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"HARDNESS AND WEAR ANALYSIS OF GRAPHITE CONTENT BASED HARDFACING COMPARATIVE STUDY ON SURFACE RESPONSE OF IRON BASED HARD FACING "

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ABSTRACT

Process of depositing a layer over a base material in order to improve the surface quality of the underlying material is known as surfacing. Hard facing is a surfacing method that involves depositing a hard layer over a soft material to increase wear resistance. In the industry, there are several procedures for depositing these rigid layers. Welding is also employed in the industry to create this hard face layer since it has several benefits such as high deposition rate, minimal dilution, and high productivity. With the use of submerged arc welding, iron-based hard facing was effectively constructed in this project. Because iron-based alloys are less expensive and have superior metallurgical properties, they were chosen for the last experiment in this investigation. Three hard facing layers with varying carbon concentration were created effectively and without flaws. The mechanical and metallurgical characteristics of the created hard face alloy has been investigated, and it demonstrates a considerable increase in properties over the basic material. Erosive wear studies were also performed on all created hard facing layers, revealing an improvement in erosion resistance of the deposited layer when compared to the base material, and erosion resistance increases with increasing carbon % as more carbon creates greater volume of carbides.

Key Words: *Iron based hard facing, Submerged arc welding, Fe-Cr-C, Erosive wear*

I. INTRODUCTION

Wear is the continuous or gradual degradation of any metal caused by misuse through material loss. It results in the loss of pre-formation due to a part's deterioration in condition. Wear can limit lifetime and productivity, resulting in increased energy consumption and poorer yield. It may also raise the overall cost of upkeep.

Surface improvement is achieved by depositing additional layer of material over a base metal or substrate. In other words, an or multi-layer of another metal or alloy is deposited over a base metal to improve its wear resistant qualities such as resistance to abrasion, corrosion, and friction. This process is known as Surfacing. Types of surfacing include; Cladding, Build up, Buttering, and hard facing. When any metal or alloy is deposited over another metal i.e. base metal to improve it hardness and also protect the base metal from different wear (abrasion, impact, erosion, galling, and cavitation) is known as hard facing. Majorly hard facing makes a metal to be abrasion resistant. Approx. three layer of any alloy needed to be deposit in hard facing. In this process one should avoid excessive penetration so that excessive dilution may not take place which reduces the effectiveness. It extends the service life of metal component. The process is used to restore worn parts to usable condition.

To deposit very thick (1 to 10mm) layer of wear resistance material with high bond strength welding process are used.

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There are number of welding techniques which can be used for weld hard facing as metal-inert gas (MIG), tungsten-inert gas (TIG), plasma transferred arc (PTA), submerged arc welding (SAW) and manual metal arc (MMA). A very vast range of coating material which includes cobalt-based alloys, nickel alloys, martensitic and high-speed steels and WC-Co cemented carbides can be applied. It is necessary to finish the surface after deposition by any of above welding method.

II. LITERATURE REVIEW

Chang, et al. [2021] had practice through GTAW over a high carbon Fe-Cr-C hard facing alloy. ASTM A36 Steel was used as substrate and chromium and graphite alloy used as filler. When adding different grades of Graphite we get different microstructure of Fe-Cr phase and [(Fe Cr)7 C3] carbide. As the carbon content increases so the fraction of primary [(Fe Cr)7 C3] carbide increases and hardness of hard facing alloy is simultaneously increases. After abrasive wear test, it observes that as the hardness of primary [(Fe Cr)7 C3] carbide (about 1600HV) is higher than the quartz (1000-1100HV) so the primary [(Fe Cr)7 C3] carbide can effectively resist over the abrasive particle. At the adding of low carbon it founds continuo us scratches whereas when the carbon content increased and primary [(Fe Cr)7 C3] carbide also increased the discontinuous scratches were formed and craters formation were also increased. So this results that on the addition of graphite in the Fe-Cr-C alloy, it promotes the formation of hard [(Fe Cr)7 C3] carbides. With the formation of hard carbides, on wear test it gives discontinuous scratches and craters which states the abrasive wear resisting property of the alloy.

Jie-Hao Chen et al. [2020] had used Fe-Cr-C hard facing alloy for cladding process through gas tungsten arc welding. Pure commercial Fe with the different composition of Cr-C is used as a filler metal and deposit as hard facing alloy over low Carbon Steel. The specimen was of 100X40X10 mm3 dimension. Filler using in that experiment was prepared by a powder mixture with different amount of Fe & Cr-C to obtain different microstructure of hard facing alloy system. After experiment had been done optical emission spectrograph was used to analyze the chemical composition of hard facing layer. Optical microscopy (OM), scanning electron microscopy was used to image micro structures. X ray diffraction was used to identify the structural phases. The hardness of the top surface of alloy layer was tested by Rockwell hardness tester. After testing, different microstructures were observed. On comparison, it founds that with the increase of Cr-C content, the structures developed as hypoeutectic, near eutectic or hypereutectic. The hypoeutectic structure was composed from primary γ-Fe phase and hypereutectic was composed from primary [(Fe Cr)7 C3] carbide. Hence, the hardness of hypoeutectic microstructure was lower than other microstructures.

M. Morsy et al. [2020] had did its work over a mild steel Substrate for hard facing using different electrodes. It compares, microstructure getting from different electrodes by two welding methods i.e. GMAW & MMAW. It takes two covered electrode [DIN 8555: E6-UM-60 & E10-UM-60GR] named A&B and two tubular electrode are [E10-GF-60GR1 & E10-GF-60GR2] named C&D. First it takes XRD of this electrode for assuming the wear resistance of deposit layers. It takes substrate of mild steel of 10mm thickness and apply hard facing by using covered & tubular electrodes by MMAW process. Then it tests the microstructure & hardness of hardness substrate. Abrasive wear test pin on disc was conducted using tribometer testing machine. After testing, it concludes that martensitic microstructure with electrode A shows the lowest wear resistance. Whereas, in similar carbon equivalent of electrode B & C, electrode C (tubular) has better wear resistance than electrode B (covered). With the same carbide area fraction & same hypereutectic structure, electrode D shows larger wear resistance than electrode C. [14]

M. Kirchgabner et al. [2008] had tested the abrasion wear of various Iron based hard facing alloys. It studied the tests by using gas metal arc welding. A complex Fe Cr W Mo Nb alloy with high boron content has compared with lower alloyed material based on Fe Cr B C alloy. Its research work was to evaluate the wear behavior of six different Fe based hard facing alloys by using gas metal arc welding. It tests wear of pure abrasion and combined wear of abrasion & impact. The substrate or base metal used, was 1.0038mild steel and six different Fe based hard facing alloys was produced as flux cored wires. Two layers was carried out and 1.6mm wire diameter was kept for all welding.

III. EXPERIMENTATION

Mild steel was selected as a Base metal for the final experiment as it is widely used in the industry for machine and structural application. These plates were cut in 280 x 50 x 12 mm^3 size by power hacksaw. Plates were pre cleaned with

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the acetone to remove any oil or grease before the welding. The chemical composition of base material is given in the Table. 1.

Table: 4.1 Chemical composition of base material					
Element	C	Si	Mn	Cr	S
Weight Percentage (%)	0.178	0.162	0.49	0.081	0.038

Metal powder was sprayed over the base material in the form of paste; paste was made up of pre- defined amount of powder mixture with silicate binder. Coated Plates were left for 24 hours to dry and baked in oven at 200oC so that no moisture stay remains. Submerged arc welding was used to melt and fix this metal powder over the substrate. Baked plates were kept over the table of welding machine. DC electrode positive was used during the welding. An arc was formed over the paste to melt the metal powder. After solidification the slag was removed and a hard facing layer was formed over the surface. The weld bead was cleaned with chipping hammer and later with acetone for further processes. After so many trials final process parameters & metal powder composition was finalized which was giving defect free weld.

Table. 2. Final welding parameters	
Voltage (V)	42
Speed (mm/s)	4
Nozzle to Plate Distance (mm)	15
Wire feed (mm/s)	12

Table. 3. Final metal powder composition				
Sample	**Fe-Cr (wt%)**	**Fe-Mn (wt%)**	**Fe-Si (wt%)**	**Graphite (wt%)**
Sample-1	85	2.5	2.5	10
Sample-2	80	2.5	2.5	15
Sample-3	75	2.5	2.5	20

After finalizing welding parameters & metal powder composition final three hard faced layer was developed with different graphite percentage as per the Table 3. Graphite percentage was varied intentionally for producing three hard face layer with different carbon percentage.

These experiments were planned to study the effect of carbon percentage in the developed hard faced layer. Figure 2 shows the three different hard face layer with different carbon percentage.

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Fig. 2. Hard faced layer (a) Sample-1 (b) Sample-2 (c) Sample-3

Table. 4. Parameters used for erosive wear testing

Parameters	Particulars
Erodent Material	Alumina particles
Feed rate	4g/min
Impact angle	30°
Particle size	80 microns
Pressure	2.18 bar
Air jet velocity	70 m/s
Nozzle diameter	3 mm
Test Temperature	Room Temperature
Test Time	45 min

In erosive wear hard particles (Alumina) with compressed air was impinged on the surface of a specimen for a particular time and after the test weight of the specimen is recorded. Based on the final weight, weight loss was calculated and this data was used to predict the wear behavior of hard faced layer. The process parameter used for erosive wear was tabulated in table. 4.

IV. RESULTS AND DISCUSSION

4.1. Chemical Composition Analysis

Chemical composition analysis was done to determine the chemical composition of the developed hard faced layer. The specific focus of this study was on the transfer behavior of Chromium, Carbon and other metals. Table 5.1 shows the chemical composition in developed hard faced layer. Table
5 shows that there is significant increase in the carbon, chromium, manganese and silicon content in the hard facing layer as compared to the base metal.

Table.5. Chemical composition of hard faced layer

Element	Base Metal	Alloy 1	Alloy 2	Alloy 3
Carbon	0.178	1.18	1.31	1.38
Chromium	0.081	14.2	13.25	14.92
Manganese	0.49	1.19	1.08	1.12
Silicon	0.162	1.19	1.16	1.1

Table 5 shows as the graphite content in the paste is increasing, the amount of carbon is increasing but when we are using more than 10 % graphite there is very less amount of increase in carbon content. Since the thermal conductivity of graphite is very high so after a certain percentage it takes more heat and it doesn't a low heat flow towards the base metal so less amount of alloying elements transferred in the developed hard face layer.

4.2. Hardness Analysis

Hardness test was performed on each sample to check the hardness value. Table 5.2 shows the hardness value of

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developed hard faced layer and the base metal. Hardness of base material was taken in HRB scale while hardness of other samples was taken in HRC scale.

Table 6. Hardness value of developed hardfaced layer				
Sample	**Base Metal**	**Alloy 1**	**Alloy 2**	**Alloy 3**
Hardness	90 HRB	120 HRB	129 HRB	132 HRB

Table.6 shows with increase in alloying percentage hardness value of hardface layer is increasing. Small amount of increase in carbon percentage, significant hardness value is changing it shows that among all the other alloying element carbon is playing key element for increase in hardness value. When the amount of carbon and chromium is increasing it forms different carbides and harder carbides are produced with high amount of carbon and chromium content. Microstructures of hard facing layer also shows carbide presence and the amount of these carbides are more when hard facing alloys has the high amount of alloying element.

4.3. Erosive Wear Analysis

Erosive wear of hard face layer was studies at an angle of 30 degree as it is proven that maximum erosion of metallic material occurs at this angle only. Initial weight of all samples was taken before the test and after test also weight was taken. Mass loss of all samples were calculated and tabulated in the table 7.

Table.7. Mass loss of all samples			
Sample	**Initial Weight (gm)**	**Final Weight (gm)**	**Mass Loss (gm)**
Base Metal	14.2619	13.1466	1.1153
Sample-1	10.3215	9.264	1.0575
Sample-2	10.7402	9.823	0.9172
Sample-3	10.6301	9.743	0.8871

From table 7, it is clear that maximum erosion has been occurred at base metal and minim um erosion has been found in the sample which has higher amount of alloying elements.

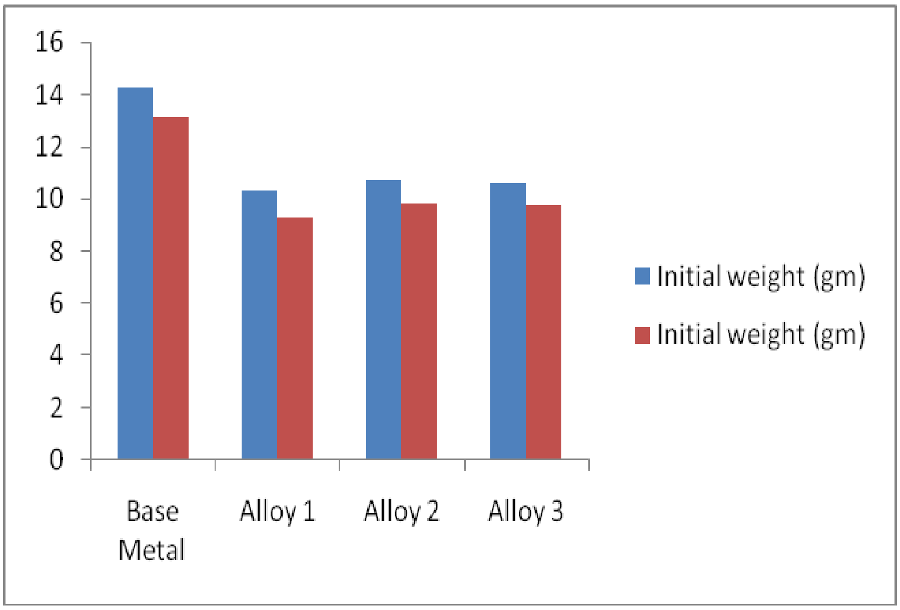

Fig. 3 Comparison of wear before and after erosion for all samples

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V. CONCLUSION

After conducting final set of experiments and all mechanical and metallurgical testing, following results have been concluded:

- Iron based hard facing layer has been successfully developed with submerged arc welding process. Visual inspection of final alloy shows defect free hard facing layer.
- Desired chemical composition in the hard facing layer has been produced with the paste technique used in this process.
- Hard faced layer has significant improvement in mechanical and metallurgical properties as compared to base material.
- Bulk hardness of final alloys shows significant improvement in hardness value as compared to base material and also it shows as carbide content is increasing hardness value is also increasing.
- Resistance to erosion has been increased in hard facing layer as compared to base material. There is also improvement in erosion resistance when carbide volume fraction is increasing in the alloy.

REFERENCES

[1] http://www.yourarticlelibrary.com/welding/surfacing/surfacing-of- metals- meaning-types-and- selection-metallurgy/97691.
[2] Bastien Gerard, Lauren calvert, Mario cordero, 1966, Fundamentals of hard facing by fusion welding, Welding Alloys.
[3] .https://www.twi-global.com/technical-knowledge/faqs/faq-what-is-hard facing.
[4] https://www.lincolnelectric.com/assets/US/EN/literature/C7710.pdf.
[5] http://www.yourarticlelibrary.com/welding/surfacing/top-10-methods-of-surfacing- metals/97671.
[6] http://arcraftplasma.blogspot.com/2016/08/classification-of-hard facing-alloys.html.
[7] http://www.yourarticlelibrary.com/metallurgy/arc-welding-electrodes/process-of-padding- and-building-up-shafts-with-diagram/83389.
[8] https://awo.aws.org/glossary/cladding/.
[9] https://www.twi-global.com/technical-knowledge/faqs/faq-what-are-the-residual-stresses- in- a-dissimilar-metal-weld.
[10] Chia-Ming Chang, Yen-Chun Chen, Weite Wu, 2009, Microstructural and abrasive characteristics of high carbon Fe–Cr–C hard facing alloy, Tribology International, pg: 929-934.