Parametric Optimization of Shielded Metal Arc Welding of Mild Steel (MS) 2062 Using Taguchi Method

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Abstract

Shielded Metal Arc Welding (SMAW) is the most widely used welding process in the small scale industries, because of its low cost, flexibility, portability and versatility. The SMAW welding parameters are most important factors affecting the quality, productivity and cost of welding. It is related to strength of weld. In this research work of Gas Metal Arc Welding (GMAW) show the current effect, voltage effect, arc length, welding speed and angle of welding on penetration and weld bead width on MS2062. The result effected electrode life E6013 and we find optimum parameters for optimum electrode life and penetration with least possible weld bead width. An experiment runs by automatic welding are conduct using on L27 orthogonal array for optimization of welding parameters level of current, voltage, speed, angle and electrode gap. Calculate signal to noise ratio and obtain optimum level of each input parameters and find least possible weld bead length and maximum possible penetration with best electrode life.

Keywords: Shielded Metal Arc Welding (SMAW), Taguchi, Gas Metal Arc Welding (GMAW), MS2062.

Introduction

Welding is one of the essential and inescapable processes in manufacturing industries. Various types of welding processes like Shielded Metal Arc Welding (SMAW), Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), and Flux Cored Arc Welding (FCAW) are being practiced in industrial environment [1]. Welding is a process of joining different material. It is more economical and such faster as compare to both casting and riveting [2]. Welding is a method of repairing or creating metal structures by joining the piece of metal or plastic through various fusion processes. Generally heat is used to weld the material. Welding equipment can utilise flames, electric arc and laser light to produce heat [3]. Among all the welding processes, SMAW is very important. The advantages of this method are that it is the simplest of the all arc welding processes. The equipment is often small in size and can be easily shifted from one place to the other. Cost of the equipment is very less. This process finds a number of applications because of the availability of a wide variety of electrodes which makes it possible to weld a number of metals and their alloys [4].

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This research is done by investigating the welding length that can be produced from a set of electrode and current, root gap, angle and welding speed. The correct amount of current, angle, arc length and speed used for the electrode can produce a nice welding bead and good penetration and the best welding length. To determine the effective welding length, several factors are being considered like the welding process, the types of welding joint, the sizes of electrode, and also the material to be welded. These factors will affect the welding process if the parameters are not being set correctly.

Scheme of Investigation

In order to maximize the quality characteristics, the present investigation has been made in the following sequence.

1. Selection of base material.
2. Identify the importance SMAW welding process parameters.
3. Perform preliminary tests.
4. Find the upper and lower limits (i.e. range) of the identified process parameters.
5. Select the orthogonal array (design of matrix).
6. Conduct the experiments as per the selected orthogonal array.
7. Record the quality characteristics.
8. Find the optimum condition for SMAW welding.
9. Conduct the confirmation test.
10. Identify the significant factors.

Experiment

Work Material and Electrode

Chemical composition of MS2062 and electrode E6013 are in percentage:

Table 1.Chemical Composition of Base Material and Electrode

Material	C	S	P	Si	Cu	Mn	Fe
MS2062	0.20	0.055	0.005	0.100	0.350	-	Bal
E6013	0.10	0.035	0.04	0.35	-	0.3	Bal

Table 2.Parameters Values and Level Design

Parameters	Code	Level 1	Level 2	Level 3
Current	A	90	100	110
Voltage	B	22	24	26
Angle	C	50	70	90
Arc length	D	2	3	4
Welding speed	E	4	5	6

In Table 2, Current is in ampere, voltage in volt, angle in degree, arc length in mm and welding speed are in mm/sec.

L27 Orthogonal Array

Taguchi orthogonal design uses a special set of predefined array called orthogonal array (OAs) to design the plan of experiment. These standard arrays stipulate the way of full information of the entire factor that affects the process performance (process responses). The corresponding OA is selected from the set of predefined OAs according to the number of factor and their levels that will be used in the experiment. Below Table 3 shows L27 orthogonal array. This is the input factor which design by Taguchi analysis.

Table 3.L27 Orthogonal Array Design by Taguchi Design Input and Output Parameters

	Input parameters					Output parameters	
No.	**Current**	**Voltage**	**Angle**	**Arc length**	**Travel speed**	**Weld bead width**	**Penetration**
1	90	22	50	2	4	7.7	2.0
2	90	22	50	2	5	7.3	2.1
3	90	22	50	2	6	6.9	1.8
4	90	24	70	3	4	7.0	2.7
5	90	24	70	3	5	6.7	2.9
6	90	24	70	3	6	6.3	2.6
7	90	26	90	4	4	8.2	2.2
8	90	26	90	4	5	7.8	2.4
9	90	26	90	4	6	7.4	2.2
10	100	22	70	4	4	7.5	2.5
11	100	22	70	4	5	7.2	2.6
12	100	22	70	4	6	7.0	2.5
13	100	24	90	2	4	8.2	2.3
14	100	24	90	2	5	8.0	2.5
15	100	24	90	2	6	7.3	2.4
16	100	26	50	3	4	7.9	2.4
17	100	26	50	3	5	7.6	2.7
18	100	26	50	3	6	7.1	2.5
19	110	22	90	3	4	7.8	2.7
20	110	22	90	3	5	7.7	2.9
21	110	22	90	3	6	7.1	2.6
22	110	24	50	4	4	8.5	2.5
23	110	24	50	4	5	8.3	2.7
24	110	24	50	4	6	7.9	2.4
25	110	26	70	2	4	7.9	2.7
26	110	26	70	2	5	7.8	2.7
27	110	26	70	2	6	7.5	2.5

Analysis of S/N Ratio

In Taguchi designs, a measure of robustness used to identify control factors that reduce variability in a product or process by minimizing the effects of uncontrollable factors (noise factors). Control factors are those design and process parameters that can be controlled. Noise factors cannot be controlled during production or product use, but can be controlled during experimentation. In a Taguchi designed experiment, you manipulate noise factors to force variability to occur and from the results, identify optimal control factor settings that make the process or product robust, or resistant to variation from the noise factors. Higher values of the signal-to-noise ratio (S/N) identify control factor settings that minimize the effects of the noise factors.

Taguchi experiments often use a 2-step optimization process. In step 1 use the signal-to-noise ratio to identify those control factors that reduce variability. In step 2, identify control factors that move the mean to target and have a small or no effect on the signal-to-noise ratio.

The signal-to-noise ratio measures how the response varies relative to the nominal or target value under different noise conditions. Different signal-to-noise ratios can be chosen depending on the goal of your experiment.

There are three categories of performance characteristics, i.e., the lower-the-better, the higher-the-better, and the nominal-the-better in the analysis of the S/N ratio. To obtain optimal machining performance, the lower-the-better performance characteristic for surface roughness and higher-the-better for material removal rate is taken. Figure 1 below shows the effect of all four input process parameters on material removal rate for Signal-to-Noise (S/N) ratio.

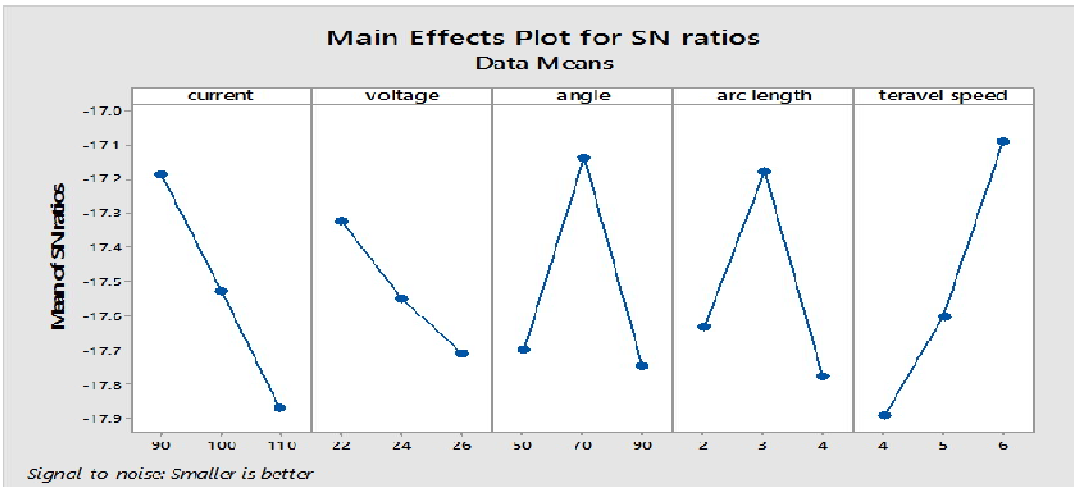

Figure 1.Means of SN Ratio of Parameters Value and Weld Bead Width

Figure 1 shows the relationship between SN ratio of parameters value and WBW. This Fig. 1 shows that current increase then WBW is increase. As well as in voltage are also shows around same result. But in angle minimum WBW is obtain at 70 degree and both other angle give higher WBW result. In arc length at 3mm give best result and travel speed increase the WBW should be decrease.

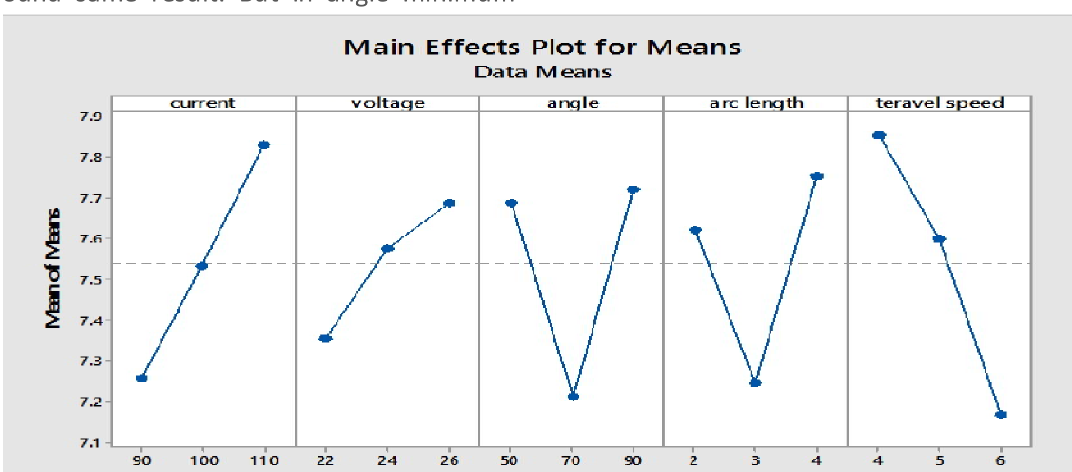

Figure 2.Means of Mean of Parameters Values with Weld Bead Width

Figure 2 shows the result relationship between Means of parameters value and WBW that show current increase then WBW is increase. As well as in voltage are also shows around same result. But in angle minimum WBW is obtaining at 70 degree and both other angle give same result. In arc length at 3mm give best result and travel speed increase the WBW should be decrease.

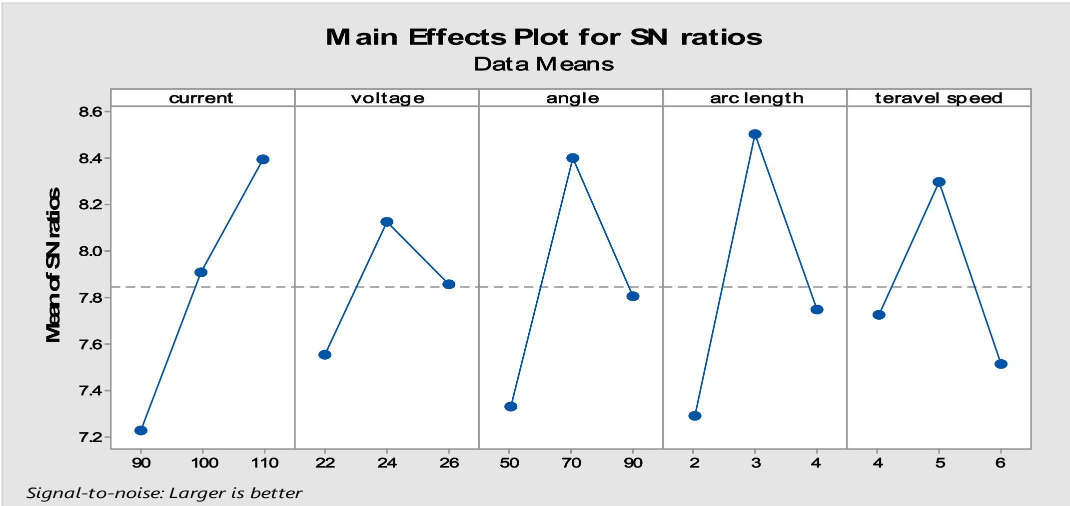

Figure 3.Means of SN Ratio of Parameters Value and Penetration

Figure 3 shows the relationship between SN Ratio and penetration. This Fig. 3 shows that current increase the value of penetration increase the max penetration is obtain at 120 ampere. And voltage best penetration is obtained at 26 volt. The angle show best result is at 70 degree and 3mm arc distance is best arc length and travel speed increase the penetration decrease but less effect on 4mm/sec and 5mm/sec.

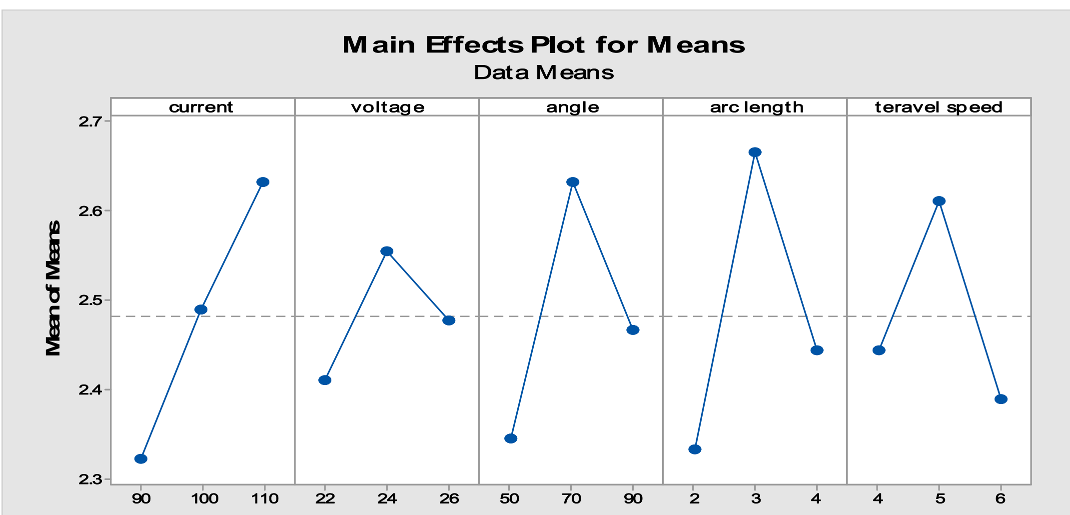

Figure 4.Means of Mean of Parameters Values and Penetration

Figure 4 shows the result b/w means of mean of parameters value and penetrations. This Fig. 4 shows that with current increase penetration is increase. But in voltage penetration first increases after that decrease and angle and arc length both gives maximum penetration at medium values and travel speed increase the penetration is decrease.

Figure 5.Mild Steel (MS) 2062 All Work Piece Plate

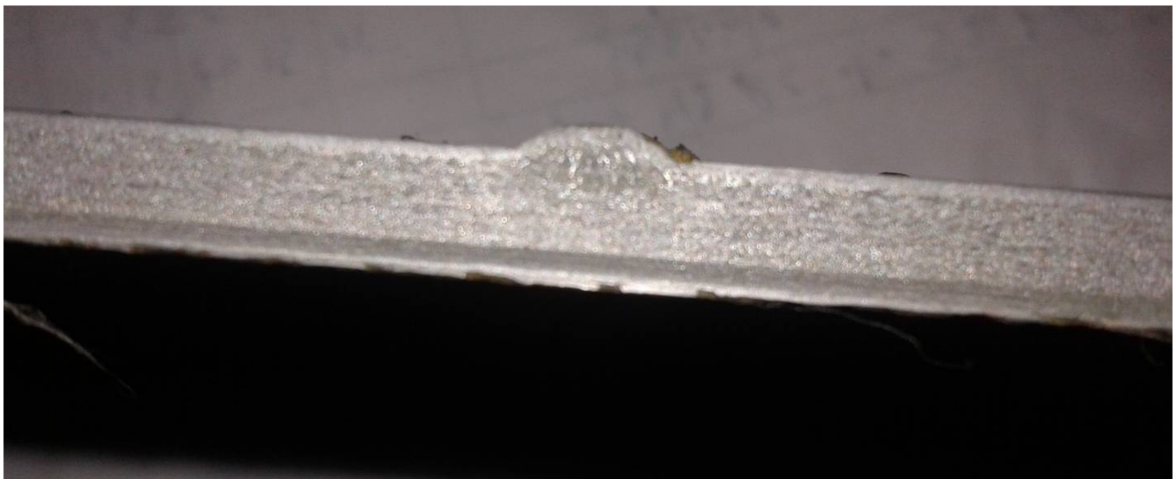

Figure 6.Mild Steel (MS) 2062 One Piece Penetration

Figure 7.Mild Steel (MS) Single Plate Work Piece

Conclusion

Based on the experimental work and the Factorial design approach the following conclusions are drawn:

1. A strong joint of mild steel is found to be produced in this work by using the SMAW technique.
2. Results indicate that processes variables influence the weld bead width and penetration to a significant extent.
3. If amperage is increased, weld bead width increases as well as penetration also increase.
4. If voltage of the arc is increased, welding bead width generally increases. At one best

possible voltage the WBW is minimum and penetration is maximum.

5. If travel speed is increased welding WBW generally decreases or penetration generally decrease but a value gives best penetration. And the travel speed increase the electrode deposition is decrease so electrode life is increase.
6. The best Arc length is around equal to core diameter we use 3.15 mm electrode we find best values of arc length at 3mm arc distance.

Optimum values are

I. Current 100 amperage
II. Voltage 24 volt
III. Angle is 70 degree
IV. Arc length is 3mm
V. Travel speed is around 5 mm/sec.

This result is given only by study and idea of given result and use of parameters value for MS2062 and electrode E 6013.

We find best quality with less WBW and maximum penetration on these values with best possible strength.

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