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Process parameter optimization of submerged arc welding process

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Abstract - *The work has been considered for Sub merged arc welding to determine process parameters with weld bead properties. weld bead that determines its mechanical qualities include the heat affected zone, the width of the weld bead, the area of penetration and the height of the reinforcement. Any welding technique can only be used effectively if associated criteria that affect the quality of the weld are understood. The size of the weld bead, mechanical characteristics, temperature distribution, and microstructural alterations are all factors in the weld quality. The primary composite design technique of response surface methodology is used to generate mathematical modelling of the impact of heat transfer on the properties of the weld bead during the SAW process. Plotting on the mean value, the scatter and contour plots show good consistency*

***Key Words*: SAW, Taguchi method, Optimization, S/N ratio, ANOVA, welding parameters, Design**

1. INTRODUCTION

In the current manufacturing period, a product's value in the market is largely determined by its quality, and all manufacturing firms must make each product in a cost-effective way without sacrificing quality. Welding is the permanent connecting technique used in the fabrication industry. It is excellent, reasonably priced, and far faster than alternative methods like casting and riveting. The benefits of using SAW to fabricate circumferential joints in boilers, pipes, and pressure vessels are deep penetration, high deposition rate, fast speed, and exceptional surface quality. SAW is also used to develop parts and overlap with stainless steel for rail car wheels, mining, construction, and agricultural equipment, as well as rollers for continuous casting steel. The bead's geometry determines the quality of the weld. The important characteristics of weld bead geometry are the depth of penetration, height of reinforcement, and width of the weld bead. Therefore, it is imperative to develop a mathematical model based on the input setup parameters in order to evaluate the quantitative value or relationship between them and the weld bead properties in submerged arc welding. The input setting parameters, such as welding current, welding voltage, welding speed, and nozzle to plate distance, define the sound weld shape. Submerged arc welding is preferred due to its high melting efficiency, high production rate, ease of robotization, and minimal operator skill requirements. Scientists and researchers working in the fields of SAW and various aspects of the fusion welding process have produced a variety of works that have been discussed.

2 Qualities of weld deposited are determined by following

Parameters

- ✓ Welding current
- ✓ Welding arc voltage
- ✓ Electrodes stick out
- ✓ Grade of wire
- ✓ Travel speed
- ✓ Size of electrode
- ✓ Flux layer depth
- ✓ Wire feed rate

3 WELDING PARAMETER AND ITS LEVEL

Table 1Welding parameter and its level

	Level		
Parameter	L1	L2	L3
Welding Current (AM)	355	430	480
Voltage	28	30	34
Speed	250	275	300
Electrode stick out	20	21	22

Test specimen

EXPERIMENTAL SET-UPS

- Welding Records
- Welding process: SAW
- Welding Position: 1G
- Material: S355J0
- Electrode Flux: EM12K+7A5
- Diameter: 4.00mm
- Size of test plate: 20 X 300 X 500

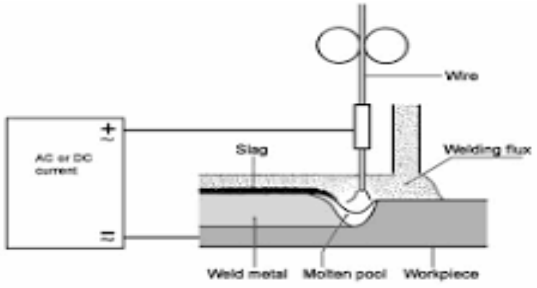


Figure 1 : saw Welding

SAW operation

EXPERIMENT VALUE						
Layers	Electrode	Volt(Volts)	Current (Amps)	Travel speed (mm/min)	Heat input KI/MM	Pre-Heat Temp .0C
1ST SIDEWELDING						
Run·l	EM12K	28	350	300	1.96	20
Run·2	EM12K	30	400	275	2.618	100
Run-3	EM12K	30	4Z5	275	2.782	100
Run·4	EM12K	32	450	300	2.88	150
Run-5	EM12K	34	450	300	3.06	200
2ND SIDE WELDING AFTER BACK GRINDING						
Run·l	EMl2K	30	425	300	2.55	18
Run·2	EMl2K	34	425	275	3.153	100
Run·3	EMl2K	34	450	300	3.06	100
Run·4	EMl2K	34	475	300	3.23	150

MEASURED VALUE							
RUN	WELDING CURRENT	VOLTAGE	SPEED	STD	BEAD WIDTH	PENETRATION	HARDNESS
1	350	28	250	20	15	3	63
2	350	30	275	21	18	4	66
3	350	34	300	22	20	6	65
4	425	28	275	22	19	9	56
5	425	30	300	20	20	12	61
6	425	34	250	21	24	15	67
7	475	28	300	21	20	17	71
8	475	30	250	22	21	18	68
9	475	34	275	20	24	20	68

The signal-to-noise ratio of a random variable (S) to random noise N is:[1]

$$\mathrm{SNR} = \frac{\mathrm{E}[S^2]}{\mathrm{E}[N^2]},$$

where E refers to the expected value, which in this case is **the mean square** of N.

If the signal is simply a constant value of s, this equation simplifies to:

$$\mathrm{SNR} = \frac{s^2}{\mathrm{E}[N^2]}.$$

Orthogonal Array experiment								
Run	current	voltage	Speed	Stick out	penetration	Hardness	bead width	SNRA1
1	350	28	250	20	3	63	15	14.4528
2	350	30	275	21	4	66.30	18	16.5880
3	350	34	300	22	6	64.65	20	19.9258
4	425	28	275	22	9	55.80	19	22.8856
5	425	30	300	20	12	61.27	20	24.8987
6	425	34	250	21	15	67.25	24	26.7083
7	475	28	300	21	17	71.23	20	26.8773
8	475	30	250	22	18	68.21	21	27.3135
9	475	34	275	20	20	67.55	24	28.2825

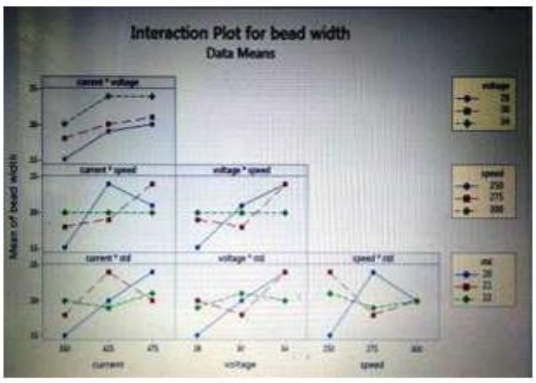
MINITAB software is used for analysis of variation. The table displays the ANOVA results for weld bead penetration, hardness, and width. Examination of the width, hardness, and penetration using ANOVA reveals that the welding process parameters that have the most effects on the weld bead's width, hardness, and penetration are welding current and arc voltage. ANOVA is often performed to determine whether the results fall within a 95% confidence level. MINITAB software is used for analysis of variation. Table displays the ANOVA table for weld bead penetration, hardness, and breadth. Bead width analysis using ANOVA demonstrates that the key welding process parameters that influence the width of the weld bead, hardness, and penetration are welding current and arc voltage. ANOVA is also performed for additional weld characteristics, revealing that welding current significantly influences weld bead width and hardness whereas electrode stick out has a negligible impact on these parameters. Arc voltage has a minor impact on the depth of bead penetration, but welding speed and welding current have a significant impact. Weld parameters are little affected by electrode stick out. The experiment's confirmation revealed that the experimental findings fall within the Weld bead width and hardness are mostly influenced by welding current, while electrode stick out has a slight impact on both. Arc voltage has a minor impact on the depth of bead penetration, but welding speed and welding current have a significant impact. Weld parameters are little affected by electrode stick out.

Optimum parameters

Level	current	voltage	speed	Electrode stick out
1	16.88	21.3	22.72	22.44
2	24.83	22.93	22.59	23.39
3	27.49	24.97	239	23.37
Delta	10.61	367	1.32	095
Rank	1	2	3	4

Optimum parameters for bead width, maximum hardness and better penetration are current at low level (16.88A) Voltage at low level (21.3 V) speed at low level(22.72mm/s) and electrode stick out at low level is22.44mm

8. Result and discussion



The Taguchi approach of experiment design optimizes the cost-effective arrangement of welding experiments. According to the ANOVA results, welding current and arc voltage are the important welding process variables that impact the hardness and breadth of the weld beads. Using input variables, the output values for MINITAB17's bead width, hardness, and penetration are computed.

9. Conclusion

Optimum parameters for bead width, maximum hardness and better penetration are current at low level (16.88A) Voltage at low level (21.3 V) speed at low level(22.72mm/s) Future research can be expanded by creating and examining a number of Methods such as genetic algorithms, flux density influence, HAZ research, and microstructure can be used to optimize process parameters.

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