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RECLAIMING EN14B STEEL GRADE IMPLEMENTS BY HARDFACING

Engineering

KEYWORDS: Hard-facing, Welding, Wear, Weight loss, , Taguchi.

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ABSTRACT

Hard facing is a low cost method of depositing a hard and wear resistant layer on metal components to reclaim or extend the service life of machine parts used for various applications in industries. The prime requirement of a metal is to have good resistance to wear, corrosion and high temperature. This paper primarily focuses on the impact of Composition (in terms of C, Si, Cr and Mn), load applied and the time for which the tool is used on the weight loss of the tool and thereby analyzes the wear of the material. The results were optimized in an experimental study while using Design of Experiment, based on which it was concluded that the H-1 type hard-faced alloy provides us with least weight loss and thus least wear.

I. INTRODUCTION

Corrosion of materials by wear brings about high losses in a few businesses, for example, automobiles, agriculture, infrastructure, and so on. Such wear and tear of materials causes the materials to be replaced resulting in high costs of the equipment. Engineers, today, are focusing on discovering materials that provide appropriate wear resistance. An assortment of mass materials (ferrous, non-ferrous metals and compound) can be adjusted by alloying, blending, compositing and covering to accomplish satisfactory wear resistance. Hard-facing is such a technique. Hard-facing is a surface adjustment method which is utilized to revamp the surface of a work piece to reduce wear. Basically it employs the deposition of a wear-resistant and hard material to areas susceptible to wear and tear. Hard-facing is brought about by means of arc welding, gas welding, powder spraying or laser hard-facing, the most easily approachable being welding. The different welding techniques used to bring about hard-facing are SMAW (shielded metal arc welding), SAW (submerged arc welding), ESW (electro slag welding), GMAW (gas metal arc welding), GTAW (gas tungsten arc welding) and PAW (plasma arc welding). Here we have used SMAW or MMAW (manual metal arc welding) which employs welding with stick electrodes. The heat required for fusion is generated by the electric arc formed between the metallic electrode and the base metal. The temperature of the weld is about 5000C. This technique is employed to improve surface properties of industrial and agricultural tools, components for mining operation, soil preparation equipments, earth moving equipments, etc. as shown in fig 1.1. Since it is flexible, inexpensive, and versatile and supports all positions of welding.

Basically the need for hard-facing arises because an industry can't keep changing tools on a regular basis owing to the cost incurred in the same. So, a wise decision would be to invest a little more in hard-facing the tool in order to increase the shelf life of the tool than merely replacing the tool time and again due to wear and tear.

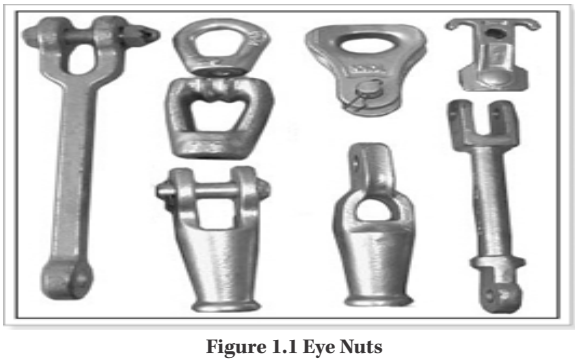

Figure 1.1 Eye Nuts

II. PROBLEM FORMULATION

Engineering practice in India involves extensive wear of tools, the most common example being of the agricultural and mining tools which bear heavy loads from materials and are also subjected to abrasive and frictional wear. Generally high alloy steels are employed or to increase the life of the wearied components, hard-facing may be done. The prime requirement of any metal used in engineering application is to have good resistance to wear, corrosion and high temperature. Instead of making an entire part from an expensive wear resistant alloy, it is more economical to make it from ordinary steel and then cover the critical surfaces with a layer of weld metal capable of withstanding the service conditions. Hard-facing is one such low cost method of depositing wear resistant surfaces on metal components to extend service life of the tool subjected to wear. There is this general perception that higher the amount of alloying element, higher is the strength which may not be true in this case. This paper employs the Taguchi approach to study the effect of different percentages of Carbon primarily and Chromium, silicon and manganese subsequently on the wear behavior of the deposited hard-facing layers. (Note that these elements were selected as the difference in their composition affects the properties greatly).

III. OBJECTIVE

Taguchi states that the product should be designed in such a manner that it remains unaffected by uncontrollable environmental factors. The signal (product quality) to noise (uncontrollable factors) ratio should be high. This project basically studies the wear behavior of different alloys produced by the combination of different composition of Carbon, Silicon, Manganese and Chromium. Following are the purposes of writing this project:

(a) To select the substrate material vastly used in industries that bears the load while conducting various engineering operations and is damaged due to abrasion wear between machine and the tool.

(b) To choose the hard-facing material that can protect the tools from wear and weight loss.

(c) To design experimentation series using Design of Experiments (DOE) layout, thus to study the wear behavior of the hard-faced alloy. Design of experiments (DOE) method are among the most effective and useful statistical quality control technique to investigate the individual and interaction effects of the process parameters, DOE methods can be an important part of system optimization, yielding definitive system design or redesign recommendations.

(d) To study about the best combination of solution in order to maintain best possible composition of the hard-faced alloy in order to achieve maximum wear resistance.

IV. EXPERIMENTATION

This paper investigates the effects and parametric optimization of process parameters for the weight loss of the different hard-faced and unhard-faced alloys used over tools. The following methodology was employed-

STEP	INFERENCE
Selection of Substrate	The substrate selected is made of High Tensile Steel EN-14B of the following composition by wt% – C-0.24, Mn-1.29, Si-0.27, Cr-0.34, S-0.024, P-0.032, Al-0.03, Cu-0.14, Mo-0.01, Ni-0.04, Pb-0.01, V-0.01, W-0.02
Sample Preparation	Cylindrical samples of EN-14B of length 30mm and diameter 8mm are prepared for testing.
Selection of Hard-facing Electrodes	Since the wear resistance of the substrate can be improved by adding C, Cr, etc in the form of weld consumables. So two such hard-facing alloys were used here with the following compositions respectively – 1. H-1 – C-4.5, Si-0.8, Mn-1.6, Cr-33 2. H-2 – C-5, Si-2, Mn-0.7, Cr-23
Deposition of hard-facing Layer	MMAW Technique was used to deposit the hard-faced layer and thus we now has three samples as listed below.
Wear Test (ASTM G-99)	Wear Testing was done on a pin-on-disc apparatus. The hardness of the carbon steel EN-31 disc in the machine was 62-65 HRC. Wear tests were carried out in cycles of 10, 20 and 40 minute's cycles. Weight loss of the prepared samples was tested after each cycle.

The samples used here are as follows –

SAMPLE	COMPOSITION			
	C	Si	Mn	Cr
Unhard-faced	0.24	0.27	1.29	0.34
H-1 (Hard-faced-1)	4.5	0.8	1.6	33
H-2 (Hard-faced-2)	5	2	0.7	23
*NOTE – For the sake of simplicity, only Carbon Composition is used to refer to the different kinds of samples used.				

Now, Minitab 17 was used to carry out the desired analysis. The process parameters viz. Carbon% (to represent the respective samples), load (in kN) and time (in min) are considered and experiments are conducted based on L9 orthogonal array (OA).Process response i.e. weight loss of the hard-faced or unhard-faced samples are measured for every experimental run. For minimum Weight loss, the process parameters are optimized based on Taguchi method. Analysis of variation (ANOVA) is performed to get the contribution of each process parameter on the performance characteristics.

V. RESULTS & OBSERVATIONS

The experimental design strategy, using Taguchi orthogonal arrays concept is displayed below. The L-9 orthogonal array to study the weight loss of the samples as stated below was used.

Table 1.1 L-9 orthogonal array was applied for weight loss

L-9 Orthogonal array for Weight Loss (in gms)				
Run	Carbon %	Load (in kN)	Time (in min)	Wt Loss (in gms)
1	0.24	30	10	0.0222
2	0.24	40	20	0.0672
3	0.24	50	40	0.1543
4	4.5	30	20	0.0006
5	4.5	40	40	0.002
6	4.5	50	10	0.0005
7	5	30	40	0.004
8	5	40	10	0.0022
9	5	50	20	0.0033

Observations in Taguchi Analysis: Weight Loss versus Carbon%, Load and Time

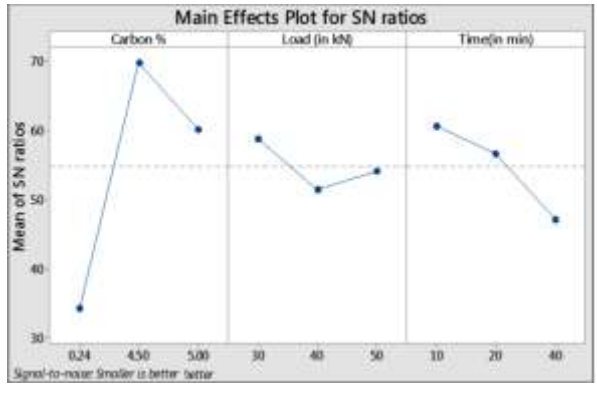

Figure 1.2 Main effects plot for S/N Ratio (Weight Loss)

The above SN ratio graph was made using 3 variables namely carbon%, load and time. The graph clearly shows that carbon content of 4.5, a load of 30kN and a time of 10 minutes gives the best output in order to minimize weight loss and second in the row is the sample with carbon content 5.

ANOVA Test results for Weight Loss of the analyzed samples.

Table 1.2 General linear Model (ANOVA) for Weight loss

Source	DF	Adj SS	Adj MS	F	P	Contribution %
Carbon %	2	0.001833	0.00091	3.25	0.235	51.68
Load (in kN)	2	0.000549	0.00027	0.97	0.506	15.48
Time (in min)	2	0.000602	0.00030	1.07	0.484	16.97
Residual Error	2	0.000564	0.00028			
Total	8	0.003547				

For the above ANOVA model, the calculations are done at 95% confidence level. In an analysis of variance table, the P value determines the most significant factor. The factor whose P value is less than 0.05 will be most effective factor. The ANOVA table, thus, indicates that all the three factors pay significance to the weight loss of the analyzed samples.

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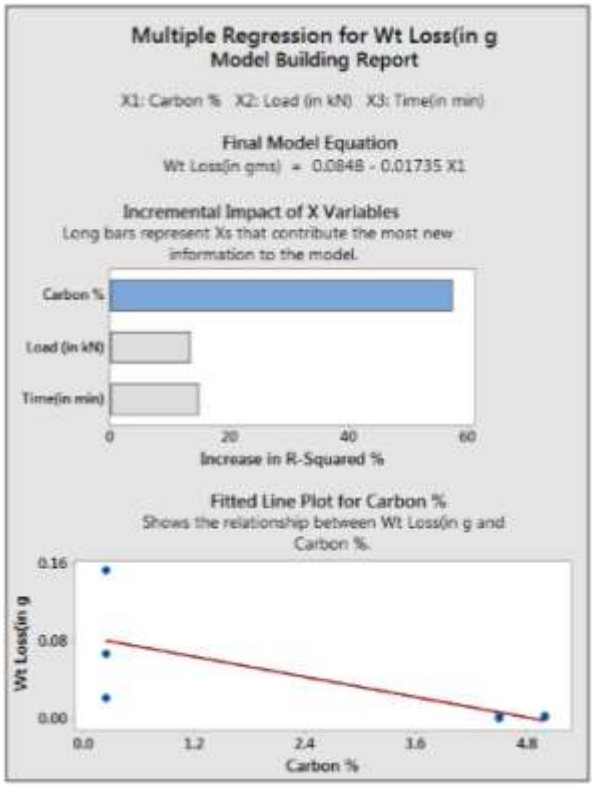

Figure 1.3 Multiple Regression for Weight Loss

As is seen from the above graphs and tables, it is clear that we obtain minimum weight loss when Carbon% is 4.5 (i.e. H-1 type hard-facing alloy), a load of 30 kN and a time cycle of 10 min.

VI. CONCLUSION

This paper presents the application of the Taguchi method in order to optimize the Weight Loss for an unhard-faced and two hard-faced rotavator blade samples thus decide which of the three shows least wear resistant. From experimental analysis done on the three samples, it was concluded that:

(1) The specimens those were hard-faced with H-1 and H-2 alloy on high alloy steel EN-14B showed significantly lower weight loss.

(2) Weight Loss for hard-faced and unhard-faced depends on all the three factors namely carbon content, load and time with carbon content holding a larger contribution to the response (note that the carbon content signifies the composition of the material).

(3) Weight loss follows the following trend –
H-1 > H-2 > Unhard-faced

(4) Lesser Weight Loss is achieved when Carbon content is 4.5 i.e. H-1 type hard-faced and load is kept to be 30 kN and time cycle of 10 minutes is maintained.

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