Optimization Of Shielded Metal Arc Welding Parameters For Welding Of Pipes By Using Taguchi Approach

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ABSTRACT

The 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 the most important factors affecting the quality, productivity and cost of welding. The objective of this study is to develop the parameters for Shielded Metal Arc Welding (SMAW) to provide continuous and leak proof joints in 48mm diameter steel pipe with 3mm thickness during the process. The selected important welding parameter like welding current, welding speed, root gap and position of electrode based on field expert suggestion available literature and on scientific reasons. On the selected parameter sufficient number of trail runs is conducted as per Taguchi method because experimental optimization of any welding process is often very costly and time consuming. For each factor optimum range is fixed, further the range is split into 5 levels. So that the experiment have become 4 parameters (factors) each with 5 levels. Based on this, L31 (5^4) Orthogonal Array (OA) is selected. Experiments are conducted according to OA and results are obtained. The leak proof joints can be identified by these results under few specific operating conditions. Under these condition effect of noise are nullified and the contribution of each parameter towards the leak is also estimated by ANOVA.

***Keywords**:* Welding parameters; Taguchi technique; Shielded metal are welding (SMAW); Optimization; Orthogonal array; Variation and Contribution.

I. INTRODUCTION

Welding preferred over other joining process like riveting, casting and nut bolting because it is faster, quieter and many more advantageous over other joining techniques. Now a day, welding is extensively used in fabrications of automobiles, aircrafts, ships, electronic equipment, machinery, and home applications etc.,[1]. In recent years the welding industry has improved significantly in terms of large number of welding methods suitable for various applications to eliminating rework and rejection. For particular task or application the existing welding processes are optimized suitably to give best results. However in welding, maintaining quality is still a challenging task. This is due to the fact that there are many numbers of variables at play. Variation in raw material (composition, thickness, internal defects, etc.,), variation in the surface condition (presence of dust, grease, oil etc.,), change of operator, variation in the gap between two pieces to be welded, variation of welding speed and possible variation in electrodes. The welding variables are categorized into two groups, one is controlled variable and the other is uncontrolled variables. The controlled variables are current, voltage, weld gap, weld metal deposition, welding speed[5], surface cleanliness, arc length and preheating temperature. The uncontrolled variables are weld bead dimensions, heat affected zone (HAZ), weld penetration, distortion, strength and leak in joints. The controlled variables are either directly or indirectly form the welding process parameters. The uncontrolled variables are the quality characteristics, but mechanism connecting these two is not known accurately and scientifically. Therefore experimental optimization of any welding process is often a very costly and time consuming task. In this contest the researcher wants to use taguchi's design of parameters to ensure test for no leakage.

II. EXPERIMENTAL DETAILS

Welding operation is conducted on Apollo steel tube of diameter 48 mm with 3mm wall thickness by using a 3 phase (Johnson arc welding

transformer) welding machine as shown in figure 1. The electrodes used for the process is Sun arc make (AWS Code E6013) of diameter 3mm to weld 3mm wall thickness pipes. The welding joints are tested for leak testing by using hydraulic hand pump of capacity 400 bars, at 30 bars and the leak testing setup is shown in figure 2. During welding tube is fixed in welding spinner and welded in 5G position as shown in figure 3 and in figure 4 shows welded tubes
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Fig 1.Johnson arc welding transformer
Fig 2. Leak testing setup

Fig 3.Welding spinner to welded pipe in 5G position. Fig 4. Welded tubes

2.1 IDENTIFYING THE PROCESS PARAMETERS AND THEIR LEVELS

Based on field experts suggestion, literature survey and on scientific reasons following welding parameters or factor are selected.

1. Welding current
2. Welding speed
3. Position of electrode
4. Root Gap

Sufficient numbers of trail runs are conducted and for each factor range is fixed. The range of current is between 80 to 100 Amps, The range of welding speed is between 4 to 6 Rpm, The angle of electrode range is between 0 to 60 and Root Gap range is between 0 to 1.5 are given in table 1.

Table1. Showing range of factors

Factors.	**Min.**	**Max**
Welding current (Amps)	80	100
Welding speed (Rpm)	4	6
Angle of electrode	0	60
Root Gap in (mm)	0	1.5

In order to study the complete range of factor two limits are fixed as per central composite rotatable factorial design. The limits are -2 and 2 the intermediate values are can be determined by using following equation and that values are given in table 2.

$$X = \frac{2[2x - (Xmax - Xmin)]}{(Xmax - Xmin)}$$

Table2.Levels of factors and their values

Factors	Levels				
	-2	**-1**	**0**	**1**	**2**
Current	80	85	90	95	100
Speed	4	4.5	5	5.5	6
Angle of electrode	0	15	30	45	60
Root gap	0	0.375	0.75	1.125	1.5

Experiments are conducted as per central composite rotatable factorial design consisting of 31sets of coded conditions, that coded conditions of L31OA as shown in Table 3

Table3.L31 Orthogonal array

RUN NO	FACTORS			
	A	**B**	**C**	**D**
1	-1	-1	-1	-1
2	1	-1	-1	-1
3	-1	1	-1	-1
4	1	1	-1	-1
5	-1	-1	-1	-1
6	1	-1	1	-1
7	-1	1	1	-1
8	1	1	1	-1
9	-1	-1	-1	1
10	1	-1	-1	1
11	-1	1	-1	1
12	1	1	-1	1
13	-1	-1	1	1
14	1	-1	1	1
15	-1	1	1	1
16	1	1	1	1
17	-2	0	0	0
18	2	0	0	0
19	0	-2	0	0
20	0	2	0	0
21	0	0	-2	0
22	0	0	2	0
23	0	0	0	-2
24	0	0	0	2
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0

31	0	0	0	0

III. RESULTS AND DISCUSSION

Experiments are conducted as per the L31 O.A. and results of diameter 48mm and thickness 3mm are tabulated in table 4.

Table4. Leak test results of diameter 48mm x 3mm pipe

Run no	Leak condition	Leak rate1bar ml/min	Remarks
1	No leak	----	----
2	No leak	----	----
3	No leak	----	----
4	No leak	----	----
5	No leak	----	----
6	No leak	----	----
7	No leak	----	----
8	No leak	----	----
9	No leak	----	----
10	No leak	----	----
11	No leak	----	----
12	No leak	----	----
13	No leak	----	----
14	No leak	----	----
15	No leak	----	----
16	No leak	----	----
17	No leak	----	----
18	Leak	97	Seepage
19	No leak	----	----
20	Leak	30	Seepage
21	No leak	----	----
22	Leak	50	Seepage
23	No leak	----	----
24	No leak	----	----
25	No leak	----	----
26	No leak	----	----
27	No leak	----	----
28	No leak	----	----
29	No leak	----	----
30	No leak	----	----
31	No leak	----	----

IV. ANALYSIS OF VARIANCE (ANOVA)

4.1. ANOVA Computations for diameter 48mm 3mm pipe

Table5. ANOVA Computations

Factors	SS	DOF	Variance	% of contribution
Mean	5.4838	---	---	---
Current	7660.9	4	1915	48.99%
Speed	1475.38	4	368.84	9.43%
Angle of electrode	2675.34	4	668.83	17.11%
Root gap	1289.83	4	322.45	8.24%
Error	2533.75	14	180.98	16.20%

For the pipe 48 mm diameters with 3 mm thickness, 31 trail runs are conducted as per OA. Out of 31 trails the trail number 1to16, 19, 21 and 23 to 31have given no leak joints. By ANOVA computation the current is the factor contributed highest of 48.99% and followed by angle of electrode is 17.11%, speed is 9.43% and root gap is 8.24%. The results of ANOVA computation are in line with the literature. That is for lower thickness pipe or plate the role current and angle of electrode are very important in getting leak proof joints. ANOVA contribution of parameter are shown in table5.

Table 6. Trails optimum values and ANOVA contribution

	A	B	C	D	Leak condition
Contribution	48.99%	9.43%	11.7%	8.24%	
Trail 1 to17,19,21 ,23 And 24 to 31	80,85,90,95	4,4.5,5,5.5	0,15,30,45	0,0.375,0.75, 1.125,1.5	no leak

4.2 Mean effect plots

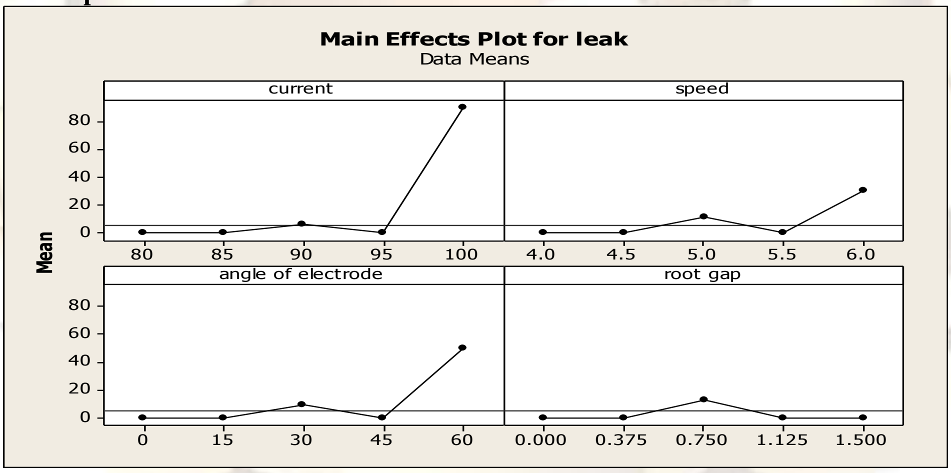

Figure5.Variations of average leak rate with mean values of factors

The variation of average leak rate for various for various factors are shown in the figure

V. CONCLUSION

i. 31 experiments are conducted as per L31OA.

ii. In getting leak proof joint welding current and angle of electrode is significant.

iii. For selected 48mm diameter and 3mm thickness pipe, 28 optimum combination of parameter to get leak proof joint are shown in table 6

iv. ANOVA supports the results obtained.

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