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WELDABILITY STUDY AND IMPROVEMENT IN WELD STRENGTH OF ALUMINIUM ALLOY

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Abstract: *This paper explores the weldability of 6063 T6 Aluminium Alloy using Response Surface Methodology (RSM) as the Design of Experiment. The study aims to investigate the influence of various welding parameters like Peak Current and Pulse-on-time on the quality of welds on the aluminium alloy and optimize these parameters to achieve desirable weld characteristics. The research utilizes RSM to develop mathematical models that can predict the weld quality based on the welding parameters. The findings of this study can contribute to enhancing the understanding of aluminium alloy weldability and provide insights for optimizing welding processes in industrial applications.*

Keywords*: Welding, PCTIG, RSM, Design of Experiment, Optimization, Weld Strength.*

Introduction

Aluminium and its alloys have been used in recent times due to their light weight, moderate strength and good corrosion resistance. Aluminum alloy has been researched upon especially as a potential candidate for industrial material. This alloy is difficult to weld using conventional welding techniques like Arc Welding. An attempt has been made in this paper to weld Aluminium alloy using PCTIG Welding. This study aims in evaluating and selecting the best intense energy welding process to produce weld strength aluminum alloy joints for industrial application by using the Response Surface Methodology (RSM).[1] Various values obtained for optimal PCTIG welding parameters namely, peak current and pulse on time were 160A and 60A respectively.

PCTIG welding process parameters Table No. 1:

Factors	Level 1 (-1)	Level 2 (0)	Level 3 (+1)
Peak Current (Amp)	140	150	160
Pulse on Time (%)	40	50	60

Design of Experiment

Design of Experiments (DOE) is a powerful statistical tool used to systematically design and analyze experiments to identify the significant factors that influence a response variable. In this experimental work Response Surface Methodology (RSM) is used as the DOE. It is a subset of DOE that is used to optimize a response variable by exploring the relationship between the response and the factors that affect it.

The RSM is used to find the optimal combination of factors that will produce the best response. It involves creating a mathematical model that relates the response to the factors, and then using this model to predict the response for different combinations of factor levels. The goal is to find the factor levels that give the maximum or minimum response.

Developing the experimental design matrix Table No. 2:

Experimental runs were conducted using three factors and three levels. Response Surface Methodology (RSM) was used to design thirteen experiments. Various conditions are presented in Table.2

Sl. No.	Run Order	Peak Current (Amp)	Pulse on Time (%)
1.	4	-1	-1
2.	3	+1	-1
3.	9	-1	+1
4.	5	+1	+1
5.	13	-1	0
6.	7	+1	0
7.	1	0	-1
8.	6	0	+1
9.	12	0	0
10.	2	0	0
11.	11	0	0
12.	8	0	0
13.	10	0	0

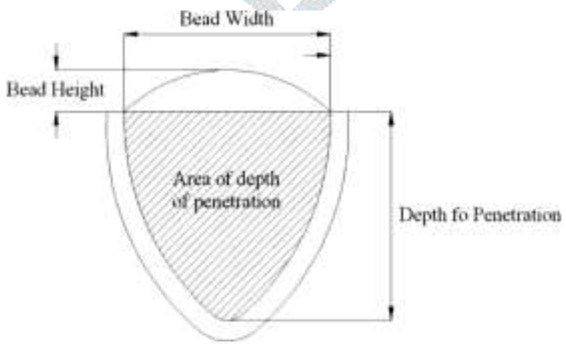
Experimental setup

Pulsed current Tungsten Inert Gas Welding is a multi-factor metal fabrication technique. Various process parameters influencing weld bead geometry. Here take welding parameters are pulse on time and peak current varied at three levels. To search optimal process conditions through a limited number of experimental runs, the present study has been planned to use four conventional process parameters viz. ultimate tensile strength, depth of penetration, bead width and height of reinforcement. Response surface methodology 13 trial has been selected for experimental runs. Design matrix has been selected based on Response surface methodology consisting of 13 sets. Experiments have been conducted with these process parameters to obtain butt joint of two Aluminium alloy 6063 T6 sheet by PCTIG welding.

Tensile test was conducted using a computer controlled universal testing machine. All the welded specimens were failed in the weld region. The ultimate tensile strength of the weld joint is the strength of the weld. Ultimate tensile strength (MPa), of the tensile specimens was measured.

Experimental procedure

Parameters to be considered: in welding two parameters that is peak current and pulse on time have the maximum influence on ultimate tensile strength, depth of penetration, height of reinforcement and weld bead. Through experimental investigation and attempts will be made to find out the range of parameters which will have maximum influence on the desired weld output. Through optimization tool using Response Surface Methodology (RSM), the desired weld parameters will be selected.



Schematic sketch of TIG weld bead geometry

Result

Ultimate Tensile Strength

Table no. 3: Measured value of Ultimate Tensile Strength

Sl. No.	Run Order	Coded Value	Coded Value	Peak Current (Amp)	Pulse on Time (%)	Ultimate Tensile Strength (MPa)
1.	4	-1	-1	140	40	125.01
2.	3	+1	-1	160	40	93.54
3.	9	-1	+1	140	60	105.13
4.	5	+1	+1	160	60	113.51
5.	13	-1	0	140	50	137.90
6.	7	+1	0	160	50	100.32
7.	1	0	-1	150	40	109.23
8.	6	0	+1	150	60	126.61
9.	12	0	0	150	50	97.17
10.	2	0	0	150	50	91.04
11.	11	0	0	150	50	99.02
12.	8	0	0	150	50	114.78
13.	10	0	0	150	50	92.93

At approximately Peak Current of 150 Amp and Pulse on Time of 40%, the Ultimate Tensile Strength is within the range of 155 MPa

Depth of Penetration

Table no. 4: Measured value of Depth of Penetration

Sl. No.	Run Order	Coded Value	Coded Value	Peak Current (Amp)	Pulse on Time (%)	Depth of Penetration (mm)
1.	4	-1	-1	140	40	1.95
2.	3	+1	-1	160	40	2.22
3.	9	-1	+1	140	60	1.26
4.	5	+1	+1	160	60	4.96
5.	13	-1	0	140	50	5.02
6.	7	+1	0	160	50	2.05
7.	1	0	-1	150	40	3.96
8.	6	0	+1	150	60	4.63
9.	12	0	0	150	50	3.36
10.	2	0	0	150	50	4.47
11.	11	0	0	150	50	3.49
12.	8	0	0	150	50	3.10
13.	10	0	0	150	50	3.60

At approximately Peak Current of 150 Amp and Pulse on Time of 40%, the Depth of Penetration is within the range of 3.96 mm.

Height of Reinforcement

Table no. 5: Measured value of Height of Reinforcement

Sl. No.	Run Order	Coded Value	Coded Value	Peak Current (Amp)	Pulse on Time (%)	Height of Reinforcement (mm)
1.	4	-1	-1	140	40	2.42
2.	3	+1	-1	160	40	2.45
3.	9	-1	+1	140	60	3.20
4.	5	+1	+1	160	60	3.21
5.	13	-1	0	140	50	2.29
6.	7	+1	0	160	50	2.36
7.	1	0	-1	150	40	3.23
8.	6	0	+1	150	60	2.66
9.	12	0	0	150	50	2.23
10.	2	0	0	150	50	3.04
11.	11	0	0	150	50	3.12
12.	8	0	0	150	50	2.63
13.	10	0	0	150	50	3.30

At approximately Peak Current of 150 Amp and Pulse on Time of 40%, the Height of Reinforcement is within the range of 3.23 mm.

Bead Width

Table no. 6: Measured value of Bead Width

At

Sl. No.	Run Order	Coded Value	Coded Value	Peak Current (Amp)	Pulse on Time (%)	Bead Width (mm)
1.	4	-1	-1	140	40	10.22
2.	3	+1	-1	160	40	10.23
3.	9	-1	+1	140	60	9.80
4.	5	+1	+1	160	60	9.38
5.	13	-1	0	140	50	8.76
6.	7	+1	0	160	50	8.10
7.	1	0	-1	150	40	6.90
8.	6	0	+1	150	60	9.82
9.	12	0	0	150	50	8.58
10.	2	0	0	150	50	9.36
11.	11	0	0	150	50	8.93
12.	8	0	0	150	50	8.87
13.	10	0	0	150	50	3.60

approximately Peak Current of 150 Amp and Pulse on Time of 40%, the Bead Width is within the range of 6.90 mm.

Conclusion

Welding of aluminium alloy AA-6063 T6 has been done PCTIG Welding machine under different parameters.

- Peak Current and Pulse on time value has tabulated and compared to each other.
- It is found that with 150 Amp Peak Current, 40% Pulse on time and 155 MPa of Ultimate tensile strength gives optimum weld quality.

- In condition with 150 Amp Peak Current, 40% Pulse on time and 3.96 mm of depth of Penetration gives optimum weld quality.
- In the third condition Peak Current of 150 Amp and Pulse on Time of 40% and the Height of Reinforcement is 3.23 mm give optimum weld quality.
- In the last condition Peak Current of 150 Amp and Pulse on Time of 40% and the Bead Width of 6.90 mm give optimum weld quality.

The limitations of the study are acknowledged, and potential areas for future research are suggested. Overall, this thesis aims to contribute to the knowledge and understanding of aluminium alloy weldability and provide insights into optimizing welding processes using Response Surface Methodology. The findings can be valuable for industries that utilize aluminium alloys in their manufacturing processes, leading to improved weld quality and overall product performance. Further experiment needs to done in varying parameter condition to get the optimum weldability result.

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