A Study of Various Wear Mechanism and its Reduction Method

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Abstract

In this paper we describes what is wear mechanism, how they can be effected in mechanical process. Mechanism of wear are reviewed and categorized (i) adhesive; occurs between the materials in two surface under relative load are stronger than the inherent material properties of the either surfaces. (ii) abrasive; occurs between surfaces of different relative hardness (iii) third body; occurs when hard particles become embedded in a soft surface (iv) corrosive; occurs by corrosive environment and (v) surface fatigue; occurs as result of the formation and growth of cracks. Many types of wear reduction method are used for controlling a wear. This paper describes briefly the wear reduction method which is currently used or proposed in industrial machine. We also describe the effect, caused and test criteria of wear. Efforts made in this study may enhance understanding of wear mechanisms and reduce the wear.
Keywords: Wear mechanism, Adhesive, Abrasive, Third body, Corrosive, Surface fatigue

I. INTRODUCTION

Wear is one of a number of processes which occur when the surface of engineering components are loaded together and are subjected to sliding and / or rolling motion [7] .Due to utilization and equipments, the reduction takes place in the dimension of parts slowly and continuously as the change in shape and surface finishing is known as Wear [1]. Wear is progressive loss of substance from the surface of a solid body caused of mechanical action. Manly five principle of wear are there; Adhesive, Abrasive, third body, Corrosive and Surface fatigue and it soon became possible to work out their mechanisms and express the amount of wear in quantitative terms.

II. WEAR MECHANISMS

A. Adhesive Wear:

This is the only universal form of wear and many sliding system it is also the most important. It arises from the fact that during sliding regions of the adhesive bonding called junctions from between the sliding surface. If one of these junctions dose not back along its original interface then a chunk from one of this sliding surface will have been transferred to the other surface. It means Adhesive wear occurs when the atomic force occurring between the materials in two surfaces under relative load are stronger than the inherent material properties of either surface. For example, when there is relative motion between two or more surfaces bonding of asperities occurs. Continued motion of the surface required breaking the bond junction. Each time a bond junctions is broken a wear particle is created usually from the weaker material (Fig-1) In this way an adhesive wear particle will have been form. Initially adhering to the other surface adhesive particle soon come off loose and can disappear from the sliding system.
The volume of adhesive wear is governed by the equation $V=kLx/3p$, where V is the total volume of adhesive wear, k is a non-dimension constant called the wear coefficient, x is the total distance of sliding and p is the indentation hardness of the surface expressed as a stress. Typical values of k are given in Table-1 [2].

A very great reduction in wear by factors of up to million can be produced in metallic sliding systems by using a good lubricant. Also there is a great advantage in making unlubricated sliding system nonmetallic and well lubricated system metallic.

Table-1
Values of the wear coefficient for adhesive wear

Surface condition	*Metal on metal*	*Nonmetal on metal, nonmetal on non-metal*
Clean	10^{-2} to 10^{-4}	10^{-5}
Poor to fair lubricant	10^{-4} to 10^{-6}	3×10^{-6}
Good lubricant	10^{-6} to 10^{-8}	10^{-6}

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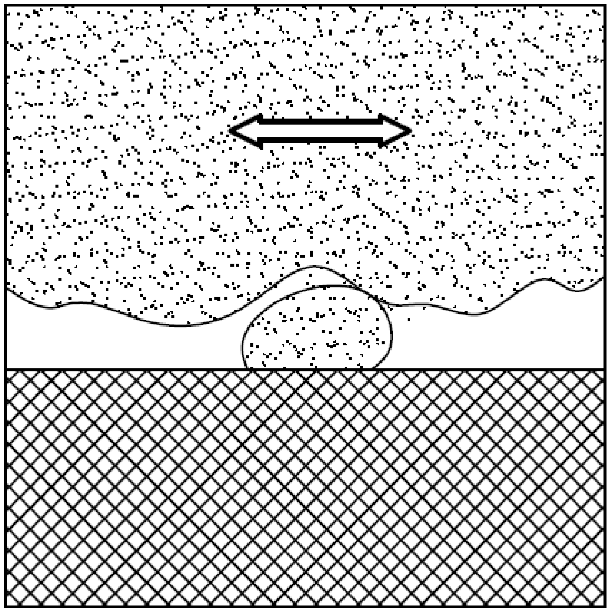

Fig. 1: Adhesive wear

Adhesive wear caused two type of failure, one being aware-out mode which occurs after long periods of sliding because too much material has been removed and a seizure mode which occurs in system which generate wear particles larger than the clearance, thus producing jamming. Since many material combinations give wear particles larger than 10 micrometers, it is dangerous to reduce the clearance of any sliding system below this value.

B. Abrasive Wear:

This is the wear produced by a hard, sharp surface sliding against a softer one and digging out a groove. It means abrasive wear occurs between surfaces of the different relative hardens. In an abrasive wear mechanism, micro roughened regions and very small asperities on the harder surface locally plow through the softer surface (Fig-2).

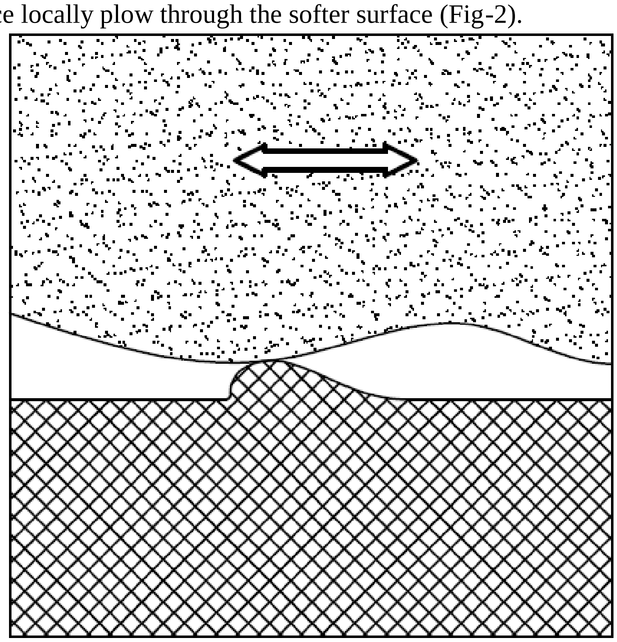

Fig. 2: Abrasive wears

The results of Abrasive wear, softer material being removed from the track traced by the asperity during the motion of the harder surface. The abrasive agent may be one of the surfaces, such as a file, or it may be third component, and sand particles in a bearing abrading material from each surface. Abrasive wear, like adhesive wear, obeys the equation given above; typical values of k are given table-2 [2]. It will be seen that abrasive wear coefficients are large compared to adhesive wear coefficients. Thus, the introduction of abrasive particles into sliding system can greatly increase the wear rate, so in automobile air and oil filter are used.

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Table-2
Values of the wear coefficient for abrasive wear

Process	*K value*
Sharp file	2×10^{-1}
Sandpapering	5×10^{-2}
Loose abrasive grains	5×10^{-3}
polishing	5×10^{-4}

C. Third Body:

Third body wear is a one type of abrasive wear that occurs when hard particles become embedded in a soft surface (Fig-3). Generally metallic or bone particles embedded in a polyethylene bearing surface as third body particles. The particles acts is much like the asperity of a hard material in abrasive wear, removing material in its path. Hard third body particles like bone cement can produce damage to both the polyethylene articulating surface and the metallic alloy femoral bearing counter face [4] .

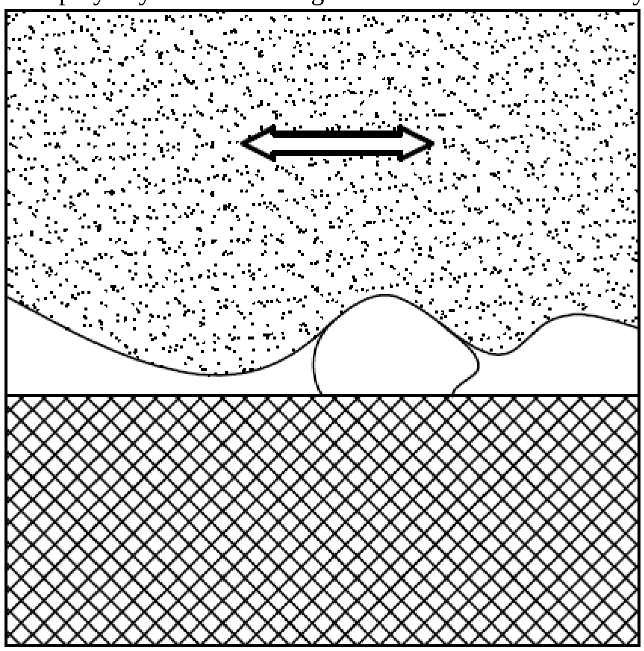

Fig. 3: Third body wear

The extent of abrasive wear of polyethylene, metallic and ceramics has been shown to be a function of the surface roughness of the metallic or ceramic counter face and the presence or absence of hard third body particles. In one vitro hip simulator study, simulation of roughened femoral head increased the amount of wear damage to the polyethylene even in an elevated cross linked polyethylene [5]. In other studies isolated scratches more dramatically increased the wear rate than generalized roughness of the metallic counter face and could also change the wear performance ranking of various polyethylene formulations [6]. Thus the magnitude of the effect of surface roughness of the metallic counter face on overall wear rate remains controversial.

D. Corrosive Wear:

This form of wear a raised when a sliding surface is in corrosive environment and the sliding action continually removes the protective corrosion product; it means Corrosive wear is an indirect wear mechanism. Thus exposing fresh surface to further corrosive attack. Corrosive wear can be considered as an accelerating mechanism for corrosion itself, because the motion of an articulation can remove corrosive products and the protective passive layer sooner than interfaces with no relative motion. No satisfactory quantitative expression of corrosive wear yet exists but when analyzing it in terms of the above equation; k values are obtained ranging all the way from less than 10-5 for surface in a gently corrosive environment to above 10-2 for surface under severe corrosive attack.

E. Surface Fatigue Wear:

This is the wear that occurs as result of the formation and growth of cracks. It means Fatigue wear occurs when surface and subsurface cyclic shear stresses or strains in the softer materials of an articulation exceed the fatigue limit for that material. Because polyethylene is the weaker of the two materials in a bearing couple, fatigue wear damage to the polyethylene component dominates. Under these repeated or cyclic loading conditions, subsurface delaminating and cracking can occur, eventually leading to the release of polyethylene particles (Fig-4).

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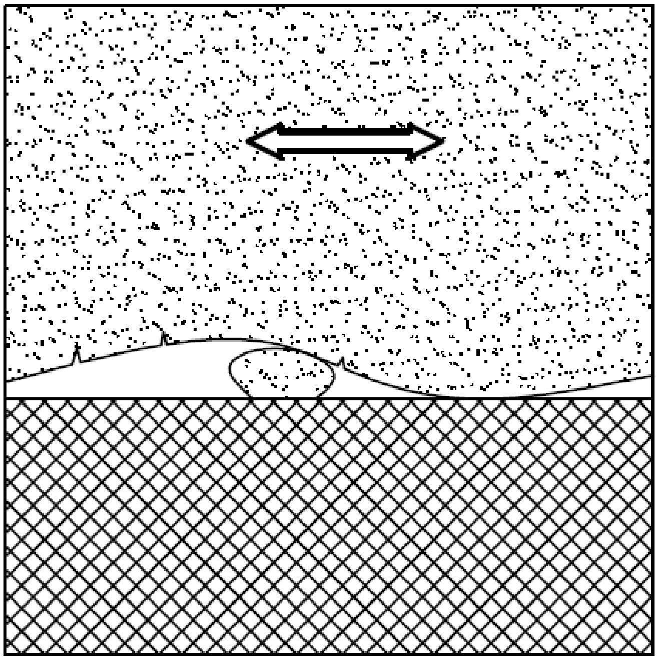

Fig. 4: Surface fatigue wear

Fatigue damage can range from very small areas of pitting, so not apparent on visual inspection to macroscopic pits several millimeters in diameter to large areas of delaminating that can encompass an entire tibial plateau. It is the main form of wear of rolling devices like ball bearing, wheels on rails and gears, during continued rolling, a crack forms at or just below the surfaces and gradually grows until a largest particles is lifted right out of the surface. As per our above discussion k value is different for different metal, which is shown in Table-3.

Table-3
Wear coefficients value for different metal [8].

Wear Surface metal	*k*
52100 steel	1.0×10^{-2}
Mild steel	2.3×10^{-3}
Leaded brass	2.0×10^{-3}
Satellite	1.8×10^{-5}
Polyethylene	4.3×10^{-8}
Aluminum bronze	2.5×10^{-8}
Carburized steel	1.6×10^{-9}

III. FLOW CHART OF WEAR MECHANISMS

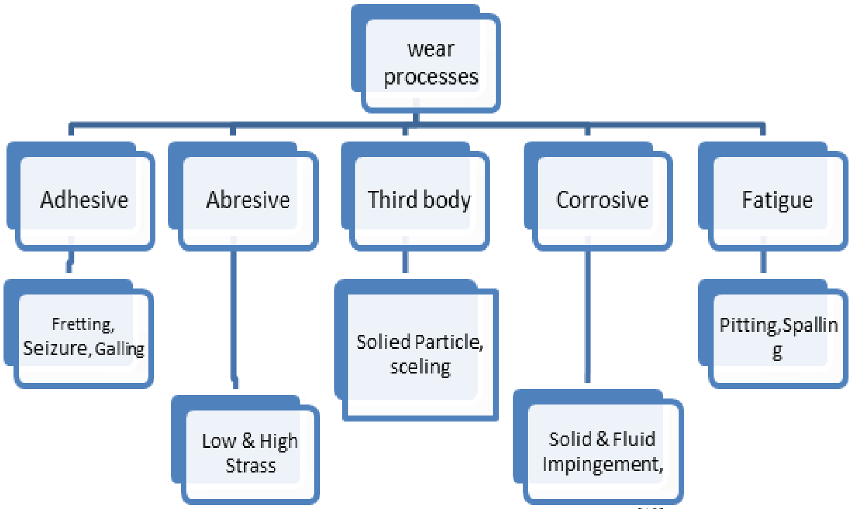

Fig. 5: Flow chart of various wear mechanisms [10].

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IV. WEAR PHENOMENA CAUSED BY MAIN WEAR MECHANISMS

Table-4
Wear phenomena with wear mechanism [9].

Wear mechanism	*Wear phenomenon*
Adhesive	*Scuffing or galling area, Holes, Plastic shearing, Material transfer*
Abrasive	*Scratches, Grooves, Ripples*
Third body	*Other metal, Extra particles*
Corrosive	*Reaction Products*
Surface fatigue	*Cracks, Pitting*

V. CAUSES OF WEAR

- Lack of Lubrication
- Overload
- Misalignments
- Friction between rubbing surface
- Faulty design
- Insufficient lubrication
- Improper lubrication
- Bad workmanship
- Rough finish on surface
- Insufficient clearance between surface
- Contest with dust/metal particle
- Effect of most air, water and chemicals
- Effect of temperature
- Improper tools used

VI. EFFECTS OF WEAR

Many effect are generated when wear are doing like Noisy operation: Due to the wear, clearance of different mechanical parts are increasing and so pair of mating parts strikes against one-another, thus striking of various parts produces continuous noise. Low quality work: If increased clearance, the rigidity of machine reduce and it's not be utilization with full capacity and finally quality of product are reduce. Lowered efficiency: Due to the more clearance standard of machine are reduce and its capacity are also reduce. When used such machine, the efficiency of this machine are reduce. Vibration: Due to the wear and tear, the clearance adjusted is changing, which is producing vibration of machine and thus at this condition machine are not properly work and it's produced poor quality of work. Misalignment: Due to the wear, clearance of the bushing and shaft, ball bearing and roller bearing are increased, so position of shaft is changes. It means shaft are not rotate properly this known as misalignment. If such machine is used further then due to its vibration caused change of alignment may lead to the failure of machine and its foundation. Overheating: Generally temperature can be bare by touching the machine. If the temperature is higher than that it can be said as overheating of machine. Due to overheating the parts are become loses its strength and machine becomes faulty due to which it stop functioning. Overheating may result into the change of metallic structure of the parts. Leakage development: Due to the vibration caused by the wear of the parts, nut-bolts of coupling and flange are loosening, thus leakage of oil are occur. Leakage is affected in producing corrosion, low efficiency of machine and low safety in operation.

VII. TEST CRITERIA OF WEAR

Selection of suitable wear test, the following points should be considered: (a) ensure that the test selected is measuring the desired properties of a material; (b) whether the material is in bulk form or is a thick or thin coating; (c) whether the forces and stress limit is suitable for the test; (d) whether abrasives be present, considering the abrasive size, form and velocity;(e) whether the contact between the components is rolling, sliding, impact or erosion only, or a both of these so bearing in mind that the surface finish of the test samples should be similar to that of the actual components; (f) whether temperature and humidity factors are important; (g) whether the test environment is similar to the actual working environment; (h) the duration of the test; and (i) whether the materials used in testing is typical of the actual material used in the machine part [3] [14].

VIII. WEAR REDUCTION METHOD

We know that wear only reduced it can’t be prevented. We can reduce the wear but wear elimination is not possible. Many technique are developed for reduce the wear, which is described below.

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A. Prevention of Overloading:

Overloading is big parameter for generating a wear in part; due to the overload lubricants oil film between the parts will be burst away and creates an extra force on the wearing surface therefore overloading should be avoided.

B. Maintain a Proper Clearance:

If the clearance between the surfaces is less, lubrication oil film cannot be provided the wearing surface and so metal to metal contact are developed. If more clearance is provided between the surfaces the motion is loss. Due to lack of lubrication parts surface worn out very rapidly, produces noisy and generate the vibration on the machine.

C. Improper Lubrication:

Improper lubrication means correct grade oil, correct lubrication method used, correct place selection and correct lubrication volume. Lubrication provided a film of lubricants in the clearance between the mating surface and its increase the smoothness of the rubbing surface and prevents the metal to metal contact of mating surface.

D. Improving the Surface Finishing:

When part are pass in machining process then different type of straight or circular lays depth is generated, which is cannot be seen by naked eyes. By Improper surface this lays are reducing and friction force not generating more. Due to the good surface a line contact are obtained instead of point contact, which is advantage in processes.

E. High Surface Hardness:

Wear of hard surface is taking place in comparison to soft surface. Shaft, bearing, guide way are heat treated to increase their surface hardness than its wear is reduced.

F. Proper Surface Treatment:

Mechanical wear can be reduced by hard layer of some metal, like Chromium, Galvanic etc. After producing hard layer of chromium on the surface, if it can be machining to get desired dimensions and surface finish. Hence it can be said that hard layer can be provided on the surface of the wear resistant metal, the wear of the part can be reduced.

G. Protection of Surface Against the Ingress of Dirt, Dust and Metal Particles:

If dirt, dust and metal particle are ingresses in to the bearing that they are crushed further. If such particles are harder than the part surface, so part surface will be wearing and it’s damaged.

H. Proper Atmosphere:

In the atmosphere dirt, dust moisture, poisonous chemical vapour and dust of product itself are present and it is affected machining functions and reduced of their service life.

Some other method are also used for reduce a wear like proper maintain at right time, the adjustments of varied clearance at time to time, proper planning, implementation of prevention maintenance, controlling the preventive maintenance activity properly, selection of suitable material for the part, reducing the sliding pairs with the replacement by rolling pairs, used automatic maintenance facility [1] .

IX. CONCLUSION

Wear only reduced it, can’t be prevented thus compulsory wear reduction technique are used at every place. If wear are more than the limit, it’s not good, but if it's in limit, it is good because mechanical power can't transfer without contact of metal.

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