Optimization of Straight Tube Butt Welding Machine Process Parameters to Reduce Weld Rejection

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***Abstract*—This paper presents the influence of welding parameters like welding current, welding voltage, chuck speed, hoist on standard steel tube material during welding. A plan of experiments based on Full Factorial Design has been used. An analysis of variance (ANOVA) are employed to study the optimization of welding parameters. The result computed is in form of contribution from each parameter, through which optimal parameters are identified to reduce the weld rejection. From this study, it is observed that the welding voltage and chuck speed are major parameters which causes the weld rejection.**

***Index Terms*—Optimization, RTR, ANOVA, Full Factorial Design.**

I. INTRODUCTION

Bharath Heavy Electricals Limited (BHEL) is a power plant equipment manufacturing company. BHEL, Trichy is manufacturing boilers, heat exchangers, coils and panels. Tubes are received as per the standard length. These standard length tubes are welded in Straight Tube Butt Welding machine (STBW) as per the production requirement. The welded joints are inspected in Real Time Radiography (RTR) where welded joints are sent to RTR. The tubes are inspected and rejection of joint may happen if there is any defect since the defect in joint may cause problem in the high pressure power plants.

In order to overcome this problem, various optimization methods can be useful to define the desired output variables through developing mathematical models to specify the relationship between the input parameters and output variables. Design of Experiment (DOE) techniques has been applied to carry out such optimization.

II. LITERATURE REVIEW

Raj et al has presented an investigation on the optimization and the effect of welding parameters on the torsional rigidity of MIG welded mild steel circular rod. The level of importance of the welding parameter on the Torsional rigidity is determined by ANOVA. Based on the ANOVA method the highly effective parameter on torsional rigidity was found as voltage and wire feed rate whereas current was less effective factor. An Optimum parameter combination for the maximum Torsional rigidity was obtained by using analysis of S/N ratio.

Patil et al proposes optimization of MIG welding parameters for improving the strength of welded joints, three mild steel failure problems encountered by loads were successfully addressed by applying the Taguchi method. A Taguchi orthogonal array, the S/N ratio and Analysis of Variance (ANOVA) were used for the optimization of welding parameters. The optimum levels are obtained and the welding speed has major influence on tensile strength of welded joints.

Amit et al deals with the use of Taguchi Grey relational analysis to optimize Gas metal arc welding parameters. The multiple response optimization process employs orthogonal array to conduct experiments along with GRA and Taguchi method. The optimal setting welding parameters simultaneously minimize bead width, bead height HAZ and maximizes weld penetration. Multiple responses in Gas metal arc welding are improved by Grey based Taguchi method.

Monikha et al proposed the effect of Heat input on the mechanical properties of MIG welded dissimilar joints. As the heat input decreases, there an increase in the tensile strength in both the joints. As the heat input decreases, there is an increase in the hardness in both the joints. And also hardness follows an increasing trend in the order of weld metal, HAZ, Base metal for both the heat inputs. Based upon the present study, it is recommended that low heat input should be preferred while welding joints using MIG welding process because of the reason that besides giving good tensile strength and hardness.

III. WELDING DEFECTS AND REASON

In STBW machine welded joints are rejected due to following defects, major cause of the defects were analysed and listed below:

1. Incomplete Penetration (ICP)
   - Too fast welding

- Chuck offset
- Land on tube edge
- Voltage problem
- Starting current
- Narrow groove
- Contact tip over heating
- Differential chuck rotation
- Long arc length

2. Burn Through (BT)
   - Joint mismatch
   - High current
   - Edge damaged
   - Root gap
   - Chuck offset

3. Undercut (UC)
   - Too fast welding
   - High Chuck speed
   - Low current welding
   - Low oscillation amplitude

4. Lack of Fusion (LF)
   - Arc length too long
   - Welding current too low
   - Improper oscillation speed
   - Rotation too fast
   - Torch over heating

5. Porosity (P)
   - External air currents
   - Improper gas mixture
   - Arc length too short
   - Rusty greasy tube ends
   - Wire feed too slow

6. Gas Hole (GH)
   - Irregular gas flow
   - Chuck rotation speed
   - Dirty tube edges
   - Rusty wire
   - Weld area contamination

7. Surface Defects (SD)
   - Undercuts exceeding 0.4 mm
   - Mismatch/ misalignment
   - Weld outside reinforcement
   - Excess penetration exceeding
   - Depression on the weld surface
   - A crater at the termination of weld
   - Non melted electrode

IV. EXPERIMENTAL PROCEDURE

In present study, in order to identify the process parameters with minimum rejection rate in STBW, the Full Factorial Design method was used. Parameters like welding current, welding voltage, chuck speed, hoist are to be considered. The levels of parameters are listed in Table 1. The observed parameters for level B are listed in Table 2.

Table 1 Levels of Parameters

LEVEL	CHUCK	HOIST	CURRENT	VOLTAGE
A	Below 400	Below 1.5	Below 85	Below 26.5
B	401-440	1.6 -2.5	86-92	26.6-29
C	441-480			

Table 2 Observed parameters for Level B

CHUCK	HOIST	CURRENT	VOLTAGE	OUTPUT
B	A	B	A	0.0785
B	B	A	A	0.0526
B	B	B	B	0.0192
B	A	A	B	0.0127
B	B	B	A	0.0235
B	A	A	A	0.0432
B	A	B	B	0.0206
B	B	A	B	0.0127

V. FULL FACTORIAL DESIGN METHOD

Full Factorial Design is used to plan the experiments. The FOE method has become a tool for improving the output so that better quality products are produced and rejection rate can be decreased. In FOE, Cube Plotting technique is used which gives three optimal parameters with rejection rate of 0.01. Thus the Design of Experiments with optimization of control parameters to best results is attained in the Full Factorial Design. Cube Plotting in Full Factorial Design gives a set of desired output, serve as objective functions in optimization, help in data analysis and estimation of optimum results.

VI. ANALYSIS OF VARIANCE (ANOVA)

The purpose of the analysis of variance (ANOVA) is to examine which parameters the welded joints. This is to accomplished by separating the total variability of the S/N ratios, which is measured by the sum of the squared deviations from the total mean S/N ratio, into contributions by each of the parameters and the error. The total sum of squared deviations $\mathbf{SS_T}$ from the total mean S/N ratio n_m can be calculated as,

$$SS_T = \sum (n_i - n_M)^2$$

VII. RESULTS

By using a Cube Plotting technique in Full Factorial Design three optimal parameters are obtained. These three optimal level gives a minimum rejection rate of 0.01. The three levels which is giving 0.01 are BBAB, BAAB, BBBB. In these three levels the chuck speed and voltage are constant. From these three levels any one of the level is taken as an optimal parameter and the parameter range for that level is listed in table 3.

Table 3 Parameter range for BBBB

CHUCK	HOIST	CURRENT	VOLTAGE
401-440	1.6-2.5	86-92	26.6-29

The three optimal parameter obtained is implemented in STBW machine. A set of four runs are to weld the tube and the output obtained is listed in table 4.

Table 4 optimum level output

RUN	BBBB	BBAB	BAAB
1	0.0113	0.0182	0.0152
2	0.0143	0.0136	0.0141
3	0.0127	0.0164	0.0129
4	0.0161	0.0147	0.0187

The implementation of results for the three optimal value gives rejection rate of 0.01.

By using ANOVA the output of the setting is verified. The ANOVA is listed in table 5.

Table 5 ANOVA

SOURCE OF VARIANCE	SS	df	MS	F	P-VALUE	F crit
Rows	1.26E-05	3	4.22E-06	0.69	0.61	9.27
Columns	5E-07	1	5E-07	0.08	0.79	10.12
Error	1.83E-05	3	6.08E-06			
Total	3.14E-05	7				

The change in the parameter repetition (Row-P value) and the level setting (Column-P value) is greater than the level of significance.

Row- 0.6148 > 0.05 & Column- 0.7930 > 0.05

It is clear that the optimal levels obtained will not have much effect on the weld result. Three optimal setting can be used for welding the tube. At constant voltage and chuck speed three different obtained setting can be used.

VIII. CONCLUSION

In this research study, voltage and chuck speed is affecting the most of the welded joints in rejection STBW. So, constant parameters for voltage and chuck speed are obtained by this research. There are three optimal parameters for the constant voltage and chuck speed. Current and hoist at constant voltage and chuck speed do not have much effect on rejection rate.

REFERENCES

[1] S. R. Patil., and C. A. Waghmare.,(2013) 'Optimization Of Mig Welding Parameters For Improving Strength Of Welded Joints' , International Journal of Advanced Engineering Research and Studies, vol-12 pp:34-37.

[2] Raj Kumar., Sandhaya Yadav., Anurag Singh., and Pankaj Singh.,(2016) 'Optimization Of Mig Welding Technique Parameters With The Help Of Taguchi Method', International Journal of Production Technology and Management,vol-7 pp:16-27.

[3] Amit Kumar., Khurana., and Pradeep K.,(2016) 'Optimization of Gas Metal Arc Welding Process Parameters', Journal of Advanced Manufacturing Technology ,vol-39 pp:1136–1143.

[4] Monika k., Bala Chennaiah ., Nanda Kumar ., Prahalada Rao.,(2013) 'The Effect of Heat input on the Mechanical Properties of MIG Welded Dissimilar Joints', International Journal of Engineering Research & Technology, vol-2 pp:1406-1413