International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 12, pp: 58-65 www.ijaem.net ISSN: 2395-5252

Optimization of Flux for for low wire consumption snd slag produced in Submerged arc welding using fuzzy logic

Dr. Brijpal Singh
Associate Professor, MSIT Janakpuri

Date of Submission: 14-11-2021 Date of Acceptance: 29-11-2021

ABSTRACT
This study has been conducted to find out the optimal flux for low consumption of wire and slag produced in submerged arc welding.Slag production is essential in SAW but large amount of slag produced and wire consumption is not desirable.So an attempt has been been made in this study to select the proper flux.. Response surface methodology has been used for designing of flux and these fluxes were made by agglomeration technique.The welding parameters such voltage, current and travel speed were made constant so the consumption of wire and slag produced cannot be decided by the welding parameters. It reveals that flux composition may play an important role in this regard. Fuzzy logic optimization suggests that the flux having composition CaF_2 5%, FeMn 5% and NiO as 8% is most suitable for low consumption of wire and low amount of slag produced..

KEYWORDS: Fuzzy logic, Submerged arc welding, Fluxes, welding parameters.

I. INTRODUCTION

The Submerged arc welding process is very old process andwas developed in 1920s in USA.But still today it is most widely used welding process in fully automatic and semiautomatic mode. Automatic SAW machines have increased the welding speed and and quality of joints have also been improved. In SAW, the electrode is in the form of wire and is fed mechanically [1]. A welding current passes through the collet to the electrode and the creates an arc between the electride and work piece. The heat produced by the arc melts and heat the workpice to be joined. In SAW, the heat also melts the granular flux which creates a covering and protects the weld from atmospheric gases.The molten slag acts as additional shield.In this welding a very large amount of flux is consumed. In SAW process large amount of current is used to heat the work piece and this current density is 5-6 times higher than that of shielded metal arc welding (SMAW). This welding process is used for as a high heat process , having high deposition rate and produces high quality welds.[2, 3]. The major applications of SAW are fabricating pipes, pressure vessels, r pipes, heavy steel fabrication work, machine components for heavy industries, rail road tank, structural parts, ship building, fabrication of trusses and beams. The submerged arc welding process is widely used for making heavy steel products.4.

Fluxes are having important role in deciding the mechanical properties of the weldmetal [5]. Pandey et.al 2010 [6] analysed the effect of welding current, voltage and BI of the flux on weld chemistry.This study reveals that flux BI has an important role in deciding the elements transfer.From the literature review , it can be concluded thatt the weld metal properties are decided by the elements transfer from the slag to the weld or vice versa.This transfer depends upon the flux composition and other welding consumables [7,8,9.10]. The first requisite for developing scientific methodology is to understand the behavior of fluxes during welding. It will be effective to use a sound scientific approach for flux formulation and use of welding consumables.

Optimization and flux formulation.

Fuzzy logic optimization model has been used by Kumar et al. 2015 [11] to obtain optimum values of NiO,MnO and MgO contents for high impact strength and hardness of the welds for SiO2 based fluxes. Rey based genetic algorithm was used for optimization of weld mechanical properties by Roy et al.(2013 [12]. Jindal etal.2013 [13] used the desirability approach to get high impact strength, hardness and other mechanical properties by using the proper selection of flux for HSLA steels... Adeyeye and Oyawale 2009[14] used the mathematical programming optimization technique. Datta et.al 2008[15] used the GRA technique in combination with the Taguchi method to obtain the slag –fresh flux mixture ratio without compromising the features of weld bead geometry and HAZ width.

Fluxes have been prepared by using agglomeration technique. These are also known as bonded fluxes. In agglomerated fluxes, the raw materials are powdered, dry mixed and bonded with either potassium silicate or sodium silicate. After bonding, the wet mixture is pelletized and baked at a temperature lower than that for fused fluxes. After this, the pellets are broken up, screened to size and packaging is done. These fluxes have lower bulk density and hence less flux is melted for a given amount of weld deposition. The main advantage of using agglomerated flux is that deoxidizers and other alloying elements can be added during the dry mixing but its main limitation is the absorption of moisture by the flux

Experimental procedure

The following steps were followed;

1 :Twenty fluxes were designed as per RSM by using central composite design. The designed matrix in the coded form is given in Table 1.

2: base fluxes CaO, SiO_2 and Al_2O_3 were selected and mixed in the ratio of 7:10:2 as per binary and ternary phase diagrams. The additives CaF_2, FeMn and NiO were added in the range of (2-8)% .

3: Twenty fluxes were prepared by agglomeration technique.The base constituents are given in Table2

4 Beads on plates were made on 18 mm thick MS plates of the given composition. The welding parameters were made constant and are given in Table3.

5: Beads were laid one over the other in order to minimize the dilution effect of base plate.

6: The measured responses are given in Table 4 and the machine used and bead on plates have been shown in figure 1. .

Table 1: Design matrix in coded form.

No. of Experiment	CaF_2 wt % A	FeMn wt% B	NiO wt % C
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

Table2: 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: Welding Parameters

S. No.	Voltage (V)	Current (A)	Travel speed Cm/min.
1	30	475	20

Table 4 measured responses

Flux	Wire consumed	Slag produced
1	760 gm.	550 gm.
2	550 gm.	600 gm.
3	500 gm.	600 gm.
4	600 gm.	500 gm.
5	550 gm.	500 gm.
6	750 gm.	550 gm
7	650 gm	500 gm.
8	750 gm.	550 gm.
9	850 gm.	550 gm.
10	850 gm.	500 gm.
11	550 gm.	250 gm.
12	550 gm.	250 gm.
13	500 gm.	250 gm.
14	700 gm.	200 gm
15	750 gm.	200 gm.
16	750 gm	150 gm
17	600 gm.	200 gm.
18	700 gm	250 gm

19	700 gm.	250 gm.
20	700 gm.	200 gm.

Figure 1. The SAW Machine used for welding

Fuzzy methodology

It consists of a fuzzy logic unit which comprises of a fuzzifier, membership functions, a fuzzy rule base, an inference engine, and a defuzzifier. The fuzzifier makes use of membership functions to fuzzify the signal to- noise ratios that had been generated by the response. The inference engine performs fuzzy reasoning on fuzzy rules to generate a fuzzy value by this. Finally, the defuzzifier converts the fuzzy value into a multi Characterization performance index (MCPI). The structure of the three-input-one-output fuzzy logic unit is shown in Fig. 2(a).The input are wire consumed and slag produced and output is (MCPI).The fuzzy inference system has been given in figure(2b).

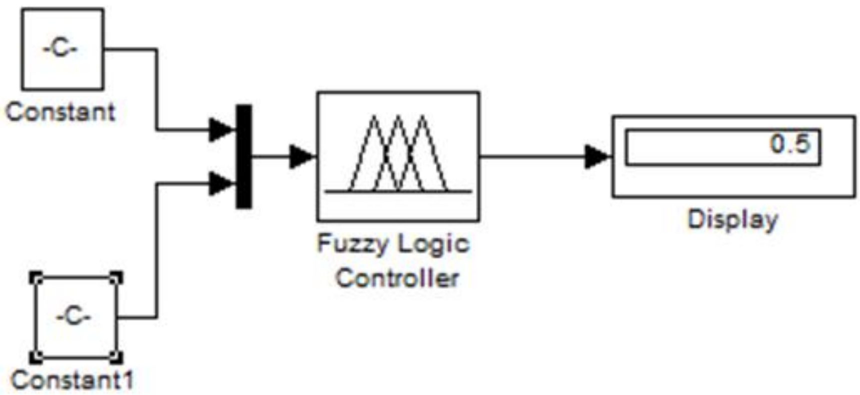
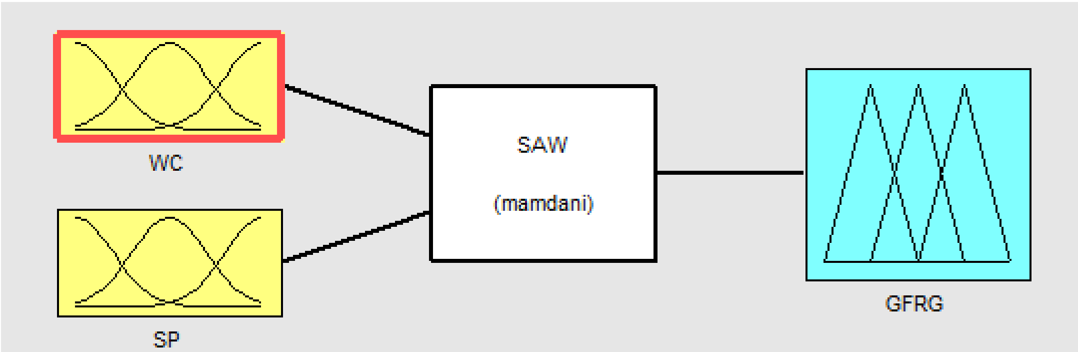


Figure 2(a)Elements of fuzzy logic system



Figure(2b) Fuzzy inference system

II. RESULT AND DISCUSSIONS

The used fuzzy model consosts of two inputs and one out put which fuzzifies the input data using three triangular membership functions. These triangular membership have been used for the two inputs and one output. This has been depicted in figures 3(a), 3(b)) respectively.Using fuzzy logic rules in the Mumdani inference, multi characterstic performace index for each experiment value has been calculated using centroid method of defuzzification as shown in Table5.The calculated value of GFRG is highest for experiment no11.So it can be suggested that the flux no 11 has given the optimal result and we can say that this is the flux for which the wire consumed anad slag produces are minimal.The fuzzy base rules are given as follows.

Rule base for fuzzy system Figure 2©

1 Ifwire cinsumption is low and slag produces is low, then GRRG low.
2 If wire consumption is low and slag produces is medium then GFRG is low.
3 If wire consumption is low and slag produces is high then GFRG is medium.
4 If wire consumption is medium and slag produces is low then GFRG is large.
5 If wire consumption is medium and slag produces is medium then GFRG ismedium.
6 If wire consumption is medium and slag produces is high then GFRG ismedium.
7 If wire consumption is high and slag produces is low then GFRG is medium
8 If wire consumption is high and slag produces is medium then GFRG is medium
9 If wire consumption is high and slag produces is high then GFRG is high

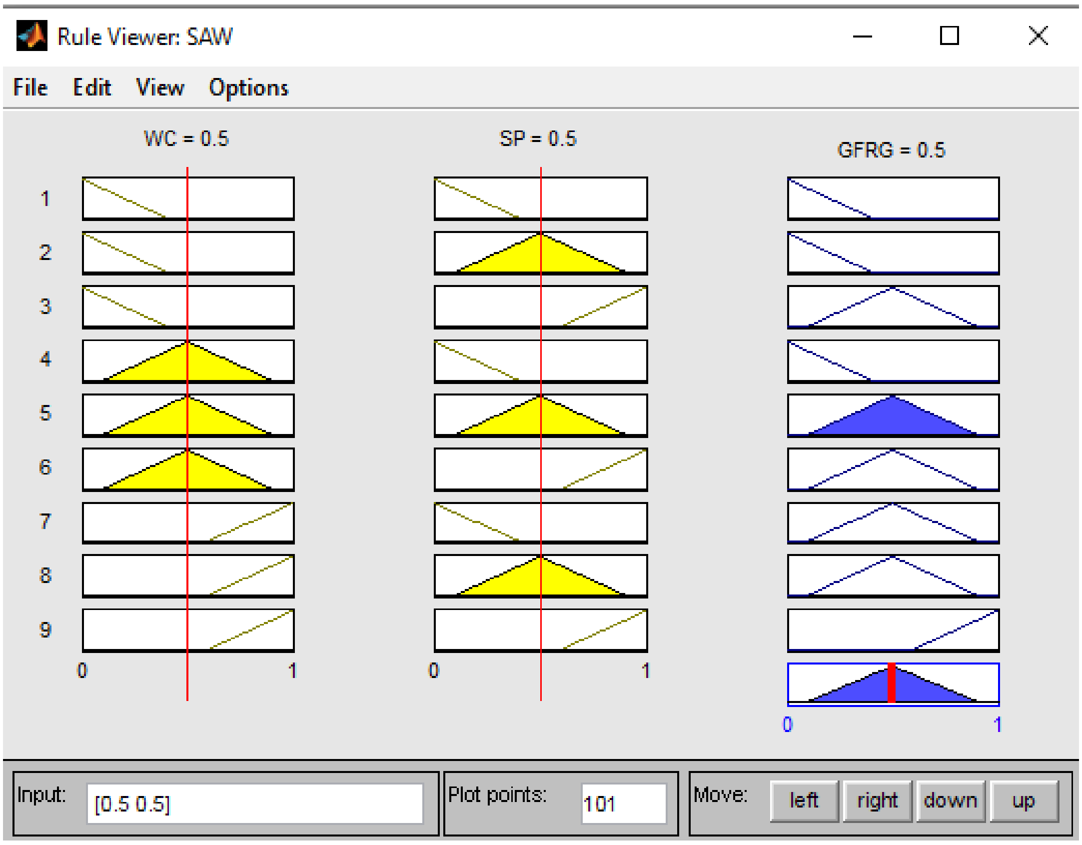


Figure (2c)

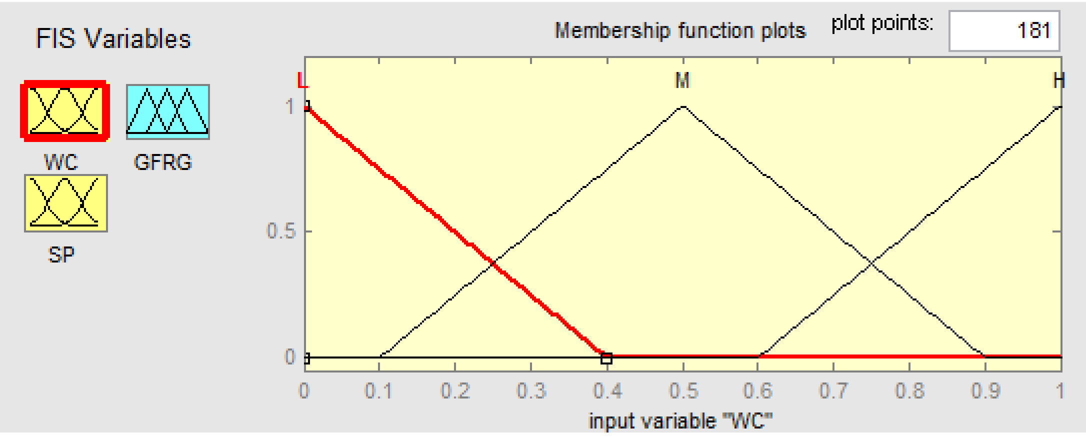


Figure 3(a) Membership function for wire consumption.

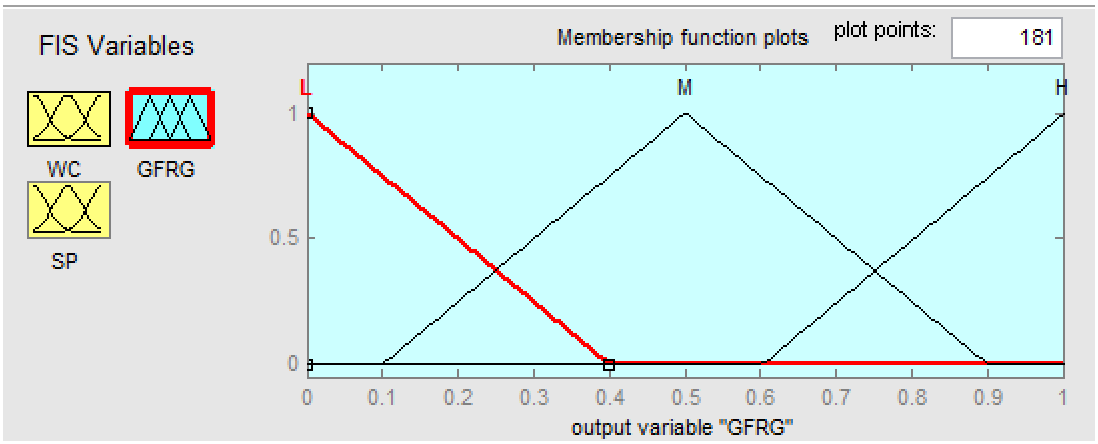


Figure 3(b) Membership function for output.

The normalized value , deviation and rankins of various experiments is given in the following table5.

Table 5 Rank of various Experiments

Flux No	WC	Normalized value WC	Deviation	GRC (Grey relation coefficient)	**SP**	Normalized value SP	Deviation	GRC (Grey relation coefficient)	GFRG	Rank
1	760	0.2571	0.7429	0.4023	550	0.1111	0.8889	0.3600	0.4848	16
2	550	0.8571	0.1429	0.7778	600	0.0000	1.0000	0.3333	0.4665	20
3	500	1.0000	0.0000	1.0000	**600**	0.0000	1.0000	0.3333	0.5000	11
4	600	0.7143	0.2857	0.6364	500	0.2222	0.7778	0.3913	0.4970	13
5	550	0.8571	0.1429	0.7778	500	0.2222	0.7778	0.3913	0.4961	14
6	750	0.2857	0.7143	0.4118	550	0.1111	0.8889	0.3600	0.4848	17
7	650	0.5714	0.4286	0.5385	500	0.2222	0.7778	0.3913	0.4971	12
8	750	0.2857	0.7143	0.4118	550	0.1111	0.8889	0.3600	0.4848	15
9	850	0.0000	1.0000	0.3333	550	0.1111	0.8889	0.3600	0.4716	18
10	850	0.0000	1.0000	0.3333	500	0.2222	0.7778	0.3913	0.4716	19
11	550	0.8571	0.1429	0.7778	250	0.7778	0.2222	0.6923	0.5479	1
12	550	0.8571	0.1429	0.7778	250	0.7778	0.2222	0.6923	0.5479	2
13	500	1.0000	0.0000	1.0000	250	0.7778	0.2222	0.6923	0.5435	3
14	700	0.4286	0.5714	0.4667	200	0.8889	0.1111	0.8182	0.5000	5
15	750	0.2857	0.7143	0.4118	200	0.8889	0.1111	0.8182	0.5000	6
16	750	0.2857	0.7143	0.4118	**150**	1.0000	0.0000	1.0000	0.5000	7
17	600	0.7143	0.2857	0.6364	200	0.8889	0.1111	0.8182	0.5151	4
18	700	0.4286	0.5714	0.4667	250	0.7778	0.2222	0.6923	0.5000	8
19	700	0.4286	0.5714	0.4667	250	0.7778	0.2222	0.6923	0.5000	9
20	700	0.4286	0.5714	0.4667	200	0.8889	0.1111	0.8182	0.5000	10

III. CONCLUSIONS

1 Response surface methodoly is used for design and the fluxes were made by agglomeration technique.
2 Multi objective optimization is done using fuzzy logic model for slag produced and wire consumed.
3 The resuls show the optimal flux for properties of the weld contains 5% CaF_2, 5% FeMn, and 8% NiO.

REFERENCES

[1]. Hould Croft, P.T., (1989) Submerged arc welding Second Ed. Abington publishing, Cambridge, England.
[2]. Parmar, R.S., (1992) Welding processes Technology. Khanna publisher, New Delhi.
[3]. Parmar R.S.(2004) Welding Engineering and Technology.Khanna Publisher New Delhi.
[4]. Welding and welding Technology R.l.Little.Mc Graw hill publisher Europe.
[5]. Brian,O, and Guzman,c 2004 "welding hand book" welding process part 2 'Americal welding society" Miami,F.L
[6]. Pandey, N.D., Bharti, A., Gupta, S.R., (1994) Effect of submerged arc welding parameters on Element transfer. Journal of Materials Processing Technology, 40: 195-211.
[7]. Kanjilal, P., Pal, T.K., Majumdar, S.K., (2006) Combined Effect of flux and welding parameters on chemical composition and mechanical properties of submerged arc weld metal. Journal of Materials Processing Technology, 171(2): 223-231.
[8]. Kanjilal, P., Pal, T.K., Majumdar, S.K., (2006) Prediction of acicular ferrite from flux ingredients in submerged arc welds metals from C-Mn-Steel. ISIJ International, 45: 876-885.
[9]. Kanjilal, P., Pal, T.K., Majumdar, S.K., (2007) Prediction of Elements transfer in submerged arc welding. Welding Journal, 86(5): 135-146.
[10]. Plessis,j.du,Toit,M.du,pistorius,P.C 2007" Control of diffusible weld metal hydrogenthrough flux chemistry modification" Welding journal vol.1.86 pp.273-280.
[11]. Kumar, A, maheshwari, S and Sharma, SK (201)5 ",Fuzzy logic optimization for SAW using silica based agglomerated flixes" Procedia Computer science vol 57 pp1140-1145.
[12]. Roy,J, Majumdar, M Barma, j.R, Rey R,N. and Shah, S.C "An approach for solving multi characterstic optimization of SAW process parameters by using grey beased genetic algorthim". Journal of scientific and industrial research.vol 77 pp 340-347.
[13]. Jindal, S., (2013) Development of submerged arc welding fluxes for welding of structural steels. Ph.D thesis, MMU, Ambala, Haryana, India.
[14]. Derringer ,G (1980) ' Simultanious optimization of several response variables" Journal of quality Technology.vol 12.pp 214-219.
[15]. Datta, Saurav, Bandyopadhyay and kumarpal pradip. Solving multi-criteria optimization problem in submerged arc welding consuming a mixture of fresh flux and fused slag. Journal of advanced manufacturing Technology. Vol 35(9)2008, pp 935-942.