A DISSERTATION ON WEAR BEHAVIOUR OF ALUMINIUM & BRASS

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Abstract: Wear is major problem in industry and its direct cost is estimated to vary between 1 to 4 % of gross national product. Therefore many efforts have been made to produce more durable materials and techniques to reduce the wear of the tools and the engineering components. These include modification of bulk properties of the materials, surface treatments and application of the coating, etc. over the last few years many efforts have been made to understand the behavior of the surfaces in sliding contact and the mechanism, which leads to wear.

The applications of the Aluminum, Mild steel composites for the machine parts, particularly due to some very attractive characteristics such as high strength to weight ratio, excellent cast ability, pressure tightness, low coefficient of thermal expansion, good thermal conductivity, good mechanical properties and corrosion resistance The composites are mainly used in aerospace, automobiles, marine engineering and turbine compressor engineering applications. MMCs are used for light weight as well as high temperature applications.

MMCs found wide applications in marine castings, motor cars & lorry fittings/pistons & engine parts, cylinder block and heads, cylinder liners, axles & wheels, rocker arms , automotive transmission casings, water cooled manifolds and jackets , piston for internal combustion engines , pump parts, high speed rotating parts and impellers etc.

I.INTRODUCTION

Wearis the removal of material from a solid surface as a result of the mechanical action exerted by another solid. Wear chiefly occurs a progressive loss of material resulting from the mechanical interaction of two sliding surfaces under load. It is such a universal phenomenon that rarely does two solid bodies slide over each other or even touches each other without measurable material transfer or material loss.

For example: Coins become worn as a result of continued contact with fabrics and human fingers; pencils become worn after sliding over paper; and rails become worn as a result of the continued rolling of train wheels over them.

Only living things (e.g., bone joints) are in general immune to the permanent damage caused by wear because only they have the property of healing through regrowth. And even a few living things do not heal themselves (e.g., teeth in humans).

II.OBJECTIVES

The study of friction, lubrication and wear has long been of bothtechnical and practical interest, since the functioning of many mechanical systems depends on friction and wear values. This field has recently doubled, "Tribology", has received increasing attention as it has
become evident that the waste of resources resulting from high friction and wear is very great (more than 6% of the Gross National Product), and that the potential savings offered by improved tribological knowledge are correspondingly great.

This study presents, in a systematic form, current insights into tribology, focusing on the concepts of surface energy and delamination. Experimental techniques and quantitative relationships in friction and wear will be discussed. Special consideration will be given to the tribological properties of brass and Aluminium to the problem of applying fundamental knowledge to the control of friction and wear behavior in practical situations.

1. Describe surface topography, physico-chemical aspects of solid surfaces, and surface interactions.
2. Recognize the laws of friction, mechanism of friction and friction space, friction and surface temperature.
3. Appreciate types of wear, including adhesive, delamination, fretting abrasive, erosive, corrosive, oxidational and wear mechanism maps.
4. Analyze the design of tribological surfaces, and how to troubleshoot tribology problems.
5. The main objective of this dissertation work is to justify the appropriate quantification of the wear rate for better conclusion and to understand the clear picture of the wear behavior of a material.

III. Recent trends in metal wear research

Most of the wear researchers carried out in the 1940s and 1950s were conducted by mechanical engineers and metallurgists to generate data for constructions of motors, drive trains, bearings bushings and other types of mechanical moving assemblies**.**

It becomes apparent during the survey that wear of the metals was a prominent topic in a large number of responses regarding feature priorities for research in triboogy. Some 22 experiences tribologists in this field, attended the 1983 'wear of materials' conference in reston prepared a ranking list. Their proposals with top priority were further investigated for mechanism of wear and this no doubt reflects the judgment that particular effect should be studied against background of the basic physical and chemical process involved in surface interactions.

Table 1:Priority in wear research

Ranking	Topics
1	Mechanism of wear
2	Surface coatings and treatments
3	Abrasive wear
4	Materials
5	Ceramic wear
6	Metallic wear
7	Polymer wear
8	Wear with lubrication
9	Piston ring cylinder liner wear
10	Corrosive wear
11	Wear in other Internal combustion engine

Petersons received the development and the use tribo materials and concluded that there are most common engineering materials and in wear application. Gray cast iron for example has been used as early as 1388. much of the wear research conducted over the 50 years is in ceramics, polymers, composite materials and coatings.

The three main ways by which intimate objects loose their usefulness are obsolescence, breakage and wear. Normally different classes of object face the impact of these three factors with different extent. Wear of the metals encountered in industrial situation can be grouped in to following categories, though there are situations where one type changes to another, or where two or more mechanisms play together.

Table 2: Types of wear in industry

Types of wear	Approximate percentage
Abrasive	50
Adhesive	15
Erosion	8
Fretting	8
Chemical	5

IV. TYPES OF WEAR

1. Adhesive wear

Adhesive wear is the surface damage and material removal, which can occur when two smooth surfaces rub against each other. Such surfaces are never perfectly smooth and have high spots where the rubbing occurs. These areas experiences concentrated contact loads and interactions and tend to adhere to each other and drag material away along the surface.

2. Abresive wear

Abresive or cutting types of wear take place whenever hard foreign particulars, such as grit metallic oxides and dust and grit from the environment are present between the rubbing surfaces. These particles first penetrate the metal and then tear off the metallic particles. Depending upon the severity, abrasive wear may be of the gouging or scratching form. Abrasive wear is one of the most common types encountered in engineering practice and it is probably the highest single cause of wear in many machine applications .

3. Laminative and delaminative wear

Laminative and delaminative wear is the term first used by Suh. It is defined as the loss of metal in the form of flanks, called by the formation and propagation of subsurface layers with fatigue cracks running parallel to the surface. Therefore, in some literature it is included under fatigue wear since, it is considered as a characteristic mode of water rather than the mechanism.

The theory put forth by Suh suggests that the normal and tangential forces are first transferred through the contacting asperities to smoothen the surface and the plastic strain gets accumulated in the surface layers. Then the cracks are nucleated below the surface layers. These cracks grow and join each other forming plate shaped particles and detach from the wearing surfacing. It is assumed that a metal under a slider wears layer by layer, in a way similar to the removal of an onionskin. Each layer consists of many sheets. The creation of these wear sheets is assumed to be cumulative process and it results from the metals being shears by a small amount by each passing asperity. A wear sheet is formed after a large number of asperities have slides over each point on the surface.

4. Corrosive wear

This form of wear occurs when sliding takes place in a corrosive environment. In the absence of sliding the products of corrosion would form a file on the surfaces, which would tend to slow or even arrest the corrosion, but the sliding action wears the film away, so that the corrosive attack can continue. It is not easy to find a good illustration of corrosive wear.

V.FACTORS AFFECTING WEAR

1. Effect of sliding distance:

In the initial stage of sliding, wear is severe and exhibits the characteristic of bright wear tracks and the production of shiny metallic-debris. At some definite time or sliding distance, the onset of mild wear occurs, exhibited by dark wear tracks and the formation of partially oxidized debris. This initial wear is transient because some time is required to develop an equilibrium surface temperature between the sliding bodies, and this temperature can be sufficient to cause oxidation of the sliding surface producing oxide debris. For severe wear, the surface temperatures reached are quite high but insufficient to cause full oxidation of the wear debris. The production of oxide during wearing is a major factor in reducing the wear rate (mild wear). Another case involves the production of a hard transformation product, which prevents excessive surface deformation, and consequent break-up of the oxide layer.

2. Effect of load:

Welsh has studied extensively the wear of plain carbon and low alloy steels with a pin sliding under different loads on the periphery of a revolving ring of identical material, transitions from mild to severe and severe to mild wear and they were dependent on both load and sliding speed. Mild wear involves relatively the slow removal of the tips of the highest contacting asperities with little substrate distortion, together with building up of an oxide film on the sliding surface and the production of partly oxidized debris. In case of severe wear, the scale of surface damage is high; the wear rate is increased by some two orders of magnitude of that of mild wear and the maximum size of wear debris increases suddenly at the transition load. The wear debris developed in severe wear is mostly metallic.

3. Effect of speed:

Since the effect of increasing speed is to cause an increase of the temperature of the sliding interface, oxide formation in air should be facilitated. An increase in temperature also means that the hardness of metal will decrease so than an increase in the rate of wear can be expected. However, the general effect of increasing sliding velocity is to cause a reduction in the rate of wear. During wearing the metal is first transferred to the disc from the wear pin and wear debris is produced from this deposited layer. The size of the transformed fragment decrease as the speed is increased, as sufficient time is not available for the junction growth. This means that the frequency of metal transfer will decrease with the increase of sliding speed resulting in a progressive fall in the rate of wear.

It is usually observed for metals that the coefficient of friction decrease as the sliding speed is increased. At low and moderate sliding speeds friction is largely due to local adhesion and shearing at region of contact. At high sliding speeds metal surfaces are subjected to very intense frictional heating which profoundly changes the state of the surface layers on which the sliding takes place.

4. Effect of hardness:

Transfer and mechanical alloying of metals can modify the relative hardness values of the sliding components at the contact point. This will depend on the dynamic change occurring in the surface layers. The hardening and softening of surface layers depends on the changes of microstructure and mechanical properties, which result from load, speed and environment. Conversely, such changes affect the wear behavior of the surface layers and hence the final result of wear.

5. Effect of surface oxides:

Quinn has postulated this wear phenomenon. At the start of wear the oxide films found on an unworn surface are destroyed and hence an initial period of severe wear commences. Then by some processes the worn-out surface recovers and a state of mild wear is reached. The thick oxide layers are established and the wear rate declines drastically from the initial high rate. When each oxide layer reaches a critical thickness it becomes too weak to withstand the load and frictional shear stress and hence is removed.

6. Effect of Temperature

Frictional and wear is governed largely by the interaction of asperities of the two sliding surfaces. Energy is dissipated due to mechanical work and inevitably causes a rise of temperature but it happens intermittently in so far as the points of actual contact are concerned due to sticking and slipping of the junctions. These high temperature flashes are short lived in the order of 10^{-4} second. The heat evolved in friction is dissipated to the surrounding with the result that the asperity tips are at a high temperature but the bulk of the component remains relatively cool. An increase in load or speed raises the temperature of the junctions. As the temperature is raised, the effect is to increase the rate of wear of the pin, which reaches a peak value at a characteristic temperature depending upon the normal load below which, the surface oxides are not completely destroyed and hence the corresponding wear rate is low. Above the transition load, metal to metal contact is extensive and hence the corresponding wear rate is high.

VI. RESULT AND DISCUSSIONS

Wear tests have been performed on brass and Aluminium test pieces on Pin-On-Disc type machine, with four different applied loads and speeds and at a sliding distance 5,000m

Experimental data's were collected in order to plot the graphs to study the effect of various process parameters like applied load, sliding speed, on Surface hardness, Frictional force, Volumetric wear rate and Normalized wear rate.

From the collected experimental data, the graphs are plotted to understand the effect of load and , weight loss, Surface hardness .

Actually during wearing, the hardness of the wearing surface will go on change due to rubbing action between the disc and the sliding surface, resulting in a surface hardening due to work hardening and softening effect due to frictional temperature but this effect of hardness is not considered so far.

Sl. No	Load in Kg	Load (N)	Weight of specimen before wear (gms)	Weight of specimen after wear (gms)	Weight loss (gms)
1.	0.5	4.905	27.95	27.85	0.06
2.	1	9.81	27.85	27.77	0.12
3.	1.5	14.715	27.77	27.64	0.15
4.	2	19.62	27.64	27.46	0.22

Estimated experimental results:
Material = aluminum
Constant speed=250RPM
Time=40min

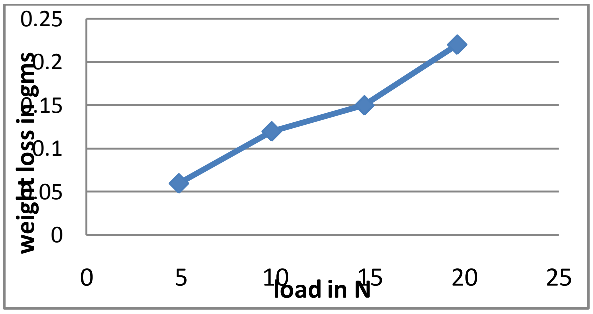

Fig 1 : Load vs weight loss of Al for 40min

Material = Aluminium
Constant speed=300RPM
Time=35min

Table 3: Data for Aluminium

Sl.No	Load in Kg	Load (N)	Weight of specimen before wear (gms)	Weight of specimen after wear (gms)	Weight loss (gms)
1.	0.5	4.905	28.25	28.20	0.05
2.	1	9.81	28.20	28.10	0.10
3.	1.5	14.715	28.10	27.97	0.13
4.	2	19.62	27.97	27.75	0.22

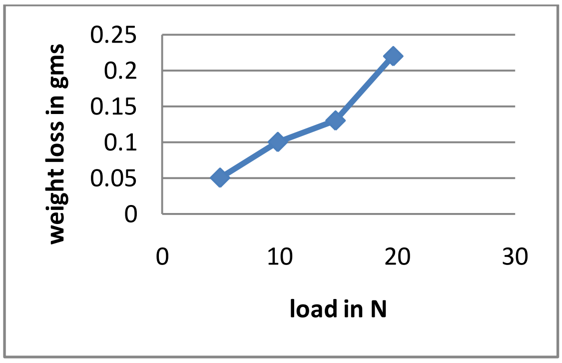

Fig 2 : Load vs weight loss of Al for 35min

Material=Brass

Speed=250rpm

Time=40min

Table 4: Data for Brass

Sl.No	Load in Kg	Load (N)	Weight of specimen before wear (gms)	Weight of specimen after wear (gms)	Weight loss (gms)
1.	0.5	4.905	88.25	87.50	0.75
2.	1	9.81	87.50	86.46	1.04
3.	1.5	14.715	86.46	85.06	1.40
4.	2	19.62	85.06	82.56	2.5

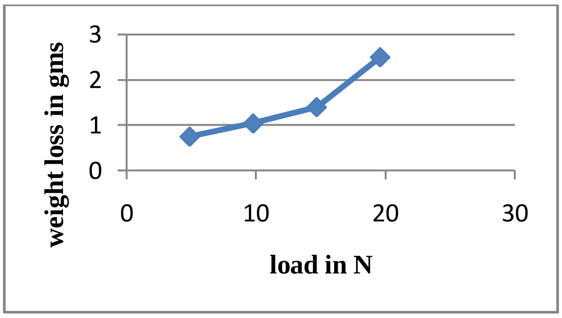

Fig 3: Load vs weight loss of brass for 40min

Material=Brass

Speed=300rpm

Time=35min

Table 4: Data for Brass

Sl.No	Load in Kg	Load (N)	Weight of specimen before wear (gms)	Weight of specimen after wear (gms)	Weight loss (gms)
1.	0.5	4.905	86.80	86.08	0.72
2.	1	9.81	86.08	85.10	0.98
3.	1.5	14.715	85.10	83.58	1.52
4.	2	19.62	83.58	80.5	3.08

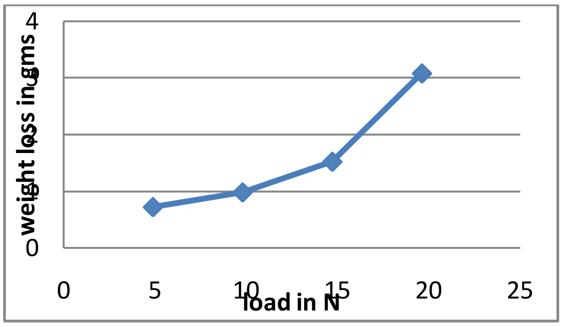

Fig 4: Load vs weight loss of brass for 35min

A. Analysis of Rockwell hardness test for Aluminium and Brass

Sl	material	scale	Indenter	Load	dail	Rockwel	AVG
1	Aluminium	B	Ball type 1/16	100	Red	42	48.75
2		B	Ball type 1/16	100	Red	48	
3		B	Ball type 1/16	100	Red	52	
4		B	Ball type 1/16	10xz rj hhnjj m0	Red	53	

B. Rockwell Hardness Test for Brass

Sl no	material	scale	Indenter	Load	Dial	Rockwell	Avg
1	BRASS	B	Ball type 1/16	100	Red	69	70
2		B	Ball type 1/16	100	Red	70	
3		B	Ball type 1/16	100	Red	72	
4		B	Ball type 1/16	100	Red	69	

VII. CONCLUSION

1. When load increases, wear rate increases gradually .The Hardness is increased with increase in the load and same is decreased with increase in the sliding speed.

2. Image Analyzer examinations of the worn out surfaces of the wearing pin indicated that Abrasive and adhesive were the dominant wear mechanism.

3.The formation of the oxidative layers and two body, three body abrasive wear were observed from the micrographs.

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