Cost Reduction of Rotor Blade by Alloy Optimization

Anil Kumar

Abstract— he material design Engineer is always sandwiched between functional behavior of a component and the cost it entails. The fluctuation in cost imported resources (alloying nutrient), enhances the complexity of material engineer. This work will be a product of the similar challenge of increased landed cost of molybdenum used in rotor blade casting. Wear rates under abrasive conditions are very sensitive to the ratio of the hardness of the surface to that of the abrasive particles. This problem of reducing the cost of rotor blade in which cost factor is the main factor. We continue to design different composition of Mo & Cr and measure the wear resistance and presently we want to improve the wear resistance. The optimization of wear resistance is a challenge given and I am interested in finding a viable mechanism to reduce cost. We will design various compositions then perform the following operations on them- casting, machining hardening & wear testing. We have also founded a composition which clearly reduces cost.

Index Terms— Abrasive Wear, Cost Reduction, Chromium, Molybdenum, Phase Balance, Rotor Blade, Wear Resistance

1 Introduction

The optimization of wear resistance of given component is a challenge and I am interested in finding a viable mechanism for-**Cost Reduction of Rotor Blade by Alloy Optimization.** This research can be used for studying various cost reduction aspects of Job order production companies, Alloy manufacturing company, Steel industries etc.

2 LITERATURE SURVEY

2.1) General introduction to shot blasting machine

Shot Blasting is a surface treatment process using high velocity steel abrasive. Shot blasting is method through which it is possible to obtain excellent cleaning and surface preparation for secondary finishing operations.

Shot blasting is commonly used for:

- The cleaning of iron, steel, non-cast parts, forgings, etc.
- Mechanical cleaning of sheets, rods, coils, wire, etc.
- Shot peening to alter mechanical properties (increasing resistance to fatigue for springs, gears, etc.)
- Preparing surfaces to be painted, coated, etc.

In general shot blasting concentrates abrasive particles at high speed (65-110 m/second) in a controlled manner at the material thereby removing surface contaminates due to the abrasive impact.

2.2 Rotor Blade in Shot blasting machine

This is provided with a blast wheel assembly comprising of an abrasive throwing wheel and a plurality of throwing blades which are evenly spaced axially on the wheel. The wheel has a central opening, an outer periphery, and plurality of channels therein for receipt of the throwing blades. The channels extend from the outer periphery with a diminishing cross-section toward the central opening. The outer periphery includes an opening for insertion of a faster. Each blade comprises of an inner end, outer end, a surface for throwing abrasive, and a bottom surface substantially perpendicular to the abrasive throwing surface.

2.3 Major Alloying Elements which impart to wear Resistance

CHROMIUM

Chromium was regarded with great interest because of its high corrosion resistance and hardness. A major development was the discovery that steel could be made highly resistant to corrosion and discoloration by adding chromium to form stainless steel. This application, along with chrome plating (electroplating with chromium) is currently the highest-volume uses of the metal. Chromium and ferrochromium are produced from the single commercially viable ore, chromite. The strengthening effect Of Forming stable metal carbides at the grain boundaries and the strong increase in corrosion resistance made chromium an important alloying material for steel. (1)

As an alloying compound, adding chromium can endow the resulting new compound with:

Color, Hardness, Strength, Resistance to: corrosion, decay & wear. (6)

Hi-Cr cast iron possesses excellent wear resistance due to the presence of hard chromium carbides. (4)

MOLYBDENUM

The ability of molybdenum to withstand extreme temperatures without significantly expanding or softening makes it useful in applications that involve intense heat, including the manufacture of aircraft parts, electrical contacts,

ISSN 2229-5518

industrial motors and filaments. Despite such small portions, more than 43,000 tones of molybdenum are used as an alloying agent each year in stainless steels, tool steels, cast irons and high-temperature super alloys.
Molybdenum contributes further corrosion resistance to "chrome-moly" type-300 stainless steels. (3)

2.4 Phase Balance

In a metal, groups of crystals having the same crystal structure are called Phases. The phase names for the three crystal structures present in the stainless steels are austenite, ferrite and martensite. (2)
The "Phase Balance" of steel determines its properties. Controlling the steel's phase balance, and, therefore its properties, demands a balance of the alloying elements.

Table 1

Alloy elements that promote formation of Phases

Ferrite formers	Austenite formers
Iron	Nickel
Chromium	Nitrogen
Molybdenum	Carbon
Silicon	Manganese
Niobium	Copper
Tungsten	Cobalt

3. Procedure Followed

The following steps will be used in completing the research and experimental work-

1. We will Study the various options for reducing the cost or to increase wear resistance.
2. Then we will make the critical analysis of various options.
3. Then experiment will be performed.
4. Then we will choose the best options.
5. After the result and its discussion will be done.

4 Problem Formulations

4.1 Role of Cost in Manufacturing Casting Element

When we create casting using Mo in a larger % this will enhances the cost of the rotor blade .But our problem belongs to a small industry and this product cannot be sold at higher prices as compared to other competing industries.

So We design 3 samples with varying % of Cr & Mo.

Table 2

% OF ALLOYING ELEMENTS IN 3 SAMPLES

S N	ALLOY Element	Ist Sample	2nd Sample	3rd Sample
1	C	2.61	2.61	2.61
2	Mn	1.95	1.95	1.95
3	S	0.032	0.032	0.032
4	P	0.065	0.065	0.065
5	Si	1.05	1.05	1.05
6	**Cr**	**11**	**20**	**27**
7	V	0.05	0.05	0.05
8	Cu	0.55	0.55	0.55
9	Sn	0.025	0.025	0.025
1	Ni	1.5	1.5	1.5
1	**Mo**	**3**	**2.5**	**2**
1	Al	0.055	0.055	0.055

Basically our target is to reduce the cost of rotor blade and to improve the wear resistance so that the life of the rotor blade increases.
We regularly increase the percentage of Cr which increase the wear resistance of rotor blade and reduce the percentage of the molybdenum. We get reduced cost of composition which is explained continuously in steps A, B and C.

4.2 Role of Alloying Element Optimization for Covering of cost

Optimization of Mo and Cr shown below

	Mo	Cr
i)	3%	11%
ii)	2.5%	20%
iii)	2%	27%

Above % of alloying element will show how they will cover the cost.

5 Experimental

5.1 Casting

First of all we cast samples in Y mould.

5.2 Sample Testing

Sample is prepared by machining. This is of PIN type which has size 3 to 12 mm (Dia). The height of pin is 1 or 2 inch. Fit the Pin in DUE COM machine pin and apply load on pin. Then rotate a disc on sample & measure the wear for different PIN samples. This is shown below in the tables.

ISSN 2229-5518

5.3 Design

Rotor blade is designed for some specific mechanical properties like (Stress & strain, hardness, ductility, brittleness, toughness, stiffness, strength, plasticity, elasticity, resilience). Different alloying elements are added in the designed product for the following purposes-

- To improve wear resistance
- To improve corrosion resistance
- To improve tensile strength, elastic limit, ductility etc.
- To improve hardenability
- To improve machinability

5.4 Wear Testing

Figure 1 Wear Testing Machine

Purpose

Records friction and wear in sliding contact in dry, lubricated, controlled environment.

Application

Fundamental wear studies. Friction & wear testing of metals , ceramics, soft and hard coatings, plastics, polymers and composites, lubricants, cutting fluids, heat processed samples.

Features

Display and record friction, wear & pin temperature in Dry, lubricated, controlled environment.

Table 3

Specification of Wear Testing Machine

Parameter	Unit	Min	Max
Pin size	Mm	3	12
Ball Dia.	Mm	10	12.7
Disc size	Mm	165*8 mm thick	-
Sliding speed	m/s	0.05	10
Disc Rotation	Rpm	200	2000
Normal Load	N	0	200
Friction Force	N	0	200
Wear	Mm	0	2

5.5) Measurement of wear resistance of rotor blade at difference composition-

5.5.1) Wear rate for 1st composition-

Table 4

Wear rate for 1st composition

Time (Sec.)	Wear (Micron)
200	30
400	38
600	39
800	39
1000	44
1200	48
1400	48

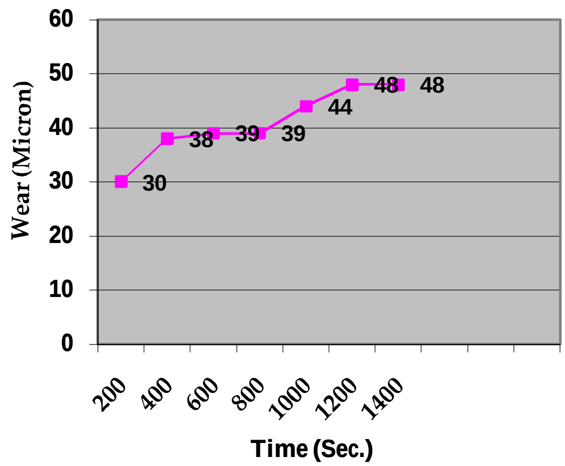

Figure 2 Graph between Wear and Time

5.5.2) Wear rate for 2nd Composition-

Table 5

Wear Rate for 2nd composition

Time (Sec.)	Wear (Micron)
200	20
400	33
600	32
800	32
1000	33
1200	32
1400	31

ISSN 2229-5518

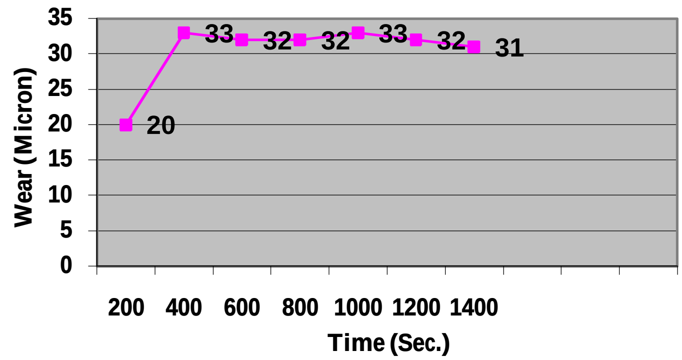

Figure 3 Graph between Wear and Time

5.5.3) Wear rate for 3rd Composition-

Table 6

Wear rate for 3rd composition

Time (Sec.)	Wear (Micron)
200	10
400	15
600	8
800	8
1000	10
1200	10.5
1400	10

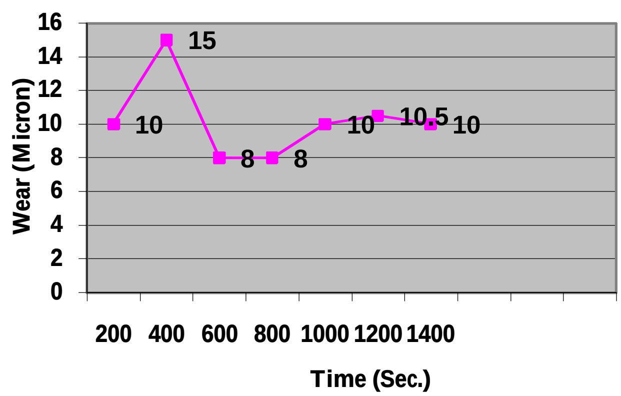

Figure 4 Graph between Wear and Time

When small industry design rotor blade with following composition –

(C-2.61,Mn-1.95,S-0.032,P-0.065,Si-1.05,Cr-11,V-0.05,Cu-0.55,Sn-0.025,Ni-1.5,Mo-3,Al-0.055)

Cost of rotor blade find out is Rs.150.90.

Taking this as base we find the cost of the other compositions with varying % of Mo & Cr which is shown below in the table.

5.6) Method of cost setting of a single rotor blade-

Table 7-

Method of cost setting

S N	Mo g./blade	Cr g./blade	Mo Rs/g.	Cr Rs./g.	Mo cost/blade	Cr cost/blade	Cost of rest Mat.	Cost/ BLADE
1	15	55	3	.08	45	4.4	101.5	150.9
2	12.5	100	3	.08	37.5	8.0	101.5	147.0
3	10	135	3	.08	30	10.8	101.5	142.3

5.7) Graph between Cost and Wear –

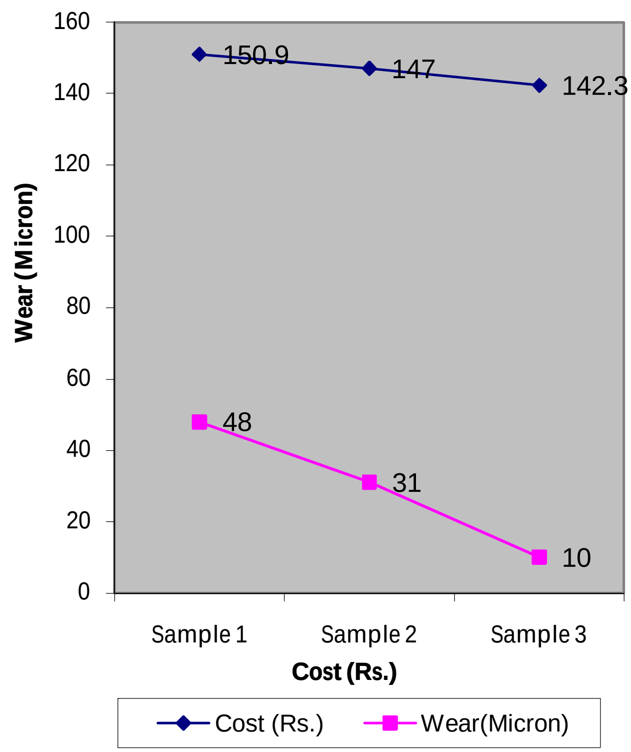

Figure 5 Graph between Cost and Wear for 3 Samples

6. RESULT & CONCLUSION

Problem is to improve wear resistance with reduced cost of rotor blade used in shot basting machine. I designed different compositions and measure the wear resistance of different compositions, their hardness. Then I calculate the cost of the composition which is described below-

C	– 2.61
Mn	– 1.95
S	– 0.032
P	– 0.065
Si	– 1.05
Cr	– 27
V	– 0.05
Cu	– 0.55
Sn	– 0.025
Ni	– 1.5
Mo	– 2
Al	– 0.055

Above composition show the improvement in wear resistance and reduction in the cost. Cost of this composition of rotor blade is Rs. 142.3., hardness is 45 (RC) and wear is 0.010mm. These values are less than other designed composition.

7. FUTURE SCOPE

The Cost of the blade can also be refined again by substituting any of the alloying elements such as vanadium or Nickel but taking care of the basic requirements i.e. Wear resistance & Phase Balance

ACKNOWLEDGMENT

I wish to thanks a lot to Mr. Rakesh Kaushik and Mr. Ranbir Sheoran who helps me a lot in obtaining the results and conclusion of this research.

REFERENCES

[1] Chromium: Not Just Fancy Trim, Written by Tom Vulcan, Thursday, 18 September 2008.
[2] Han Dong, Dangsheng Ma, Yaping Lang, Zhigang Song, Gang Yang, Maoiqu Wang "Effects & Application Of Mo In alloy Steel".
[3] http://www.imoa.org.uk
[4] A. Studnicki, J. Kilarski, M. Przybył, J. Suchoń, D. Bartocha "Wear resistance of chromium cast iron– research and application".
[5] J.P. Breyer, J. Lecomte-Beckers, L. Terziev, "Graphitization in chromium cast iron".
[6] R. Reda1, A. Nofal1, Kh. Ibrahim1 and A. Hussien2 "Investigation of improving wear performance of hypereutectic 15%Cr-2%Mo white irons".