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Optimization of the process parameters in TIG welding Process using DoE and Regression analysis

[1]Santosh Kumar, [2]Dr. Prakash Kumar

[1]PG Scholar, [2]Professor & Head, Department of Production Engineering BIT Sindri, Dhanbad, India. [1]sksinghbit12@gmail.com, [2]prakashkr.prod@bitsindri.ac.in

ABSTRACT - The objective of any industry is production of high quality products at low cost and increase the production rate. In industry fabrication is most important operation so welding is commonly used as fabrication of the parts. In industry we join the ferrous and non-ferrous material both so TIG is commonly used to complete this task. TIG welding is versatile used in industry so it is essential to optimize the various parameters such as welding current, welding voltage, gas flow rate to optimize the hardness and bending strength in this project. Many journal / paper published to optimize the various parameter of TIG welding by Taguchi method. But my project is to optimize the welding parameter of TIG welding are welding current, welding voltage, gas flow rate as input variable and Hardness, Bending strength as output variable by DoE and Regression analysis by RSM. In this project conclude DoE (Taguchi method as S/N ratio, ANOVA calculation) and Regression analysis by RSM which one gives the best optimized result i.e. hardness and bending strength of the joint is higher.

Keywords— SS 304, TIG welding, Tensile Strength, Hardness, Taguchi, ANOVA, RSM

I. INTRODUCTION

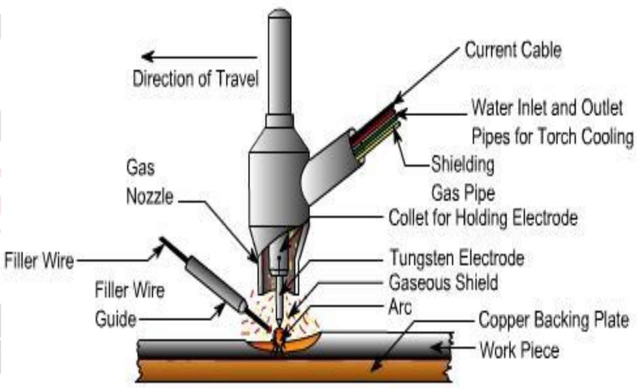
Tungsten Inert Gas (TIG) welding is also known as Gas Tungsten Arc Welding (GTAW) .In TIG welding process the non-consumable electrode is used only to create an arc; a separate filler rod is used to deposit the material. This was primarily invented to weld an alloy of aluminum and magnesium. Aluminum is very difficult to weld because as soon as it is exposed to atmosphere it forms a layer over it.

To weld these materials work piece should be given negative polarity and electrode positive polarity. When electron bombards two-third heat will be generated on work piece one-third heat generated at the negative electrode.

The tungsten electrode is normally contacted with a water cooled copper tube, which is connected to the welding cable to prevent overheating. The shielding gas (Ar, He) goes through the torch body and nozzle toward the weld pool to protect it from air. Filler metal (for joining of thicker materials) can be fed manually or automatically to the arc. It is also called tungsten inert gas (TIG) welding.

Electrode: Tungsten electrodes with 2% cerium or thorium give better electron emissivity, current-carrying capacity, and resistance to contamination than pure electrodes. Hence, the arc is more stable.

Shielding gas: Ar is heavier and offers more effective shielding and cheaper than He.



II. LITERATURE REVIEW

L.Suresh Kumar et al. [9] have investigated for welding aspects of AISI 304 & 316 by Taguchi technique for the process of TIG & MIG welding. Mechanical properties of austenitic stainless steel for the process of TIG and MIG welding have discussed here. The voltage has taken constant and various characteristics such as strength, hardness, ductility, grain structure, tensile strength breaking point, HAZ have observed in these two processes.

Prashant S Lugade et. al [1] have done optimization of tungsten inert gas welding parameters using Taguchi technique SS-304. Welding current, welding speed ,gas flow rate and electrode gap were used as input parameters in three levels for optimization of the process. He concludes that The optimum values of process parameters for weld

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specimens are, 1 mm electrode gap, 100 mm/min travel speed, 200 A welding current and 10 lit/min gas flow rate.

Angad Yadav et. al []have done optimization of tungsten inert gas welding parameters using Taguchi technique for SS-304. Welding current, gas flow rate and welding voltage were used as input parameters in three levels for optimization of the process hardness. He was observe that at current 140A , gas flow rate 25 lit/min, and welding voltage 14v is maximum hardness.

Mishra et al. [] Have done comparison of mechanical properties between TIG and MIG welded dissimilar joints. Steel and stainless-steel dissimilar material joints are quite common structural application. These dissimilar joints give good combination of mechanical properties like corrosive resistance and tensile strength with lower cost. Welding factors thought-about for MIG welding were welding current 80-400 A and voltage 26-56 volt. TIG welding was performed with 50 to 76 A current & 10 to 14-volt voltage. TIG welded dissimilar joint give better tensile strength because of less piousness. Each dissimilar joint has best ductility & yield strength for TIG and MIG welding.

C. N. Patel et al. [], evaluated the parameters; welding current, wire diameter and wire feed rate to investigate their influence on weld bead hardness for MIG welding and TIG welding by Taguchi's method and Grey Relational Analysis (GRA). From the study it was concluded that the welding current was most significant parameter for MIG and TIG welding. By use of GRA optimization technique the optimal parameter combination was found to be welding current, 100 Amp; wire diameter 1.2 mm and wire feed rate, 3 m/min for MIG welding

2.1 APPLICATIONS:

[1] Welding aluminium, magnesium ,copper ,nickel and their alloys, carbon, alloys or stainless steel, inconel ,high temperature and hard surfacing alloys like zirconium, titanium etc.
[2] Welding sheet metal and thinner sections.
[3] Welding of expansion bellows, transistor cases, instrument diaphragms, and can-sealing joints.
[4] Precision welding in atomic energy, aircraft, chemical and instrument industries.
[5] Rocket motor chamber fabrications in launch vehicles

III. EXPERIMENTAL SETUP

3.1. Methodology

1 .First collects the data from various journal and research paper.

2.Analysis the data from the journal and research paper and optimize the data of various parameter of TIG welding using Taguchi method.

3. Taguchi method gives the direct result b/n S/N ratio of bending and hardness by use of minitab software.

4. ANOVA method is used to optimize the welding parameter, and this is done easily with minitab software.

5. RSM method is used to optimized the welding parameter.

6. Compare all the method used to optimized the welding parameter**.**

3.2. Material selection

The present study has been carried out with stainless steel plate of AISI 304 and mild steel plate of IS 1015 having thickness 4mm. This material is used for general industrial purpose.

Table 3.2.1: Chemical composition

Material composition	C	Mn	Si	Cr	Ni	P	S
Weight % AISI-304	0.06	1.24	0.23	1.944	9.12	0.035	0.025
Weight% IS-1079	0.11	0.41	-	-	-	0.03	0.023

3.3 DESIGN OF EXPERIMENT:

The properties such as weld geometry, mechanical properties and distortion of weld can be defining the quality. All welding processes are used with the aim of obtaining a welded joint with the desired weld bead parameters, excellent mechanical properties with less distortion to determine the welding input parameters. that produces the desired weld quality. Application of Design of Experiment evolutionary algorithms and GRA widely used to develop a mathematical relationship between the welding process input parameters and the output variables of the weld joint. Following are the DOE techniques used in optimization work in welding.
1. Full factorial technique
2. Fractional factorial technique
3. Taguchi orthogonal array
4. Response Surfaces method (Central Composite design)

3.4 Taguchi Method:

1. Taguchi design of experiment provides a simple, efficient and systematic approach for the optimization of manufacturing process with minimum number of experiments.

2. This technique has been proved efficient tool to optimize to given experiment to the minimum number of test.

3. Taguchi method concentrates on the effect of variation on the product or process quality characteristics rather than on its averages

Taguchi method are shown in below

Nominal is the best

$$\frac{S}{N} = 10 \log \frac{\bar{y}}{s_y^{\ 2}}$$

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Lower is the best

$$\frac{S}{N} = -10\log\frac{1}{n}\left(\sum y^2\right)$$

Higher is the best:

$$\frac{S}{N} = -10\log\frac{1}{n}\left(\sum\frac{1}{y^2}\right)$$

Where, $\bar{y}$ is the average of observed data $s_y^{\,2}$, is the variation of y, n is the number of observations, and y is the observed data.

Table 3.4.1.1 Input parameters and its levels

Variables	Unit	Levels		
Current(I)	A	1	2	3
		70	80	90
Voltage(V)	V	40	50	60
Gas flow rate(G)	Liter/min	18	20	22

3.5. Proposed Design of Experiment

For this present investigation, three number of process parameters each having three levels is taken into consideration. The L9 orthogonal array [8] was used.

Table 3.5.1 L9 orthogonal array of given parameter

S.No.	Current(A)	Voltage(V)	Gas flow rate(L/m)
1	70	40	18
2	70	50	20
3	70	60	22
4	80	40	18
5	80	50	20
6	80	60	22
7	90	40	18
8	90	50	20
9	90	60	22

Table 3.5.1 S/N Ratio Calculation

Exp No.	Current (Amps) A	Voltage (Volt) B	Gas flow rate (Lit/min) C	Hardness (HRB)	Bending Strength (N/mm^2)	S/N Ratio
1	70	40	18	112.32	106.82	40.7856
2	70	50	20	102.91	42.38	34.875
3	70	60	22	123.81	81.73	39.686
4	80	40	18	94.67	110.94	40.1586
5	80	50	20	139.63	70.65	39.002
6	80	60	22	118.37	75.33	39.073
7	90	40	18	95.28	101.45	39.840
8	90	50	20	116.60	115.41	41.289
9	90	60	22	150.27	156.38	43.0707

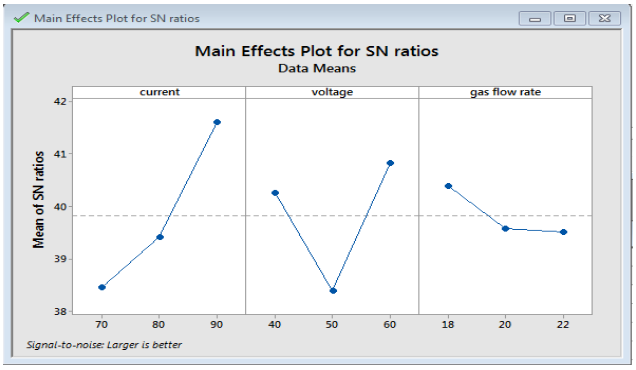

Fig 3.5.1. Graph of S/N ratio

3.6 ANOVA calculation for Hardness and Bending Strength.

Exp NO.	Current	Voltage	Gas flow rate	Hardness	Bending Strength	SRES 1	SRES 2
1	70	40	18	112.32	106.82	1.36911	0.95308
2	70	50	20	102.91	42.39	-0.99140	-1.38138
3	70	60	22	123.81	81.72	-0.37771	0.42830
4	80	40	20	94.67	110.94	-0.37771	0.42830
5	80	50	22	139.63	70.65	1.36911	0.95308
6	80	60	18	118.37	75.33	-0.99140	-1.38138
7	90	40	22	95.28	101.45	-0.99140	-1.38138
8	90	50	18	116.60	115.41	-0.37771	0.42830
9	90	60	20	150.27	156.38	1.36911	0.95308

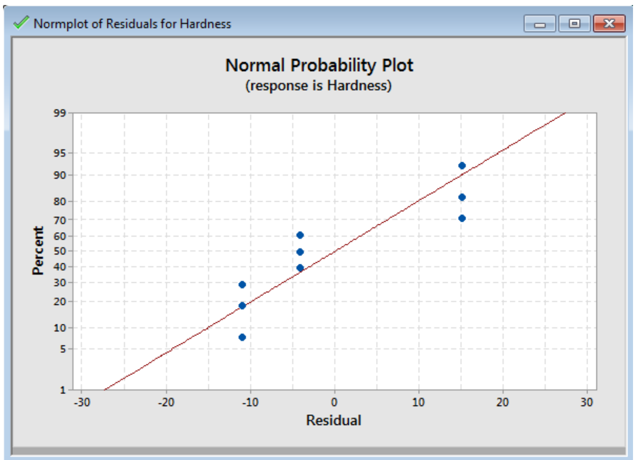

Fig.3.6.1 ANOVA graph of harness

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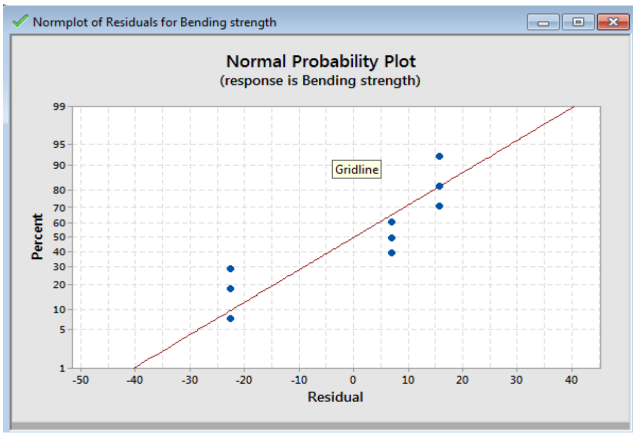


Fig.3.6.2ANOVA graph for bending strength

3.7 Regression analysis by RSM

It is a way of presenting the data primilliary

Visualizing the research finding. It has two independent variable and one is dependent variable i.e. x1, x2 independent variable and y is dependent variable

Then

Y= f(x1, x2)

Using the experimental results quadratic model was established for the hardness and bend strength with 95% of confidence level. As the hardness (H) and bend strength (B) are the function of welding current (I), Voltage (V) and Gas flow rate (G), so it can be mathematically expressed as:

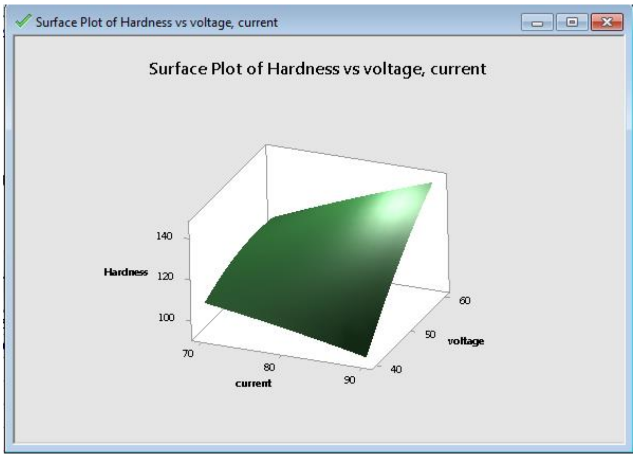
$$H = f(I, V, G) \quad \text{……..(4)}$$

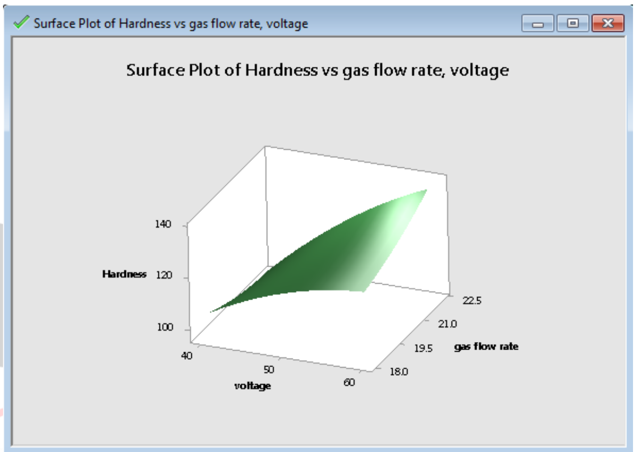
$$B = f(I, V, G) \quad \text{……..(5)}$$

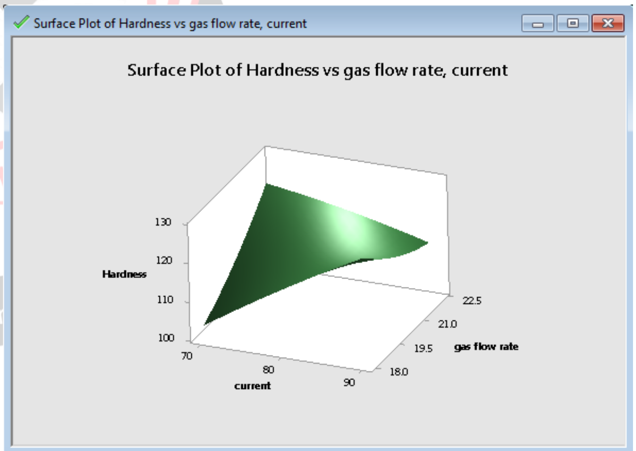
$$Hardness = 307 - 3.9I - 3.3V - 0.007I^2 - 0.039V^2 + 0.1088VI \quad \text{……..(6)}$$

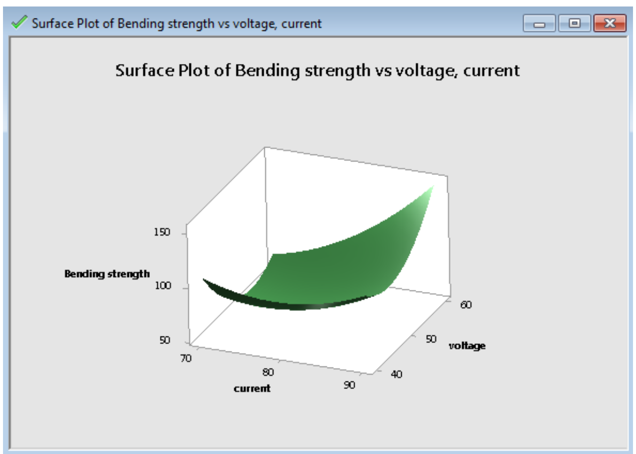
$$B = 29 - 24.5I + 99G + 0.151I^2 - 2.83G^2 + 0.139IG \quad \text{……..(7)}$$

Equation 6 and 7 showing the regression equation for hardness (H) and bend strength (B). The following figure below shows the interaction plot of process parameters and their effects on the response values (hardness and bending strength). These plots are 3D plots explains the behavior of response values at various conditions of process parameters. The response surface plots shows variation in hardness and bending strength when each welding parameter moves from there reference point.









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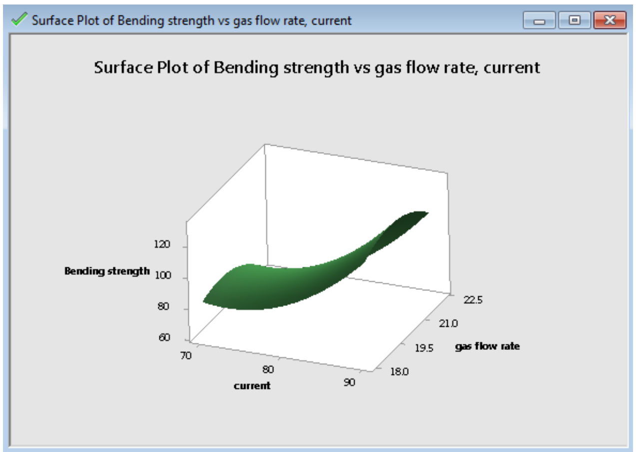

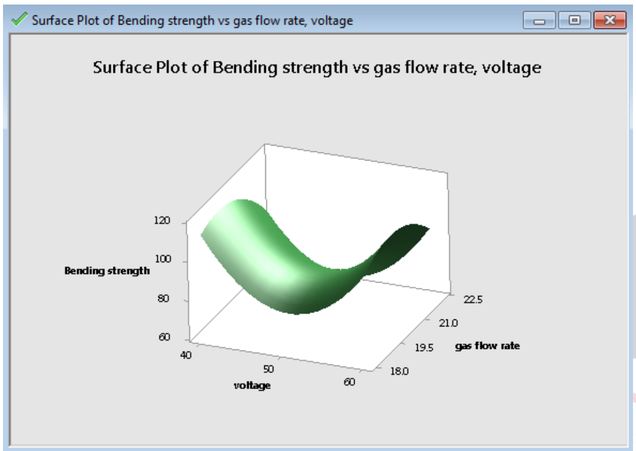

IV. CONCLUSION

In this project a Taguchi orthogonal (L9) array, the signal to noise (S/N) ratio and analysis of variance (ANOVA) and regression analysis by RSM is used to optimize the TIG Welding. The welding parameters to join the stainless steel following conclusion can be drawn based on experimental results of this project:

- Hardness and welding strength both will be maximum in S/N ratio table when current (I)=90A, V=60Volts,Gas flow rate= 22Lit/min i.e. larger the value of current and voltage gives most significant result.
- In ANOVA calculation highest value of p is 0.997, then factor value is 0.00. So current is most significant factor for hardness.
- In ANOVA calculation for maximum bending strength highest value of p is 0.807, then factor value is 0.24, then we find gas flow rate is most significant factor for bending strength.
- A regression relation by RSM is a way of presenting the data primilliary visualizing the research finding. Because it has two independent variable and one is dependent variable, it presents the data in 3D plotting.
- Use of all these optimization method by minitab software we conclude that ANOVA method is best rest and it can be find easily.

V. FUTURE SCOPE

(1) In this study only three parameters are chosen. A detailed study may be carried out for other parameter also.
(2) Apply this technique to more used for non-ferrous and ferrous material to increase its life.
(3) This technique also applies to prediction software for prediction of parameters and compares that model with TAGUCHI model.
(4) This technique also used to investigate the study of more mechanical such as fatigue life, impact strength, toughness etc. to give a complete solution of commonly used material.

REFERENCES

[1] Ajit Hooda, Ashwani Dhingra and Satpal Sharma, “Optimization of MIG welding process parameter to predict maximum yield strength in AISI 1040”, International journal of Mechanical engineering and Robotics research, October (2012), Vol 1, No. 3, pp.-203-213.

[2] Balasubramanian V., Ravisankar V. and Madhusudhan Reddy G., “Effect of pulsed current welding on mechanical properties of high strength aluminium alloy", International Journal of Advanced Manufacturing Technology, (2008), vol 36, pp. 254-262.

[3] Pal K., Kumar V. (2014), Effect of Activated TIG welding on wear properties and dilution percentage in medium carbon steel welds, journal Emerging Technology and advanced Engineering vol. 4, pp 175 – 182

[4] Pasupathy J., Ravisankar V. (2013), Parametric optimization of TIG welding parameters using Taguchi method for dissimilar joint (low carbon steel and AA1050), Journal of Scientific & Engineering Research vol. 4, pp 25 - 28.

[5] Prashant S Lugade1 , Manish J Deshmukh2 [2015]”Optimization of Process Parameters of Activated Tungsten Inert Gas (A-TIG) Welding for Stainless Steel 304L using Taguchi Method” Volume 3, Issue.

[6] Pawan Kumar, Dr. B. K. Roy and Nishant, “Parameters optimization for the gas metal arc welding of austenitic stainless steel (AISI 304) & the low carbon steel using the Taguchi’s technique”, International journal of engineering and management research, in August (2013), pp.-18-22.

[7] Tewari, S.P., Prakash, J., and Gupta, A., “The effect of Welding process Parameters on the Weldability of Materials”, International Journal of Engineering Science and Technology, (2010), Vol. 2, No. 4, pp. 512–516.

[8] Angad Yadav, Dr. Dharamvir Mangal[2017] “ Optimization of Process Parameter for Mechanical Properties of S.S 304 by TIG(Tungsten Inert Gas) Weldingusing Filler Wire” International Journal of Engineering Technology Science and Research IJETSR ISSN 2394 – 3386 Volume 4, Issue 5 May 2017

[9] Suresh Kumar L.et.al. discussed the austenitic stainless steel 304 mechanical properties with dye penetrate testing welded by TIG and MIG. In this study the TIG welding produced the less hardness value then the MIG welding.

[10] Sanjay KUMAR , Pravin K SINGH, D PATEL, Shashi B PRASAD. “Optimization of welding parameters of GTAW using response surface methodology” vol 79, Scientific Bulletin Series-D, 2017.

 DOI : 10.35291/2454-9150.2020.0649