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Experimental Investigation of Surface Properties of Hardox 400 Hardfaced with WC

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***Abstract*—An experimental investigation was carried out in order to improve the wear properties of Hardox 400 base metal by hardfacing it with WC hardfacing electrode. 1 and 2 layer of hardfacing alloy were deposited over the base metal surface by using Manual Arc welding process. Pin on disc wear test was performed in order to check the wear. Corrosion test was also performed on samples. Hardness test was also performed to check the hardness of new surface. It was found that the wear of unhardfaced surface (0.00412 gm) was more than the hardfaced surface (0.00011 gm). It was also found that no red rust were visible on the hardfaced surface whereas red rust was visible over the base metal surface. Hardness also increases by 1.7 times of time base metal.**

Keywords—Hardfacing, Hardox 400, MMAW , Pin on disc

I. INTRODUCTION

Wear related problem of components are always a major concern in the industry which leads to down time of machineries which is totally unacceptable for any industry. Researchers are working over the years to minimize wear. In order to overcome this problem they come up with a solution called hardfacing which applies over the components to reduce the wear. Hardfacing is a method used for improving various surface properties of components like wear, corrosion resistance under high pressure and high temperature. Basic

Principle of hardfacing consists of depositing a material having better properties than the base metal over components either by using welding or cladding to enhance surface properties. Among the various techniques of surface modification, welding is very generally preferred because of its relatively simpler operation. Hardfacing consist of deposit a wear or corrosion resistant alloy depending upon situation either on a tattered or torn component or a new component of machines which is subjected to wear [1].

Various Industries faces the wear related problem of components during service. Due to wear these components it need to be replaced, which required extra amount of money and causes downtime of the equipment which not economical. The hardfacing process will be economically successful only when suitable alloys will selected for hardfacing. Hardfacing alloys may vary from application to application. Carbon and chromium are the major constituents of hardfacing alloy which are used in hardfacing.

It is observed that by varying the percentage of carbon and chromium wear and corrosion resistance can be enhanced [2]. Properties of hardfaced surface depend upon percentage dilution of alloy into base metal. The principle of hardfacing Technology is the depositing superior metal on the base metal. Hardfacing now a day's used in almost every industry. In this study an attempt is made to improve the service life of wear resistant material which are used in mining, agricultural industry etc. for this a material having high wear resistance and fair corrosion resistance properties is selected. The hardfacing will be performed by using Manual metal arc welding.

II. HARDFACING METHOD

Manual metal arc welding process was used to deposit the alloys over the base metal. Tungsten carbide hardfacing electrode is used for overlaying the base metal surface. The presence of carbon in such electrode provides excellent resistance to wear. Electrode used is having dia 4.0mm and length of 350 mm. Initially the electrode was baked at temperature of 350°C an hour before the final use. Area around the weld is cleaned properly make sure that there is no dust particle around the weld area. By using this electrode 1 and 2 layer was deposited over the base metal surface.

III. EXPERIMENTATION

A. Selection of base metal

Base metal selected for this research work is wear resistance steel Hardox 400. It's having typical application in components and structure subjected to wear directly. It is having high toughness, good bendability and weldability and hardness. HARDOX 400 is a abrasion resistant steel having hardness 370 HBW. It is an all around wear resistant steel. Their major chemical constituents are given in table I.

Table I
Chemical composition of Hardox 400

C	Si	Mn	P	S	Cr	Ni	Mo	B
0.32	0.70	1.60	0.025	0.010	1.40	1.50	0.60	0.004

B. Selection of hardfacing electrode

Tungsten carbide (WC) hardfacing electrode is mainly used when the component is subjected to very high wear and to minimize that wear over laying of tungsten carbide it reduces the wear and improve the service life up to 4 to 8 times. It's having excellent wear resistance properties along

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with moderate corrosion properties. It can sustain into a very high temperature environment. Their major chemical constituents are given in table II.

Table II
Chemical composition of WC hardfacing electrode

C	MN	Si	W
2.16	0.70	2.06	52.2

C. *Test to be performed*

The parameters given in Table III were followed for during hardfacing and preparing samples for wear test.

Table III
Parameters for test

Sample No.	Current (I)	Hardfacing layers
1	160	2
2	160	1
3	140	2
4	140	1

Once the samples gets prepared now it's time to check whether the surface properties has improved or not. In order to examine the wear properties ASTM G99 Pin on Disc wear test was performed and samples prepared according to requirement. Samples having dia. 10mm and length of 30mm for each was prepared as shown in figure 2 and load of 10N was applied for the test. Weight loss method was adopted for investigating wear. Test was performed at Ducom instruments Lab. Bangalore.

Pin on disc apparatus is shown in figure 1 on which the wear test was performed.

Sliding speed in (m/sec) = πDN/ 60,000 (1)
Sliding distance in meter = πDNT / 60,000 (2)

Where
π = 3.142
D = Dia. of wear track in mm
N = Disc speed in rpm
T = Test duration in sec's
Sliding distance:

Table IV
Parameters for wear test

Description	Detail
Disc rotation speed	350 RPM
Disc dia.	60 mm
Load applied	10N
Sliding speed	1.09 m/sec
Sliding distance	989 m
Pin size	10 mm
Software	Winducom 2010

Corrosion test was performed at Spectro analytics lab Delhi by using ASTM B117 Salt spray corrosion test for alloy steel. Samples were prepared according to them a smooth shiny surface was prepared such that any rust form over the surface can be easily detected. Specifications for the test are given in table no V.

Fig. 1 Pin on disc wear test setup

Fig. 2 sample for wear test

Table V
Specification for salt spray test

Description	Detail
Salt solution (NaCl)	50g/1 ± 10g/1
Temperature	35 ± 2°c
pH	6.5 - 7.2
Fog collection	1–2 ml/hour in 80 cm 2 Area
Duration	120 hrs

Hardness test was performed on Rockwell hardness tester as per ASTM E-18 standard in Lovely Professional University. Initially the specimen was placed over the Rockwell hardness tester and minor load was applied to set the scale to zero then a major load of 150 Kgf was applied over the sample to check their hardness on HRC scale.

IV. RESULT & DISCUSSION

A. *Wear test*

Wear test was perform on Pin on disc apparatus weight loss method was consider for wear and the result obtained from the test is given in Table no VI. Test was performed for 15 min. Initial weight of sample was measured using weight machine once 15 min. completed the sample weight was measured and the difference between these two weight is consider as weight loss or wear(gm).

Table VI
Wear test results

Sample No	Current (I)	Hardfacing layers	Initial weight (gm)	Final weight (gm)	Weight loss (gm) / Wear (gm)
1	160	2	18.74670	18.74659	0.00011
2	160	1	18.87391	18.87378	0.00013
3	140	2	18.58376	18.58345	0.00031
4	140	1	18.31950	18.31876	0.00074
5	BM	-	19.16765	19.16353	0.00412

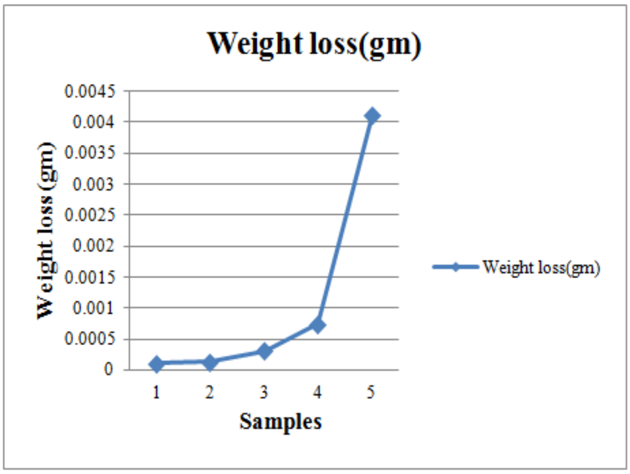

Fig. 3 Plot b/w samples and wt. loss

The weight losses from the samples are given in table VI. It is found that the weight loss for sample number 1 is lowest 0.00011 gm so the wear in sample number 1 is lowest where as the weight loss in sample number 5 that is base metal is highest 0.00412 gm. Whereas the weight loss in sample number 2 is 0.00013gm .which is quite more the sample no 1.The weight loss in sample number 3 is 0.00031 gm and in sample number 4 it was found that 0.00074 gm means it is found that the weight loss from of hardfaced samples are less than the unhardfaced base metal. The reason for having less wear in hard faced samples is their chemical compositions as the percentage of C in the hardfacing electrode is very high that 2.16% which provide a harder surface and it also consists of high amount of Si that is 2.06% provides a harder surface to remove particle as compare to base metal which consists of 0.32 % of carbon. Base metal also consists of 0.70% of Si and 1.4 % of Cr which provide a hard surface makes it a wear resistant material.

Effect of current(I) on wear

It is found from the table no VI and shown in figure 4 that as increase in current (I) there is decrease in wear. When Current (I) was 140A and Hardfacing layer was 1 wear comes out 0.00074 gm and when the hardfacing layer was increased from 1 to 2 at same current level it comes out 0.00031 gm.

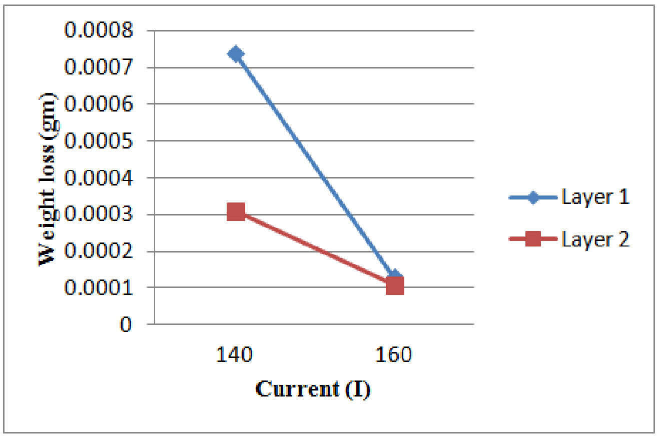

Fig.4 Plot b/w current (I) and weight loss

When current (I) increased from 140A to 160 A at hardfacing layer 1 the wear comes out 0.00013 gm and for hardfacing layer 2 it comes 0.00011 gm. Wear shows decreasing pattern when current (I) increasing .This might be due to as increase in current the heat input increases which lead to slower down the cooling rate that will produce fine grain In heat affected zone (HAZ). Cooling of weld bead at room temperature provides it fine grains not exactly fine but approximate to fine grains the process will act as normalization which leads to increase the hardness .As much as the material is harder less will be wear.

Effect of hardfacing layer on wear

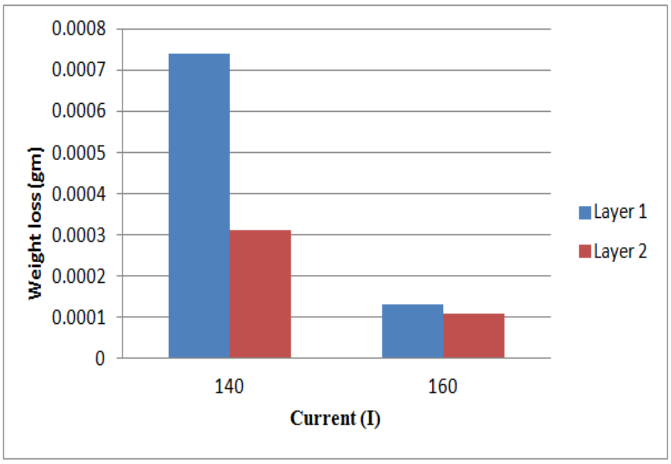

Fig. 5 Plot b/w current (I) and weight loss

It was found that on increasing the hardfacing layer there is decrease in wear as shown in figure 5.When the current (I) was 140A and layer was 1 wear comes out 0.00074 gm but an increase in hardfacing layer at same current level the comes out 0.00031gm where as for current (I) 160A when layer was 1 wear comes out 0.00013 gm as increase in layer from 1 to 2 there is decrease in wear comes out 0.00011 gm which shows a decreasing pattern of wear when hardfacing layer increases from 1 to 2 .This decrease in wear is due to decrease in dilution percentage. As the layers will increase dilution will decrease because the small amount of base metal composition will mix with the upper layer and as it increases the mixing of base metal constituents into the deposited layer will decreases.

B. Corrosion test result

Table VII
Corrosion test result

S. No	Temp. (°c)	Duration (Hr.)	Result		
			Top	Bottom	Cutting edge
1	35	120	No rust visible	No rust visible	Red rust Visible
2	35	120	No rust visible	No rust visible	No rust Visible

The data obtained from the salt spray test is given in table VII. Sample number 1 that is base metal is having less resistance to corrosion as compare to the hardfaced surface there is red rust is found on to the base metal cutting edge where as there no red rust was visible over the hardfaced surface either on top surface or bottom surface as shown in figure 6. The formation of red rust over the base metal surface indicates that it having less resistance to corrosion properties. Whereas the hardfaced surface was yellowish surface in some area but they can not be consider as rust. As there is no rust was visible over the hardfaced surface it can be say that the resistance to corrosion of the new surface after hardfacing get better as compare to un hardfaced base metal surface.

(a)

(b)

(c)

Fig 6 (a), (b) Base metal surface (c) hard faced surface

D. Hardness test

Table VIII
Hardness test result

S. No	Layers	Hardness(HRC)
1	1	61
2	2	66
3	Base metal	38

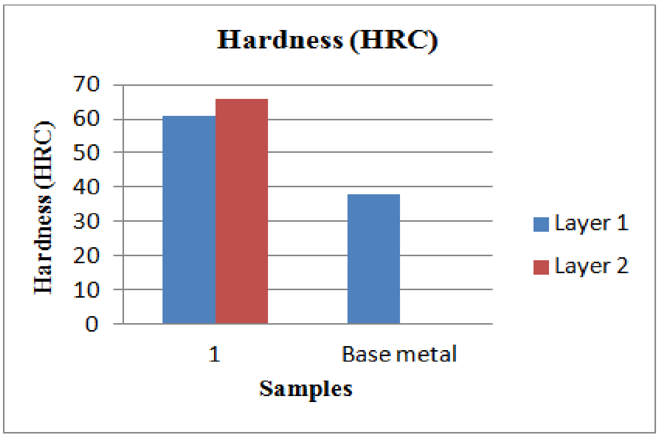

Fig.7 Hardness test plot

Table VIII showing the result of hardness test. The base emtal is having hardness value of 38HRC. Where as the new surface hardfaced with WC hardfacing electrode is having hardness 61 HRC when one layer is applied and when the deposited layer increases from 1 to 2 layer the hardness increases from 61HRC to 66HRC which shows a better hardness can be achieved by applying more no of layer over the base metal surface.The hardness of base metal is also good because of it consists C, Cr, Si as major constiuents which provide a harder surface. The hardness increses from base metal to hardfaced surface is due to the chemical composition of the deposited alloy.As increse in hardfacing layer the hardness increase is due to dilution as in first layer the more amount of base emtal constients will mix with the deposting alloy in weld zone and solidify so the maximum hardness can't be achieved so to achieve the maximum har dness the numbers of layers should increases as in this case when the numbers of layers increses from 1 to 2 hardness also increases because of the less amount of base metal ha solidify with the second layer surface.

V. CONCLUSION

1. The new surface obtained from hardfacing is having better wear resistance property than the base metal.
2. The resistance to corrosion of hardfaced surface is better than the base metal surface.
3. The hardness of hardfaced surface was increased 1.7 times of unhardfaced base metal.
4. On increasing current there is decrease in wear.
5. As increase in hardfacing layer wear decreases.

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REFERENCES

[1] E. N. Gregory, “Llerdheina,” no. April, pp. 129–134, 1978.
[2] V. Shibe and V. Chawla, “ENHANCEMENT IN WEAR RESISTANCE BY HARDFACING : A REVIEW,” vol. 2, no. 3, pp. 111–122, 2013
[3] D. W. M. Chan and K. W. Y. Chan, “Repair and Maintenance,” vol. 2003, pp. 26–27,2005.
[4] I. K. Ř. Íková, B. Szewczyková, P. Blaškovitš, E. Hodúlová, and E. L. Č, “STUDY AND CHARACTERISTIC OF ABRASIVE WEAR MECHANISMS,” pp. 1–9.
[5] S. Singla, A. S. Kang, J. S. Grewal, and G. S. Cheema, “Wear Behavior of Weld Overlays on Excavator Bucket Teeth,” Procedia Mater. Sci., vol. 5, pp. 256–266, 2014.
[6] A. S. Kang, G. S. Cheema, and S. Singla, “Wear Behavior of Hardfacings on Rotary Tiller Blades,” Procedia Eng., vol. 97, pp. 1442–1451, 2014.
[7] K. M. Kenchireddy, C. T. Jayadeva, K. Yathiraj, and A. B. Metal, “G j e s r,” vol. 1, no.6, 2014.
[8] H. Vasudev, “HARDFACED LAYER ON MILD STEEL MADE BY PASTE TECHNIQUE WITH SMAW ELECTRODE TO IMPROVE SURFACE PROPERTIES,” Int. J. Adv. Res., no. 1, 2014.
[9] G. R. C. Pradeep, A. Ramesh, and B. D. Prasad, “Steel by Three Different Welding Processes,” 2013.
[10] P. W. Leech, X. S. Li, and N. Alam, “Comparison of abrasive wear of a complex high alloy hardfacing deposit and WC-Ni based metal matrix composite,” Wear, vol. 294–295, pp.380–386, 2012.
[11] J. S. Gill and A. Kumar, “SOME STUDIES ON THE BEHAVIOR OF IRON BASED HARDFACING ELECTRODES ON LOW CARBON STEELS USING SMAW PROCESS,”2012.
[12] Y. Bayhan, “Reduction of wear via hardfacing of chisel ploughshare,” Tribol. Int., vol. 39, no. 6, pp. 570–574, 2006.
[13] A. Klimpel, L. A. Dobrza, D. Janicki, and A. Lisiecki, “Abrasion resistance of GMA metal cored wires surfaced deposits.”