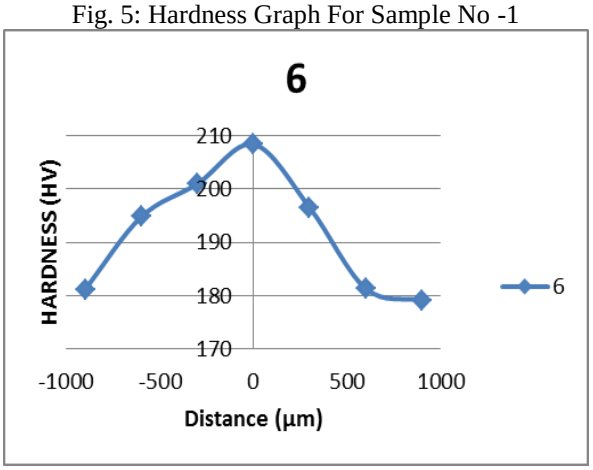

Fig. 5: Hardness Graph For Sample No -1

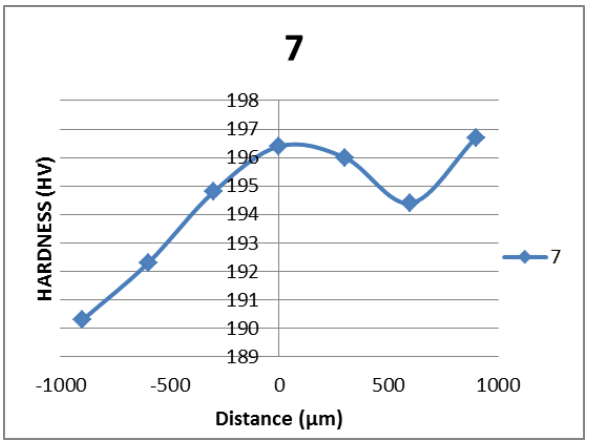

Fig. 6: Hardness Graph For Sample No -1

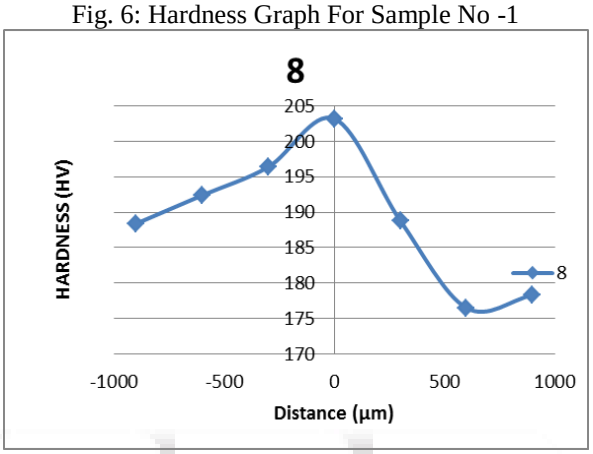

Fig. 7: Hardness Graph For Sample No -1

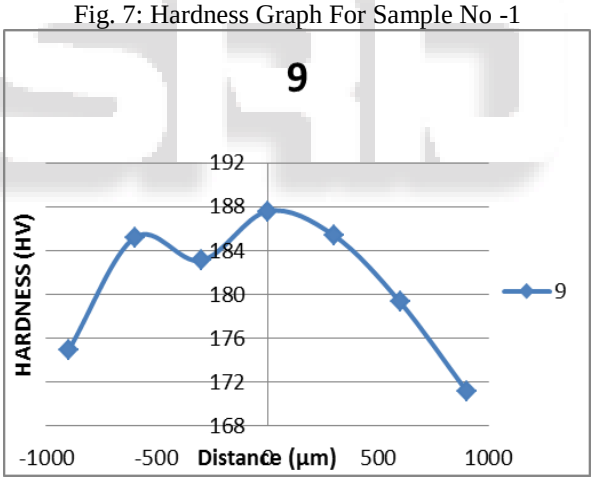

Fig. 8: Hardness Graph For Sample No -1

IV. Conclusion of the Present Study

1) Visual inspection shows some defects like little undercut at the end, and lack of penetration in few samples. However, under certain combinations of current, weld speed, gas flow rate and torch angle, the joints were found defect free.
2) From the tensile test of the samples, it was observed that ultimate tensile strength is satisfactory for many of the joints made at different levels of current, weld speed , gas flow rate and torch angle
3) From the micro-hardness tests it was observed that the hardness value increased from base region to HAZ and HAZ to weld region However, consistency in this trend is not observed for all the samples

4) Surface plots and Perturbation plot are generated by using mathematical models developed for Penetration, weld width, fusion area and UTS These plots may be useful for prediction of the responses like UTS, penetration ,width and fusion area the response can also be estimated from these plots.
5) Predicted vs actual graph for UTS, penetration. Weld width and weld area , show that actual value are very close to the predicted values
6) ANOVA shows that weld speed is the most significant factor, followed by current and gas flow rate. Penetration is highly influenced by weld speed and very little weld torch angle, current and weld speed have nearly same influence on weld width. Torch angle have more influence on weld width as compare to penetration
7) Increase in micro hardness of weld joint are less as compare to conventional arc welding

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