International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
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Research Article

Effect of Saw Parameters on Manganese Element Transfer in SS-202

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Accepted 25 May 2015, Available online 01 June 2015, **Vol.5, No.3 (June 2015)**

Abstract

The aim of the present work was to study the effect of welding current, arc voltage, and weld speed on Manganese and element transfer and to optimize the process following suitable Taguchi experimental design. Beads on plate weld were deposited on SS-202 at different welding parameter combinations. During analysis of Manganese Welding voltage and current were found to be the most significant factors leading to changes in manganese element transfer. The results revealed that welding voltage has an appreciable influence on weld composition of Manganese element. Data investigated in this paper can be used to specify welding variables for desired manganese composition.

Keywords: *Submerged arc welding, chemical composition, Taguchi design of experiment, S/N ratio, Experimental Design*

Nomenclature

SAW:	Submerged Arc Welding
SN:	Signal to Noise
ANNOVA:	Analysis of Variance
WS:	Welding Speed
DCEP:	Direct current Electrode Positive
DCEN:	Direct Current Electrode Negative
AC:	Alternating Current
DC:	Direct Current
CV:	Constant Voltage
GA:	Genetic algorithm
PSO:	Particle Swarm Optimization

1. Introduction

Welding as it is generally understood today is comparatively a new comer amongst the fabrication processes though smith forging to join metal pieces was practiced even before Christ. Though there are a number of well-established welding processes but arc welding with coated electrodes is still the most popular welding process over the world. Arc welding in its present form appeared on the industrial scene in 1880's. Arc welding, however, was not accepted for fabrication of critical components till about 1920 by which time coatings for electrodes had been well developed. Submerged Arc Welding is a fusion welding process in which heat is produced from an arc between the work and a continuously fed filler metal electrode. The molten weld pool is protected from the surrounding atmosphere by thick blanket of molten flux and slag formed from the granular fluxing material pre-placed on the work.

1.2 Control Parameters

The control factors and their values were chosen on the basis of a pilot experiment by varying one factor at a time. Based on the pilot study, current, voltage, welding speed, was identified as the control factors. The levels of the possible contributing factors were decided using the following methodology

1.2.1 Welding Current

When we increase the welding current the pressure exerted by the arc increases which drives out the molten metal from beneath the arc and that lead to increased depth of penetration. The width of weld remains almost unaffected. As the increased welding current is accompanied by increase in wire feed rate, it results in greater weld reinforcement. Variation in current density has nearly the same effect on weld geometry as the variation in magnitude of current. Welding with DCEP produces deeper penetration than DCEN. For a given welding current, a decrease of wire diameter results in increase in current density. This results in a weld with deeper penetration but of somewhat reduced width. The submerged arc welding process usually employs wires of 2 to 5mm diameter, thus for deeper penetration at low currents a wire of diameter 2 to 3mm is best suited.

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1.2.2Arc-Voltage

Arc voltage varies in direct proportion to the arc length. With the increase in arc length the arc voltage increases and thus more heat is available to melt the metal and the flux. However, increased arc length means more spread of arc column, this leads to increase in weld width and volume of reinforcement while the depth of penetration decreases. The arc voltage varies with welding current and wire diameter, and in SAW it usually ranges between 30 to 50 volts.

1.2.3 Weld Speed

With increase in welding speed, the width of weld decreases. However, if the increase in speed is small the depth of penetration increases because the layer of molten metal is reduced which leads to higher heat conduction towards the bottom of the plate. With further increase in welding speed, above 40 m/hour, the heat input per unit length of the weld decreases considerably and the depth of penetration is thus reduced. At speed above 80 m/hour, lack of fusion may result. It has been established experimentally that as a first approximation the welding speed, S, for a well shaped weld should be based on the following relationship.

$S = 2500/I_n$ m/hour

Where I_n is the welding current in amperes (Pandey*et al*, 1994)

2. Materials and Methods

2.1 Materials

In this study SS-202 was used having dimensions 100x62x9 mm. The samples were cut from SS-202 flat and were machined to get the desired dimensions. The chemical composition of the material is shown in table 1.

Table 1 Chemical composition of SS-202

Material	%age by weight
C	0.115
Mn	8.946
P	0.02646
S	0.01946
Si	0.6461
Cu	0.1103
Ni	4.756
Cr	18.2
V	0.0645

Fig.1 Specimen

2.2. Design of experiments

Expt. No.	V	I	WS
	(V)	(A)	(m/hr)
1	26	210	24
2	26	240	26
3	26	270	28
4	26	300	30
5	28	210	26
6	28	240	24
7	28	270	30
8	28	300	28
9	30	210	28
10	30	240	30
11	30	270	24
12	30	300	26
13	32	210	30
14	32	240	28
15	32	270	26
16	32	300	24

2.2.1 Selection of welding parameters

Table 2 Values of parameters

Welding Parameters	Units	Symbol	Levels			
Current	A	A	210	240	270	300
Voltage	V	V	26	28	30	32
Weld Speed	m/hr	WS	24	26	28	30

Using the trial experiments the various values given in table 2 were taken to build the L-16 array using Minitab software. The experiments were performed according to the L-16 array shown in figure 2.2.

Fig.2 Welded specimens

3. Results and discussion

3.1 Responses

Table 3 Responses as per Taguchi array

Expt. No.	V (V)	I (A)	WS (m/hr)	Mn (%)
1	26	210	24	2.475
2	26	240	26	3.856
3	26	270	28	2.946
4	26	300	30	4.254
5	28	210	26	3.249
6	28	240	24	1.949
7	28	270	30	3.045
8	28	300	28	3.622
9	30	210	28	3.607
10	30	240	30	3.87
11	30	270	24	3.518
12	30	300	26	3.886
13	32	210	30	4.382
14	32	240	28	5.907
15	32	270	26	3.726
16	32	300	24	5.744

Table 4 S/N ratio

Expt. No.	V (V)	I (A)	S (m/hr)	Mn S/N ratio
1	26	210	24	7.871504
2	26	240	26	11.72274
3	26	270	28	9.384655
4	26	300	30	12.57595
5	28	210	26	10.23499
6	28	240	24	5.796237
7	28	270	30	16.27162
8	28	300	28	15.57749
9	30	210	28	14.96531
10	30	240	30	15.22352
11	30	270	24	14.94824
12	30	300	26	15.10225
13	32	210	30	16.08279
14	32	240	28	15.37276
15	32	270	26	15.49034
16	32	300	24	16.09641

3.2 Analysis of experimental data

The Manganese (Mn) element along with the input process parameters is given in table 3. Minitab 17 software was used to analyze the measured response.

3.2.1 Effect of input factors on Mn:

The response table for signal to noise ratio for Mn is shown in table 4 and the responses in table 3. For Mn, the calculation of S/N ratio follows Larger the Better model. Therefore, voltage (V) has the maximum effect on Manganese in the weld metal. The effect is shown in table5.

Table 5 Response Table for Signal to Noise Ratios Larger is better

Level	V(Volt)	I(Amp)	WS(m/h)
1	10.389	10.521	9.944
2	9.220	11.175	11.293
3	11.403	10.352	11.783
4	13.717	12.682	11.709
Delta	4.497	2.331	1.839
Rank	1	2	3

Table 6 Response Table for Means

Level	V(Volt)	I(Amp)	WS(m/hr)
1	3.383	3.428	3.422
2	2.966	3.896	3.679
3	3.720	3.309	4.021
4	4.940	4.377	3.888
Delta	1.974	1.068	0.599
Rank	1	2	3

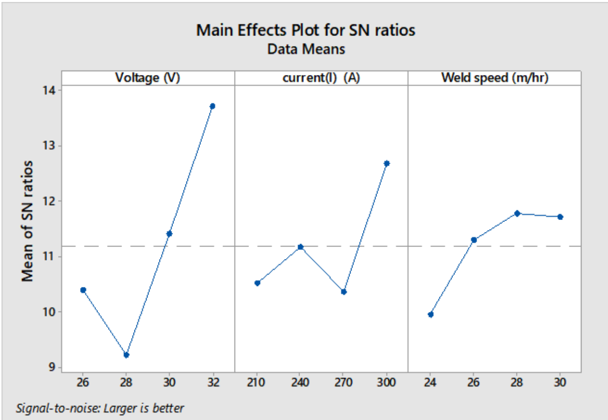

Table 7ANOVA Table for Signal to Noise ratio

Source	DF	Seq SS	Adj. SS	Adj. MS	F
Voltage	3	43.818	43.818	14.606	4.35
Current(I) A	3	13.510	13.510	4.503	1.34
Weld speed(m/hr)	3	8.732	8.732	2.911	0.87
Residual error	6	20.141	20.141	3.357	
Total	15	86.201			

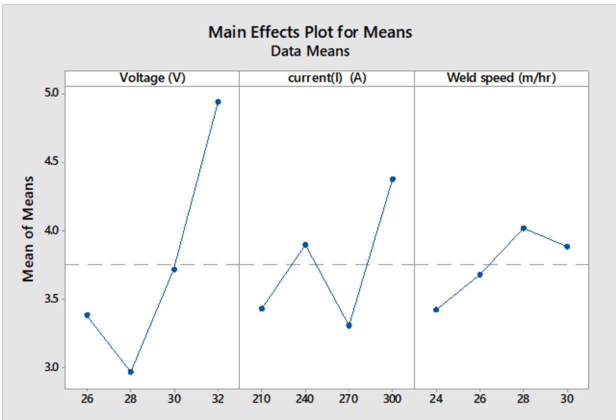

Table 8ANOVA Table for Means

Source	DF	Seq SS	Adj. SS	Adj. MS	F	P
Voltage	3	8.662	8.662	2.8873	5.17	0.042
Current(I) A	3	2.8475	2.8475	0.9492	1.7	0.266
Weld speed(m/hr)	3	0.8202	0.8202	0.2734	0.49	0.702
Residual error	6	3.3514	3.3514	0.5586		
Total	15	15.6811				

3.2.4 Optimization of parameters

Table 9 Optimal Parameters of Input Factors

Physical	Optimal Combination		
Requirement	V(V)	I(A)	WS(m/hr)
Maximum Mn	32	210	26
	(LEVEL-4)	(LEVEL-1)	(LEVEL-2)

It can be seen from the graphs that for Mnto be maximum factor V (V) has to be at level 4, current (A) has to be at high level 1 & weld speed has to be at high level 2.

Conclusion

The combined effect of welding parameters on weld metal Mn in SAW process was examined. Accordingly, the following conclusions can be drawn:

- For controlling the manganese metal transfer, welding voltage is more effective than the speed.

Scope for future work

In this present study only Manganese metal transfer has been studied. Keeping the view of future scope, other elements transfer like carbon, sulphur, phosphorous etc. can be studied. Also, the other parameters like electrode extension, electrode polarity, and different fluxes can be added.

Acknowledgements

The help in the work by Mr. Karun is acknowledged.

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