PARAMETRIC OPTIMIZATION OF TIG WELDING ON STAINLESS STEEL 316

Gurdev Singh, Aman Bansal
Deptt.of Mechanical Engineering,
Institute of Engineering &Technology (IET) Bhaddal, Ropar, Punjab

Abstract:

The main objective of thispaper to find out near optimal solution for welding parameters in TIG (tungsten inert gas) welding. The mechanicals properties like Tensile strength, Impact force, Hardness of the welded joints are influenced by many welding process parameters. The weld quality is affected by weld bead shape during joining operation.In present work, an attempt is made to model the welding process for predicting the bead shape parameters (commonly called as bead geometry parameters)of welded joints. This paper also includes the modeling and optimization of bead shape parameters for tungsten inert gas (TIG) welding process and further bead shape strength is predicted in the last part of the paper. Taguchi and ANOVA technique is used to find the optimal solution.

Keywords: *TIG welding, process parameters, mechanical properties, optimal solution*

I. Introduction

Modernization in welding technology started in the start of 20^{th} Century to join the material more effectively and it is done with a focus of developing the better ways to generate high heat in required localized zone.

Welding generally need a high heat source to generate large temperaturesin the required area of work so that welding could take place between two metal pieces without any problem [1]. There are so many techniques available as well as many new researches are going on to find solution for effective welding. With the increase in demand of joining of many new materials with new challenges like joining of materials with large thicknesscomponents, high quality work piece cause to find out new welding operation which was first known to the welding engineer, is no longer satisfactory and improved such as metal inert gas welding, tungsten inert gas welding, electron and laser beam welding have been developed [2].The basic equipment for TIG welding comprises a power source, a welding torch, a supply of an inert shield gas and supply of filler wire. In the TIG welding process uses direct current with theelectrode connected to the negative pole and work piece connected with positive terminal of the power source.

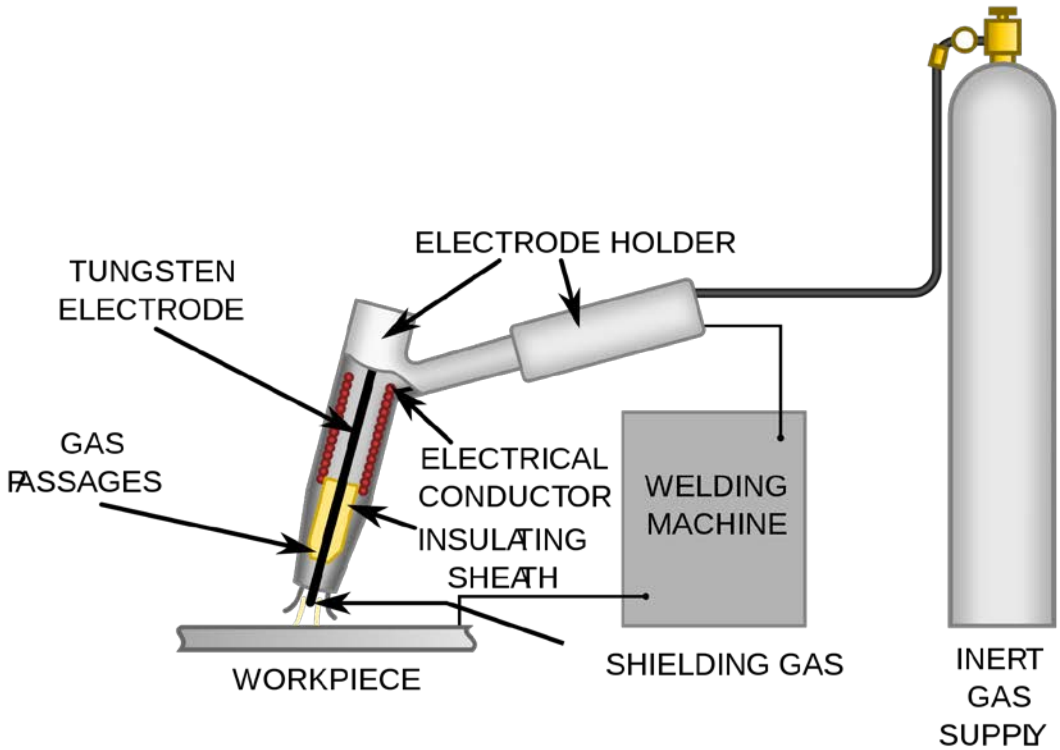


Fig no. 1 TIG welding

To avoid atmospheric contamination of the molten weld pool, a shielding gas (argon or helium) is used. Argon is more widely used than helium because it is heavier gas, producing better shielding at lower flow rate. The shielding gas displaces the air surrounding the arc and weld pool. This prevents the contamination of the weld metal by the oxygen and nitrogen in the air.Anotherimportant feature of the gas shielded arc welding processes is that the bulk of the heat is generated at the positive pole. BayramKocabekir et.al [3]aimed their research to find out the effect of welding time in different weldatmosphericand weld cooling conditions on the resistance spotweld quality of 316L stainless steel. M. Balasubramanian et.al [4] another author proposed that by increasing the pulsed current,better results are seen and usedthe mathematical equations to predict the weld pool geometry. Hence, the development of mathematical models using four factors, five levels, central composite design was attempted. The developed models were checked for their adequacy. P. Sathiya et.al [5]analyzed a method to find near optimal parameter settings in friction welding of stainless steel (AISI 304) by using nontraditional methods. The methods also proposed in this study were used to analyze the welding process parameters by which good tensile strength and minimized metal loss were obtained in friction welding. K. Shanmugam et.al [6]worked onmetals such as austenitic stainless steel, ferritic stainless steel and duplex stainless steel on fatigue crack growth behavior of the gas tungsten arc welded ferritic stainless steel joints was founded out. A. Kumar et.al [7], in his work showed the results for the improvementof mechanical properties of AA 5456 Aluminum alloy weldsthrough pulsed Tungsten Inert Gas (TIG) welding process. Taguchi method was used to optimize the pulsed TIG welding process parameters of AA 5456 Aluminum alloy welds for increasing the mechanical properties. In paper presented by D.S. Nagesh et.al [8],The authors explainedintegrated method with a new approach using experiment designmatrix of experimental designs technique on the experimental data available from conventional experimentation, application of neural network for predicting the weld bead geometric descriptors and use of genetic algorithm for optimization of process parameters. Kuang-Hung et.al [9]investigated the effect on the mechanicals properties of oxides autogenously in TIG welding applied to 6mm thick stainless steel plates through a thin layer of flux to produce a bead-on-plate welded joint. The oxide fluxes used were packed in powered form. The experimental results show that the SiO_2flux facilitated root pass joint penetration, but Al_2O_3flux led to the deterioration in the weld and bead width compared with conventional TIG welding process. M. Aghakhani et.al [10],in this research paper authors investigated optimal parameters with the help of Taguchi method. Usingdesign of experiments, a mathematical model was developed using parameters such as, wire feed rate (W), welding voltage (V), nozzle-to-plate distance (N), weldingspeed (S) and gas flow rate (G) on weld dilution. After collecting data, signal-to-noise ratios (S/N) were calculated and used in order to obtain the optimal results.It can be observed from the above review of literatures that the optimization for input process can be calculated for Stainless Steel using Taguchi.

2. EXPERIMENT SETUP:

WorkpieceMaterial: Stainless steel-316 has low carbon percentage to minimize carbide precipitate. It is less heatsensitivethan other 18:8 steels. Used in high-temperature applications. Its wide application in chairs, tables, Food processing equipment, particularly in beer brewing, milk processing & wine making, kitchen benches,sinks, troughs, equipment and appliances, coil,Heat exchanger in furnace.

Table 1: Composition of Stainless Steel-316 and filler rod 316L

Elements	C	Cr	MO	Ni	P	Mn	S	Si
Composition of work piece	0.03	17.55	3.1	13.65	≤ 0.040	1.2	≤0.030	0.80
Filler rod	0.03	17	3.0	12	≤ 0.03	1.2	≤ 0.03	0.65

Electrode & Filler Rod: The material used for electrode in GTAW is made of tungsten or a tungsten alloy, because tungsten has the highest melting temperature among pure metals, at 3,422 °C (6,192 °F). As a result, the electrode is not consumed during welding, though some erosion (called burn-off) can occur. Electrode should clean finish or a ground finish clean finish electrodes have been chemically cleaned, while ground finish electrodes have been ground to a

ISSN: 2229-6913 (Print), ISSN: 2320-0332 (Online) -, Web Presence: http://www.ijoes.vidyapublications.com

uniform size and have a polished surface, making them optimal for heat conduction. The electrode diameter vary between 0.5 and 6.4mm (0.02 and 0.25 in), and length very from 70 to 620 mm (3.0 to 24 in). In this operation argon gas is used as shielding gas. In presented welding operation, Cr_2O_3 used as a flux.

3. METHEDOLOGY:

TAGUCHI'S Optimization Method:

Parametric optimization is the good way in the Taguchi method to find out good quality of product in machining operation. According to Taguchi method, the S/N ratio is the ratio of Signal to Noise where signal shows the desirable valueand noise represents the unexpected value. The response parameter tensile strength shown in Table 4 is used to calculate the S/N ratio using the equation. These experimental results are now changed in to signal to noise ratio. Larger is bettercharacteristic is helpful for S/N ratio calculation because tensile strength is desired to be at maximum. This best optimal setting would be the one which can be achievedlarger S/N ratio .The values of calculated S/N ratio are shown in Table 4.$S/N = -10 \times \log (1/n \Sigma y^2)$

Table no 2: Input parameters of TIG welding

Parameters	Code	Levels		
Welding Current(Amps)	I	90	120	160
Welding voltage	V	20	27	35
Gas flow(liter/min)	G	10	12	14

Table no 3: L 9 Taguchi designfor welding

Run	Current	voltage	Gas flow
1	90	20	10
2	90	27	12
3	90	35	14
4	120	20	12
5	120	27	14
6	120	35	10
7	160	20	14
8	160	27	10
9	160	35	12

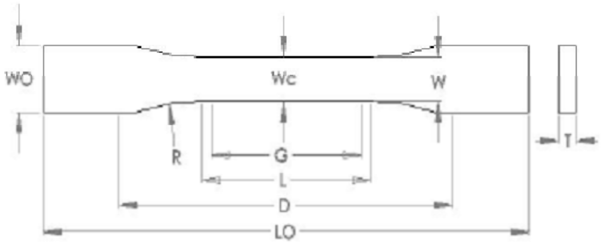


Fig no 2. Geometry of work piece **Fig no 3. Tensile specimen before work piece**

Table no 4: Results of Experiments

Run	Tensile 1	Tensile 2	Mean tensile	S/N ratio
1	154.20	155.50	154.850	43.7980
2	198.5	200.7	199.600	46.0028
3	235.70	239.15	237.425	47.5098
4	209.60	211.45	210.525	46.4658
5	279.30	281.60	280.450	48.9569
6	380.40	381.80	381.100	51.6207
7	220.15	221.50	220.825	46.8808
8	299.40	297.10	298.250	49.4914
9	397.70	398.40	398.050	51.9987

Analysis of S/N Ratios:

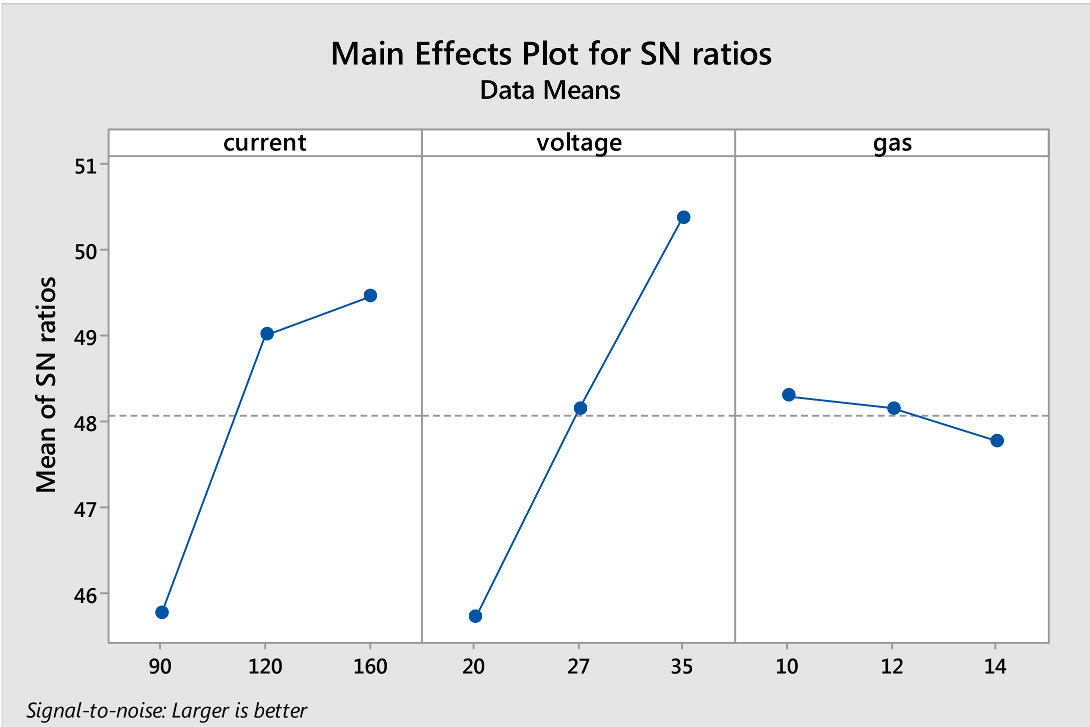
The analysis of variance (ANOVA) carried out for Tensile strength. The analysis of variance was conducted on for a 95% confidence level. The ANOVA Tables seen that, the F value respecting to all parameters are large than the tabulate value of F0.05. The main reason of the analysis of variance is to investigate the influence of design parameters on optimal surface finish by indicating the parameters that significantly affect the quality characteristics of the machined surfaces.

Table no 5: Analysis of Variance

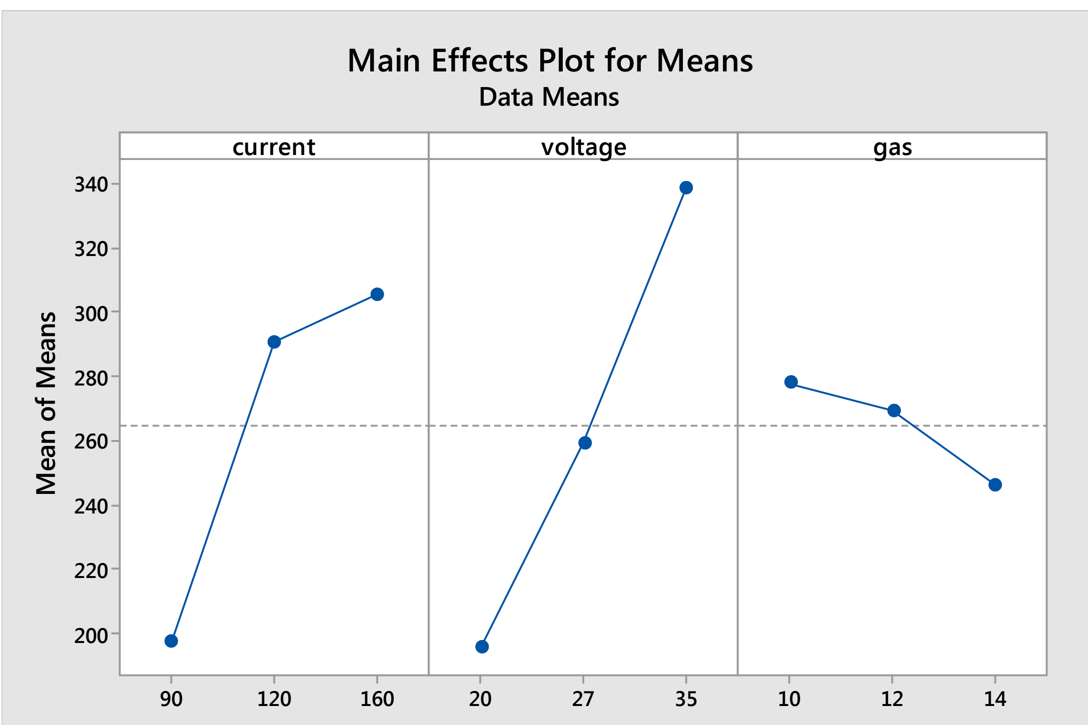
Source	DF	Adj SS	Adj MS	F-Value	P-Value
current	2	20373	10186.4	15.45	0.061
voltage	2	31079	15539.6	23.56	0.041
gas	2	1525	762.5	1.16	0.464
Error	2	1319	659.5		
Total	8	54296			

The model P values show that points .022, .018 are significant. In this case welding current and welding voltage are significant parameter and gas flow is non-significant parameter.

Graph for S/N ratio :



Graph for Mean :



ISSN: 2229-6913 (Print), ISSN: 2320-0332 (Online) -, Web Presence: http://www.ijoes.vidyapublications.com

Gas flow is unsignificant parameter also graph shows that gas voltage have a least effect on the welding specimen. The Average effect response table for mean under the array in Table indicates the mean of the response variable means for each level of each control factor. This specifies the mean surface roughness value that each level of each control factor produced during this experiment. The S/N effect table under the array in indicates the mean of the S/N values for each level of each control factor Table shows average effect response for the raw data and effect response table for S/N ratio.

4.Conclusions:

1. The use of L9 orthogonal array, with three control parameters allowed this study to be conducted with a sample of 18 work pieces.

2.The study found that the control factors had varying effects on the Tensile strength, welding voltage having the highest effects.

3.Optimum parameter setting for weld strength is obtained at current of 160 amps, 35 volt, and 10-litre/min-gas flow.

References :

[1] P. Kumar , A. khatter , "Optimization of Process Parameter in TIG Welding Using Taguchi of Stainless Steel-304",InternatIonal Journal of research In MechanIcal engineering & technology 4,2013-2014, pp. 31-36.

[2] RadhakrishnanV.M.,"Welding Technology & Design", McGraw Hill, New York, 2006.

[3] BayramKocabekir, RamazanKacar, SuleymanGundu z, FatihHayat,"An effect of heat input, weld atmosphere and weld cooling conditions on the resistance spot weldability of 316L austenitic stainless steel", Journal of Materials Processing Technology 195, 2008, pp. 327–335.

[4] M. Balasubramanian, V. Jayabalan, V. Balasubramanian, "Developing mathematical models to predict tensile properties of pulsed current gas tungsten arc welded Ti–6Al–4V alloy", Materials and Design 29 (2008) pp. 92–97.

[5] P. Sathiya, S. Aravindan, A. NoorulHaq, K. Paneerselvam"Optimization of friction welding parameters using evolutionary computational techniques", Journal of materials processing technology 209, 2009, pp. 2576–2584.

[6] K. Shanmugam, A.K. Lakshminarayanan, V. Balasubramanian,"Effect of weld metal properties on fatigue crack growth behaviour of gas tungsten arc welded AISI 409M grade ferritic stainless steel joints", International Journal of Pressure Vessels and Piping 86, 2009, pp. 517–524.

[7] A. Kumar, S. Sundarrajan,"Optimization of pulsed TIG welding process parameters on mechanical properties of AA 5456 Aluminum alloy weld-ments", Materials and Design 30, 2009, pp. 1288–1297.

[8] D.S. Nagesh, G.L. Datta,"Genetic algorithm for optimization of welding variables for height to width ratio and application of ANN for prediction of bead geometry for TIG welding process Applied Soft Computing", 10, 2010, pp. 897–907.

[9] Kuang-Hung Tseng, Chih-YuHsu,"Performance of activated TIG process in austenitic stainless steel welds", Journal of Materials Processing Technology 211, 2011, pp. 503–512, 2011.

[10] M. Aghakhani, E. Mehrdad, E. Hayati,"Parametric Optimization of Gas Metal Arc Welding Process by Taguchi Method on Weld Dilution, 2011.

[11] Ross P. J,"Taguchi Techniques for quality engineering", McGraw Hill, New York, 1996.

[12] BipinkumarSrivastava, S.P. Tewari, JyotiPrakash, "A Review on effect of arc welding parameters on mechanical behaviourof ferrous metals/alloys", 2010.

[13] Ross P. J,"Taguchi Techniques for quality engineering", McGraw Hill, New York, 1996.