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RECLAMATION OF SLAG AS FLUX CONSUMPTION BY THE EFFECT OF WELDING PARAMETERS IN SAW

[1] Jay Chaudhary, [2]Jogendra Kumar
[1] Department of Mechanical Engineering, SRM University ,India
[2] Department of Mechanical Engineering, Dr.APJ Abdul Kalam Technical University, India
netboyjai@gmail.com

***Abstract*— Submerged arc welding (SAW) is a common arc welding process where the total welding cost includes the cost of the flux consumed during welding. It has high deposition rate and productivityFlux used in submerged arc welding contributes a major part towards welding cost In the present work Slag generated during submerged arc welding has been recycled by mixing variousPercentages of crushed slag in virgin flux to use in subsequent runs. A 30 % slag flux mixture has been used. The influence of using flux-slag mixture on weld chemistry and appearance has been investigatedThe response surface methodology (RSM) technique has been used to the calculate runThe results indicate that the use of such a mixture in submerged arc welding does not effect the chemistry and appearance of the weld metal.**

***Index Terms* — R.S.M , Submerged Arc Welding , Weld Metal , Slag , Flux.**

I. INTRODUCTION

Submerged arc welding (SAW) is a common arc welding process where the total welding cost includes the cost of the flux consumed during welding . SAW is a very complex process that includes physical and chemical reactions. Moreover, it is very difficult to investigate the whole SAW process using numerical simulations.

However, the molten zone and heat-affected zone (HAZ)could be estimated using the finite element method (FEM) and considering just the conduction heat transfer.. still it is preferred over other methods of welding because of its inherent qualities like easy control of process variables, quality is high, deep penetration, smooth surface finish, welding of thicker sections.In submerged arc welding (SAW), the total welding cost includes the cost of the flux c o n s u m e d . S i n c e t h e d e v e l o p m e n t o f submerged arc welding process, welding engineers are striving for reduction in welding cost without compromise in the performance of the weld. [1]Wen et al. (2001) modeled multi-wire SAW of thick-wall line pipe and calculated the thermal distributions under various welding conditions [2] Mahapatra et al. (2006) predicted the temperature distributions and angular distortions in single-pass butt joints using three-dimensional simulations. Sharma et al.[3] (2009) suggested and validated a volumetric heat source model of twin-wire SAW by using different electrode diameters and polarities. [4]Kiran et al. (2010) simulated a three-dimensional heat transfer of a V-groove tandem SAW process for various welding conditions using FEM.

Response surface methodology (RSM) is a technique to determine and represent the cause and effect relationship between true mean responses and input control variables influencing the responses as a two or three dimensional hyper surface It is a set of techniques that encompasses (i) the designing of a set of experiments for adequate and reliable measurement of the true mean response of interest; (ii) the determining of mathematical model with best fits; (iii) finding the optimum set of experimental factors that produces maximum or minimum value of response; and (iv) representing the direct and interactive effects of process variables on the bead parameters through two dimensional and three dimensional graphs. The accuracy and effectiveness of an experimental program depends on careful planning and executionOf the experimental procedures.

In the present work an attempt has been made to use slag waste as a flux in submerged arc welding. Slag generated during submerged arc welding is recycled by mixing varying percentages of crushed slag with fresh flux to use in subsequent runs. The effect of operating voltage, welding current, travel speed and stick out on flux consumption was studied. These four welding parameters were used to weld IS: 2062 Mild steel plate. Flux consumption for each bead was determined.RSM technique has been used for design of experiments The mathematical models to predict and control the flux consumption in terms of welding the parameters have been developed and analyzed using ANOVA (f - test) . It was found that flux consumption increases when current, voltage & stick out increases, when increases welding speed flux consumption decreases

II. E X P E R I M E N T A T I O N PROCEDURE

For the purpose of experimenting an submersed arc welding was done on the workpiece and the slag that was generated during the process were collected and was crushed and meshed upto the granular size of the original flux and then mixed with the fresh flux in varying proportions (30%, 60% & 100%). The designing of the experiments were based on Central Composite Design (CCD) using Stat-Ease Design Expert v7.0.0 . The experiment was conducted as per the design matrix using TORNANDO SAW M-800 machine. Experimental welding bead applied on Mild Steel plate. The size of each specimen used for the experimentation were have dimension of about 300*200 mm and thickness of 10 mm.The slag collected before were mixed with ESABSA1 (E8) copper coated wire of 4 mm diameter and was used for welding. Two transverse specimens were cut f r o m e a c h w e l d m e n t a n d s t a n d a r d metallographic procedures were adopted for the process . The bead profiles were drawn using a reflective type profile projector and the parameters were measured using an accurate digital planimeter [7]. Slag as flux consumption measured by weighing flux before starting and completing of bead [8].

Flux crushed slag
Fig. 1: (Pure Flux & Crushed Slag as Flux)

III. S T E P S I N V O V L E S D U R I N G INVESTIGATION

A. Identification Of The Process Parameters

The various Process parameters were identified to carry out the experiments:

1. open-circuit Voltage (V);
2. Current (C);
3. Welding speed (S);
4. Stick out (D) .

B. Finding the upper and lower limits of the control variables

Trial runs were carried out by varying one of the process parameters and keeping the rest at constant values. The working range was decided upon by inspecting the bead for smooth appearance and the absence of any visible defects. The upper limit of a factor was coded as +2 and the lower as -2, the coded values being calculated from the following relationship given below:

$$X_i = 2[2X (X_{max} + X_{min})]$$
$$(X_{max} - X_{min})$$

Where,

X_i is the required coded value of a variable X; and X is any value of the variable from X_{min} To X_{max}. The selected process parameters with their limits, units and notations are given in Table 1 below.

Tables 1 showing process parameters with their Limits, units and notations

Parameters	Units	Levels				
		-2	-1	0	+1	+2
Current (c)	Ampere	300	350	400	450	500
Voltage (v)	Volts	20	25	30	35	40
Travel speed (s)	M/Hr	21	23	25	27	29
Stick out (d)	MM	24	26	28	30	32

1. Developing the design matrix

The selected design matrix is a design consisting of 30 sets of coded conditions. It comprises a full replication [2]. All welding parameters at the intermediate level points and the combinations of each of the welding variables at either its lowest (+2) level or highest (-2) level with the other three variables at the intermediate levels constitute the star points. Thus the 30 experimental runs allowed the estimation of the linear, quadratic and two-way interactive effects of the process parameters.

2. Conducting the experiment

The experiments were conducted as per the design matrix at random, to avoid the possibility of systematic errors infiltrating the system.

3. Development of mathematical models

The response function representing any of the weld bead dimensions can be expressed as [3].

$$Y = f (V, C, S, D)$$

The relationship is a second degree and it can be expressed as:

$$Y=b_0+b_1V+b_2C+b_3S+b_4D+b_{11}V^2+b_{22}C^2+b_{33}S^2+b_{44}D^2+b_{12}VC+b_{13}VS+b_{14}VD+b_{23}CS+b_{24}CD+b_{34}SD$$

Table 2 : shows results of experiment for various parameter

	Process Parameters				Response Factors
Standard experiment	Current	Voltage	Welding Speed	Nozzle to plate distance	Slag flux mixture composition
	(Amperes)	(Volts)	(M/Hr)	(MM)	(Gm's)
1	350	25	23	26	35
2	450	25	23	26	47
3	350	35	23	26	49
4	450	35	23	26	53
5	350	25	27	26	54
6	450	25	27	26	55
7	350	35	27	26	50
8	450	35	27	26	56
9	350	25	23	30	33
10	450	25	23	30	49
11	350	35	23	30	45
12	450	35	23	30	55
13	350	25	27	30	37
14	450	25	27	30	51
15	350	35	27	30	56
16	450	35	27	30	34

IV. RESULTS AND DISCUSSIONS

After performing the experiment it was revealed that the quadratic model is the best suggested model, also the goodness of the fitted quadratic model was also evaluated through "lack of fit test" [7].The "Probe > F" for all these tests was found in excess of 0.001, implying that the lack of fit is insignificant. So, for further analysis this model was used.The difference in effect of one variable when a second variable is changed from one to another is known as interaction effect and study of interaction effects of process variables on bead dimensions is very useful for understanding the process behavior.

CONCLUSION

From the experiment the following conclusions can be drawn:

1. Flux consumption increased with the increase in open circuit voltage and very small increases with increases in current.
2. Slag mixed in a specific proportion with flux does not affect the appearance and weld quality.
3. Welding speed has negative effect on flux consumption. Flux consumption also small decreases with the increase in nozzle to plate distance.
4. RSM can be used effectively in analyzing the cause and the effect of process used parameters on response. The RSM is also to draw contour graphs for various responses to show the interaction effects of different process parameters.

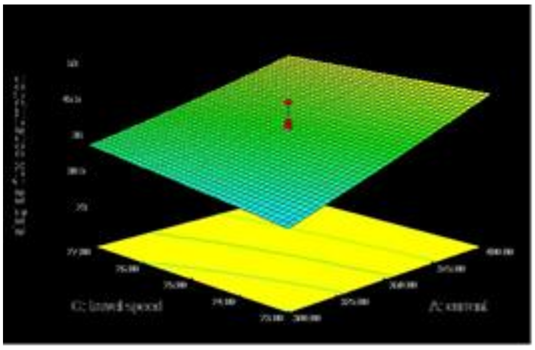

Fig. 2: 3D surface graphs for the Flux Consumption between Travel speed and current

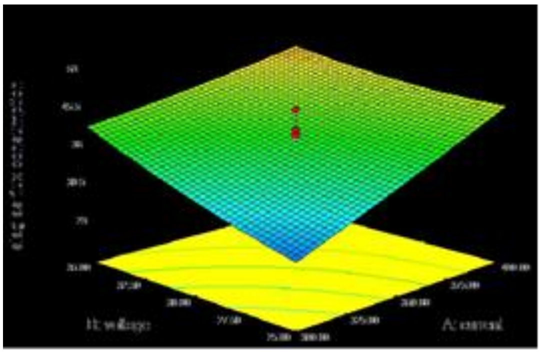

Fig. 3: 3D surface graphs for the Flux Consumption between voltage and current

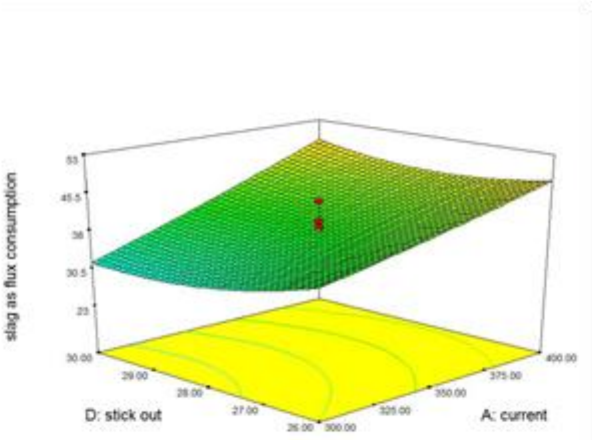

Fig. 4: 3D surface graphs for the Flux Consumption between welding speed and current.

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