Optimization of Welding Parameters on Mechanical Properties of Dissimilar Metal Welds Using GTAW Process.

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***Abstract*— Tungsten Inert Gas (TIG) welding also known as GTAW (Gas Tungsten Arc Welding) is highly used fabrication process to join metals. Dissimilar material welding is complex technique due to difference in chemical and thermal properties. The purpose of this research work is to obtain perfect process parameters using Gas Tungsten Arc Welding for dissimilar metals. Study the mechanical properties of weld joint and optimizing process parameters so as to achieve optimum weld strength and micro hardness. With control over welding parameters such as root gap, joint angle, welding current, etc. The experiment is done by setting the parameters range based on trial experiments and studying research paper. The DOE (Design of Experiment) method used for the experiments is Response Surface method (RSM) with Central Composite Design (CCD). The DOE are designed by MINITAB software. The readings for UTS and micro hardness are noted of the weld joint. Moreover microstructure will be performed to examine microscopic description of the individual constituent of material. Optimization of process parameters will be been carried out using the Response Surface Methodology (RSM).**

***IndexTerms*—GTAW, Dissimilar Welding, AISI 316**

I. Introduction

An electric arc between an electrode and a workpiece or between two electrodes is utilized to heat to be welded. Most of these processes use some shielding gas while others employ fluxes or coating to protect the weld pool from the ill effect of the surrounding atmosphere. In such welding processes the power supply could be AC/DC, the electrode could be consumable or non-consumable and a filler material may or may not be added.Welding of dissimilar metals is the joining of metals by different welding processes which has different physical, chemical and metallurgical properties. Different kinds of metals feature with different physical, chemical, and metallurgical properties. Some are more resistible to corrosion, some are stronger, and some are lighter, so this area got priority among the engineering industry.

II. LITERATURE REVIEW

Mehdi Rahmani, Abbas Eghlimi, and MortezaShamanian used to study the effect of chemical composition on microstructural features and mechanical properties of dissimilar joints between super duplex stainless steel (alloy 2507) and austenitic stainless steel (AISI 304L), welding was attempted by gas tungsten arc welding process with a super duplex (ER2594) and an austenitic (ER309LMo) stainless steel filler metal. The input process para meters were current, voltage, welding speed and heat input. The ferrite content of samples was measured using Clemex Vision image analysis point counting software and also a Fisher FMP30 ferrite-scope and Microhardness was measured using a Vickers hardness tester. The fracture surfaces were examined by a Philips scanning electron microscope

S. Pandit, V. Joshi, M. Agrawal, M. Manikandan, K. D. Ramkumar, N. Arivazhagan, S. Narayanan was investigates the weldability of dissimilar metals (Monel 400 and Hastelloy C276) by Gas Tungsten Arc Welding technique employing ERNiCrMo-3 filler wire. The studies were carried out to characterize the weldments.

P. Bharath,V.G. Sridhar, M. Senthilkumar presents Optimization of 316 Stainless Steel Weld Joint Characteristics using Taguchi Technique with objective of this research is used to determine the influence of various welding parameters on the weld bead of AISI 316 welded joint. The result shows that speed is most influencing factor to have highest bend strength and current that is to be used while welding is the most influencing factor to get higher tensile strength.

III. Objective

The aim of this dissertation work is to obtain optimum process parameters for dissimilar metals welding using Gas Tungsten Arc Welding (GTAW) process. Study the metallurgical and mechanical properties of weld joint and optimizing process parameters so as to achieve optimum weld strength. Thus, it is proposed to optimization problem and solved utilizing a Response Surface Methodology (RSM) with a penalty function approach.

IV. Methodology Adopted

The experimental setup contained of semi-automatic welding machine with control over welding parameters such as root gap, welding current, joint angle, etc. The experiment was done using set or controlled process parameters based on trial exp. In dept knowledge of process parameters from research paper.

The DOE method applied for the experiments is Response Surface method (RSM) with Central Composite Design (CCD). The DOE will be prepared using MINITAB software.

The experimental readings will be then taken like ultimate tensile strength and micro-hardness of the weld joint. Moreover microstructure will be performed to examine microscopic description of the individual constituent of material, and macrostructure inspection will be performed to examine of weld quality

V. Experimentation

The experiments have been conducted using a Unitor UWI 400 Power Source . In this automated Gas Tungsten Arc Welding torch as well as automatic filler wires feeding units is provided. For experimentation, servo motors are used to maintain speed. It gives good weld rather manual moving of the torch. While using automated TIG torch welding speed can be set to specific value directly on this machine.

- Material

Material	C	Cr		Fe		Mn	Ni		P	S	Si
	Max	Min.	Max.	Min.	Max.	Max	Min.	Max.	Max	Max	Max
AISI 316	0.08	16	18	66.3	74	2	10	14	0.045	0.03	1

Table.1: Chemical Composition of AISI 316

Material	Tin	Phosphorus	Iron	Copper
Copper base	0.004	0.041	0.003	99.931

Table.2 : Chemical composition of pure copper

VI. Design of Experiment

A scientific approach to plan the experiments is a necessity for efficient conduct of experiments.. An experiment design must satisfy two objectives:

1. The number of trials must be determined
2. The conditions for each trial must be specified.

Factors	Notation	Levels		
		-1	0	+1
Root Gap (mm)	RG	1.5	2	2.5
Joint Angle (°)	JA	60	75	90
Welding Current (Amps)	I	150	185	220

Table.2: Factors and Levels

Std Order	Run Order	Pt Type	Blocks	Input Parameter			Output Parameter	
				Root Gap (mm) (1.5-3)	Joint Angle (°) (60°-90°)	Welding Current (Amps) (150-220)	Ultimate Tensile Strength (MPa)	Micro-hardness (HV)
15	1	0	1	2	75	185	205.000	148.125
5	2	1	1	1.5	60	220	219.563	139.256
12	3	-1	1	2	90	185	208.300	142.587
18	4	0	1	2	75	185	205.000	148.125
7	5	1	1	1.5	90	220	212.300	140.353
8	6	1	1	2.5	90	220	229.600	135.142
1	7	1	1	1.5	60	150	205.200	135.141
19	8	0	1	2	75	185	205.000	148.125
10	9	-1	1	2.5	75	185	214.700	141.021
2	10	1	1	2.5	60	150	208.100	138.032
13	11	-1	1	2	75	150	199.600	145.719
11	12	-1	1	2	60	185	213.951	142.480
20	13	0	1	2	75	185	205.000	148.125
4	14	1	1	2.5	90	150	210.800	134.214
16	15	0	1	2	75	185	205.000	148.125
17	16	0	1	2	75	185	205.000	148.125
3	17	1	1	1.5	90	150	196.300	137.745
9	18	-1	1	1.5	75	185	205.851	141.214
6	19	1	1	2.5	60	220	229.600	142.154
14	20	-1	1	2	75	220	215.300	149.012

Table.3 : Experimental Results

VII. ANALYSIS (ANOVA)

In design of experiment the result are analyzed due to one or more of the

following three objectives.

1. To figure out the best condition for the product or process,
2. To figure out the contribution of individual factors,
3. To figure out the response under optimal conditions

- **Regression Model analysis for Ultimate Tensile Strength**

The Regression equation is:

*Ultimate Tensile Strength (UTS) =350 - 33.1 RG - 3.44 JA - 0.041 C + 0.212 RG*JA + 0.0487 RG*C - 0.000253 JA*C + 3.40 RGSQ+ 0.0193 JASQ + 0.000540 CSQ*

Predictor	Coef	SE Coef	T	P
Constant	350.50	23.81	14.72	0.000
RG	-33.053	8.225	-4.02	0.002
JA	-3.4376	0.5365	-6.41	0.000
C	-0.0413	0.2406	-0.17	0.867

S = 1.25670 R-Sq = 98.9% R-Sq(adj) = 97.9%

- **Regression Model analysis for Micro hardness of Weld (HV)**
  - The Regression equation is:

Microhardness of Weld (HV)= - 63.4 + 65.7 RG + 3.52 JA + 0.046 C - 0.163 RG*JA- 0.00823 RG*C - 0.00112 JA*C - 11.6 RGSQ - 0.0200 JASQ+ 0.000267 CSQ

Predictor	Coef	SE Coef	T	P
Constant	-63.41	12.80	-4.95	0.001
RG	65.704	4.424	14.85	0.000
JA	3.5231	0.2885	12.21	0.000
C	0.0463	0.1294	0.36	0.728

S = 0.675890 R-Sq = 99.0% R-Sq(adj) = 98.2%

VIII. OPTIMIZATION AND VALIDATION

Optimization is a mathematical discipline that concerns the finding of minima and maxima of functions, subject to so-called constraints.

Constraint programming is a solution technique that developed out of programming language research and artificial intelligence. It employs specialized algorithms in the general framework of tree search, and has been successfully applied to production scheduling problems.

One of the most important aims of experiments related to welding is to achieve optimum value of Ultimate Tensile Strength and Microhardness. The Response Surface optimization is a technique for determining best welding parameter combination. Here goal is to maximize UTS and minimize Microhardness.

Parameters	Goal	Optimum Combination			Lower	Target	Upper	Predicted Response
		Root Gape	Joint Angle	Current				
Ultimate Tensile Strength	Maxi-mum	1.5	60	220	196.3	229.6	229.6	220.551
Micro-hardness	Mini-mum	1.5	60	220	134.214	134.214	149.012	139.188

Table 4: Composite Response Optimization for process parameter
Composite Desirability = 0.695318

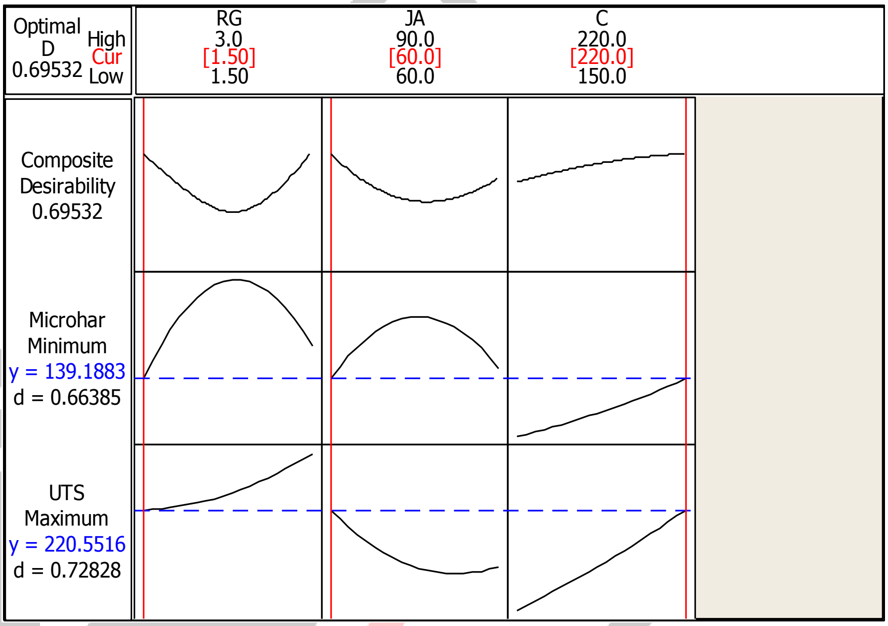

Fig. Composite Optimization Plot of UTS, Microhardness

➢ Validation through practical experiment

The results obtained through optimization had to be validated. This was done through practical performance of the experiment in the same manner as the practicals performed earlier as per DOE. The results are tabulated as under:

Input Parameters	Value	Predicted values of output parameters		Actual obtained values of output parameters		% Error
		UTS (Mpa)	Microhardness (HV)	UTS (MPa)	Microhardness (HV)	
Root Gap	1.5 mm	220.552	139.188	229.6	134.214	4%
Joint Angle	60°					
Current	220 Amps					

IX. CONCLUSION

Conclusion of the work is as followed.

1. Successfully welds of copper and AISI 316 Stainless Steel could be obtained satisfactory value. Such as UTS is 229.600 and Microhardness is 134.214.

Effect of root gap: There is a slight decrease with increase in ultimate tensile strength when root gap is higher side
Effect of joint angle: When there're is donward with upward in ultimate tensile strength with increase in joint angle
Effect of welding current: Ultimate tensile strength increase with increase in current

2.Effect of process parameters on Microhardness was concluded as under :

Effect of root gap: There is a increase with decrease in microhardness of weld with the increase in root gap
Effect of joint angle: There is a increase with decrease microhardness of weld with increase in joint angle
Effect of welding current: There is a increase with decrease microhardness of weld with increase in current

3.The formation of steel globules in copper matrix and copper globules in steel matrix in the fusion zone.

4.There were some steel globules in the fusion zone and delta ferrite phase in the austenite grain boundaries at the SS side.

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