OPTIMIZATION OF WELDING PARAMETER FOR ARC WELDING OF MILD STEEL PLATE (GRADE-40)

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Abstract:
Welding is a basic manufacturing process for making components or assemblies. Recent welding economics research has focused on developing the reliable machinery database to ensure optimum production. There are many welding parameters in welding process, the major factors whose selection contributes to the welded product as they all affect the strength and quality to a larger extent are weld design (edge preparation), Root face, and Root gap. In this paper, the optimization of welding input process parameters for obtaining greater weld strength in the Electric arc welding of metal like mild steel is presented. The Taguchi method is adopted to analyze the effect of each welding process parameter on the weld strength, and the optimal process parameters are obtained to achieve greater weld strength. The study includes selection of parameters, utilizing an orthogonal array, conducting experimental runs, data analysis, determining the optimum combination, finally the experimental verification. Experimental results are provided to illustrate the proposed approach.
Keywords: Mild steel plate, welding parameters, Electric Arc Welding, Taguchi method.

INTRODUCTION:

Welding is a process of fabrication that joins materials usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld for joining the metals[1-2]. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces. It has been found that ultimate tensile strength if weld joint in mild steel is largely influenced by thickness of material.Thus optimum setting of selected parameters i.e. thickness of material, carbon percentage of material and electrode diameter for mild steel is tried to obtain and verify using Taguchi and Minitab. Now a day, welding is extensively used in fabrications of automobiles, aircrafts, ships, electronic equipment, machinery, and home applications etc. as an alternative of casting or as a replacement of riveted or bolted joints. There are two main types of arc-welding processes. They are shielded metal arc welding and gas shielded arc welding. The main advantages of shielded metal arc welding are that high-quality welds are made rapidly at a low cost. Shielded Metal Arc Welding, also known as manual metal arc welding, stick welding, or electric arc welding, is the most widely used of the various arc welding processes. Welding is performed with the heat of an electric arc that is maintained between the end of a coated metal electrode and the work piece.

2. Experiment Procedure

Arc welding is a type of welding that use a welding power supply to create an electric arc between an electrode and the base material to melt the metal at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, or slag. Arc welding process may be manual, semi automatic or fully automatic. The heat generated by the electric arc is used to melt and join the base metal [3]. In this study an Electric arc welding machine is used to weld the base plates of Mild steel. The chemical composition of Mild steel is given in Table 1. Welding is carried out in the down hand position and beads are laid along the weld pad centerline to form a butt joint. The plates are allowed to cool to room temperature, after the completion of welding. To evaluate the quality of the Electric arc welds, a measurement of the tensile strength is performed by using an ultimate tensile testing (UTM) machine. The tensile strength of the weld has a higher-the-better quality characteristic. After welding, the joints are sliced in transverse direction to prepare the specimens for the purpose of to prepare the specimens for the purpose of measuring the tensile strength of the weld.

Fig 1 shows the electric arc welding process.

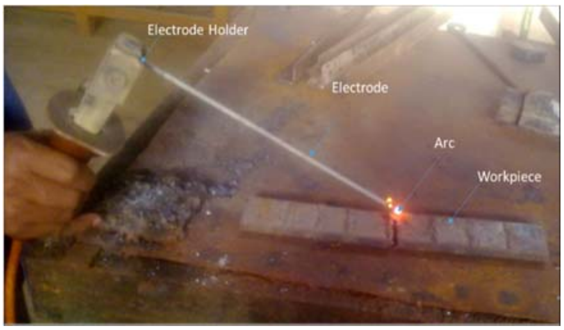

Fig.1.Electric Arc welding Process

Table 1 Chemical composition of Mild steel grade 40 in wt%

Element	**C**	**Mn**	**P**	**S**	**Cu**	**Si**	**Ni**	**Cr**	**As**
Wt %	0.37	0.90	0.04	0.04	0.3	0.17	0.3	0.25	0.08

3. Methodology

3.1 Taguchi Method:

Taguchi method is the process of engineering optimization in a three step approach namely system design, parameter design and tolerance design. In the system design, a basic functional prototype design will be produced by applying scientific and engineering knowledge. In parameter design, independent process parameter values will be optimized and where as in tolerance design, tolerances will be determined and analyzed for optimal values set by parameter design. Taguchi method is a powerful design of experiments (DOE) tool for optimization of engineering processes.

Select the quality characteristic
↓
Select the Control factors & Noise factors
↓
Select Appropriate Orthogonal Array
↓
Conduct the Experiments Accordingly
↓
Analyzing the results; Determine optimum Factor-Level combination
↓
Predict the Optimum performance with The optimum Factor-Level combination
↓
Confirmation of Experimental Design

3.1.1 Optimal selection of process parameters

In this section, the use of the Taguchi method [4-6] to determine the process parameters in the Electric arc welding of Mild steel plate. Optimal welding process parameters with greater weld strength are determined and verified.

Table 2: Process Parameters and their levels.

Parameter	Level1	Level2	Level3
Thickness of plates (mm)	8	10	12
Carbon percentage of material.	0.4	0.6	0.8
Electrode Diameter(mm)	2.6	2.8	3.6

3.1.2Orthogonal array Experiment

In the present study, three 3-level process parameters i.e. thickness of material, carbon percentage of material and diameter of electrode are considered. The values of the welding process parameters are listed in Table 2. The ranges and levels are fixed based on the screening experiments. The interaction effect between the parameters is not considered. The total degrees of freedom of all process parameters are 8. The degrees of freedom of the orthogonal array should be greater than or at least equal to the degrees of freedom of all the process parameters. Hence, L9 (3^3) Orthogonal array was chosen which has 8 degrees of freedom. Table 3 shows the nine experiments based on L9 orthogonal array and their corresponding measured ultimate tensile strengths.

Table 3: Experiment layout of L9 Orthogonal Array

S.No.	Thickness of plates (mm)	Carbon percentage of material	Electrode Diameter (mm)	Ultimate tensile strength (kg)
1.	8	0.4	2.6	5000
2.	8	0.6	2.8	3800
3.	8	0.8	3.6	2600
4.	10	0.4	2.8	6100
5.	10	0.6	3.6	6000
6.	10	0.8	2.6	6000
7.	12	0.4	3.6	6500
8.	12	0.6	2.6	6100
9.	12	0.8	2.8	5200

4. Results & Discussion

Taguchi Analysis: ultimate tensile versus thickness of material, carbon percentage of material, rod diameter (mm).

Table 4: Response Table for Signal to Noise Ratios (larger is better)

Level	Thickness of plates(mm)	Carbon percentage of Material	Electrode Diameter (mm)
1	71.29	75.31	75.08
2	75.61	74.29	73.87
3	75.43	72.73	73.37
Delta	4.32	2.59	1.71
Rank	1	2	3

Table 4 shows the response table for signal to noise ratio for Larger the better. It can be seen that ultimate tensile strength is largely influenced by thickness of material, then by carbon percentage of material and then by electrode diameter. Same result can be seen in main effect plot for SN ratio, based on above analysis recommended thickness of material, carbon percentage and electrode diameter for maximum ultimate tensile strength are 10 mm, 0.4% and 2.6 mm respectively.Fig-2 shows that graph between SN ratio, thickness of material, carbon percentage, and electrode diameter. As shown in figure in the first graph SN ratio is maximum at 10mm thickness of material, in second graph SN ratio is maximum at 0.4% carbon percentage of material and in third graph SN ratio is maximum at 2.6mm electrode diameter.

4.1 Analysis of variance (ANOVA)

The purpose of the ANOVA [7-9] is to investigate which welding process parameter has significantly affected the tensile strength. The results of ANOVA are shown in Table 5. This is accomplished by separating the total variability of the S/N Ratios, which is measured by the sum of squared deviations from the total mean of the S/N ratio, into contributions by each welding process parameter and the error. The percentage contribution by each of the welding process parameters in the total sum of the squared deviations can be used to evaluate the importance of the process parameter change on the quality characteristic.

Table.5.Result of the ANOVA

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Thickness of plates(mm)	2	9548889	9548889	4774444	20.36	0.047
Corbon % of material	2	2415556	2415556	1207778	5.15	0.163
Electrode diameter(mm)	2	888889	888889	444444	1.90	0.345
Error	2	468889	468889	234444		
Total	8	13322222				

From the ANOVA result, the percentage contribution of the p value of thickness of plates is less than 0.05, compared with the other welding parameters.

4.2 Confirmation tests

Since the optimal level of the process parameters has been selected, the final step is to predict and verify the improvement of the ultimate tensile strength using the optimal setting of the process parameters. The estimated S/N ratios for the ultimate tensile strength using the optimal combination were determined by **Minitab-15 software**. The calculated results are shown in Table 6.

Table 6: Calculated results by Predicted Vs Experimental value

S. No	Thickness of material (mm)	Carbon Percentage of Material	Electrode Diameter	Predicted SN ratio	Experimental SN ratio
1	10	0.4	2.6	77.78	70.85

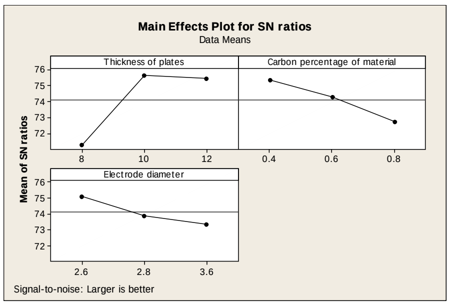

Fig-2: Graph between SN ratio, Thickness of material, Carbon % and Electrode Diameter

Conclusion:

The tensile strength of the mild steel welded plates is measured in the Universal Testing Machine (UTM). Taguchi analysis for optimization of ultimate tensile strength is applied and found to be satisfactory.It has been found that ultimate tensile strength is largely influenced by thickness of material.The optimum setting of selected parameters i.e. thickness of material, carbon percentage of material and electrode diameter are 10mm, 0.4%, 2.6mm respectively.The ultimate tensile stength obtained in above setting of parameters in conformation exeperiment is 7000 kg which is very large as compared to ultimate tensile strength recorded based on L9 orthogonal array.

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