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HARDFACED LAYER ON MILD STEEL MADE BY PASTE TECHNIQUE WITH SMAW ELECTRODE TO IMPROVE SURFACE PROPERTIES

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Abstract— Mild steel (MS) is a soft metal having various applications in the field of engineering. Mild steel is subjected to surface contact with other metals such in lathe guide ways, dipper dozer teeth's with soil, nozzles to impact jets etc. Surface improvement technique has been chosen for the study to improve the surface characteristics of material. Hardfacing has been done on mild steel after applying chromium paste .Three factorial design has been chosen by taking chromium percentage and current as parameters. Higher percentage of chromium and lower current gives higher hardness and having minimum wear rate.

Keywords— Hardfacing, Wear, Mild steel, Hardness and Paste technique.

I.INTRODUCTION

Surface improvement can be done by two ways either by improvement of the surface characteristics or by using the costly metals having elements like chromium. Hardfacing techniques as well as advances in hardfacing electrode have given rise to surface coatings with excellent wear resistant properties under severe service conditions, thus enlarging the field of applications. In this presented thesis on wear study, the Shielded Metal Arc Welding (SMAW) method of making surface modification to improve the wear properties of mild steel materials has been used. The mild steel is hardfaced with different compositions of chromium. The mild steel is frequently used material due to its low cost, which at same time soft material with poor wear properties. To reduce this wear problem, the hardfacing was done by welding coating (welding of Cr and sodium silicate) using SMAW on the mild steel plate and were investigated with regard to their wear and microhardness characteristics. The deposition of overlay coatings, by welding or thermal spraying techniques, is frequently employed in industry, either during maintenance or in the manufacture of new components [1,2], to improve the wear resistant properties of surfaces in contact. One of the most important factors affecting abrasion resistance is the microstructure of the material being abraded.This can be related to its hardness, which indicates a material's resistance to indentation, for example an abrasive particle. Generally, the greater the abrasive penetration the higher the wear rate [3]. It has been rated that an optimum hardness/microstructural condition exists which provides the highest wear resistance. This was achieved at low temperatures [4]. The deposition of surfacing layers by welding techniques, such as shield manual arc welding (SMAW), submerged arc welding (SAW), plasma arc welding (PAW), oxyacetylene welding etc. have been widely applied commercially in a wide range of industries in order to improve the wear and corrosion resistance of the parts [4-8].

II.MATERIALS AND METHODS

The design matrix developed to conduct the nine trials runs of 3^2 factorial design. Beads on the mild steel plates have been deposited as per the design matrix with the SMAW E-7014 electrode.

2.1 *SELECTION OF BASE METAL*

Mild steel was selected as base material for hardfacing purpose, as we know that it is mainly used in wide application in the fabrication industry. Mild steel is low carbon steel having low wear resistance and low hardness. Due to low hardness it does not have the wear resistance so mild steel has been chosen for the study. Surface characteristics like wear can be increased by applying different surface techniques. Hardfacing is a deposition of metal over a substrate metal for which mild steel has been harfaced after paste coating of chromium powder which was mixed with binder named sodium silicate.

2.2 *SELECTION OF METAL POWDERS*

One hardfacing powder was selected. This hardfacing powder is mixed in sodium silicate and coating is applied in the form of paste. This hardfacing powder was mixed in different proportions in sodium silicate to prepare pastes, which was applied on to the surface to be hardfaced in the form of coating. Chromium powder and Sodium silicate were used. Three sets of specimens have been made on which chromium powder was applied. Custom die had been made for the purpose to support the specimen during paste coating technique.

Fig.1 Mild Steel Plates

2.3 PROCESS PARAMETERS AND THEIR LEVELS FOR EXPERIMENTATION

The process parameters affecting wear have been identified to enable the carrying out the experimental work and the development of mathematical models. They are welding current (C), chromium percentage (Cr %).The upper limit of a factor is coded as (H) and lower limit as (L) or intermediate limit as (I). The decided values of process parameters with their units and notations are given in table 1.

TABLE 1 PROCESS PARAMETERS AND THEIR LEVELS FOR EXPERIMENTATION

Sr.no.	**Parameters**	**Units**	**Higher level**	**Intermediate Level**	**Lower Level**
1.	Cr %	--------	90 %	80 %	70 %
2.	Current	Ampere	150	130	110

2.4 DEVELOPMENT OF DESIGN MATRIX

The design matrix developed to conduct the nine trials of 3^2 (=9) three level factorial design. Where H denotes higher level, I denote intermediate level, L denotes lower level.

2.5 PREPARATION OF BASE MATERIAL

Three mild steel plates (200×30×10) mm has been selected. The mild steel specimen were taken as the base metal or substrate material upon which the hard facing material was deposited by SMAW welding after the application of paste.

Fig.2 Paste coated mild steel plate

As per the data generated by the trial runs the actual experiments were conducted by laying down the beads of different powders paste. To develop chromium carbide based harfacing alloy a paste was made with the mixture of chromium and a binder (sodium silicate), coated on a mild steel plate with the help of custom made die.Depositions were made with different formulationsTotal 9 samples with 3 categories were investigated.

TABLE 2: DESIGN MATRIX, WHERE H DENOTES HIGHER LEVEL, I DENOTE INTERMEDIATE LEVEL, AND L DENOTES LOWER LEVEL

Sr. No.	**Sample name**	**Cr %**	**Current**
1	HH	H	H
2.	HI	H	I
3.	HL	H	L
4.	IH	I	H
5.	II	I	I
6.	IL	I	L
7.	LH	L	H
8.	LI	L	I
9.	LL	L	L

2.6 MICROHARDNESS TEST

Micro hardness measurement was carried out at Institute for Auto Parts & Hand Tools Technology, Ludhiana using micro hardness tester on VHN (Vickers Hardness Number) Scale.

2.7 WEAR TEST

Wear test was carried out on wear test machine at Metallurgy Laboratory of Mechanical Engineering department, LPU, Phagwara. The wheel rotation was 1000 rpm. Three reading were taken to find out the average value. The sample weight was checked after 5 minute. Final loss in weight was measured of the samples; loss in weight can be correlated to indicate the wear rate of each sample.

III. RESULTS AND DISCUSSIONS

3.1 MICROHARDNESS

All the ten samples were first polished on disc polishing machine and after that the micro hardness was checked. The micro hardness was checked on middle position. At every sample one reading was taken. Hardness readings are shown in Table 3 Micro hardness of base metal is 208 VHN.

TABLE 3 MICRO HARDNESS RESULT (ALL SAMPLES)

Sample no.	**Sample name**	**Harness in VHN**
1.	HH	637
2.	HI	587
3.	HL	557
4.	IH	615
5.	II	589
6.	IL	562
7.	LH	365
8.	LI	321
9.	LL	282
10.	BASE METAL	208

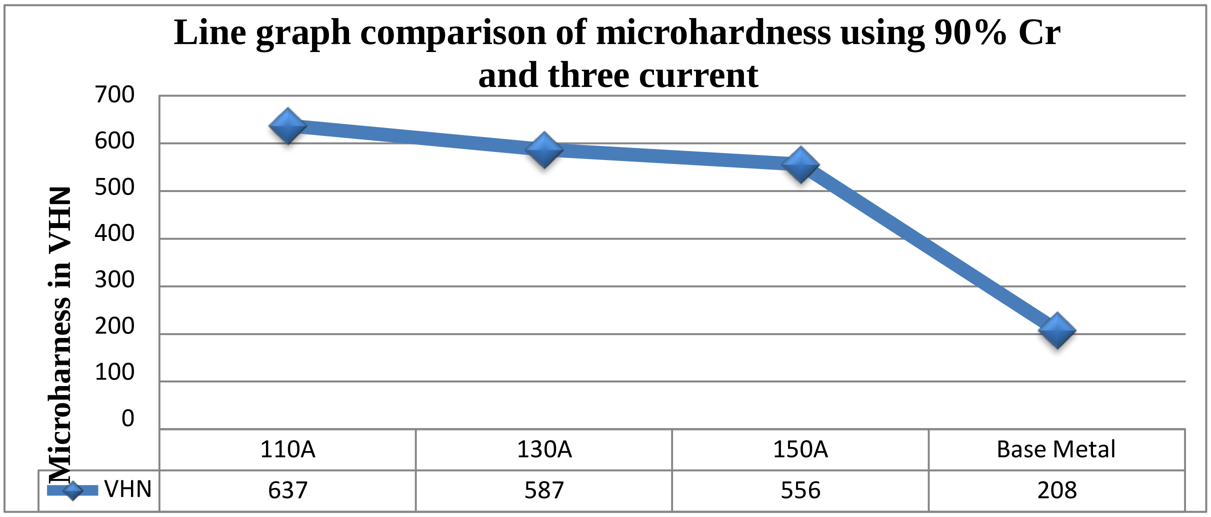

Fig. 4 **Line graph comparison of micro hardness of 90% Cr using three current**

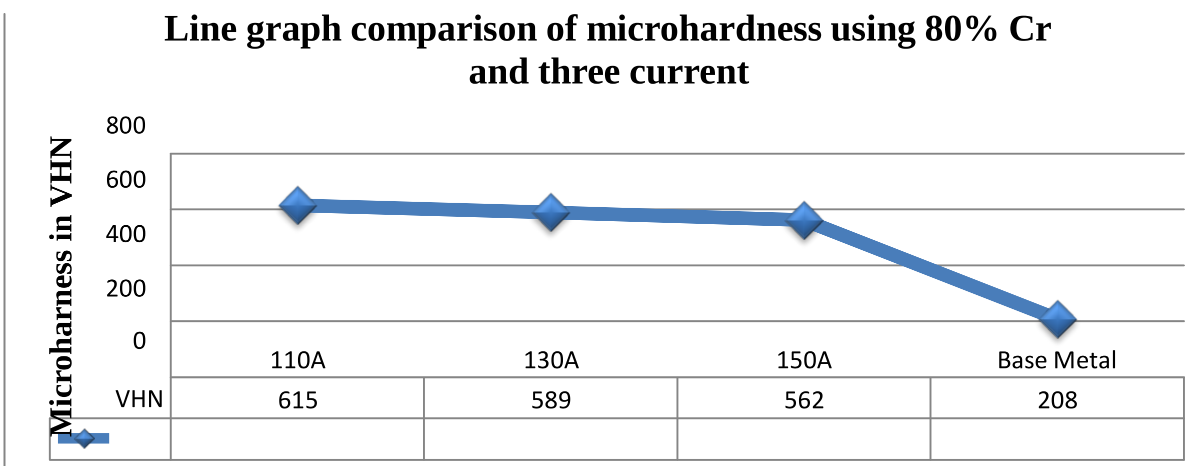

Fig. 5 **Line graph comparison of micro hardness of 80% Cr using three current**

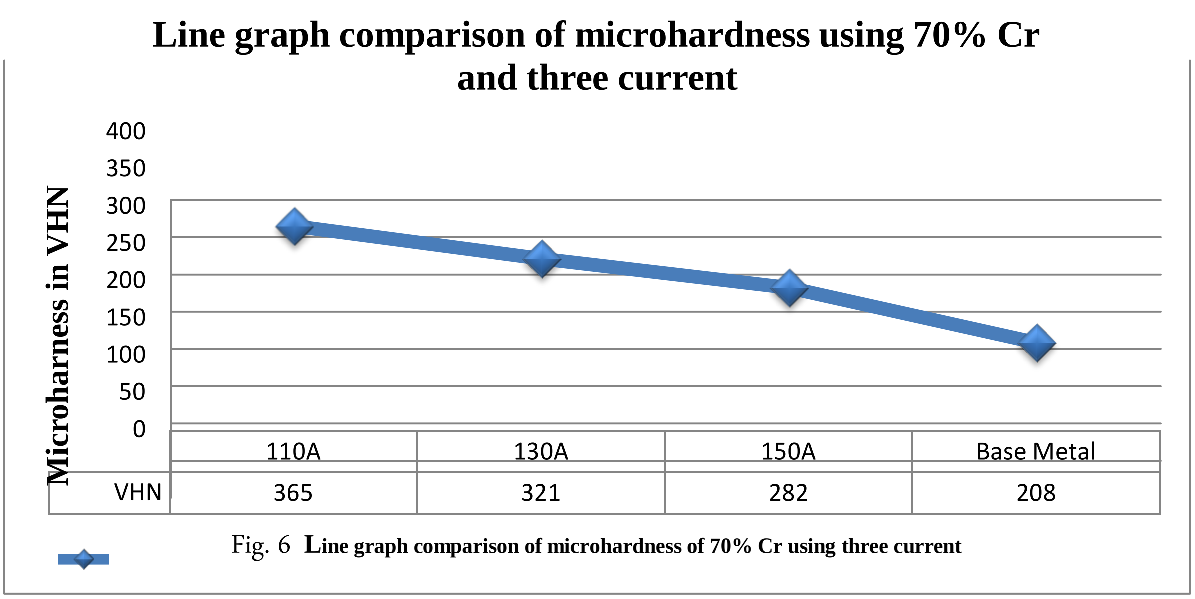

Fig. 6 **Line graph comparison of microhardness of 70% Cr using three current**

From the above observation it can be easily concluded that at 110A current the micohardness is coming higher as compared to micohardness values at 130A an150 A. The main reason is that with the increase of current hardness decrease for all the three compositions of the paste due to reason that high current results in slower cooling rates resulting in softer matrix having lower hardness. Higher the cooling rate will produce higher micohardness. It has been also observed that the hardness values can be enhanced by approximately 3.10 times using 90% Cr, 3.04 times by using 80% Cr and 1.88 times by using 70% Cr Powder, due to the reason that higher amount of chromium results in increased carbide formation.

3.2 WEAR TEST

Wear rate was calculated by measuring initial and final weights of samples. Loss in weight was calculated for the running wear period of 5 min. Then the wear rate was calculated per hour i.e for 60 min from loss of weight for 5 min.

TABLE 5. WEAR RATE READINGS OF ALL SAMPLES

Sample no.	Name	Initial Weight(g)	Loss Weight(g)	Final Weight(g)	Wear rate (g/hr.)
1	HH	5.6896	0.0051	5.6845	0.0612
2	HI	5.6825	0.0039	5.6786	0.0468
3	HL	5.6876	0.0021	5.6855	0.0252
4	IH	5.5934	0.0051	5.6845	0.0924
5	II	5.6382	0.0049	5.6333	0.0588
6	IL	5.801	0.0046	5.7964	0.0552
7	LH	5.589	0.0108	5.5782	0.1296
8	LI	5.6341	0.0089	5.6252	0.1068
9	LL	5.6559	0.0081	5.6528	0.0972
10	BASE METAL	5.5611	0.134	5.4271	1.608

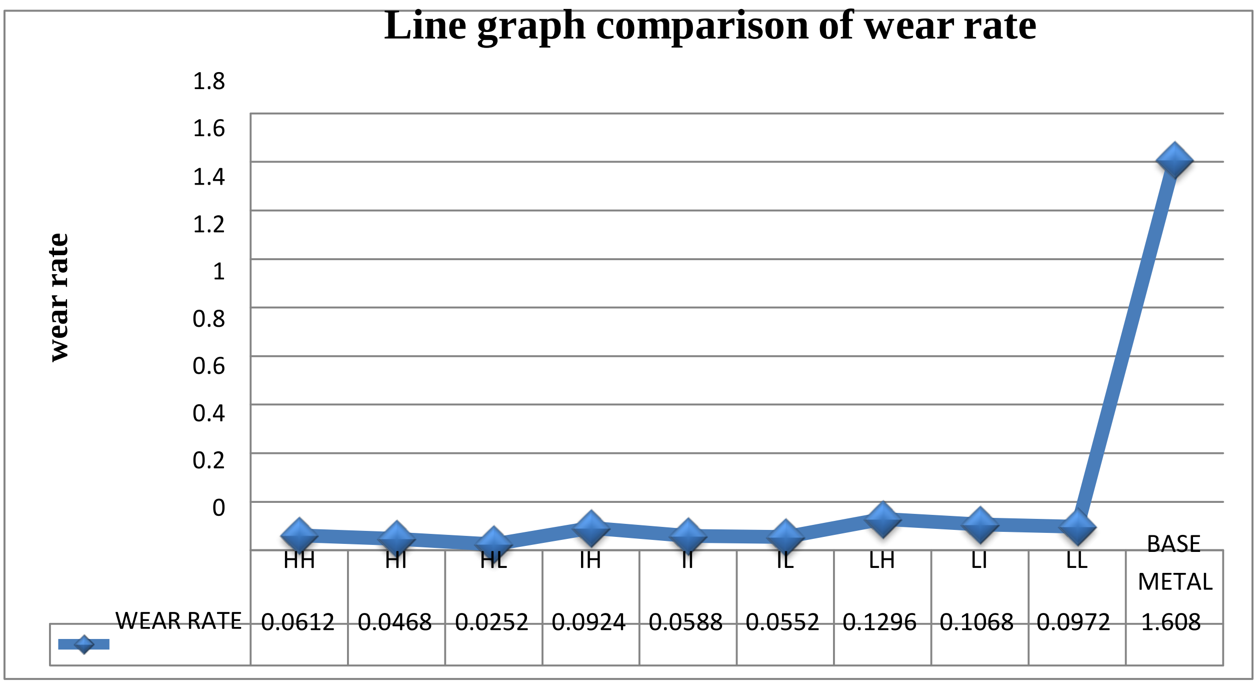

Fig. 10 **Line graph comparison of wear rate for all samples**

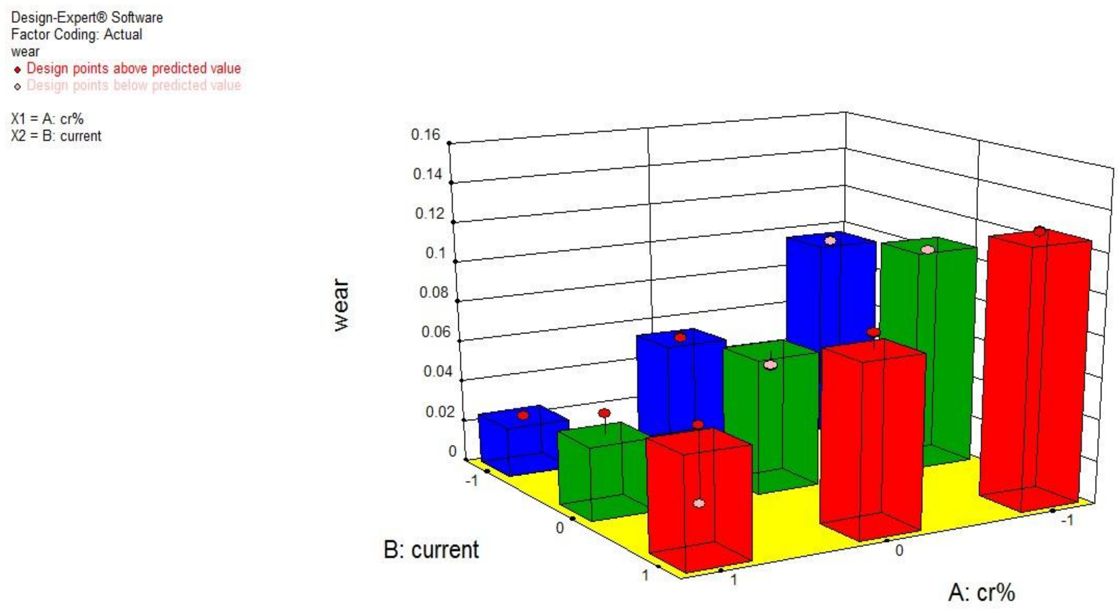

Fig .11 **Combined Interaction of process parameters (3 dimensional views)**

Fig .11 shows the combined effect of process parameters on wear. it has been observed that as the current is increasing the wear rate also increasing due to decreasing hardness and when cr% is increasing the wear rate decreasing due to higher formation of carbides. The same observations have been noticed in all the three compositions of paste.

IV.CONCLUSIONS

The hardness values can be enhanced by approximately 3.10 times using 90% Cr, 3.04 times by using 80% Cr and 1.88 times by using 70% Cr Powder. Wear resistance can be increased up to 26 times using 90% Cr, 17 times using 80% Cr and 12 times by using 70% Cr than base metal (mild steel).Considering all the aspects it may be concluded that paste with 90% Cr gives better wear properties and micro-hardness as compared to paste with 80% and &70% Cr content.

It has been also observed that dilution increasing when welding current increasing. It is due to the fact that current density increases with increase in welding current as a result higher melting of electrode because with an increase in welding current there is a linear increase in arc heat while the resistance heat increase exponentially which are responsible for electrode melting resulting increase the area of penetration hence dilution. It has been observed that with the increase of current hardness decrease for all the three compositions of the paste due to reason that high current results in slower cooling rates resulting in softer matrix having lower hardness.

The wear studies show that as the current is increasing the wear rate also increasing due to decreasing hardness. The same observations have been noticed in all the three compositions of paste.

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