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EFFECT OF PERFORMANCE PARAMETERS WITH DIFFERENT FLUX COMPOSITION ON WELD BEAD GEOMETRY DURING SUBMERGED ARC WELDING (SAW) OF STEEL

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ABSTRACT

The present work is an attempt to study the effect of flux (basicity index) on the tensile strength, micro hardness, micro structure of high strength low alloy (IS 2062) weld made during the submerged arc welding. The effect of different kind of fluxes by keeping the welding current, welding voltage and travel speed constant has been evaluated for high strength low alloy (IS 2062) steel.

A combined approach for experimental and analytical method is used. The effect of all the input parameters on the output responses have been analyzed using the analysis of variance (ANOVA). The effect of variation of input parameters has been studied on the microstructure of heat affected zone (HAZ). Plots of significant factors and S/N ratio have been used to determine the best-fit relationship between the response and the model parameters.

KEYWORDS: Image segmentation, Watershed transform, and Fluid Vector Flow.

INTRODUCTION

Submerged arc welding (SAW) is a common arc welding process. It requires a continuously fed consumable solid electrode. The molten weld and the arc zone are protected from atmospheric contamination by being "submerged" under a blanket of granular fusible flux. When molten, the flux becomes conductive, and provides a current path between the electrode and the work. The thick layer of flux completely covers the molten metal thus preventing spatter and sparks as well as suppressing the intense ultraviolet radiation and fumes. SAW is normally operated in the automatic or mechanized mode, however, semi-automatic (hand-held) SAW guns with pressurized or gravity flux feed delivery are available.

PRINCIPLE OF OPERATION

The modern submerged arc welding (SAW) is an arc welding process, in which one or more arcs formed between one or more bare wire electrodes and the work piece provides the heat for coalescence. The flux is supplied through a funnel located ahead of the filler wire which is fed continuously. The flux exercises a shielding function. During welding, part of it is converted into a readily removable slag. In fully-automatic welding, the flux is fed mechanically to the joint ahead of the arc, the wire is fed automatically to the welding head, the arc length is automatically controlled and the traverse of the arc or the work piece is also mechanized. Flux feed may be by gravity flow, through a nozzle concentric with the electrode from a small hopper a top the gun, or it may be through a concentric nozzle connected to an air-pressurized flux tank. Flux may also be applied in advance of the .welding operation or ahead of the arc from a hopper run along the joint. [1]

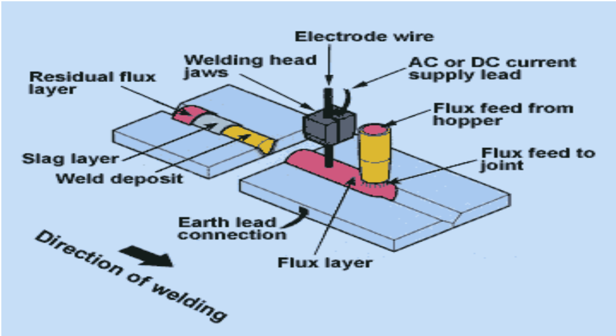

Fig. 1.1-Submerged Arc Welding Process [2]

Fig.-1.1 shows a typical setup for automatic SAW. A continuous electrode is being fed into the joint by mechanically powered drive rolls. Electrical current, which produces the arc, is supplied to the electrode through the contact tube. The current can be direct current with electrode positive (reverse polarity), with electrode negative (straight polarity), or alternating current. Fig.-1.2 shows the melting and solidification sequence of SAW. After welding is completed and the weld metal has

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solidified, the un-fused flux and slag are removed. The un-fused flux may be screened and reused. The solidified slag may be collected, crushed, resized, and blended back into new flux. Submerged arc welding is adaptable to both semiautomatic and fully automatic operation, although the latter, because of its inherent advantages, is more popular.

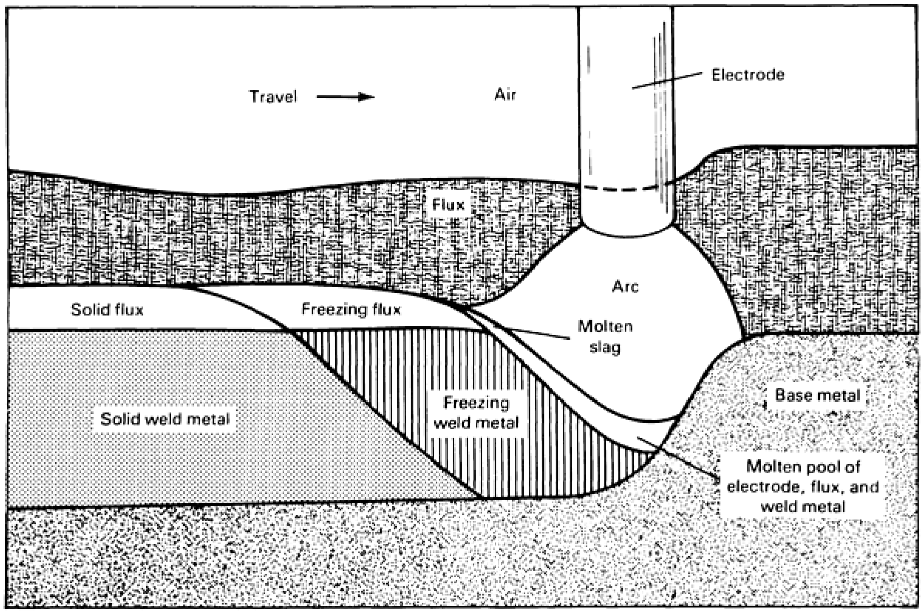

Fig. 1.2- Melting and Solidification Sequence of SAW [4]

Table 3.1 Parameters and level values used for the orthogonal array

Sr. No.	Parameters	Units	Level 1	Level 2	Level 3	Level 4
1.	Flux	-	1	2	3	4
2.	Voltage	Volt	28	32		
3.	Current	Ampere	300	350		
4.	Travel speed	m/hr	18	24		

3.1.1 D.O.F. allocated to various factor combinations

Table 3.2 D.O.F. allocated to various factor combinations

Parameters	Units	D.O.F.
Flux	-	3
Voltage	volts	1
Current	Ampere	1
Travel speed	m/hr	1
Error	_	1
Total	=	7

SELECTION OF ORTHOGONAL ARRAY

In this experimental study, four parameters are varied to three levels each in the orthogonal array of L_8. The experimental layout for the welding parameters using the L_8 orthogonal array is shown in Table 3.3.

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Table 3.3 L_8 orthogonal arrays for experimentation

Exp. No.	Flux	Voltage (V)	Current (A)	Travel speed (m/hr)
1	1	300	28	18
2	1	350	32	24
3	2	300	28	18
4	2	350	32	24
5	3	300	28	18
6	3	350	32	24
7	4	300	28	18
8	4	350	32	24

The degrees of freedom for the orthogonal array should be greater than, or at least equal to the D.O.F. of the experiment. In this study, an L_9 orthogonal array with three columns and nine rows is used.

This array has seven degrees of freedom and it can handle four process parameters. Therefore, only eight experiments are required to study the entire welding parameter space using the L_8 orthogonal array.

PREPARATION OF FLUX

For preparation of fluxes, constituting elements were weighed separately on digital weighing balance (accuracy 1mg) according to weight percentage, as per table 3.4, and then mixed thoroughly in a container with sodium silicate binder (20% by weight) for about 30 minutes to get homogeneous semi-solid mass as shown in fig. 3.1,3.2 and 3.3. Sodium silicate is added for better arc stability and binding the individual ingredients together. The solid mass was dried in air for 24 h and then baked in a muffle furnace at 750°C for nearly 1 h. After cooling, these fluxes were crushed and sieved and then kept in air tight bags.

Table 3.4 Weight %age of each flux.

Flux no.	Varied Mixture Components (% wt)	BI			
	CaO	Al2O3	CaF2	MgO	
1	10	40	10	18	1.5
2	10	18	10	40	2.5
3	35	8	25	10	3.7
4	35	23	10	10	2.1

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RESULTS & DISCUSSION

TENSILE TEST

Base metal	Maximum tensile load (kN)	Maximum tensile strength (N/mm^2)
Mild steel(IS2062)	91.68	505

Maximum tensile strength at different parameters. ANOVA for mean of tensile strength

Experiment No.	Flux	Current (A)	Voltage (V)	Travel speed (m/hr)	Maximum tensile strength (N/mm^2)
1	1	300	28	18	506
2	1	350	32	24	580
3	2	300	28	18	472
4	2	350	32	24	528
5	3	300	28	18	422
6	3	350	32	24	456
7	4	300	28	18	498
8	4	350	32	24	518

.2.3 Discussion on tensile strength
Voltage has significant effect on the tensile strength with contribution of 61.69 %, whereas travel speed and flux have insignificant effected the tensile strength with contribution of 10.28 % and 25.87 %. Tensile strength is maximum (A_3, B_1, C_3 580 N/mm^2) at voltage 34 V, travel speed 10 m\hr and flux 3. The confidence interval is 553± 36.75 N/mm^2.

HARDNESS TEST
T

Experiment No.	Flux	Current (A)	Voltage (V)	Travel speed(m/hr)	On base metal (HV)	On welding (HV)	On HAZ (HV)	Mean hardness (HV)
1	1	300	28	18	214	203	198	205
2	2	350	32	24	215	221.5	228	221.5
3	2	300	28	18	325	275	264	288
4	2	350	32	24	240	265	260	255
5	3	300	28	18	234	212	208	218
6	3	350	32	24	214.5	197	214	208.5
7	4	300	28	18	220	246	245	237.5
8	4	350	32	24	140	165	208	171.0

The result of the analysis of variance for signal to noise ratio of the hardness is shown in Table 4.9.

Discussion on hardness
Flux and voltage have significant effect on the hardness with contribution of 55.59 % and 25.37%, whereas travel speed has insignificantly effected with contribution of 17.72 %. Hardness of mild steel of grade IS 2062 will be the maximum (A_3, B_1, C_3 233 HV) when we using voltage 34 V, travel speed 10 m\hr and flux 3. The confidence interval around the estimated hardness is 226.21± 20.73HV.

CHEMICAL COMPOSITION
The chemical composition of eight samples is taken into consideration. The % age of the basic elements in the weld bead vary differently in the samples. The following table shows the composition of elements wrt. change in % age of base metal.

Table 4.12(a) Elements with their change in %age after welding.

Exp. No.	C	C in base metal	%age change in C	Mn	Mn in base metal	% age change in Mn
1	0.0815	0.14	41.78	1.267	0.800	57.37
2	0.0924	0.14	34	1.439	0.800	51.12
3	0.0603	0.14	56.92	0.9467	0.800	18.33
4	0.0758	0.14	45.85	0.7440	0.800	7
5	0.0783	0.14	44.07	1.223	0.800	48.06
6	0.0649	0.14	53.64	0.8469	0.800	5.86
7	0.0624	0.14	55.42	0.8317	0.800	3.96
8	0.0849	0.14	39.35	0.8250	0.800	3.125

Table 4.12(b)

Exp. No.	P	P in base metal	%age change in P	S	S in base metal	%age change in S
1	0.05289	0.027	95.88	0.01811	0.014	29.35
2	0.03225	0.027	18.51	0.01440	0.014	2.85
3	0.03379	0.027	25.148	0.05084	0.014	257.14
4	0.03067	0.027	13.59	0.03702	0.014	164.42
5	0.01185	0.027	56.11	0.04396	0.014	214
6	0.02946	0.027	9.11	0.05461	0.014	290
7	0.02713	0.027	0.48	0.07407	0.014	429.07
8	0.03731	0.027	38.18	0.06485	0.014	363.214

Table 4.12(c)

Exp. No.	Si	Si in base metal	%age change in Si	Exp. No.	Si	Si in base metal	%age change in Si
1	0.4166	0.124	235.96	5	0.0790	0.124	36.20
2	0.2410	0.124	94.35	6	0.1564	0.124	26.129
3	0.1423	0.124	14.75	7	0.1235	0.124	0.40
4	0.0840	0.124	32.25	8	0.1790	0.124	44.35

CONCLUSION & SCOPE FOR FUTURE

CONCLUSION

In this research work, processing time and weld bead strength is improved over base material IS 2062. The following conclusions are achieved in this research work:

The optimal value of tensile strength and hardness is on the same parameter A_3, B_1, C_3.

Weld joint strength is best after nickel metal powder addition (20%) as compared to normal weld joint strength in single pass.

Voltage has significant effect on the tensile strength with contribution of 61.69 %, whereas travel speed and flux have insignificant effected the tensile strength with contribution of 10.28 % and 25.87 %.

Flux and voltage have significant effect on the hardness with contribution of 55.59 % and 25.37%, whereas travel speed has insignificantly effected with contribution of 17.72 %.

SCOPE FOR FUTURE WORK

Although, voltage, travel speed and flux composition is varied in the research work to achieve the optimal results. Still, wide scope for future work may be in the following directions:

Other parameters such as current, electrical stick out, diameter of the electrode, etc. can be varied.

Weld bead geometry and HAZ properties can be correlated with different submerged arc welding parameters.

Specimen size and material can be varied for varied results.

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