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Optimal Effect of Ferroboron Content by Paste Technique on Microhardness in Hardfaced Mild Steel

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Abstract - **Hardfacing by welding is one of the most economical way to enhance the life of components which are exposed to varied conditions of environment. The use of hardfacing is increasing rapidly because of the increasing cost of the components. Surface properties and quality achieved of the hardfaced component depends upon the nature of selected hardfacing alloys and the welding process used for hardfacing. Ferro boron is a master alloy used in the manufacture of metallic glass and magnetic materials, and in alloying of steel. For decades, ferro boron has been utilized to increase the mechanical properties of steel. Shielded metal arc welding is most commonly used process for hardfacing due to its easier availability and operational versatility. Low carbon steel has been selected for the present work as substrate material due to its low cost, easy availability and wide applications. In the present work three different content of Ferroboron has been used and sodium silicate has been used as a binder deposited on mild steel by paste coating process. On coating weld metal AWS E6013 SMAW electrode was deposited with SMAW Process. Mild steel plate $100\times 75\times 12$ mm^3 were used for depositing the hardfacing layers with Ferroboron by paste technique using shielded metal arc welding. The present study deals with an experimental study carried out in order to optimize the process parameters namely Ferroboron content (mg/mm^2) Welding current (A) and Average welding speed (mm/min).The results have been analyzed using Taguchi's method. A plan of experiments generated through Taguchi technique is used to analyze the hardfacing with Ferroboron by paste technique based on L9 orthogonal array. Analysis of Variance (ANOVA) and Signal to Noise ratio (S/N) are used to investigate the influence of Ferroboron content, Welding current and Average welding speed on Microhardness of weld metal**.

Keywords - Hardfacing, paste coating, ANOVA, microhardness, SMAW

1. INTRODUCTION

Hardfacing is primarily done to enhance the surface properties of the base metal (substrate) and hardfaced materials generally exhibit better wear, corrosion, and oxidation resistance than the base metal. Percentage dilution plays a major role in determining the properties of a hardfaced surface [Gourd, 1998]. Hardfacing is applied to serve the purpose of enhancing resistance to wear, abrasion, impact, erosion, galling and cavitation. This process is widely used to repair the railway rolling stock, earth moving and agricultural machineries, large gear wheels, conveyor shafts, chutes, turbine parts and innumerable other components [Horsfield,1980]. Selection of an alloy is generally considered in terms of a compromise between wear and cost. Other important parameters which must be taken into account are the base metal, deposition process, corrosion and oxidation capacity. In general, for selecting an alloy the following steps should be considered; when choosing an alloy. Service conditions, Selection of the hardfacing alloy, Compatibility of the hardfacing alloy with the base metal, Hardfacing process and level of dilution and the overall cost [Choteborsky et al., 2008].

2. LITERATURE REVIEW

Whang et al., (2005) studied the Microstructure and properties of TiC/Fe-based alloy hardfacing layers. TiC/Fe-based alloy hardfacing layers were obtained by shielded metal arc welding (SMAW), in which H08A bare electrode was coated with a powder mixture of ferrotitanium, rutile, graphite, calcium carbonate and calcium fluoride.Wang et al.,(2006) investigated optimization of cobalt based hardfacing in carbon steel using the fuzzy analysis for the robust design. This paper presents the application of fuzzy logic analysis to a Taguchi orthogonal experiment for developing a robust model with high efficiency in multiple performance characteristics (MPCs) of the plasma transfer arc welding (PTAW) hardfacing process. Buchanan et al., (2007) studied the comparison of the abrasive wear behaviour of iron-chromium based hardfaced coatings deposited by SMAW and electric arc spraying. Shamanian et al., (2009) investigated the effect of silicon content on the microstructure and properties of Fe–Cr–C hardfacing alloys. In this study, the surface of St52 steel was alloyed with preplaced powders 55Fe39Cr6C, 49Fe39Cr6C6Si, and 45Fe39Cr6C10Si using a tungsten-inert gas as the heat source. Kazemipour et al., (2010) investigated the influence of the matrix microstructure on abrasive wear resistance of heat-treated Fe–32Cr–4.5C wt.

% hardfacing alloy. The abrasion wear resistance of Fe–32Cr–4.5C wt. % hardfacing alloy was investigated as a function of matrix microstructure.

Many researchers have worked on different processes such as an automatic flux cored wire, a laser, electron beam, TIG, SMAW or plasma transferred arc welding for surface alloying using low alloy ferrous materials, high chromium white irons or high alloy ferrous materials, carbides nickel base alloy or cobalt base alloys but very few literature is available on pure boron powder or powder containing boron for surfacing using SMAW process. Hence, the objectives of the present work is to study the effect of the various parameters namely ferroboron content (mg /mm^2), welding current (A) & average welding speed (mm/min) on microhardness (HV) of the weld metal in SMAW welding process.

3. ADOPTED METHODOLOGY

A plan of experiments generated through Taguchi technique is employed to analyze the hardfacing with Ferroboron by paste technique based on L9 orthogonal array. Analysis of Variance (ANOVA) and Signal to Noise ratio (S/N) are used to investigate the influence of ferroboron content, welding current and average welding speed on microhardness of weld metal.

For our experimentation, we have used L9 orthogonal array.

The standard L9 orthogonal array is shown in Table 1, where A, B, & C being control factors having three levels each.

Table 1 Standard layout of L9 orthogonal array

Runs	Factors		
	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Here factor A, B, and C have three levels each. Interaction between column 1 and 2 is orthogonal to all columns and hence, can be estimated without sacrificing any column [Phadke, 1989].

4. EXPERIMENTATION

Ferroboron powder is used in the form of paste made up of sodium silicate and ferro boron powder. Then it was applied with the help of paint brush on the base plate used with the custom made dies. In trial runs three different amount of ferroboron i.e. 10 g, 20 g, and 30 g were used on 2500 mm^2 area. Amount of ferro boron was measured by digital weighing-machine.

Table 2 Process parameters and their working range

Parameter	Ferroboron content(mg/mm^2)	Welding current(A)	Average welding speed(mm/min)
Level 1	4	90	45
Level 2	8	120	90
Level 3	12	150	135

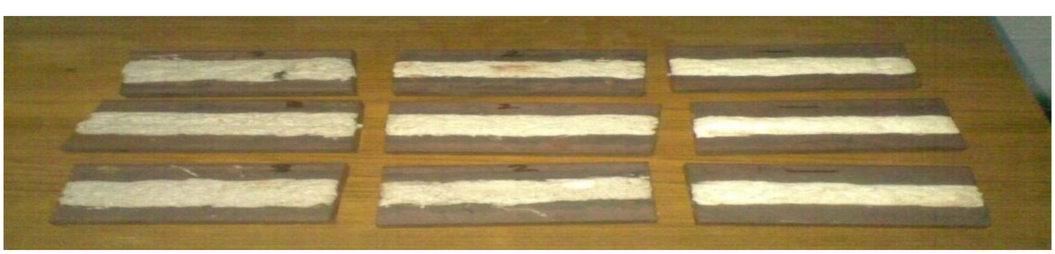

Fig.1. Paste coated plate

A well formulated paste coating of ferro boron and sodium silicate was deposited on mild steel plate. The paste was applied with the help of paint brush on the base plate. Three important parameters ferroboron content, welding current and average welding speed were selected on the experimental work. Paste was applied on 9 different plates with three different ferro boron content such as 4, 8 and 12 mg/mm^2, three different welding current 90,120 and 150 Ampere and three different average welding speed 45, 90 and 135 mm/min according to the combination selected from the orthogonal array.

Fig.2. Hard-faced mild steel plate

4.1. Microhardness test

The micro hardness test was carried out by polishing the cross-sectioned samples with emery papers up to grade 2000. For micro-hardness testing the specimens were prepared using standard procedure like belt grinding, polishing using successively fine grades of emery up to 2000 grit size. This was helpful in removing coarse and fine oxide layer as well as scratches on the surface that were to be metal graphically analyzed. Micro-hardness tester was used to measure micro-hardness at various zones of interest in different weldments. A load of 10 kgf and a dwell time of 20 seconds were used for these studies.

Fig.3. Sample for microhardness testing

4. RESULTS AND DISCUSSION

Table 3 Results of Mean Microhardness and S/N ratio of Mean Microhardness

Ferroboron content (mg/mm^2)	Welding current (A)	Average Welding speed (mm/min)	Mean Microhardness (HV)	S/N ratio Mean Microhardness
4	90	45	280	48.9432
4	120	90	274	48.7550
4	150	135	260	48.2995
8	90	90	315	49.9662
8	120	135	305	49.6860
8	150	45	285	49.0969
12	90	135	380	51.5957
12	120	45	365	51.2459
12	150	90	348	50.8316

5.2.1. ANALYSIS OF MICRO-HARDNESS (HV)

Microhardness is a dependable variable and there are three factors namely ferroboron content (mg/mm^2), welding current (A) and average welding speed (mm/min). Various tests and graphs have been determining to know which factors have a statistically significant effect on micro-hardness in shown in Table 4. The measured response was analyzed by using a standard commercial statistical software package MINITAB 17.

Table 4 Analysis of variance for S/N ratios

Parameters	Degree of freedom(DF)	Sum of square(SS)	Mean square(MS)	F-value	P-value
Ferroboron content (mg/mm^2)	2	10.0810	5.04052	13257.93	0.000
Welding current(A)	2	0.8870	0.44350	1166.53	0.001
Average welding speed (mm/min)	2	0.0177	0.00884	23.26	0.041
Residual Error	2	.0008	0.00038		
Total	8	10.9865			

Since the P-value in the Table 4 is less than 0.05, there is a statistically significant relationship between the variables at the 95.0% confidence level .The dependable variable micro-hardness (HV) and three independable variables namely ferro boron content (mg/mm^2), welding current (A) and average welding speed (mm/min) are studied to test the significance and to develop the model.

Table 5 Response for Signal to Noise Ratios Larger is better

Level	Ferroboron content (mg/mm^2)	Welding current (A)	Average welding speed (mm/min)
1	48.67	50.17	49.76
2	49.58	49.90	49.85
3	51.22	49.41	49.86
Delta	2.56	0.76	0.10
Rank	1	2	3

5.2.2. Main Effects Plot S/N ratios for Micro-hardness (HV)

The main effects plots for S/N ratios are shown in Figure 4. These show the variation of micro-hardness (HV) with the three parameters i.e. ferro boron content (mg/mm^2), welding current (A), average welding speed (mm/min) separately. In the plots, the x-axis indicates the value of each process parameter at three levels , y-axis the response value. Horizontal line indicates the mean value of the response. The main effects plots are used to determine the optimum design conditions to obtain the optimum micro-hardness (HV). Main effects plot for micro-hardness (HV) are plotted between Micro-hardness (HV) Vs Ferroboron content (mg/mm^2), Micro-hardness (HV) Vs Welding Current (A) and Micro-hardness (HV) Vs Welding speed (mm/min)

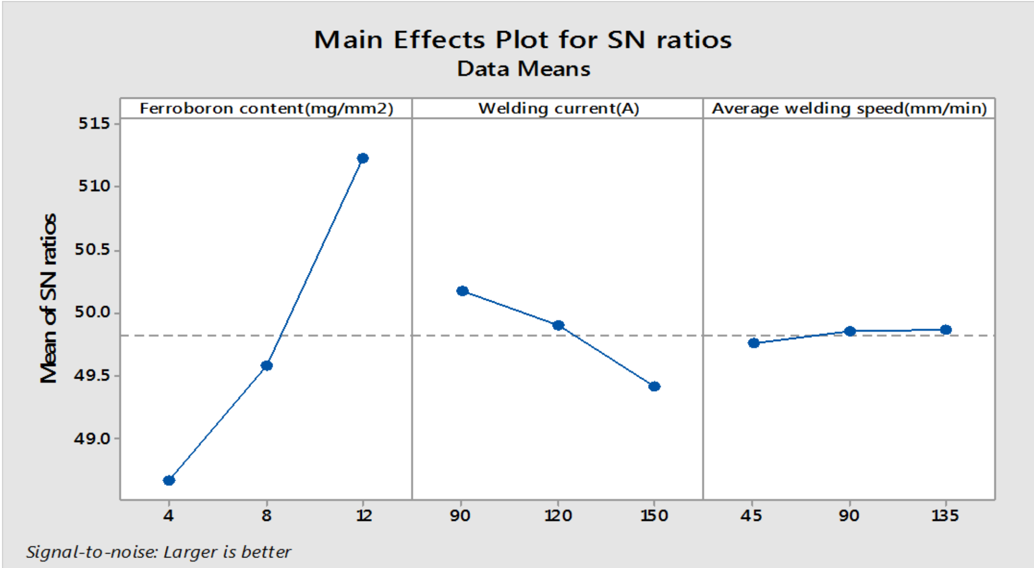

Fig.4. Main Effects Plot for S/N ratios for Micro hardness (HV)

There are three levels for each of the three factors. Thus effect of each factor is plotted by the lines of graph. Figure 4 shows the main effect plot for S/N ratios for Micro-hardness. This shows the main effects plot between micro-hardness (HV) and ferroboron content (mg/mm^2), whereas micro-hardness is found to be increasing with increase in ferroboron content (mg/mm^2). The ferro boron content (mg/mm^2) has more significant effect on the micro-hardness, when ferroboron content increases micro hardness increases. Microhardness decreases linearly with the increase in welding current because higher welding current gives higher heat input, higher heat input gives lower microhardness due to reason that higher current results in slower cooling rates resulting in softer matrix having lower microhardness. Higher the cooling rate become higher microhardness. The plot between microhardness (HV) and welding speed shows that micro-hardness increase, with increase in welding speed because higher welding speed gives lower heat input and lower heat input gives higher micro-hardness.

The optimum parameters of micro-hardness are **A3B1C3.**

Ferroboron content 12 mg/mm^2, welding current 90 A, and welding speed 135 mm/min. According to the present study, it can be concluded that the parameter ferro boron content (mg/mm^2) have the most significant effect on micro-hardness (HV).

5. CONCLUSIONS

The analysis of result obtained from the study of the process parameters of hardfacing with ferro boron by paste technique using shielded metal arc welding the following conclusions may be drawn.

- Micro-hardness increases with increase in ferro boron content (mg/mm^2) due to hypereutectic boron content.
- Micro -hardness decreases linearly with the increase in welding current 90 A to 150 A because higher welding current gives higher heat input , higher heat input gives lower microhardness.
- Micro-hardness increases, with increase in welding speed 45 to 135 mm/min because higher welding speed gives lower heat input and lower heat input gives higher micro-hardness.
- The optimum parameters of micro-hardness are **A3B1C3** ie.12 mg/mm^2 ferro boron content, 90 A welding speed & 135 mm/min average welding speed.

REFERENCES

[1] Gourd, L.M. (1998). Principles of welding technology. *Viva Book, New Delhi*

[2] Horsfield, A. M. (1980).Weld Surfacing and Hardfacing. *The Welding Institute, Abington Hall, pp. 32-39.*

[3] Choteborsky, R., Hrabe, P., Muller, M., Jirka, M. (2008). Abrasive wear of high chromium Fe-Cr- C hardfacing alloys. *Res. Agr. Eng. Vol. 54, pp. 192-198.*
[4] Wang, X.H., Zou, Z. D., Qu, S.Y., Song, S.L., (2005). Microstructure and properties of the TiC/Fe- based alloy Hardfacing layers. *J of Materials Science (2005), vol.40, pp.3629-3633.*
[5] Wang, J. T., & Jean, M. D. (2006).Optimasation of cobalt based hardfacing in carbon steel using the fuzzy analysis for the robust design. *Int J Adv Manual Technol (2006), vol. 28, pp. 909-918.*
[6] Buchanan, V.E., Shipway, P.H., & Mecartney, D.G.(2006). Microstructure and abrasive wear behaviour of shielded metal arc welding hardfacing used in the sugarcane industry. *Wear (2007), vol.263,pp.99-110*
[7] Azimi, G., Shamanian, M. (2009). Effect of silicon content on the microstructure and properties of Fe–Cr–C hardfacing alloys. *J Mater Sci (2010), vol 45,pp.842-849.*
[8] Kazemipour, M., Shokrollahi, H.,& Sharafi, Sh. (2010). Influence of the matrix microstructure on abrasive wear resistance of heat-treated Fe–32Cr–4.5C wt% hardfacing alloy. *Tribol Lett (2010),vol.39,pp.181-192*
[9] Phadke, M.S., Quality Engineering using Robust Design. *Prentice Hall Englewood cliffs New Jerry. USA (1989)*