Optimization of Shielded Metal Arc Welding Parameters for Welding of Pipes by using Taguchi Approach

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ABSTRACT
The objective of this paper is to Design Parameters for Shielded Metal Arc Welding to ensure no leak to occur during the process. To achieve the objective an attempt has been made to select important welding parameters like welding current, welding speed, root gap and position of electrode based on field expert's suggestions, available literature and on scientific reasons. On the selected parameters, trails have been conducted as per Taguchi method and fixed the levels for the parameters. Further, for each parameter 3 different levels are fixed,. so that the experiment have become 4 parameters (factors) and each with 3 levels. Based on this, L9 (3^4) Orthogonal Array (OA) experiments are conducted and results are obtained. The results have indicated that leak proof joints can be produced in few specific operating conditions. Under these conditions effects of noise are nullified. 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; Sum of squares; Variation and Contribution.

1. INTRODUCTION:

In recent years the welding industry has improved significantly in terms of large number of welding methods suitable for various applications. For particular task or application the existing welding processes are modified suitably to give best results. Further the use of robots for welding application enhanced the strength and capability of the industry. The Robots can sense the varying gap between two pieces to be welded and based on this feed back, it can change the weaving length. However in welding, maintaining Quality is still a challenging task [1-3]. This is due to the fact that there are many number of variables at play. Variation in raw material (composition, thickness, internal defects, etc) variation in the surface condition (presence of dust, grease and oil),change of operator, variation in the gap between two pieces to be welded, variation of welding speed and possible variation in electrodes[4]. 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, Surface cleanliness, Arc length and Preheating temperature. The uncontrolled variables are Weld bead dimensions, Heat affected zone (HAZ), Wed penetration, distortion, Strength and leak in joints. The controlled variables are either directly or indirectly form the welding process parameters and the uncontrolled variables are the quality characteristics, but mechanism connecting these two is not known accurately and scientifically [5-7]. Therefore experimental optimization of any welding process is often a very costly and time consuming task. In light above the researcher wants to use taguchi's design of parameters to ensure no leakage

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2. EXPERIMENTAL DETAILS:

Welding operation is conducted on Apollo steel tube of diameter 60 mm, with 3mm and 4mm wall thickness, by using a 3 phase (Johnson arc welding transformer) welding machine and is shown in figure1. The electrodes used for the process is Don arc make (AWS Code E6013) of diameter 3mm and 4mm to weld 3mm and 4mm wall thickness pipes respectively. 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 operation the tube is fixed in welding spinner and welded in 5G position as shown in figure 3.and in figure 4 shows welded tubes are shown.

Fig. 1 Johnson arc welding transformer

Fig. 2 Leak testing setup

Fig. 3. Welding spinner to weld pipes in 5G position

Fig. 4 Welded tubes with threaded ends wound with Teflon

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. Root Gap
4. Position of electrode

Sufficient number of trail runs is conducted and for each factor optimum range is fixed. Further, the range is split into 3 levels. At different levels, the selected parameters are welded the tube satisfactorily. The range of factors are given in the following tables 1 and table 2 for the diameter 60mm, with 3mm and 4mm thickness respectively. Similarly factors at different levels are given in table 3 and in the table 4.

Table1. Showing range of factors

Factors	Min.	Max.
Welding current (Amps)	80	100
Welding speed (Rpm)	3.5	5
Electrode position (degrees)	0	60
Root Gap in (mm)	0	1.5

Table2. Showing range of factors

Factors	Min.	Max.
Welding current(Amps)	100	150
Welding speed (Rpm)	3.5	5
Electrode position (degrees)	0	60
Root Gap in (mm)	0	1.5

Table3. Levels of factors and values

Levels	1	2	3
Welding current(Amps)	80	90	100
Welding speed (Rpm)	3.5	4	5
Electrode position (degrees)	0	30	60
Root Gap in (mm)	0	0.7	1.5

Table4. Levels of factors and values

Levels	1	2	3
Welding current(Amps)	100	125	150
Welding speed(Rpm)	3.5	4	5
Electrode position (degrees)	0	30	60
Root Gap in (mm)	0	0.7	1.5

2.2 Orthogonal Array

Based on the number factors and levels in each factor L9 (3^4) OA is selected for both 3mm and 4mm wall thickness with diameter 60mm.The table 5 shows L9 OA.

Table 5. L9 Orthogonal Array

Trails no.	**1**	**2**	**3**	**4**
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

3. Results and discussion

Experiments are conducted as per the L9 O.A. and results of diameter 60mm and thickness 3mm are tabulated in table 6.The results of diameter 60mm and 4mm thickness are tabulated in table 7.

Table 6. Leak test results of diameter 60mm x 3mm pipe

Trails no	**Leak condition**	**Leak rate 1bar ml/min**	**Remarks**
1	Leak	150	Failed at 10 bars
2	No Leak	---	---
3	Leak	450	at three points
4	No leak	300	at two point
5	Leak	308.57	at three point
6	No leak	170	at two points
7	No leak	---	---
8	Leak	40	at two point
9	Leak	20	Seepage

Table 7. Leak test results of diameter 60mm x 4mm pipe

Trails no	**Leak condition**	**Leak rate 1bar ml/min**	**Remarks**
1	Leak	10	Seepage
2	Leak	275	at three points
3	Leak	450	at two point
4	leak	180	at three points
5	Leak	400	at two point
6	Leak	300	at two point
7	No leak	---	---
8	No Leak	---	---
9	Leak	2.6	Seepage

3. Analysis of Variance (ANOVA)

3.1 ANOVA Computations for diameter 60mm x 3mm pipe

Factors	**SS**	**DOF**	**Variance**	**% contribution**
Mean	211003.59	8	---	---
Current	93312.46	2	93312.46	44.18
Speed	14600.46	2	14600.46	6.91
Electrode position	39198.59	2	39198.59	18.56
Root gap	64069.18	2	64069.18	30.33

3.2 ANOVA Computations for diameter 60mm x 4mm pipe

Factors	SS	DOF	Variance	% contribution
Mean	269895.12	8	---	---
Current	147472.39	2	147472.39	54.64
Speed	61973.42	2	61973.42	22.96
Electrode position	8518.31	2	8518.31	19.24
Root gap	51929.28	2	51929.28	3.156

For pipe diameter 60mm and 3mm thickness, 9 trail runs are conducted as per OA. Out of 9 trails 2 trails, run 2 and run 7 have given welding joints with no leak. In these trails the temperature gradient and local cooling rate, have supported the solidification of liquid metal without any micro porosity or voids either the weld bead or in the line of joint between parent metal and weld bead [8]. However, by visual inspection of bead dimension, continuity and penetration of both the successful trails. It is found that trail run 7 is superior in quality than the tail run 2.This attributed to the fact that trail run 7 will run at higher current with relatively less welding speed 3.5rpm (11mm per sec.).These interpretations are strongly supported by the ANOVA results. As contribution of current is 54.64% and the contribution of welding speed is 22.96%.Figure 5 and Figure 6 shows the variation of mean effects of current and welding speed.

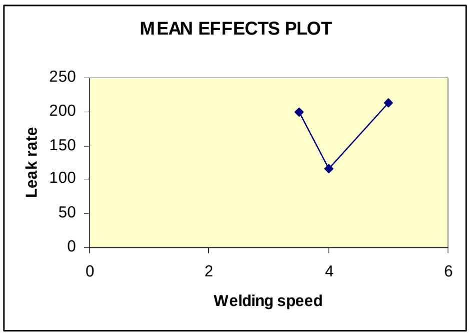

Figure 5. Mean effect plot

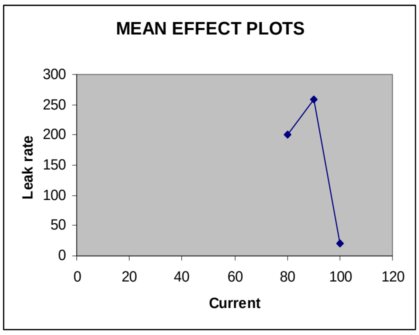

Figure 6. Mean effect plot

For pipe diameter 60mm and 4mm thickness, 9 trail runs are conducted as per OA. Out of 9 trails 2 trails, run 7 and run 8 have given welding joints with no leak. These trial runs are conducted at 150 Amps. Thus the process is more sensitive to variations the welding current. This is supported by the results of ANOVA. That is contribution welding current is 54.64%, it is very much high than any other parameters. On visual inspection if found that both success full joints are almost same in other aspects like bead dimension, continuity and penetration. Hence both are equally robust.

Figure 7 shows the mean effect plot for variation of leak rate with variation of welding current.

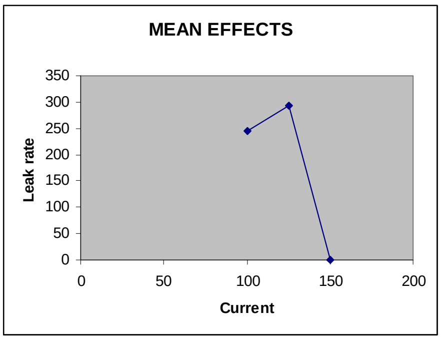

Figure 6. Mean effect plot

References:

[1] Balasubramani M. Journal of materials technology, Vol.24 (2008).

[2] Chen Y.H.International journal of materials and product technology, V0l.11 (1996) pp333.

[3] Ross J.R. Taguchi techniques for Quality Engineering, McGraw-Hill, New York.

[4] B.S.Praveen Kumar and Dr, Y.Vijaya Kumar, "Optimum blending of powders to obtain desired Mechanical properties by DOE,' at NATCON-2005 proceeding, Ghousia college of engineering, Ramanagaram Bangalore.

[5] Selection of process parameters for Mechanical properties of A1 alloys for centrifugal casting Using Taguchi Method Approach, Shailesh and Sundarrajan, Indian foundry journal, Vol.51, March, 2005.

[6] Song Liu and Robert.G.Batson (2004) On experimental design for gauge gain in steel tube Manufacturing, Quality Engineering, Vol.16, No.2, PP269-282.

[7] S.H.Robust design and analysis for quality engineering, Chapman and Hall, New York.

[8] A.C.Atkinson and Donev, Optimum experimental designs, Claredon Press, Oxford,U.