International Journal of Research in Advent Technology, Special Issue, March 2019
E-ISSN: 2321-9637
3rd National Conference on Recent Trends & Innovations In Mechanical Engineering
15th & 16th March 2019
Available online at www.ijrat.org

Experimental Investigation on MIG Welding For Mild Steel

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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 voltage, wire speed, wire diameter and gas flow on hardness of mild 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 confirmation tests have been carried out to get the difference between the predicted values with the experimental values to find the effectiveness in the analysis of hardness.

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.

2. EXPERIMENTAL SETUP:

MIG (Metal Inert Gas) welding is a welding process that is now widely used for welding a variety of Materials, ferrous and non-ferrous. The essential feature of the process is the small diameter electrode wire, which is fed continuously into the arc from a coil. As a result this process can produce quick and neat welds over a wide range of joints.
Equipment consists of:

- DC output power source
- Wire feed unit
- Torch
- Shielding gas supply,(normally form cylinder)

Fig. No. 1 DC output power source

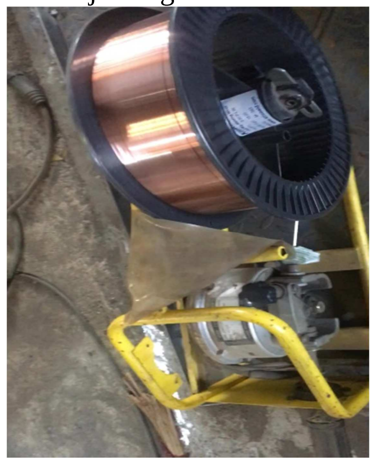

Fig. No. 2 Wire feed unit

Fig. No. 3 Torch

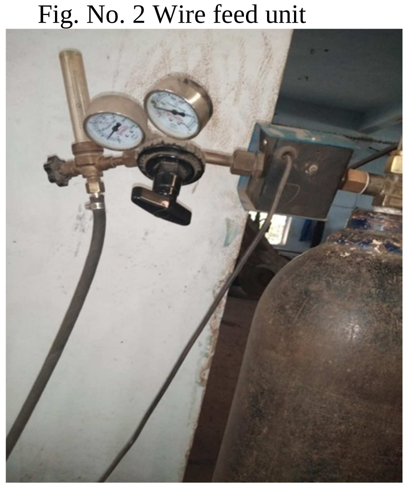

Fig. No. 4 Shielding gas

Fig. No .5 Rockwell hardness machine

2.1 Work Piece Material

Mild steel length 150 mm, width 100 mm, thickness 6 mm. Welding Gas: CO_2 is used. The composition of mild steel is listed in weight percentage as C 0.16%, Al 0.07%, Si 0.168%, Mn 0.18%, P 0.025%, Cu 0.09% and Fe remaining. It is used in construction works, rolled structural sections, manufacturing of various tools and equipment, for rail track, transmission towers and industrial buildings.

Fig. No.6 Work piece material

3. EXPERIMENTAL DESIGN:

Experiments have been carried out using Taguchi's L16 Orthogonal Array (OA) experimental design which consists of 16 combinations of velocity, wire speed, gas flow and wire diameter. According to the design catalogue prepared by Taguchi, four process parameters to be varied in four finite levels

Table 1: Control factors & levels

Levels	Voltage (A) (v)	Wire speed(B) (inch/min)	Gas flow(C) (kg/cm^2)	Wire diameter(D) (mm)
1	3	2	2	0.8
2	4	3	4	0.8
3	5	4	6	0.8
4	6	5	8	0.8

Table 2: Experimental design with corresponding results and S/N ratio

Experiment no	Voltage(v) A	Wire speed (inch/min) B	Gas flow (kg/cm^2) C	Wire diameter (mm) D	RHN	S/N Ratio
1	3	2	2	0.8	120	2.079
2	3	3	4	0.8	117	2.068
3	3	4	6	0.8	102	2.008
4	3	5	8	0.8	159	2.201
5	4	2	4	0.8	83	1.910
6	4	3	2	0.8	124	2.093
7	4	4	8	0.8	152	2.181
8	4	5	6	0.8	153	2.184
9	5	2	6	0.8	93	1.986
10	5	3	8	0.8	124	2.093
11	5	4	2	0.8	97	1.986
12	5	5	4	0.8	148	2.170
13	6	2	8	0.8	140	2.146
14	6	3	6	0.8	140	2.146
15	6	4	4	0.8	129	2.110
16	6	5	2	0.8	130	2.113

4. RESULTS AND DISCUSSION:

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. More simply put, when using a fixed force (load) and a given indenter, the smaller the indentation, the harder the material.

Hardness is measured precisely with the help of a Rockwell hardness tester equipment and the results are tabulated in table no 2. For each experiment the corresponding S/N values are also tabulated. Optimization of Hardness is carried out using Taguchi method. Confirmatory test have also been conducted to validate optimal results.

Table No 3: Summary of S/N Ratios

Factors	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Voltage (A) (v)	2.089	2.092	2.054	**2.128**
Wire speed(B) (inch/min)	2.025	2.100	2.071	**2.167**
Gas flow(C) (kg/cm^2)	2.067	2.064	2.076	**2.155**
Wire diameter(D) (mm)	2.025	2.100	2.071	**2.167**

The best condition for voltage is level 4 (6), for wire speed is level 4 (5), for gas flow is level 4 (8) and wire diameter is level 4 (0.8). Thus, the optimum conditions chosen were: **A4-B4-C4-D4**. A confirmation test is performed with the obtained optimum parameters, the hardness is measured and the S/N ratio is calculated. The conformation test results are tabulated in the table no 5.

Table No 4: Optimum Set of Control Factors for flooded condition

Levels	**Voltage (A) (v)**	**Wire speed(B) (inch/min)**	**Gas flow(C) (kg/cm^2)**	**Wire diameter(D) (mm)**
Optimum Value	6	5	8	0.8

From table no. 4 the following calculations are done, for all the cases the predicted value is calculated in the same procedure.

$$\eta_{predicted} = Y + (A4-Y) + (B4-Y) + (C4-Y) + (D4-Y)$$
$$= A4+B4+C4+D4-3Y$$
$$= [(2.128) + (2.167) + (2.155) + (2.167)] – [3X (2.092)]$$
$$\eta_{predicted} = 2.341$$

Therefore, the predicted average for optimum condition of hardness is 2.341

5. CONCLUSIONS:

A confirmation test is performed with the obtained optimum welding parameters for voltage is level 4 (6), for wire speed is level 4 (5), for gas flow is level 4 (8) and wire diameter is level 4 (0.8). The Hardness value is measured and the S/N ratio is calculated for this condition. The conformation test and the predicted values are tabulated in the table no 5 & 6.

Table No 5: Conformation Test Results

Hardness Values	S/N RATIO
135	2.13

Table No. 6: Comparison Of S/N Ratios

η predicted	2.341
η conformation	2.13

The objective of the present paper is to find out the set of optimum conditions in order to improve Hardness, using Taguchi methodology considering the welding parameters for the Mild Steel material. Based on the results of the present experimentation the following conclusions are drawn:

- In the present experimentation the voltage is obtained using Taguchi Robust Design Methodology is 6 volts. Similarly the results obtained for wire speed, gas flow are 5 inch/min and 8 kg/cm^2 respectively. The corresponding wire diameter is 0.8mm.

- The S/N ratio of predicted value and verification test values are valid when compared with the optimum values. It is found that S/N ratio value of verification test is within the limits of the predicted value and the objective of the work is full filled.

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