Special Issue - 2018
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Confcall - 2018 Conference Proceedings

An Optimization of Welding Parameters for MIG Welding

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Abstract--**Metal Inert Gas welding is one of the most widely used processes in industry. The input parameters play a very significant role in determining the quality of a welded joint. In fact, weld geometry directly affects the complexity of weld schedules and thereby the construction and manufacturing costs of steel structures and mechanical devices. Therefore, these parameters affecting the arc and welding should be estimated and their changing conditions during process must be known before in order to obtain optimum results; in fact a perfect arc can be achieved when all the parameters are in conformity. In this paper, MIG welding is performed on the mild steel at a speed of 2.25mm/sec. Different mild steel pieces are welded by varying the currents, 150amp, 200amp and 250amps. The hardness and tensile tests are performed to determine the optimal welding currents. Taguchi method is used to determine the optimal process parameters for high tensile strength and hardness. The process parameters considered for Taguchi method are current 150amps, 250amps and weld feed rate 3.2mm/min and 4.2mm/min. Thermal analysis and structural analysis is performed to determine the heat transfer rates and the strength of the pieces at the applied load respectively. Modeling is done in Pro/Engineer and analysis is done in Ansys.**

Keywords: ANSYS, Welding, Taguchi, Optimization**.**

I. INTRODUCTION

Metal Inert Gas welding is one of the most widely used processes in industry. The input parameters play a very significant role in determining the quality of a welded joint. In fact, weld geometry directly affects the complexity of weld schedules and thereby the construction and manufacturing costs of steel structures and mechanical devices. Therefore, these parameters affecting the arc and welding should be estimated and their changing conditions during process must be known before in order to obtain optimum results; in fact a perfect arc can be achieved when all the parameters are in conformity. These are combined in two groups as first order adjustable and second order adjustable parameters defined before welding process. Former are welding 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. Their values should be recorded for every different type of weld to permit reproducibility.

II. WORKING PRINCIPLE OF MIG WELDING

As shown in fig. the electrode in this process is in the form of coil and continuously fed towards the work during the process. At the same time inert gas (e.g. argon, helium, or $CCCC2$) is passed around electrode from the same torch. Inert gas usually argon, helium, or a suitable mixture of these is used to prevent the atmosphere from contacting the molten metal and HAZ. When gas is supplied, it gets ionized and an arc is initiated in between electrode and work piece. Heat is therefore produced. Electrode melts due to the heat and molten filler metal falls on the heated joint. The arc may be produced between a continuously fed wire and the work. Continuous welding with coiled wire helps high metal depositions rate and high welding speed. The filler wire is generally connected to the positive polarity of DC source forming one of the electrodes. The workpiece is connected to the negative polarity. The power source could be constant voltage DC power source, with electrode positive and it yields a stable arc and smooth metal transfer with least spatter for the entire currentrange.

III. EXPERIMENTAL INVESTIGATION

Experimental investigation is done to verify the mechanical properties of mig welding of mild steel. The properties investigated are tensile strength and hardness compared before and after welding. The welding is done on Conventional mig welding machine. MIG welding set up is as shown in Fig.1.

Fig.1. MIG welding machine.

TABLE I: Machine Specifications

SAMPLES	CURRENT (amps)
Sample 1	150
Sample2	200
Sample3	250

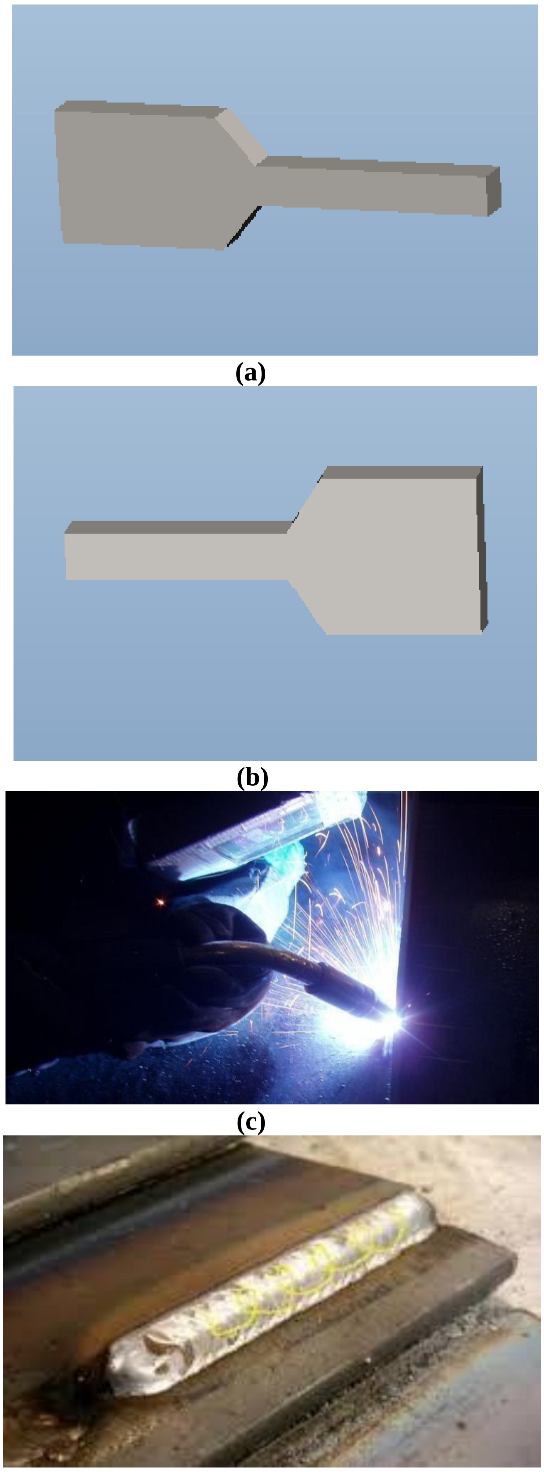

Fig.2. Work piece (a&b) before welding, (c) at the time of process and (d) after welding.

IV. TESTING DATA

A. Tensile Test

Type of test – Mechanical Tensile Equipment used – UTM 600KN Specimen Width – 20mm Specimen Thickness – 6mm

TABLE II:

	BEFORE WELDING
	TENSILE STRENGTH (N/mm^2)
MILD STEEL	250
	UTS (MPa)
Sample 1	166.16
Sample 2	329.17
Sample 3	178.89

Brinell Hardness Test Machine Details
Name – BRINELL HARDNESS MACHINE MODEL – 2008/073, MRB 250

Test Details:
Test Reference – IS 1586:2000 Type of Hardness – HRB Hardness of Mild Steel – 120HRB

TABLE III:

	Location	Hardness value
Sample 1	Weld zone	78HRB
Sample 2	Weld zone	89 HRB
Sample 3	Weld zone	82 HRB

V. INTRODUCTION TO TAGUCHI TECHNIQUE

Taguchi defines Quality Level of a product as the Total Loss incurred by society due to failure of a product to perform as desired when it deviates from the delivered target performance levels. This includes costs associated with poor performance, operating costs (which changes as a product ages) and any added expenses due to harmful side effects of the product in use.

A. Taguchi Methods

- Help companies to perform the Quality Fix!
- Quality problems are due to Noises in the product or process system
- Noise is any undesirable effect that increases variability
- Conduct extensive Problem Analyses
- Employ Inter-disciplinary Teams
- Perform Designed Experimental Analyses

Optimization of Welding Parameters for MIG Welding

- Evaluate Experiments using ANOVA and Signal-to noise techniques

Defining the Taguchi Approach

- Noise Factors Cause Functional Variation
- They Fall Into Three ―Classes‖
  - Outer Noise – Environmental Conditions
  - Inner Noise – Lifetime Deterioration
  - Between Product Noise – Piece To Piece Variation
- The Point Then Is To Produce Processes Or Products The Are *ROBUST AGAINST NOISES*
  - Don't spend the money to eliminate all noise, build designs (product and process) that can perform as desired – low variability – in the presence of noise!

- WE SAY:
- ROBUSTNESS = HIGH QUALITY

VI. TAGUCHI PARAMETER DESIGN FOR MIG WELDING PROCESS

In order to identify the process parameters affecting the selected machine quality characteristics of welding, the following process parameters are selected for the present work: Current (A), Wire Feed Rate (B). The selection of parameters of interest and their ranges is based on literature experiments conducted.

A. Selection of Orthogonal Array

The process parameters and their values are given in table. It was also decided to study the two – factor interaction effects of process parameters on the selected characteristics while machining Mild Steel. These interactions were considered between Current, Wire Feed Rate (AxB).

TABLE IV:

FACTORS	PROCESS PARAMETERS	LE VEL1	LEVEL2
A	CURRENT (Amps)	150	250
B	WIRE FEED RATE (mm/min)	3.2	4.2

VII. RESULTS

Using randomization technique, specimens were machined and Tensile Strength and Hardness were measured. The experimental data for the cutting forces have been reported in Tables. Tensile Strength and Hardness ‗larger the better' type of machining quality characteristics, the S/N ratio for this type of response was and is given b

$$S/N\ ratio = -10\log\left[\frac{1}{n}(y_1^2 + y_2^2 + \ldots + y_n^2)\right] \quad (1)$$

Where y1,y2,…..,yn are the responses of the machining characteristics for each parameter at different levels.

TABLE V: Taguchi Orthogonal Array

JOB NO.	CURRENT (rpm)	WIRE FEED RATE (mm/min)
1	150	3.2
2	150	4.2
3	250	3.2
4	250	4.2

TABLE VI: Observation

JOB NO.	CURRENT (rpm)	WIRE FEED RATE (mm/min)	TENSILE STRENGTH (N/mm^2)	HARDNESS (HRB)
1	150	3.2	166.16	78
2	150	4.2	169.3	79
3	250	3.2	178.89	82
4	250	4.2	181.2	83

VIII. OPTIMIZATION OF PROCESS PARAMETERS FOR HARDNESS

Optimization of process **is** as shown in Figs.3 to 8.

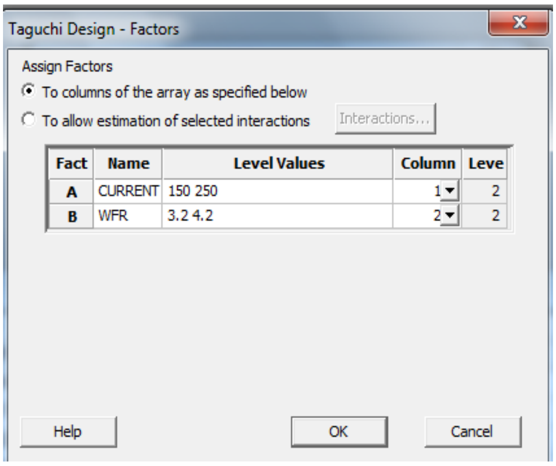

Fig.3. Design Factor GUI.

Worksheet 3 ***

↓	C1	C2	C3	C4
	CURRENT	WFR	HARDNESS	HARDNESS1
1	150	3.2	78	78.1
2	150	4.2	79	79.2
3	250	3.2	82	82.1
4	250	4.2	83	83.2
5				

Fig.4.Worksheet.

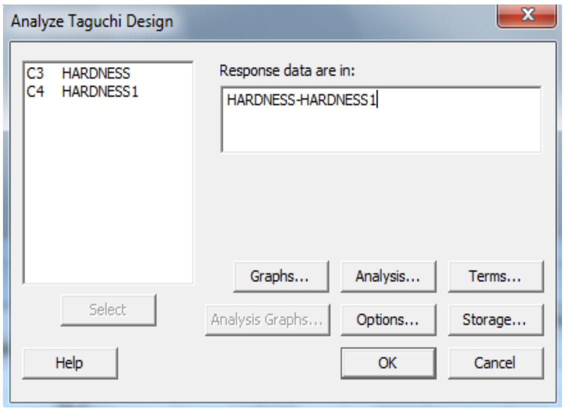

Fig.5. Analyze Taguchi Design – Select Responses.

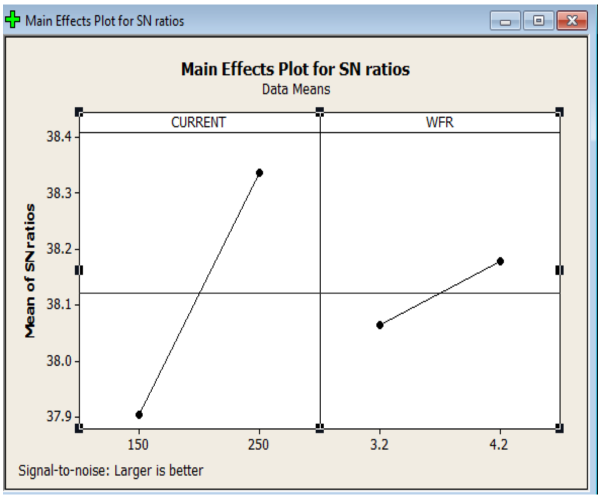

Fig.6. Effect of welding parameters on hardness for S/N ratio.

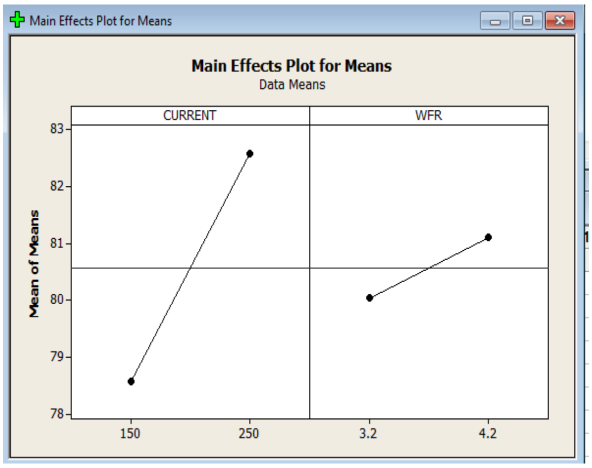

Fig.7. Effect of welding parameters on hardness for Means.

TABLE VII: RESULTS TABLE

Thermal analysis

Cases	Temperature (^{0}C)	Heat flux(W/mm^2)
Case1	1502	0.982383
Case2	1650	1.0827
Case3	1800	1.183

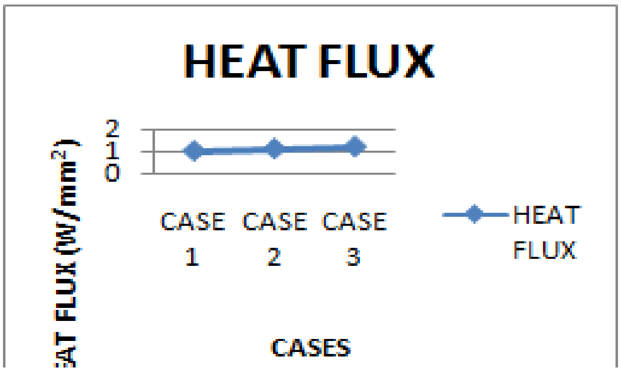

Fig.8. Heat Flux.

TABLE VIII: Structural Analysis

At load(KN)	Deformation(mm)	Stress(N/mm^2)	Strain
14.01	3.1626	4668.2	0.02341

VIII. CONCLUSION

In this work MIG welding is performed on the Mild steel pieces by varying the welding current at constant weld speed. The welding currents are 150amps, 200amps and 250 amps. Hardness and tensile tests are performed on the pieces. The brinell hardness of mild steel is 120HRB. By observing the hardness test results, the hardness is decreased after welding. By increasing the welding current the hardness is increased from 150amp to 200amp and again it is decreased for 250amp. The strength of mild steel is 250MPa. By observing the tensile test results, welding done at the currents of 150amp and 250amp is safe since the stress values are less than that of strength of mild steel. By observing the Taguchi method the following conclusions can be made: To get high tensile strength, the optimal parameters are current – 250amps, wire feed rate – 4.2mm/min. To get more hardness, the optimal parameters are current – 250amps, wire feed rate – 4.2mm/min. So it can be concluded that welding at the current of 250amps gives the better results. Thermal analysis is done. By observing the results, the heat flux is increasing by increasing the welding current. Structural analysis is also done. By observing the result, the applied load is very high and the welding is broken since the analyzed stress value is more than that of the strength of the material.

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