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Selection Of Optimum Process Parameters Of Shielded Metal Arc Welding (SMAW) To Weld Steel Pipes By Design Of Experiments

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ABSTRACT

The focus of this work is to design parameters for shielded metal arc welding to ensure continuous and leak proof joints. To achieve the object an attempt has been made to selected important welding parameters. The selected welding parameters are welding current, welding speed, electrode angle and electrode angle. The selection is purely based on field expert's suggestions, literature Survey and on Scientific reasons. On the selected parameters, trails runs have been conducted and fixed the higher levels and lower 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 (O.A) is selected. Experiments are conducted according to O.A and results are obtained. The results have indicated that a 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 computations.

1. INTRODUCTION

Rework and Rejections are non value added activities in the industry. The rework and rejections can be eliminated by making the process more stable and under controlled [1]. This can be achieved by designing the process parameters to the specific work. The designed process parameters should be such that, the affects of uncontrolled factors should be nullified. This condition of the process is called Robust Process or Robust Design of process parameters [2].

Welding process falls under special processes. The manufacturing processes which are directly linked with quality of the ultimate products are called special process. There fore failure of welding joint is the failure of the product it self. The situation becomes further critical, when welding is used to weld pipes lines of the pressurized or evacuated systems. Here meager amount of seepage in a smallest hole can affects the functioning of entire system. Leaks are special type of flaw that can have tremendous importance where they influence the safety or performance of the engineering systems. The leak testing is performed to prevent material leakage loss, environmental contamination hazards and premature failure of system containing fluids under pressure or vacuum [3-4]

Welding is unlike other manufacturing processes, because the number of process variables at play are relatively more and its influence on quality of weld are significant. 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. The welding variables are categorized into two groups, one is controlled variable and the other is uncontrolled variables [5-6]. 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, 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. 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 [7-9].

2. Experimental Details

Welding is performed on Apollo steel pipe of 48mm diameter 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 (AWS Code E6013) of diameter 4mm. The welding joints are tested for leak testing by using hydraulic hand pump of capacity 400 bars, at 1 bar and the leak testing setup is shown in figure 2. During welding tube is fixed in welding spinner and welded in 1G position as shown in figure 3.and figure 4 shows welded tubes.

Fig. 1 Johnson arc welding transformer

Fig. 2 Leak testing setup

Fig. 3 Welding spinner to weld pipes in 1G position

Fig. 4 Welded tubes with threaded ends wound with Teflon

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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 numbers of trail runs are conducted and each factor range is fixed. Further, the range is split into 3 levels. At different levels, the selected parameters can weld the pipe satisfactorily. The range of factor are given the following tables 1 for pipe diameter 48mm and 4mm thickness. The factors at different levels are given in table 2

Table 1. Showing range of factors

Factors	Min.	Max.
Welding current (Amps)	100	150
Welding speed (Rpm)	4	6
Electrode position (degrees)	0	60
Root Gap in (mm)	0	1.5

Table 2. Showing levels of factors

Factors	L1	L2	L3
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

2.3 Orthogonal Array

Based on the number factors and levels in each factor, L9 (3^4) OA is selected to weld 48mm diameter with 4mm pipe. The table 3 shows OA L9.

Table 3. Orthogonal Array L9

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 tabulated in the table 3.

Table 3. Shows the leak test results

Trails no	Leak condition	Leak rate 1bar ml/min	Remarks
1	No Leak	---	----
2	Leak	450	At one point
3	Leak	600	At three points
4	leak	37.5	Seepage
5	No Leak	---	---
6	leak	2.85	Seepage
7	No leak	---	---
8	Leak	240	At two point
9	No Leak	---	Seepage

Nine trail runs are conducted as per O.A. the trail numbers 1, 5, 7 and 9 have given no leak joints. However during conformation trails, the trail number 7 is failed to give leak proof joint. This failure is acceptable due to the fact that, in all the successful trail electrode position is zero degrees (exactly 90 degrees to the electrode holder) but in the trail 7 it is 30^0. This change in electrode position is not supported by the ANOVA results, shown in table 4 . As the contribution of electrode position is 30.21%,it is second highest after the current contribution (44.85%).Thus the trails 1, 5, and 9 are trail runs with optimum parameters. The successful trails with optimum parameters and ANOVA contribution of parameters are shown in the table5.

3.1 ANOVA Computations for diameter 48 mm x 4 mm pipe

Table 4. ANOVA Computations

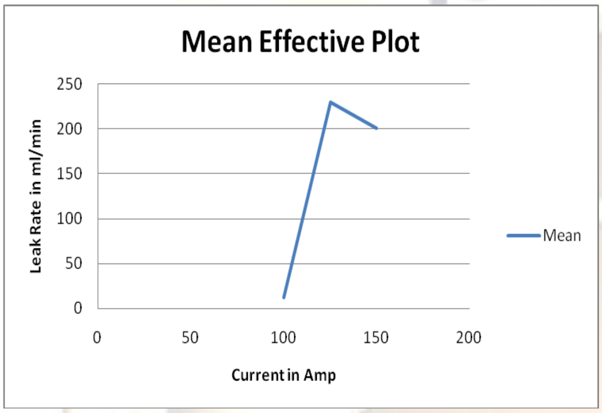
Factors	SS	DOF	Variance	% contribution
Mean		8	---	---
Current	190594.80	2	190594.80	44.85
Speed	83663.555	2	83663.555	19.69
Electrode position	128378.555	2	128378.555	30.21
Root gap	22229.555	2	22229.555	5.23

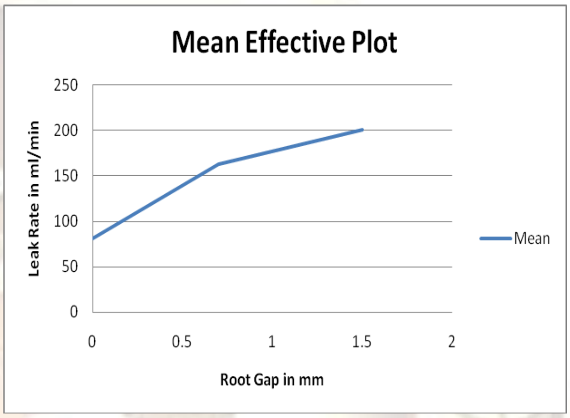
Table 5. Trails, Optimum valves and ANOVA Contributions

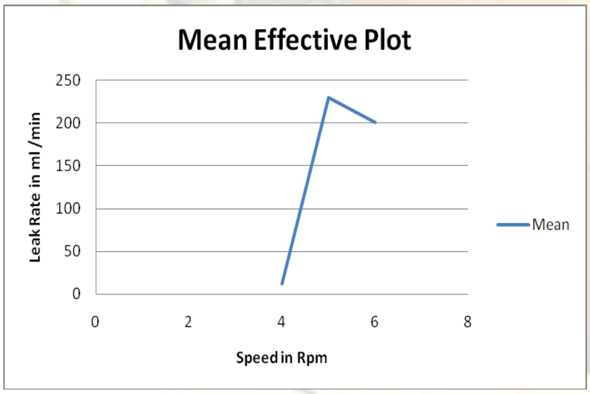
	Current (Amp)	Speed (Rpm)	Root gap (mm)	Electrode Position (Degree)	Leak condition
Contribution	44.85%	19.69%	5.23%	30.21%	
Trail 1	100	4	0	0	No Leak
Trail 5	125	5	1.5	0	No Leak
trail 9	150	6	0.7	0	No Leak

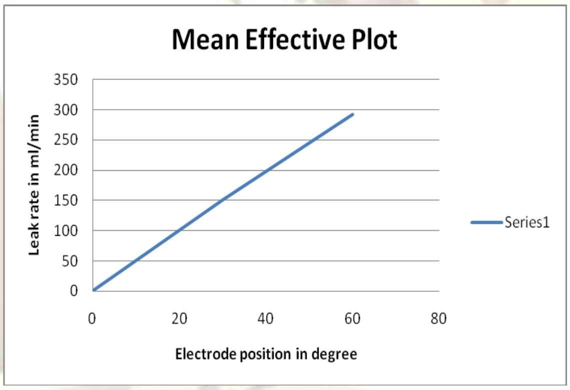
3.2 Mean effect plots

The mean effect plots of various factor and leak rate are shown below









Graph 1. Shows mean effect plots for operating parameters

4. Conclusions

i) Nine experiments are conducted as L9 O.A.

ii) For the selected 48mm diameter and wall thickness mild steel pipe (Apollo make), they are
Three optimum combinations are there, they given in table 5.

iii) In getting leak proof joints electrode angle is significant.

iv) Trail runs conformed the results and they are logically correct

v) ANOVA Supports the results obtained.

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