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Experimental Investigation of Effect of Fe-Cr-C based Hardfacing on Wear Properties of Mild Steel

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***Abstract*—An experimental investigation was carried out to improve the wear properties of mild steel hardfacing it with Fe-Cr-C based hardfacing electrode. Shielded metal arc welding process was used to deposit 1 and 3 layers of the alloys over the mild steel base metal surface. In order to check whether the wear property is improved or not Pin on Disc wear test was performed. Hardness test was also performed and the microstructural observations of the samples were investigated using optical microscopy. It was found that Wear resistance increases by 79.48%, as the hardfacing layers are increased from 1 to 3. Hardness also increases by 32.26%, as the hardfacing layers are increased from 1 to 3.**

Keywords— Hardfacing ,POD, Mild steel, Buffer layer

I. INTRODUCTION

Hardfacing is the deposition of a special alloy material on a metallic part, by various welding processes, to obtain more desirable wear properties or dimensions. The properties usually sought are greater resistance to wear from abrasion, impact, adhesion (metal-to-metal), heat, corrosion or any combination of these factors. A wide range of surfacing alloys is available to fit the need of practically any metal part. Some alloys are very hard; others are softer with hard abrasion resistant particles dispersed throughout. Certain alloys are designed to build a part up to a required dimension, while others are designed to be a final overlay that protects the work surface. [1] Hardfacing is the process of depositing of metal by one of various welding techniques, a layer or layers of metal of specific properties on certain areas of metal parts to resist wear, erosion, corrosion, high temperature, or impact. [2] Hardfacing can be done for a new part also while producing it and also for worn out part to re-establish the worn out portion. Thus hard-facing has capability to enhance service life of a part and there by extend life of equipment. Hardfacing can help reduce both maintenance and manufacturing costs. Maintenance costs are reduced because hardfaced parts are less likely to fail and therefore need to be replaced less often. Also, parts that would otherwise need to be replaced can be repaired using hardfacing. Production cost is also reduced because parts do not have to be made out of expensive metal alloys. They can be made out of less expensive metals and then hardfaced for strength.[3]

II. HARDFACING PROCEDURE

The hardfacing alloy is deposited over the base metal surface by using shielded metal arc welding process. Fe-Cr-C based electrode is used to overlyed the surface of base metal. Such type of electrode is having the chromium as major constituents which provide better resistance against wear. Buffer layer is used before hardfacing and an interpass temperature of 250°C is maintained between subsequent passes. Once the buffer layer is applied the Fe-Cr-c hardfacing alloy is deposited over the surface by using shielded metal arc welding. The electrode used is having dia. 3.2mm and length 350mm.

III. EXPERIMENTATION

A. *selection of base metal*

For this research work mild steel was selected as base metal having chemical composition given below.

Table I

Chemical composition of base metal

C	Si	Mn	P	S	Cr	Mo	Ni	Cu
0.21	0.12	0.40	0.02	0.002	0.10	0.01	0.11	0.20

B. *Selection of hardfacing electrode*

Fe-Cr-C based hardfacing electrode was selected for the experiment and the chemical composition is given below.

Table II
Chemical composition of Fe-Cr-C hardfacing electrode

C	Mn	Si	Cr	Mo	V
0.60	0.70	0.50	6.2	0.45	0.30

C. *Selection of buffer eletrode*

The buffer layer electrode has been used to provide proper bonding between the base metal and hardfacing electrode. And their chemical composition is given below.

Table III
Chemical composition of buffer electrode

C	Mn	Si	S	P	Ni+Cr+Mo+V
0.06	1.40	0.40	0.010	0.019	< 1.75

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D. Test to be performed

The parameters selected for hardfacing the base metal is given in table IV.

Table IV
Parameters for test

Sample no	Current	Hardfacing Layers
1	180	3
2	180	1
3	150	3
4	150	1

In order to investigate wear properties ASTM G99 Pin on disc wear test is performed. The specimens prepared are having dia.6mm and length 25 mm as shown in Fig.1.The pin on disc set up is shown in fig.2.

Wear volume loss in mm^3 = Weight loss / 10*D (1)

Wear rate in mm^3/Nm = Weight *10000/ S*D*T (2)

Where

D = density

S= sliding distance

T= time

Table V
Parameters for wear test

Disc rotation speed	250 RPM
Disc dia.	80 mm
Load applied	3 Kg
Sliding distance	1500 meters
Intervals	4
Total time	24 min

Hardness test was performed at Punjabi University, Patiala. The hardness test is carried out by polishing the cross-sectioned samples with amri papers up to grade 2000 with a load of 500 grams.

Microstructural observations have been taken by optical microscope at the magnification of 100X in Lovely University, Phagwara (Punjab). Prior to observations, the samples are polished and etched with 3% nital for 10 seconds.

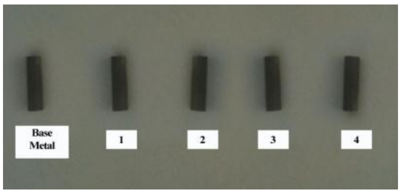

Fig. 1 Pins for wear test

Fig. 2 Pin on disc machine

IV. RESULTS & DISCUSSION

A. Wear test result

Mass loss

Wear resistance test is carried out to measure the increase in wear resistance of hard faced samples as shown in figure 3. Mass loss is measured during the wear resistance test for the sliding distance of 1500 meters. Mass loss is minimum (0.0020 g) in sample number 3 followed by sample number 1 (0.0023 g), sample number 4 (0.0085 g), sample number 2 (0.0090 g) and base metal (0.0102). Sample number 3 has highest %age of chromium along with negotiable amounts of Mo and V. Cr increases wear resistance whereas Mo, V increases hardness. Mass loss is associated with presence of allowing elements and microstructure of an alloy/metal. Base metal mild steel has highest mass loss among all samples due to softer pearlitic phase in microstructure and unavailability of alloying elements as compared to other samples.

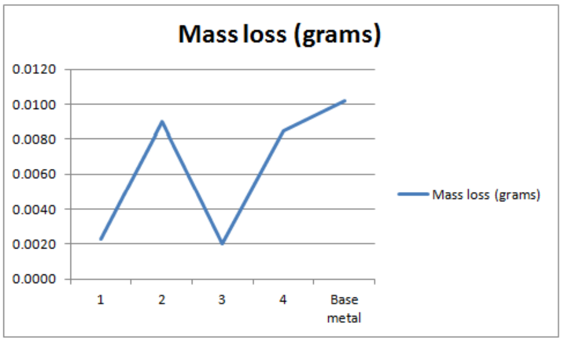

Fig. 3 Wear test result

Wear volume loss

Wear volume loss is measured in mm^3 for the samples with the equation (1) Figure 4 shows wear volume loss is maximum in sample number 2 followed by sample number 4, sample number 1 and sample number 3. Wear volume loss gets decreased with sliding distance except for sample number 2, in which wear volume loss increases up to 1125 meters and then decreases. The decreased wear volume loss is associated with work hardening of substrate.

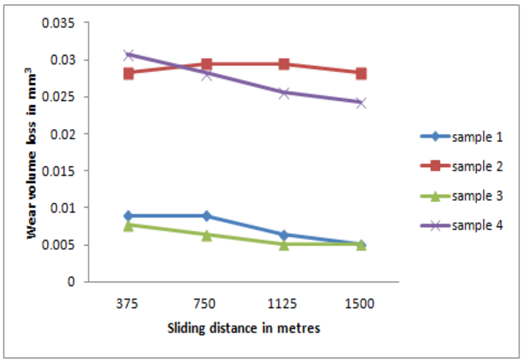

Fig. 4 Wear volume loss vs. sliding distance

Wear rate

Wear rate is measured in mm^3/Nm. Sample number 1 and sample number 3 shows least wear rate as compared to sample number 2 and sample number 4. Sample number 1 and sample number 3 have 5.22% and 5.19% of chromium as compared to 3.08% and 3.73% in sample number 2 and sample number 4 respectively as shown in figure 5. Higher amount of Cr in samples number 1 and sample number 3 decreased the wear rate as higher amount of chromium results in increased carbide formation which acts as barrier to the removal of material in wear, hence lower wear rate. Except Cr, other key elements in sample number 1 and sample number 3 are Mo and V, which tends to increase in hardness. As the hardness increases, there is decrease in wear rate. Wear rate decreases with time and tends to stable.

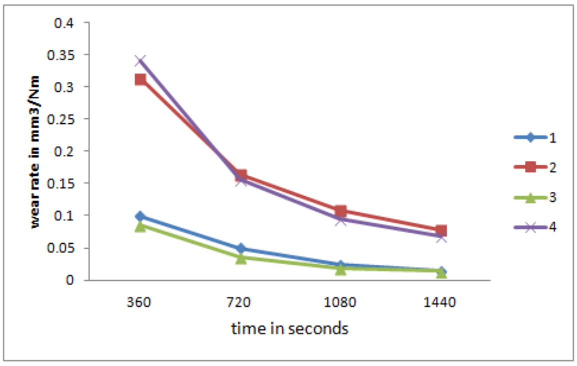

Fig. 5 Plot b/w Wear rate vs. time

Wear resistance

Wear resistance is reciprocal of wear rate. Wear resistance is maximum for sample number 3, which has minimum wear rate among all samples. Similarly sample number 2 has minimum wear resistance among all hardfaced samples with maximum wear rate Increased wear resistance is associated with presence of alloying elements and wear resistance particle in substrate. Sample number 1 and sample number 3 has higher amount of Cr, V and Mo causing better wear resistance than sample no 2 and sample no 4.

B. Hardness test

Hardness is maximum (871 HV) in sample number 3. In which lower current (150Amperes) and 3layers of hardfacing are used which produces finer grained structure as compare to single layered samples, causing an increase in hardness. Whereas sample 2has the lowest hardness (575HV) across all the hard faced samples except base metal. Which is due to high current (180 amperes) and single layer hardfacing High current result in slower cooling rates resulting in softer matrix having lower hardness. The hardness of mild steel is (250 HV) this is due to presence of relative softer phases than hard faced samples. Sample 1 has slightly low hardness (840 HV) than sample 3which is due to similar welding conditions except high current in sample 1 as compared to sample 3 which results in coarser dendritc segregation thereby reduced hardness. Figure 6 showing the plot b/w samples and hardness.

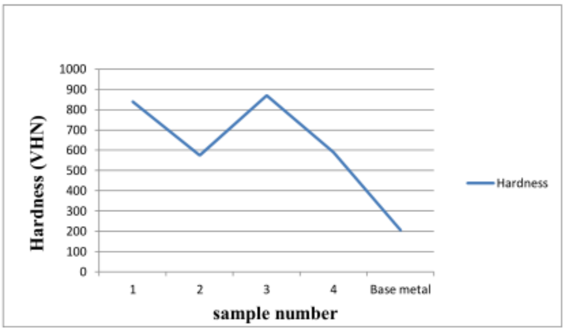

Fig.6 Plot b/w samples and hardness

C. Microstructural observations

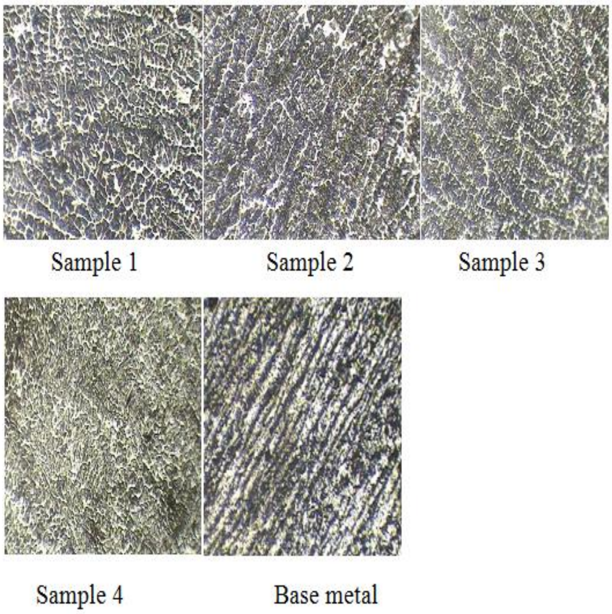

Fig. 7 Microstructural observations

All the hard faced shows a microstructure composed of martensite and retained austenite with a pattern of dendritic segregation which becomes more redefined as current has reduced. Sample no 1 and 3 shows microstructure tempered by subsequent passes produces further precipitation of small carbides whereas in sample 2 and 4 shows coarser grain as compared to sample no 1 and 3 due to slower cooling rates. Whereas base metal shows pearlitic phase embedded in matrix of ferrite. Figure 7 is showing the microstructural observations of samples.

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V. CONCLUSION

1. Hardness and wear resistance increases with increase in hardfacing layers and decreases with increase in current.

2. Hardness increases by 32.26%, as the hardfacing layers are increased from 1 to 3.

3. Wear resistance increases by 79.48%, as the hardfacing layers are increased from 1 to 3.

4. Hardness and wear resistance decrease by 3.55% and 12.22% respectively with 16.66% increase in current.

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