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Investigating the Effect of Process Parameters in Manual Metal Arc Welding for Joining Dissimilar Metals

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Abstract: ***In this research work, two dissimilar metals are welded to get optimum weld deposition rate with high weld strength by optimizing input process parameters. In manual metal arc welding input process parameters are taken as welding current, welding speed, root gap, electrode angle. Dissimilar metals are low carbon steel and stainless steel 304L. Taguchi L9 array is used for conducting the experiment and results obtained through experiments are used for deciding levels for optimization.***

Keywords: Metal Deposition rate, Manual Meta Arc Welding, Taguchi, Weld strength

1. Introduction

Welding is a manufacturing process by which fusion of surfaces two different or same material of part are joined together with or without the application of heat, pressure and a filler material. Many times in industries instead of riveting, casting and nut bolt welding is preferred over these because of its efficiency, faster, quieter, easy joining process.

Welding process is classified in two main groups: pressure welding, in which the joined is achieved by pressure; and heat welding in which weld is achieved by heat. Most important manufacturing process for joining is arc welding which is heat –type welding used for joining structural elements for applications, automobiles, nuclear reactors pressure vessels, boilers, economizers, building structures.

Industries use welding as an alternative for casting, or replacement of rivet, joints for fabrication of automobile, aircraft, and civil engineering structure. Alloy steel is highly costly to reduce its cost it is combined with the carbon steel. These dissimilar metals are welded together by arc welding for high strength as well as for cost reduction. This objective can be achieved by optimizing the welding parameters like electrode angle, welding speed, welding current, welding voltage, root gap, arc length, type of electrode used.

2. Literature Survey

Lenin N et al [1] in this paper, manual metal arc welding of dissimilar metals like stainless steel and carbon steel are welded; the optimization of welding input process parameters for obtaining greater weld strength is done. The Taguchi method is adopted to analyze the effect of each welding process parameter on the weld strength. The experimental results are provided to illustrate the proposed approach.

Y.S. Tarng et al [2] used grey-based Taguchi methods for the optimization of process parameters in hard facing the submerged arc welding (SAW). Experimental results have shown that optimal SAW process parameters in hard facing can be determined effectively so as to improve multiple weld qualities through this new approach.

U. S. Patil et al [3] in his research work, considered multiple weld qualities of welding input process parameters for obtaining greater weld strength with optimum metal deposition rate in welding of dissimilar metals like stainless steel and Mild steel . The process used for welding is Manual Metal Arc welding and dissimilar metals used are low carbon steel and Stainless steel. Welding speed, voltage, current, electrode angle are taken as controlling variables.

Gyanendra Singh et al [4] studied Submerged Arc Welding process which finds large industrial application due to its normal applicability, high current density & ability to submit a large amount of weld metal using more than one wire in the same time. The weld quality of weld depends on bead geometry of the weld which in turned depends on the process variables. Welding input parameters play a most significant role in determining the quality of a welded joint. The joint quality can be assessed in the terms of properties such as weld-bead geometry, mechanical properties and distortion.

S. S. Sathe et al [5] aim at work is welding of dissimilar metals by the use of activated flux. Mild steel & Stainless steel which find extensive application in the field of Civil, Nuclear, Thermal Power plant etc. Taguchi method is used for optimization of process parameters. The weld specimen is subjected to tensile testing to find out qualitative properties of the weld. ANOVA helps to find out percentage contribution of each parameter & its effect verses objective function.

Edwin Raja Dhas et al [6] in this paper review of all optimization techniques is discussed which can be used for optimization of input process parameters to detect the desirable output welding. The weld parameters will vary for different welding types and are chosen according to the effect of process parameters characteristics to strength, deposition rate, bead geometry. In this experiment author discussed about only expensive machine or methods are not needed but control process parameters can give control output for the process.

Arvind Kumar Kachhoriya et al [7] studied 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. He used optimization method which includes selection of parameters, utilizing an orthogonal array, conducting experimental runs, data analysis, determining the optimum combination, finally the experimental verification and comparison by regression modelling.

3. Optimization of Process Parameters by Taguchi Method

When conventional experimental design techniques were applied to industrial experimentation for last few decades come across certain limitations. The optimization of process parameters and experimental design was not easy task. Number of experiment conducted for classical method is more and depending on process parameters again it go on increasing. Dr. Genichi Taguchi, a Japanese engineer, developed a new concept of robust design and design of experiment. In taguchii method optimization of process parameters is the key step to achieve high quality product with less cost. Optimum process parameters obtained from taguchii method are insensitive to environmental conditions and noise factors thus can improve the quality characteristics of product or process. Taguchii developed the orthogonal array special way of conducting experiment with entire process parameters in less number of experiments.

After conducting the experiment the optimum parameters are tested for the output result. The Taguchii method uses statistical measure of performances called as signal to noise (S/N) ratio based on the electrical control theory to analyze the results of the experiment. Signal to noise ratio is explained in simple way it is the ratio of mean (signal) to standard deviation (noise). The S/N ratio developed by the Taguchii measures the performance and helps to choose the control level of process parameters for the output. The S/N equation depends on the quality characteristic of process parameters on the output to be optimized. This quality characteristic are analyzed by S/N ratio is categories in three lower-the-better, higher-the-better and nominal-the- better. Regardless of the quality of quality characteristic, a large S/N ratio will correspond to better quality characteristic. Therefore, the optimal level of process parameters is the level with the highest S/N ratio.

4. Experimental Details

4.1 Work Material

Experiment is carried out by consuming 309L grade stainless steel electrode for joining the two dissimilar metals. This selection of the electrode is based on the industrial survey were this electrode is used for joining two dissimilar metal used for high pressure boiler, super heater, economizer. In this experiment manual metal arc welding is used for joining stainless steel 304L and mild steel.

The chemical composition of stainless steel is mentioned in the table1 and mild steel is mentioned in the table 1 as given below. The size of plate for stainless steel 100mmX50mmX3mm and for mild steel is 100mmX50mmX3mm are welded and allowed to cool at room temperatures.

Figure 1: Manual metal welding

Table 1: Chemical Properties of SS304 & Mild steel

Alloys (%)	Cr	Ni	C	Mn	S	P	Si	N
SS304	18.2	8.06	0.08	2	.03	.045	.75	.1
MS	.069	.01	.19	.8	.04	.017	.4	--

5. Optimal Selection of Process Parameters

Welding process parameters are selected on basic of effect of input process parameter's quality characteristics on the weld strength. Independently control process parameters are affecting the weld strength as well as metal deposition rate.

5.1Orthogonal Array Experiment

Experimental results are analyzed through the Taguchii method. Process parameters are welding current, welding speed, electrode angle, and root gap selected for this experiment and their levels range are decided.

Table 2: Process Parameter & level

S r	Factors	Level range
1	Welding current (Ampere)	80--180
2	Welding Speed (mm/s^2)	5--12.5
3	Electrode Angle (Degree)	30--90
4	Root gap (mm)	1--2

5.2 Experimental observation & overall Loss Function & its S/N ratio

Tensile strength of joint is measured on universal testing machine. Metal deposition rate is calculated by measuring weight of work piece before welding and after welding.
Calculations are performed by using Minitab software

Table 3: Experimental Result & Analysis of S/N Ratio

	welding current (A)	welding speed (mm/s2)	root gap (mm)	Electrode angle (degree)	welding Strength (Mpa)	SNRatio
1	80	5	1	30	466.66	53.38
2	80	8	1.5	60	413.66	52.33
3	80	12.5	2	90	374.66	51.47
4	130	5	1.5	90	429.33	52.65
5	130	8	2	30	402.66	52.09
6	130	12.5	1	60	417.33	52.4
7	150	5	2	60	302.66	49.61
8	150	8	1	90	398.66	52.01
9	150	12.5	1.5	30	401.33	52.07

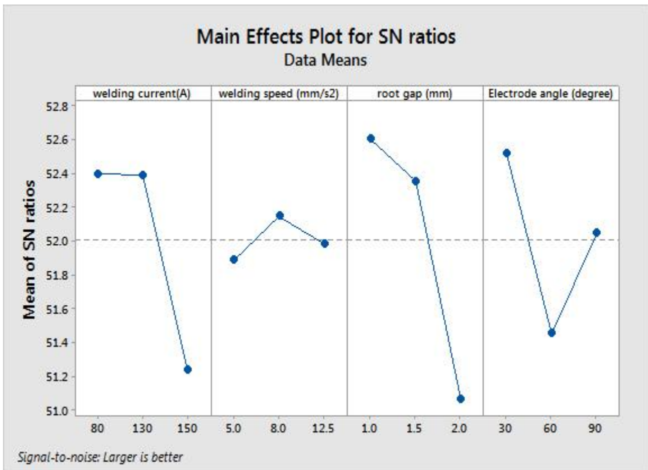

Figure 2: Effect of input process parameters on weld strength

L9 orthogonal array is used for the analysis of the experiment

After analyzing S/N response for welding strength it is clear that welding current (Ampere) at 80-130, welding Speed (mm/s^2) at 5-8, electrode angle (Degree) at 30-60 and root gap(mm) at (1-1.5) the best approach as per larger is the better. After analyzing S/N response for weld deposition rate it is clear that welding current (Ampere) is in range 80-130, welding speed (mm/s^2) at 5-8, electrode angle (Degree) at 30-60 and root gap(mm) at (1-1.5) the best approach as per smaller is the better.

Table 4: Experimental Result & Analysis of S/N Ratio

	welding current (A)	welding speed (mm/s2)	root gap (mm)	Electrode angle (degree)	Weld depostion(gms)	SNRatio
1	80	5	1	30	5.34	-14.55
2	80	8	1.5	60	3.51	-10.95
3	80	12.5	2	90	2.03	-6.14
4	130	5	1.5	90	5.39	-14.63
5	130	8	2	30	4.03	-12.1
6	130	12.5	1	60	2.42	-7.67
7	150	5	2	60	3.55	-11
8	150	8	1	90	3.11	-9.855
9	150	12.5	1.5	30	2.16	-6.68

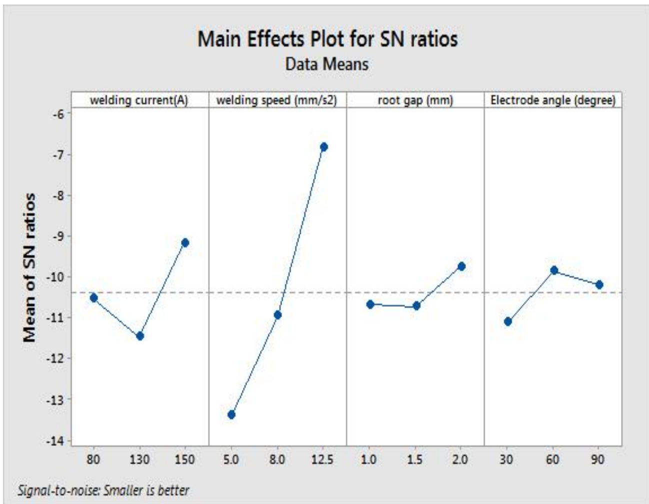

Figure 3: Effect of input process parameters on weld deposition rate

6. Conclusion

The Taguchi and DOE methods are used to find the different optimum values of process parameters for the manual metal arc welding process. From experimentation it may conclude that the optimization of MMA welding process parameter for increasing tensile strength and reducing the metal rate deposition is obtained . When welding current, welding speed , electrode angle and root gap are in optimum range as per S/N response curve then weld strength is high and metal deposition rate is low.

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