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Optimization of Process Parameters in Tig Welding of Dissimilar Metals by Using Activated Flux Powder

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Abstract: ***The welding quality is strongly characterized by the weld bead geometry; which plays an important role in determining the mechanical properties of the weld. The aim of the 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.***

Keywords: Activated Flux Coated Tungsten Inert Gas Welding, Heat input, Tensile strength

1. Introduction

1.1 Introduction of Welding

Welding is widely used by metalworkers in the fabrication, maintenance and repair of parts and structures. Generally, welding can be defined as any process in which two or more pieces of metal are joined together by the application of heat, pressure, or a combination of both. Most of the processes may be grouped into two main categories: pressure welding, in which the weld is achieved by pressure; and heat welding, which is achieved by heat. Heat welding is the most common welding used today. Arc welding, which is heat-type welding, is one of the most important manufacturing operations for the joining of structural elements for applications, including guide way for trains, ships, bridges, building structures, automobiles, and nuclear reactors, to name a few. It requires a continuous supply of either direct or alternating electric current, which create an electric arc to generate enough heat to melt the metal and form a weld.

The most widely used arc welding processes include;
• Shielded metal arc welding (SMAW),
• Gas tungsten arc welding (GTAW or TIG),
• Gas metal arc welding (GMAW),
• Submerged metal arc welding (SAW).

1.2 Tungsten Inert Gas Welding

Tungsten inert gas welding (TIG) is a form of shielded metal arc welding. However, in tungsten inert gas welding, the electrode is used only for creating the arc. The electrode is not consumed in the weld as in the shielded metal-arc process. The basic TIG process involves an intense arc between the base metal and a tungsten electrode. The arc, the electrode, and the weld zone are surrounded by an inert gas (i.e. either helium or argon or a mixture of the two as usual) that displaces the air and eliminates the possibility of weld contamination by the oxygen and nitrogen present in the atmosphere. The high melting point of tungsten electrode made it virtually non-consumable. Nowadays, TIG welding has become an indispensable tool for many industries since high-quality welds are produced with low equipment costs. A modified Tig welding process that uses flux compound such as oxides, chlorides, is used to overcome the limitation like edge preparation, Single pass operation can be used

2. Literature Review

Ugur Esme et al, [1] studied Application of Taguchi method for the optimization of resistance spot welding Low carbon steel is extensively used for deep drawing of motor car bodies, motor cycle parts, and other domestic applications. Therefore, the present work was planned to optimize the resistance spot welding parameters of SAE 1010 steel sheets with different thicknesses. The level of importance of the welding parameters on the tensile shear strength is determined by using ANOVA. Based on the ANOVA method, the highly effective parameters on tensile shear strength were found as welding current and electrode force, whereas electrode diameter and welding time were less effective factors. The results showed that welding current was about two times more important than the second ranking factor (electrode force) for controlling the tensile shear strength. An optimum parameter combination for the maximum tensile shear strength was obtained by using the analysis of signal-to-noise (S/N) ratio. The confirmation tests indicated that it is possible to increase tensile shear strength significantly by using the proposed statistical technique.

S. P. Gadeawar et al, [2] Investigated Weld characteristics for a single pass TIG Welding for SS304 This paper tries to investigate the effect of process parameters like weld current, gas flow and work piece thickness on the Bead Geometry (Front width and Back width) of the welded joint. The working range of the experimentation is decided by test experiments. For joining the work piece by TIG welding for 304 stainless steel , the process parameters play an important role. During experimentation it is found that, increase in the welding current result in increase in heat input. This increased heat is utilized to melt the base metal. Similarly as thickness of the work piece increases rate of gas flow need to be increased to increase the heat diffusion rate. Increase in gas flow avoids the vaporization of the molten metal. It also increases the penetration. The increase in weld current and gas flow results in change in Bead Geometry of the welded joint which dominates the weld characteristics. The variations in the process parameters affect the mechanical properties with great extent. The effect of shielding gas flow on Bead Geometry when the current is kept constant. It is observed that for different shielding gas flow the change in Front width and Back width is observed across the weld. For lower thickness of work piece the Front width and Back width value is low ranging from 3mm to 4mm. It is observed that as thickness of the work piece increases the Front width and Back width value across the weld also increases, it is observed for 2mm thickness work piece and 3mm thickness work piece, the Front width and Back width value is ranged between 4mm to 7mm for change in shielding gas flow. For all the gas flow the value of the front width and Back width almost deviate slightly across the mean value.

Radha Raman Mishra et al, **[3]** carried out a study on tensile strength of Mig & Tig welded dissimilar joints of mild steel & stainless steel. During the study, mild steel and stainless steel of different grades were joined using TIG and MIG welding process. The tensile strength and dilution of welded joints were investigated. The main flaw which occurs in welding dissimilar material by MIG is the development of cracks during the welding, which needs more effort for achieving similar weld has by TIG welding.

R. Sathish et al, [4] carried out a study of Weld ability and Process Parameter Optimization of Dissimilar Pipe Joints Using GTAW. The following conclusions are derived from this project, the Gas flow rate is the factor that significantly contributed to a higher percentage and has greater influence on the tensile strength followed by contributions from current and bevel angle. Variation in heat input resulted in significant changes in the mechanical properties of the weld. Results show that lower heat input resulted in lower tensile strength and too high heat input also resulted in reduced tensile strength. An intermediate value of average heat input in the range of 1500 to 1600 J/mm gave the highest tensile strength.

S A Patil et al, [5] studied the optimization of process parameters for enhancing welding penetration in activated flux coated tungsten inert gas welding. During his study they were investigated that the optimum parameters for enhancing weld penetration for AISI304 steel plate 100mm*70mm*5mm* are obtained, when current is 175amp, Gas flow rate is 12.5 litter per mintute, welding speed 1.6mm/second.

Raghuvir Singh et al, [6] investigated the effect of Tig welding parameters like welding current, speed, and flux on depth of penetration & width in welding of 304l stainless steel has been studied. From study it was observed that flux used has the most significant effect on depth of penetration followed by welding current. However Sio2 flux has more significant effect on depth. Optimization was done to maximize penetration & having less bead width

N.Lenin et al, [7] optimized the welding input process parameters for obtaining greater welding strength in manual metal arc welding of dissimilar metals. The higher-the-better quality characteristic was considered in the weld strength prediction. Taguchi method was used to analyze the effect of each welding process parameters and optimal process parameters were obtained.

3. Taguchi Method for Optimization of Process Parameters

Since the last four decades, there were limitations when conventional experimental design techniques were applied to industrial experimentation. The process parameter design is a complex & not easy task Dr. Genichi Taguchi, a Japanese engineer, developed a new method that is known as orthogonal array design, which adds a new dimension to conventional experimental design. Taguchi's DOE's are denoted by 'Labc' where 'La' the orthogonal arrays of variables or design matrix, 'b' the levels of variables and 'c' numbers of variables. Taguchi method is a broadly accepted method of DOE which has proven in producing high quality products at subsequently low cost. Taguchi design only conducts the balanced (orthogonal) experimental combinations, which makes the Taguchi design even more effective than a fractional factorial design. By using the Taguchi technique, industries are able to greatly reduce product development cycle time for both design and production thus reducing costs and increasing profit. Taguchi proposed that engineering optimization of a process or product should be carried out in a three-step approach: system design, parameter design and tolerance design. Taguchi suggests two different routes for carrying out the complete analysis. In the standard approach, the results of a single run or the average of repetitive runs are processed through the main effect and ANOVA (raw data analysis). The second approach, which Taguchi strongly recommends for multiple runs is to use the Signal to- Noise (S/N) ratio for the same steps in the analysis

4. Experimental Details

4.1 Work Material

The cylindrical rods of ss304 & mild steel of length 115mm & diameter 10mm were used for final experimentation. The chemical composition is given below.

Table 1: Chemical Properties of SS304 & Mild steel

Alloys (%)	Cr	Ni	C	Mn	S	P	Si	N
SS304	18.22	8.06	0.08	2	0.03	0.045	0.75	0.1
Mild steel	0.069	0.01	0.19	0.8	0.04	0.017	0.4	-

4.2 Selection of Activated Flux Powder

Tio2, CaO, Sio2, Cr2O3, flux powder are used & a paste is prepared by the use of Acetone, Which is applied on Work piece prior to Tig welding, & Trial experiment are performed to select correct flux powder. The results obtained during trail experimentation are as follows.

Table 2: Result of trial for various flux powder

Sr no.	Sample	Ultimate tensile strength in MPA
1	Uncoated	420
2	Tio2	430
3	Cr2O3	437
4	Al2O3	432
5	CaO	428
6	Sio2	457

Sio2 powder is selected as Activated flux powder for coating as it gives good result compare to other.

5. Optimal Selection of Process Parameters

Welding process parameters are selected from the list of quality characteristic effecting parameter such as welding current, speed, gas flow rate, welding torch angle, nozzle to tip distance by performing one variable at a time approach

5.1 Orthogonal Array Experiment

Process parameters are welding current, gas flow rate, welding speed

Table 3: Process Parameter & There Level

S. NO	Parameter	Level1	Level2	Level3
1	Welding Current (Amp)	150	175	200
2	Gas Flow Rate (LPM)	10	12.5	15
3	Welding Speed (mm/s)	6.66	3.33	1.66

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

The Tensile strength is measured in Universal Testing Machine. & the results are found as follows.

Table 6: Experimental Result & Analysis of S/N Ratio

Sr No	Current (Amp)	Gas Flow Rate (LPM)	Welding Speed (mm/s)	UTS(MPA)	S/N ratio
1	150	10	6.66	400.8	52.0586
2	150	12.5	3.33	401.76	52.0793
3	150	15	1.66	398.5	52.0086
4	175	10	3.33	408.7	52.2281
5	175	12.5	1.66	409.25	52.2398
6	175	15	6.66	424.95	52.5668
7	200	10	1.66	392.5	51.8768
8	200	12.5	6.66	405.2	52.1534
9	200	15	3.33	406.25	52.1759

After Analyzing S/N Response it is clear that Welding current at Level2, Gas flow rate at level3, & welding speed at level1 are the best approach as per larger is the better

5.3 Analysis of Variable

The relative importance of the different welding parameter with respect to tensile strength of weld was investigate to determine more accurately the optimum combination of the welding parameters by using ANOVA. The result of ANOVA are presented in table no 5

Table 5: Analysis of S/N Ratio

Source	DF	Adj SS	Adj MS	F-Value	P-value
current	2	0.164325	0.082163	54.58	0.018
Gas flow rate	2	0.057626	0.028813	19.14	0.050
Welding Speed	2	0.07141	0.035705	23.72	0.04
Error	2	0.003011	0.001505		
Total	8	0.296373			

The model F value indicates that model is significant. Value of “Prob>F” less than 0.0500 indicate that model term are significant. The value above 0.100 indicates that model is not significant. In this case Welding Current, Gas Flow Rate & Welding Speed are significant parameter. With above parameter confirmation test is performed. Calculation are performed by the use Minitab software

6. Conclusion

From experimentation it may conclude that the optimization of welding process parameter for increasing Tensile Strength is obtained with SiO2 Activated flux powder. When welding current at Level2, Gas flow rate at level3, & welding speed at level1. & From ANOVA it is clear that above parameters are significant.

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