Effect of Heat Treatment on Tribological Behavior of Roller bearing

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Abstract

Steel is an alloy of iron and carbon that finds its application in both stationary and moving components/machines having relative motion with each other. The superior tribological behaviour makes it suitable for use in construction automobiles, aerospace, bearings etc. Depending upon the loading and type of motion the tribological characteristics may vary accordingly. The present study focuses on analysing the tribological characteristics of steel under high-load applications. To achieve this, a bearing material was prepared by combining chromium and steel and was heat treatedto augment its tribological characteristics. The result of the current study suggests that prepared bearing material possesses high strength, hardness and wear resistance under extreme loading and relative motion. The principal wearmechanism in Chrome steel and the coefficient of friction with load have also been studied and discussed.

Keywords: Steel; Tribological; Bearing; High load; Heat treated; Wear resistance.

1. Introduction

Tribology is proper knowledge related to friction, wear and lubrication, the design of bearings and the science of interacting surfaces in relative motion. The case of friction and wear is an important engineering problem. To improve tribological behaviours there are various research and developments are done by researchers Also Vrushali et.al [1] studied about BN nanoparticles into basematrix-bearing steel which helped to improve the mechanical and tribological properties of the substance material on heat treatment. Sanjay et.al [2] havestudied the surface properties of bearing steel SAE51200 with selection of some method deepening upon solubility adhesion and bond strength and got improvement on tribological propertiesVishal Saxena et. al. [3] has studied different lubrication and found that a Tio2 concentration of 150mg/L in a fuel blend will reduce the friction, wear and wear volume. Another researcher SougataRoy et. al.[4] have studied the tribological behaviour of carburized AISI8620 steel on heat treatment with carburizingand quenching techniques and got high hardness and moderately high levels with more abrasive wear resistance.Some researcher Dohyeng et.al.[5] has studied about the wear performance of merging 18Ni300 steel fabricated with selective laser melting and got the wear resistance got increased.Patrcia et.al. [6] has studied about the effect of deepcryogenic treatment on various materials. Especially on steel and get that treatment of DCT with heat treatment will improve steels properties. constantin et. al. [7] have investigated the influence of thermomagnetic treatment on metallurgic and mechanical properties in rolling bearing steel and found that fatigue reliability is increased with treated steel.Fang bin et. al. [8] have studied the effect of rotating speed on the stiffness of ball bearing under three typical load conditions and found high versatile and change of the stiffness along with rotating speed are greatly by influencedby the load conditions. Fei Huang et. al. [9] studied on steel plates (20Mn2Cr and 20Mn2CrNb) by using isothermal heat treatment. The result show as the austenitizing temperature increased, the original austenite grain size -80 both steels increased. Adepu et.al. [10] has worked on laser treated layer obtained on 100Cr6 bearing steel surface includingdifferent thermal processing conditions and results in improvement hardness and compressive residual stress. Also feng et.al. [11] has worked on the carbide dissolution and precipitation of M50 bearing steel got the formation of stable self- lubrication film within the subsurface layer of the specimen.Alekesy M. Megrin et. al. [12] has studied about the Al-Si-Cu-Sn-Pb alloys and found an antifrictional property and also a good tribological properties with and without lubricants. Sukru Taktak et. al. [13] studied on AISI 440C and 52100 and bearing steel were borided by Pack methodat 950^{0}C of 2h. These test indicated that wear rates of unborided and borided steel increases with temperature compared with unborided steels.K. Celmons [14] has studied about the processing structure properties relationship in the bearing steels and are compared baseline 52100 and 440C that shows yield strength is better with the load capacity.

Young Sik Pyun [15] studied on SAE52100 bearing steel special heat treatment and super polishing process are used and adapted to improve the strength. These analysis shows that these enhancement can change the size and weight ofslim bearing down to nearly 3.40-21.25% and 26.03%.

The above-cited research work has revealed that there is a need to develop a new class of material (steel alloy) which have superior tribological characteristics and can be successfully used under extreme loading and motion condition. Hence in this work, we are using chromium steel alloy for ball bearing where we get a high load capacity superior hardness large working life and also high corrosion resistance.

2. Materials and Method

Material

The high carbon content in SAE 52100 ball bearings allow for high resistance to cracking during high temperature heating. Chromium steel balls are used for precision ball bearing applications and are crafted to be very hard and have a high load capacity. These properties offer a durable, cost-effective solution for ball bearings. The compostions of prepared test samples are shown in Table 1 as:

Table. 1: Composition of prepared test sample

Composition	Fraction in (%)
Carbon	0.98-1.1
Chromium	1.3-1.6
Manganese	0.25-0.45
Phosphorus	0.025 max
Silicon	0.15- 0.35
Sulphur	0.025 max

The machined specimen has a greater surface hardness than the untreated specimen.The reason for this increasein hardness is that it forms a finer pearlite and ferrite microstructure than can be achieved by slow cooling in ambientair. In principle, when steel cools quickly, carbon atoms have less time to move through the lattice to form larger carbides.

When too much load is applied, the texture and shape of the surface changes due to the increase in the coefficient of friction.

Preparation method of test samples

The alloy is supplied for forging at 2200F down to 1700F.Then it is spheroidizing and annealed at 1200F which improves the overall machinability of the alloy. After that machinability of 52100 alloys is done by conventional methods then forming methods are applied such as hot working in the range of 400F to 1000F and cold working. After that heat treatment consists of heating to 1500F followed by oil quenches for hardening of the alloy. A normalizing heat treatment at 1600F and slow cooling to relieve machining stress are employed for the 1500F and quenching treatment. The Chrome steel bearings were purchased from the market then it was melted &cast in form of rods of different diameters. Further the samples were machined on lathe machines to obtain proper dimensions which are mentioned in Table 2 and in Fig.1 as:

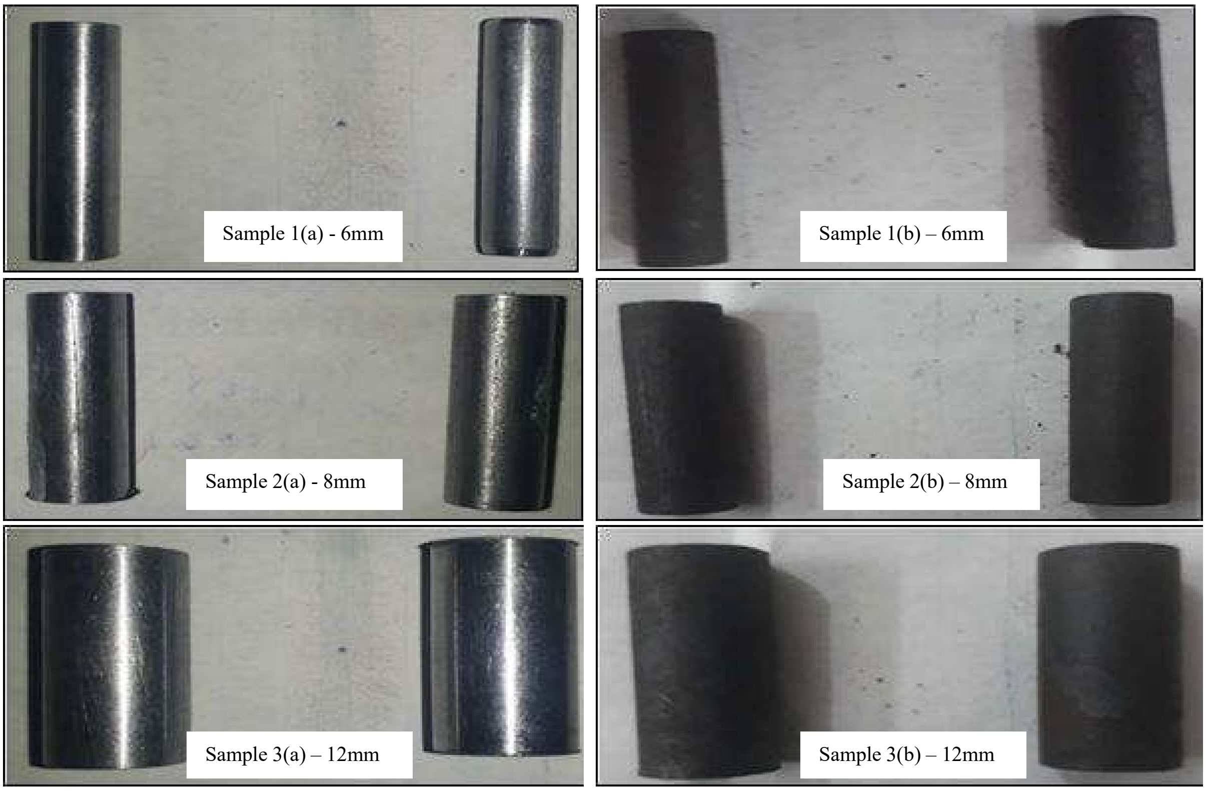


Fig.1. Actual test samples of various diameters (a) before and (b) after heat treatment process.

Experimental setup: -

The experiments were conducted on Pin on Disc machine (make and model: Contech Microsystems- Bangalore) available in the tribology lab of Mechanical Engineering department, MJP Rohilkhand University Bareilly. the experiment were conducted as per ASTM G99-90 standards, using counter face of steel disc 316L/EN-32 hardness to 70-74 HRC. The actual machine and there loading arrangement with rubbing disc and pin arrangement and instrumentation panel is shown in Fig. 2

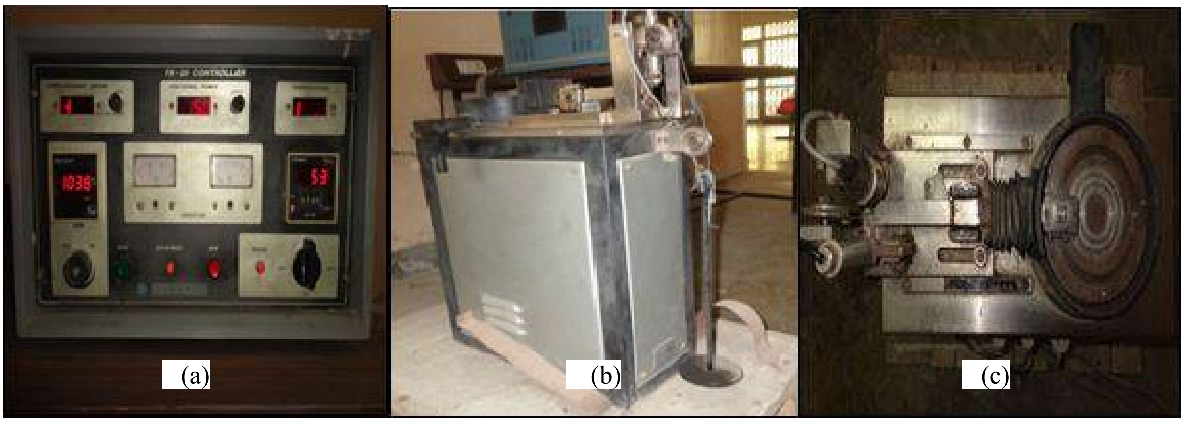
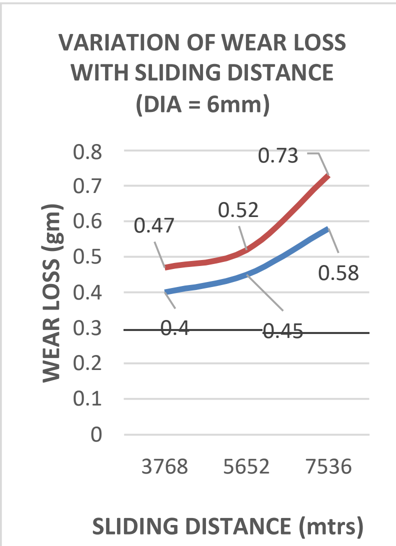


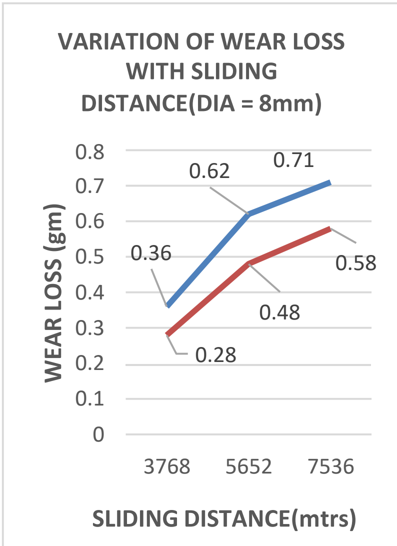
Fig.2. (a)Experimental test machine (b) Instrumentation panel (c) Loading arrangement

The variables involved in wear test includes, normal load, sliding velocity and sliding distance
Wear measurement: - Wear rate was measured by measuring the weight loss in the specimen after each test.
Hardness test – the hardness of chrome steel samples was determined by using Brinell's hardness tests with and applied load of 750 kgf Hardness- 285HBN.
Abrasive test - Pin on Disc machine at selected variables.

3. Result and discussion

From experimental data, we have obtain some graphical relationships of various parameters. Firstly we have plotted the graph (1,2,3) between variation of wear loss with sliding distance with different diameters of samples (6mm,8mm,12mm) in this we get that wear loss in smaller diameter pins was more than in large diameter pins but wear loss shows an increasing trend with time. Also the treated samples have more surface hardness than untreated samples and more wear resistance.





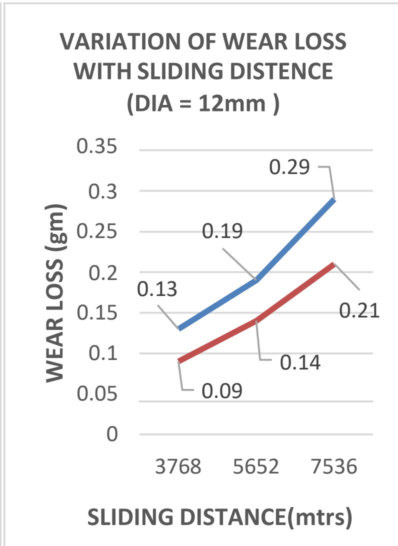


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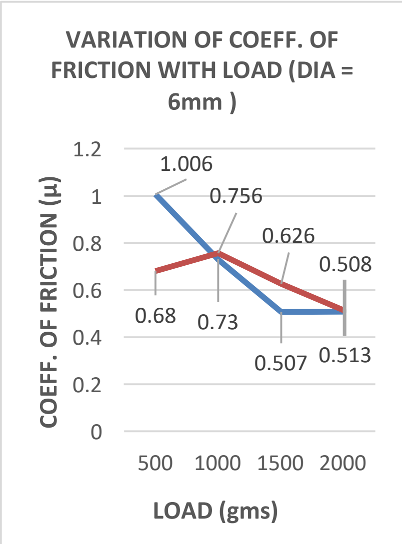
Table. 2 Data of wear loss with sliding distance with different diameters of samples (6mm,8mm,12mm)

	DIA=6mm			DIA=8mm			DIA=12mm		
UNTREATED	0.47	0.52	0.73	0.36	0.62	0.71	0.13	0.19	0.29
TREATED	0.4	0.45	0.58	0.28	0.48	0.58	0.09	0.14	0.21

Another graph (4,5,6) is plotted between variation of coefficient of friction with load with different diameters of samples and we got that nature and trend of coefficient of friction with an increase in load and time were almost the same for pin i.e with the increase in load coefficient friction it starts decreasing and becomes almost constant after sometimes. Also, we got to know that the friction coefficient increases with increasing sliding distance as well as wear rate.



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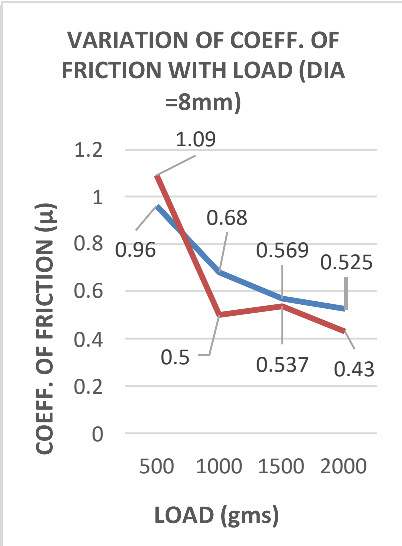

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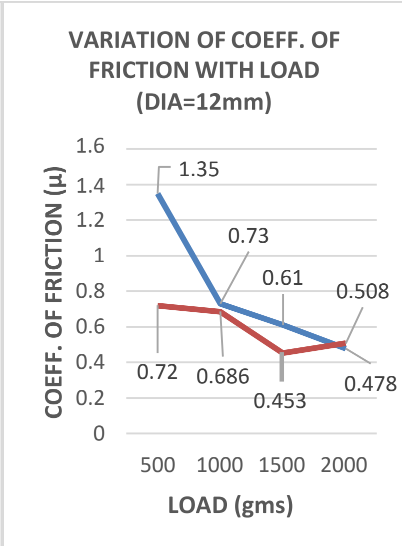

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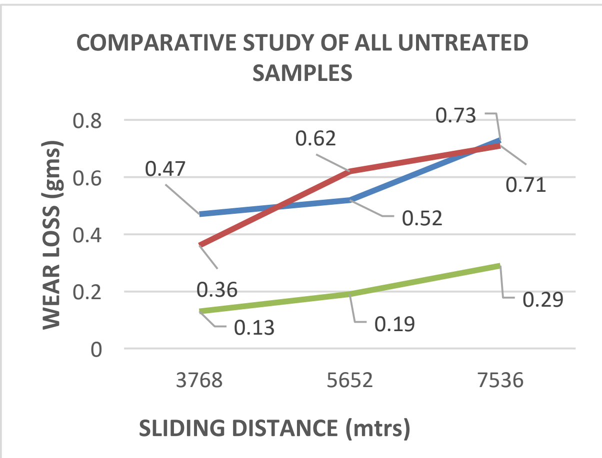
Table. 3 Data of coefficient of friction with load with different diameters of samples

	DIA=6mm				DIA=8mm				DIA=12mm			
µ(UT)	1.006	0.73	0.507	0.508	0.96	0.68	0.569	0.525	1.35	0.73	0.61	0.478
µ(T)	0.68	0.756	0.626	0.513	1.09	0.5	0.537	0.43	0.72	0.686	0.453	0.508

At last we have done comparative study of all untreated samples with different diameters and treated samples with different diameters and drawn graphs (7,8) table no.4 between wear loss and sliding distance and we got a result that wear loss in treated samples was much lower from untreated samples also wear loss in smaller diameter pins was more than the larger pin diameter and wear loss shows an increasing trend with time and also increases with increase in load.



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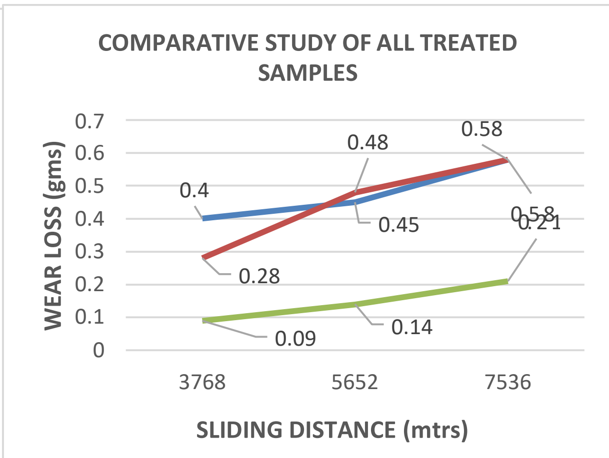

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Table.3Comparative analysis between Treated and Untreated model.

	UNTREATED			TREATED		
DIA=6mm	0.47	0.52	0.73	0.4	0.45	0.58
DIA=8mm	0.36	0.62	0.71	0.28	0.48	0.58
DIA=12mm	0.13	0.19	0.29	0.09	0.14	0.21

We have taken microstructure images of samples from scanning electron microscope. Fig.3(a) shows the SEM image of untreated samples before wear loss Fig.3(b) shows the SEM image of untreated samples after wear loss.

(a) (b)

Fig.3 SEM image of untreated sample(a) before wear loss (b) after wear loss

Also Fig.4(a) shows the SEM image of treated samples before wear loss and Fig.4(b) shows the SEM image of treated samples after wear loss

Fig.(a) Fig. (b)

Fig.4 SEM image of treated sample (a) before wear loss (b) after wear loss

Conclusion

From the experimental data from an experiment conducted on chrome steel pins on a pin-on-disc machine, it is seen that when the load is increased there was an increase in the temperature of rubbing bodies which results in to decrease in flow stresses in the material up to a certain extent which results in an increase in the plastic zone size in the subsurface of the rubbing bodies. Wear loss in smaller diameter pins was more than in larger diameter pins. Also wear loss showed an increasing trend with time and increases in load. Wear loss in treated samples was much lower than in untreated samples. When we have taken microstructure photographed by SEM indicates that the surface of heat-treated samples is martensite.

We have achieved approx. 8.7 Mohs hardness scale after heat treatment of materials.

In the above study, we obtained a material with low wear resistance, high load capacity, good hardness, long service life and high corrosion resistance compared to other materials.

In the future, this material could be used to provide high load capacity with good hardness and minimal wear loss.

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