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Optimization of Welding Parameter in MIG Welding by Taguchi Method

[I]K.Sivasakthivel, [II]K.Janarthanan, [III]R.Rajkumar
[I,II]Faculty of University college of Engineering Arni
[III]Student of University college of Engineering Arni
[I,II,III]Dept. of Mechanical Engineering, University college of Engineering, Arni, Thatchur
Email: ksivasakthivel73@gmail.com, k.jana1977@gmail.com, rajkumar.machine@gmail.com

Abstract

Manufacturer face the problem of control the process input parameters to obtain a good welded joint with the required weld quality. Traditionally, it has been necessary to study the weld input parameters for welded product to obtain a welded joint with the required quality. It requires a time-consuming trial and error development method. The purpose of this study is to propose a method to decide optimal settings of the welding process parameters in MIG welding. Properties include Tensile strength, Impact strength, Hardness, etc also influenced process parameters. In this study which parameter is most effectively effect the weld strength. Weld strength varies under various conditions. By using Taguchi and ANOVA technique an optimal solution is find out, which provides us an optimal results of the varying condition.

Key words

MIG welding setup, Titanium alloy, Taguchi, L9 array, ANOVA & S/N ratio

I. Introduction

Metal Inert Gas welding (MIG) welding is a welding process that is now widely used for welding a variety of materials, ferrous and non-ferrous. In manual welding operation, the welder has to have control over the welding variables which affect the weld penetration, bead geometry and overall weld quality. A proper chances of welding variables like welding current, welding voltage, travel speed, wire electrode size, type of shielding gas, Electrode angle, weld joint position etc.., will increase the chances of producing welds of a satisfactory quality. Titanium ally plates are joined by MIG welding process. Three main parameters of MIG welding viz., current, voltage, and travel speed are taken for the analysis. Taguchi Design of experiment techniques are used to find out optimization of welding parameters. The analysis of signal to noise ratio was done using MINITAB 17 software for higher the better quality characteristics.

II.Literature Survey

1. Dinesh Mohan arya, Vedanshchaturvedi and jyotiVimal studied to investigate the optimization process parameters for Metal Inert Gas welding (MIG). This paper presents the influence of welding parameters like wire diameter, welding current, arc voltage welding speed, and gas flow rate optimization based on bead geometry of welding joint. The objective function have been chosen in relation to parameters of MIG welding bead geometry tensile strength, Bead height, Penetration and Heat affected zone (HAZ) for quality target. The most significant factor also found in this case welding current is having maximum percentage contribution. So it is most significant factor in this result.
2. Lenin N., sivakumar M. and vigneshkumar D has studied welding as a basic manufacturing process for making components or assemblies. In this paper, the optimization of the process parameters for MMA welding of stainless steel and low carbon steel with greater weld strength has been reported. The higher-the-better quality characteristics is considered in the weld strength prediction.
3. M.Aghakhani, E.Mehrdad, and E.Hayati has studied that gas metal arc welding is fusion welding process having wide applications in industry. One of the important welding output parameters in this process is weld dilution affecting the quality and productivity of weldment. The wire feed rate has the most significant effect as such as far as the dilution is concerned.
4. L. Suresh kumar, S.M. Verma, P.Radhakrishna Prasad, P.Kirankumar, T.Sivasankar has studied that TIG welded specimen can bear higher load than MIG welded specimen.
5. A.S.Vagh, S.N. Pandya studied that tool design is the main process parameter that has the highest statistical influence on mechanical properties. However other parameter such as tool rotation speed and Tool travel speed has also significant effect on mechanical properties.
6. S.V, Sapakal selected input parameter are welding current, wire feed and output are tensile strength and hardness.
7. G. Harigopal, PVR Ravindra Reddy, G. Chandra Mohan Reddy presented current is the most influencing parameter on UTS with a contribution of 57.5% at 99% confidence level. Pressure is the most significant parameter for proof stress.
8. A. Narayana and T.Srihari has presented optimizing weld bead geometry by process variables viz current, speed, wire feed rate, nozzle plate distance. If some more parameters like inclination of nozzle to the plate, wire diameter, polarity etc can be used optimize bead geometry more precision.

III. Taguchi Method

Taguchi design of experiment is one of these techniques which are used widely. The Taguchi method involves reducing the variation in a process through robust design experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. The Taguchi method was developed by Dr. Genichi Taguchi of Japan who maintained that variation. The experimental design proposed by Taguchi involves using orthogonal arrays to organize the parameters affecting and the levels at which they should be varies. "Orthogonal Arrays" (OA) provide a set of well balanced (minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results.

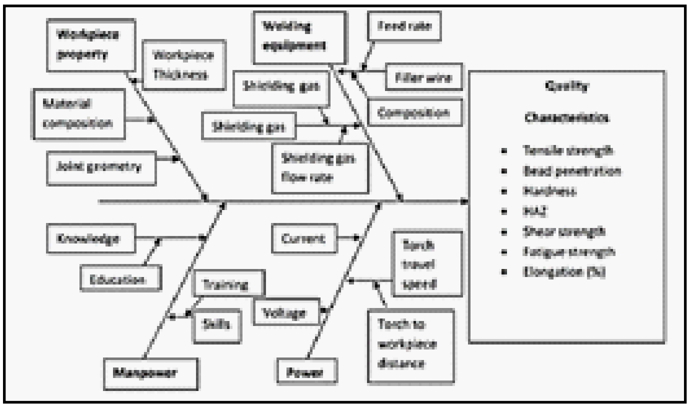
There are 3 Signal-to-Noise ratios of common interest for optimization

- $\left(\frac{S}{N}\right) HB = -10 \, \log_{10}\left(\frac{1}{n}\right) \sum_{i=1}^{n} \left(\frac{1}{\sqrt{Yi}}\right)$
- $\left(\frac{S}{N}\right) LB = -10 \, \log_{10}\left(\frac{1}{n}\right) \sum_{i=1}^{n} \left(\sqrt{Yi}\right)$
- $\left(\frac{S}{N}\right) NB = -10 \, \log_{10}\left(\frac{1}{n}\right) \sum_{i=1}^{n} \left(\sqrt{(Yi - M)^{4}}\right)$

Selection of process parameters

The cause-effect diagram was constructed to identify process parameters which may affect the desired quantity characteristics of the final job. These parameters can be listed in four categories as follows:

(i) Power source
(ii) Welding equipment
(iii) Work piece properties
(iv) Manpower



Based on cause-effect diagram three variables and three levels are selected

Table 1 : Process parameters and their values at different levels

Parameters	Level 1	Level 2	Level 3
Current (A)	250	280	310
Voltage (V)	20	25	30
Speed (cm/min.)	55	60	65

L9 3 Level Taguchi Orthogonal Array

Taguchi orthogonal design uses a special set of predefined array called orthogonal arrays (OAs) to design the plan of experiment. These standard arrays stipulate the way of full information of all the factors that affects the process performance (process responses).

Table 2 L9 orthogonal array

Exp. Trial No	Process Current (A)	Voltage (V)	Speed (cm/ min.)
1	250	20	55
2	250	25	60
3	250	30	65
4	280	20	60
5	280	25	65
6	280	30	55
7	310	20	65
8	310	25	55
9	310	30	60

IV. Experimental Plan And Details

The consumable electrode (Titanium wire) is continuously supplied and an arc is discharged between the point of the consumable electrode and the base metal (Titanium) to be welded, with the space between them filled with inert gas, so that the titanium is welded melted by the arc heat. Helium is normally used as the shielding inert gas.

Work Material

The work material used for present work is Titanium alloy, the dimensions of the work piece length 150mm, width of 75mm, thickness 6mm. Argon is used as inert gas.

Table 3: % of chemical composition of base metal

Al	V	C	N	O	H	Fe	Y	Ti
6	4	0.08	0.5	0.2	0.012	0.3	0.005	Bal.

V. Analysis of Signal to Noise Ratio

In the Taguchi Method the term 'signal' represents the desirable value (mean) for the output characteristics and the term 'noise' represents the undesirable value (standard Deviation) for the output characteristics. Therefore, the S/N ratio to the mean to the S.D. S/N ratio used to measure the quality characteristics deviating from the desired value. To obtain optimal welding performance, higher-the-better quality characteristics for penetration and higher Tensile strength must be taken.

Table 5: S/N response table for penetration

Level	Current (A)	Voltage (V)	Speed (cm/min)
1	8.457	4.926	9.891
2	10.070	11.231	9.611
3	10.845	13.215	9.871
Delta	2.388	8.289	0.279
Rank	2	1	3

Table 6: Experimental result for Tensile Strength and S/N ratio

Exp. Trial No.	Process Current (A)	Voltage (V)	Speed (cm/min)	Tensile Strength (M pa)	S/N ratio
1	250	20	55	580	55.2686
2	250	25	60	771.78	57.7499
3	250	30	65	671.55	56.5416
4	280	20	60	764.14	57.6635
5	280	25	65	756.57	57.5770
6	280	30	55	643.8	56.1750
7	310	20	65	779.5	57.8363
8	310	25	55	669.55	56.5157
9	310	30	60	758.85	57.6031

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Table 7: S/N response table for Tensile Strength

Level	Current (A)	Voltage (V)	Speed (cm/min.)
1	56.52	56.92	55.99
2	57.14	57.28	57.67
3	57.32	56.77	57.32
Delta	0.80	0.51	1.69
Rank	2	3	1

VI. Conclusion

The optimum value was predicted using MINITAB 17 software. Based on the investigation following conclusion are drawn

MIG Welding process is very successful to join Titanium alloy

Based on the S/N ratio analysis and ANOVA, the process parameters which significantly affects the Tensile Strength was speed, current and Voltage.

Confirmation test carried out shows that results coming of at optimum level are under the interval range obtained at 95% conference level.

The effect of parameters on penetration can be ranked has voltage, current and speed.

Argon gas has shielding gas has been found to work satisfactory.

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