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Metal Inert Gas (Mig) Welding Parameters Optimization

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Abstract

Metal Inert Gas welding (MIG) process is an important welding operation for joining ferrous and non ferrous metals. The MIG input welding parameters are the most important factors affecting the quality of the welding and weld quality is strongly characterized by weld bead geometry. This paper presents the effect of welding parameters like welding current, welding voltage, welding speed on penetration depth of AISI 1020 steel during welding. A plan of experiments based on Taguchi technique has been used to plan the experiment, acquire the data and to optimize the welding parameters as well as the process. Finally the conformations tests have been carried out to get the difference between the predicated values with the experimental values to find the effectiveness in the analysis of penetration.

Keywords: *MIG welding, AISI 1020 steel, Taguchi approach*

1. Introduction

MIG welding is a versatile technique suitable for both thin sheet and thick section components. An arc is struck between the end of a wire electrode and the work piece, melting both of them to form a weld pool. MIG is widely used in most industry sectors because of flexibility, deposition rates and suitability for mechanization.

Now-a-days, determination of optimum values of process parameters in manufacturing are the areas of great interest for researchers and manufacturing engineers. The input parameters play a very significant role in determining the quality of a welded joint. The parameters affecting the arc and welding should be estimated and their changing conditions during process must be known.

The welding parameters are current, arc voltage and welding speed. These parameters will affect the weld characteristics to a great extent. Because these factors can be varied over a large range, they are considered the primary adjustments in any welding operation.

Depth of penetration is the dominant magnitude related to the weldability of the processed material, the welding conditions, and the strength requirements. Therefore, attempt should be made to maximize depth of penetration.

Weld Bead Geometry

The weld bead shape is an indication of bead geometry which affects the load carrying capacity of the weldments and number of passes needed to fill the groove of a joint. The bead geometry is specified by bead width, reinforcement, penetration, penetration shape factor and reinforcement form factor.Weld bead penetration is the maximum distance between the base plate top surface and depth to which the fusion has taken place. The more the penetration, the less is the number of welding passes required to fill the weld joint which consequently results in higher production rate. It is observed that the penetration is influenced by welding current, polarity, arc travel speed, electrode stick-out, basicity index and physical properties of the flux. The penetration was directly proportional to welding current.

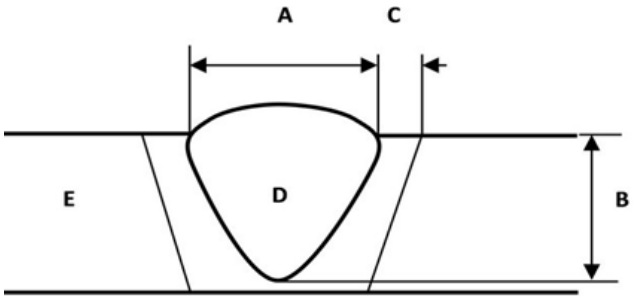

Fig.1 Weld bead shape parameter. A: Bead width, B: Depth of penetration, C: HAZ width, D: Weld metal, E: Base metal

The penetration was indirectly proportional to welding speed and electrode diameter. Penetration decreases with the increase in welding speed because the time during which the arc force is allowed to penetrate into the material's surface decreases.

2. Taguchi DOE

Taguchi's design of experiment methodology is a convenient tool to optimize the welding parameters with less experimental runs. Taguchi primarily recommends experimental design as a tool to make products more robust sensitive to noise factors. The experimental design procedure is suitable tool for reducing the effect of variation on product and process quality characteristics. Analysis of Variance (ANOVA) can be employed to variables and interaction effects. "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.

In the Taguchi Method the term 'signal' represents the desirable value (mean) for the output characteristic and the term 'noise' represents the undesirable value (standard Deviation) for the output characteristic. Therefore, the S/N ratio to the mean to the S. D. S/N ratio used to measure the quality characteristic deviating from the desired value. The S/N ratio η is defined as

η= -10 log (M.S.D.)

Where, M.S.D. is the mean square deviation for the output characteristic.

To obtain optimal welding performance, higher-the-better quality characteristic for penetration must be taken. The M.S.D. for higher-the –better quality characteristic can be expressed

$$M.S.D = \frac{1}{m}\sum\frac{1}{P_i^2}$$

Where, Pi is the value of penetration

3. Experimental Details

3.1 Work piece material

AISI 1020 flats length 300 mm, width 150mm, thickness 6 mm. Welding Gas: CO2 is used. The composition of AISI 1020 is listed in weight percentage as C 0.23%, Mn 0.60%, P 0.04%, S 0.5% and Fe remaining. The properties are given in Table. It is used in bullets, automotive industries, nuts and bolts, chain, hingers, knives, amours, pipes, magnets and many other applications.

3.2 Design of experiment

Experiments have been carried out using Taguchi's L9 Orthogonal Array (OA) experimental design which consists of 9 combinations of cutting velocity, feed and depth of cut. According to the design catalogue prepared by Taguchi, three process parameters (without interaction) to be varied in three finite levels.

Table 1 L_9 Orthogonal array

Test	Parameter 1	Parameter 2	Parameter 3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	2
9	3	3	1

3.3 Measurement of Depth Penetration

Depth of penetration has been measured by microscope shown in Figure. "Vardhan SPM07" is a specially designed microscope with a high resolution CCD camera to view, instantly photograph and measure exact Weld penetration depth in all types of welded samples. The test specimen is polished using emery papers of different grades, polished with the help of polishing machine & then etched with appropriate chemical reagent like Nital. Specimen is then kept below the microscope.

3.4 Process parameters and their levels

Table 2 Input parameters and their levels

Parameters	Levels		
Welding current, C	60	90	120
Welding voltage, V	20	25	30
Welding speed, S	2	4	6

4. Results and discussion

Table 3 Experiment Data

Ex. No	C	V	S	Penetration	SN Ratio
1	60	20	2	1.72	4.25
2	60	25	4	5.82	15.01
3	60	30	6	5.63	14.50
4	90	20	4	1.87	3.82
5	90	25	6	5.04	13.78
6	90	30	2	2.93	8.52
7	120	20	6	1.35	1.41
8	120	25	2	3.81	11.25
9	120	30	4	5.28	14.22

Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal

level of the process parameters is the level with the greatest S/N ratio. The S/N response table for penetration is shown in Table No.3.

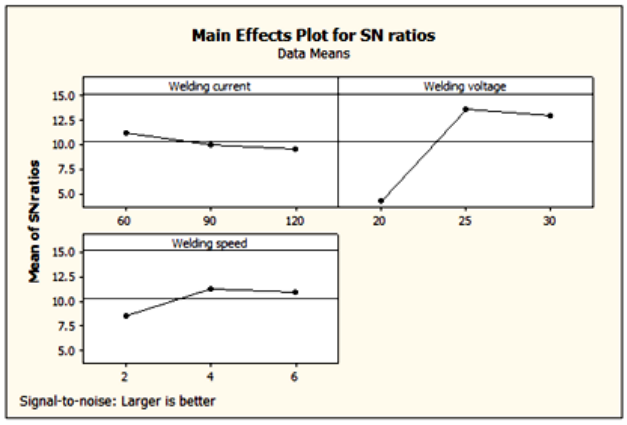

Fig. 2 Main effect plot

Table 4 Analysis of variance for Penetration

Source	DOF	SS	Mean	F	%
C	2	9.95	4.977	0.64	4.42
V	2	183.22	97.65	16.23	85.23
S	2	14.75	7.856	1.32	6.23
Error	2	12.22	5.42		4.12
Total	8				100

Conclusion

Taguchi optimization method was applied to find the optimal process parameters for penetration. A Taguchi orthogonal array, the signal-to-noise (S/N) ratio and analysis of variance were used for the optimization of welding parameters. The experiment value that is observed from optimal welding parameters, the penetration is 5.82mm. & S/N ratio is 15.01.

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