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BEAD GEOMETRY OPTIMIZATION IN SUBMERGED ARC WELDING USING RESPONSE SURFACE METHODOLOGY AND GREY RELATIONAL ANALYSIS

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ABSTRACT

This study suggests an optimum flux for a good bead shape and geometry.As BG decides the load carrying capacity of the joint so an attempt has been made to design a flux for high load carrying capacity. The fluxes were designed using RSM and were made by agglomeration technique. The optimal flux composition is CaF2 2%, FeMn 8% and NiO as 2%.

Keywords **SAW, BG,RSM, Elements transfer**

I. Introduction

In submerged arc welding the arc is covered under a granular flux. The arc is maintained between the end of the electrode and the work piece. The electrode is constantly fed into the the arc as it is melted. The melting rate of the electrode and the work piece is 4-5 times larger than the shielded metal arc welding. So, it is used for welding of thick plates.SAW is widely used because the quality of the weld is very high. The quality is high because the weld has double protection from the atmospheric contamination. The slag and unused flux both provides the double protection. (Houldcroft, 1989). This welding process is used for low alloy steels, mild steels, low carbon steels as well as nickel based alloys, stainless steels and other non-ferrous metals. The properties of the welds are affected by the physical and chemical properties of fluxes. The flux should be selected in such a way that it may give a suitable bead geometry.

1.1 Bead geometrty

The weld bead geometry is represented In terms of width, reinforcement and penetration. The study of weld bead geometry or shape relationship for welds include the studies of weld bead width (W), depth of penetration (P), height of reinforcement R, weld penetration shape factor i.e. $\frac{W}{P}$ (WPSF) and weld reinforcement form factor $\frac{W}{R}$ i.e (WRFF). The dimension and shape of the weld bead decided the load carrying capacity of the joint (Raveendra and Parmar, 1987). The dimensions of the weld bead depend on both the welding process parameters and flux composition.

1.2 Weld Width And Reinforcement

Weld bead width is the maximum width of the weld metal deposited on base plate. It increases flux consumption rate and affects chemistry of weld metal. Weld width and reinforcement are important physical properties of a weldment as they help in determining the strength of a welded joint (Srihari,1992). According to Tregelsky (1968), reinforcement should usually be 20% of plate thickness. Excessive reinforcement does not improve the strength of the weld but increases weld consumption

1.3Weld Penetration

Weld penetration is the maximum distance between the base plate top surface and depth to which the fusion has taken place. The more is the penetration, the less no of passes are required to complete the weld and consequently the higher production rate. The penetration is influenced by flux composition, welding speed, polarity, travel speed, electrode stick out, basicity index and physical properties of the flux. Generally it is assumed that the depth of penetration depends upon the heat input by the arc. It is also reported that the diameter of the electrode affects the penetration and other aspects of the bead geometry (Caddell, 1967).

II. LITERATURE REVIEW

Gupta and Parmer (1986) developed mathematical models by using fractional factorial technique to predict the weld bead geometry and shape relationship in SAW. They investigated the effect on WPSF, WRFF, penetration and width of the weld. The input variables were open circuit voltage, wire feed rate, nozzle to plate distance, welding speed and work material thickness. From this study they investigated the followings. The researchers concluded that High wire feed rate increases the weld penetration steeply with increase of open circuit voltage while at low feed rate it increases moderately with increase of open circuit voltage. The weld width increases with increase of wire feed rate and as travel speed decreases, the penetration increases.With increase in voltage the penetration, dilution of the weld and width increases whereas reinforcement of the weld is decreased.

Chandel et al. (1997) studied the effect of increasing deposition rate on bead geometry of SAW welds. For a given heat input usually the melting rate can be increased by using high current, straight polarity, small diameter electrode or by using longer electrode extension. The researchers concluded that for a given heat input, weld features such as bead height, bead width and weld penetration were affected in a different way and by a different magnitude. The percentage difference in melting rate, bead height, width and bead penetration were affected by the current level and polarity. Nagesh and Datta (2002) studied the effect of welding process parameters on bead geometry and penetration in SMAW. It was revealed from the study that high arc travel rate and low arc power produced poor fusion. Higher electrode feed rate produced high width, making the flatter bead. The current, voltage and travel speed all affect the depth of penetration. From this study, they concluded that longer arc length produced shallow penetration. Heat conductivity of the material, arc length and arc force were also found to affect significantly.

III. Experimental procedure

In this study RSM was used for designing the fluxes and twenty fluxes were designed. The fluxes were made by the agglomeration technique. The design matrix in coded form is given in Table 1. The base constituents CaO, SiO_2 and $Al2O_3$ were selected and CaF_2, FeMn and NiO were added to these fluxes. The composition of base fluxes is hown in Table2.For 18 mm thick low carbon steel plates the bead on plate welds were made by all the twenty fluxes.The polishing and etching was done by emery paper and natal solution.The polished samples are given in Figure 1. The bead profile was measured by software known as caliper pro. The measured values are given in Table3.

Table 1: Design Matrix			
No. of Experiment	CaF_2 wt%	FeMn wt%	NiO wt%
1	+1	–1	–1
2	0	+1	0
3	+1	–1	+1
4	–1	–1	–1
5	0	0	0
6	0	0	0
7	+1	+1	+1
8	0	0	0
9	0	–1	0
10	+1	0	0
11	0	0	+1
12	–1	–1	+1
13	0	0	0
14	0	0	0
15	+1	+1	–1
16	–1	0	0
17	0	0	0
18	0	0	–1
19	–1	+1	+1
20	–1	+1	–1

Table 2: Base constituents and additives of the flux						
Flux	CaF_2 gm	FeMn gm	NiO gm	CaO gm	SiO_2 gm	Al_2O_3 gm
1	120	30	30	486	695	139
2	75	120	75	453	647	130
3	120	30	120	453	647	130
4	30	30	30	519	742	148
5	75	75	75	470	671	134
6	75	75	75	470	671	134
7	120	120	120	420	600	120
8	75	75	75	470	671	134
9	75	30	75	486	695	139
10	120	75	75	453	647	130
11	75	75	120	453	647	130

12	30	30	120	486	695	139
13	75	75	75	470	671	134
14	75	75	75	470	671	134
15	120	120	30	453	647	130
16	30	75	75	486	695	139
17	75	75	75	470	671	134
18	75	75	30	486	695	139
19	30	120	120	453	647	130
20	30	120	30	486	695	139

Table3 Measured responses

Flux	CaF_2 (%)	FeMn (%)	NiO (%)	W (mm)	P (mm)
1	8	2	2	34	7.19
2	5	8	5	48.73	9.31
3	8	2	8	41.7	9.18
4	2	2	2	42.1	8.01
5	5	5	5	51.47	8.83
6	5	5	5	49.6	9.42
7	8	8	8	45.51	6.5
8	5	5	5	42.42	9.53
9	5	2	5	43.51	10
10	8	5	5	42.42	6.25
11	5	5	8	46.53	9.25
12	2	2	8	44.23	9.76
13	5	5	5	51.47	8.83
14	5	5	5	51.5	9
15	8	8	2	36.8	6.04
16	2	5	5	44.02	7.33
17	5	5	5	48.14	9.51
18	5	5	2	39.5	8.69
19	2	8	8	40.6	9.24
20	2	8	2	35.53	9

IV. GREY RELATIONAL ANALYSIS

As GRA is a technique which is based on the grey theory. This theory was developed by Deng (1989). In this theory, the data are of black and white type. The black data is used for unknown information while white data represents the known information. Besides the above two systems, there may be some another situation in which part of information is known and part of information is unknown. This incomplete information is known as grey system. In this study two responses width of the weld and penetration are considered as per the requirement, width should be minimum and the penetration should be high. In GRA the following steps are used (Vijyan and Rao, 2014).In this method, first all the input data are normalized so that there units may not show any effect on the out put. After normalization, the deviation for each data are calculated and finally the grey relational coefficients are calculated for each experiment. The following formulas are used for the above. For maximization and minimization of the responses the following relation given in equation 1 and 2 are used.

For maximizing the responses (Vijayan and Rao, 2014).

$$x_i^*(k) = \frac{x_i^0(k) - \max x_i^0(k)}{\max x_i^0(k) - \min x_i^0(k)} \quad (1)$$

$$x_i^*(k) = \frac{\max x_i^0(k) - x_i^0(k)}{\max x_i^0(k) - \min x_i^0(k)} \quad (2)$$

The grey relational coefficients are calculated from the given below equation no3. This is represented by ξ (k) and can be calculated from the given relation in equation 3.

$$\xi(k) = \frac{\Delta_{min} + \xi\Delta_{max}}{\Delta_{oi}(k) + \xi\Delta_{max}} \quad (3)$$

After calculating the grey relational coefficients, the grey relational grades are calculated by taking the average of coefficients of various factors.

V. RESULTS AND DISCUSSIONS

The results in Table4 shows that the rank of the experiment flux no twenty is one. It shows that for the given inputs, this is the best experiment.

Table 4 Ranking of various experiments

Flux No	Width Mm(W)	Nor.Value	Dev.w	GRC-Width	Penetration (P) mm	Nor. value	Dev.P	GRC-P	GRG	Ranks
1	34	1	0	1	7.19	0.29	0.71	0.41	0.707	3
2	48.73	0.16	0.84	0.373	9.31	0.83	0.17	0.75	0.560	12
3	41.7	0.56	0.44	0.532	9.18	0.79	0.21	0.70	0.618	7
4	42.1	0.54	0.46	0.521	8.01	0.5	0.5	0.50	0.510	14
5	51.47	0	1	0.333	8.83	0.7	0.3	0.63	0.479	16
6	49.6	0.11	0.89	0.360	9.42	0.85	0.15	0.77	0.564	11
7	45.51	0.34	0.66	0.431	6.5	0.12	0.88	0.36	0.397	20

8	42.42	0.52	0.48	0.510	9.53	0.88	0.12	0.81	0.658	5
9	43.51	0.46	0.54	0.481	10	1	0	1.00	0.740	2
10	42.42	0.52	0.48	0.510	6.25	0.05	0.95	0.34	0.428	19
11	46.53	0.28	0.72	0.410	9.25	0.81	0.19	0.72	0.567	10
12	44.23	0.42	0.58	0.463	9.76	0.94	0.06	0.89	0.678	4
13	51.47	0	1	0.333	8.83	0.7	0.3	0.63	0.479	17
14	51.5	0	1	0.333	9	0.75	0.25	0.67	0.500	15
15	36.8	0.84	0.16	0.758	6.04	0	1	0.33	0.545	13
16	44.02	0.43	0.57	0.467	7.33	0.33	0.67	0.43	0.447	18
17	48.14	0.19	0.81	0.382	9.51	0.88	0.12	0.81	0.594	9
18	39.5	0.69	0.31	0.617	8.69	0.67	0.33	0.60	0.610	8
19	40.6	0.62	0.38	0.568	9.24	0.81	0.19	0.72	0.646	6
20	35.53	0.91	0.09	0.847	9	0.75	0.25	0.67	0.757	1

V.CONCLUSIONS

(1) GRA and PCA can be applied to find the optimum value of flux for the output.

(2) PCA shows that the two factors are having equal weightage.

(3) The optimum flux for low weld width and high penetration is CaF_2, 2%, FeMn 8% and NiO as 2%.

REFERENCES

[1.] Hould Croft, P.T., (1989) Submerged arc welding Second Ed. Abington publishing, Cambridge, England.

[2.] Raveendra, J., Parmar, R.S., (1987) Mathematical models to predict weld bead geometry for flux cored arc welding. Metal construction, 19: 31-35.

[3.] Srihari, T., (1992) Submerged arc welding of high strength low alloy steels. Ph.D. Thesis, I.I.T, Delhi.

[4.] Tregelsky, V., (1968) The electric welder. Foreign Languages pub. House, Moscow.

[5.] Caddell, R.M., (1967) The influence of physical properties on penetration in arc welding. Transaction of ASME Journal of Engineering for Industry, 37(5): 328-332.

[6.] Gupta, V.K., Parmar, R.S., (1986) Fractional factorial technique to predict dimensions of weld bead in automatic submerged arc welding. Journal of Institutions of Engineers, India, 70: 67-71.

[7.] Chandel, R.S., Seow, H.P., Cheone, F.L., (1997) Effect of increasing deposition rate on bead geometry of submerged arc weld. Journal of material processing technology, 72(1): 124-128.

[8.] Nagesh, D.S., Datta, G.L., (2002) Prediction of weld bead geometry and penetration in shielded metal arc welding using ANN. J. Mater. Processes Technology, 123: 303-312.

[9.] Deng, J., (1989) Introduction to grey system. Journal of grey system, 1(1): 1-24

[10.] Vijayan, D., Rao, V.S., (2014) C Fricton stir welding of age hardenable aluminium alloys: A parametric approach using RSM base GRA coupled with PCA. Journal of Institutions of Engineers, India, Sec C 95(2): 127-141.