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# A study on the Wear Mechanism of Aluminium Alloys

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**ABSTRACT**

*Aluminium is one of the most use metal on earth surface which finds in application in almost every sector on the economy, right from the air craft industry where duralumin is used for aircraft body, in the space craft and rockets, medical science where aluminium finds its applications in various medicine to the small kitchen appliances like cans, foil, Kitchen utensils .with the development of building technologies, Various uses of aluminium have been emerged like the aluminium doors, frames and windows, Even the frames of the glasses are made of aluminium and its alloys, the major used of aluminium is in the automobile sector where the body of cars, scooter and sophisticated part where the need of aesthetic finish and the light weight technology is there, Aluminium and its alloy is the solution. Keeping in mind the use of aluminium and its alloy. A review on its Tribological properties have been done and its four major type of wear mechanism have been discussed in this study.*

***Keywords:*** *Aluminium Alloys; Wear Mechanism; Tribological Properties.*

## 1.0 Introduction

Aluminium metal is blessed with light weight, low density, high strength, corrosion resistance and non-magnetic property at low cost. That is why aluminium is the topmost priority of the researchers. B.N Pramila bai [ 1] studied the dry sliding wear of AL-Si Alloy and made concluded that the binary modified alloy whose composition is about 4 to 24 percent by weight of silicone has the lower wear as compared to the alloys which had no silicone in it. The second conclusion made by the researcher was that systematic trend was absent in the particular alloy containing four to twenty-four percent by weight of silicone content.

The Wear rate is proportional to pressure and it shows a linearly increasing and monotonically with the pressure. But the most important point to conclude that the coefficient of friction is insensitive to the variation of speed, Silicone content and the variation of pressure. The following observation was made from the experiment which was done for the Pin on disc experiment whose pressure range was varied from 0.105 - 1.733 MPa with the speed of minimum value of 0.19 and the maximum value of 0.94 m s-l. K.

Mohammed Jasim and E. S. Dwarakadasa [2] experimented on the dry sliding wear of the aluminium and the silicone alloy on a pin on disc machine setup and used steel disc as counter face .The average hardness of the disc used was 30 and 50 HRC. Two separate discs were used for the experiment purposes. In the experiment the pin was made to rub on the surface of the disc and the bearing load was taken as 0.5 N.

The volume of wear is estimated through the weight loss and the observation was done for 60 minutes. The variation in the parameters was done by changing the rotational speed of the disc which led to the change in sliding speed. The point to be noted was that they kept the distance of the disc axis and pin was constant. After conducting the successful experiment the researchers jotted the following conclusions which were firstly the wear in binary AL-SI alloys is based on subsurface damage Zone in which the spheroids (3 - 5 pm size) of silicon-rich phase is present. The second key point was that the wear calculated was the function of Sliding Speed,

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Disc Hardness, Alloy composition and the bearing pressure and it was also observed that the wear rate does not depend on the structure of the silicone alloy. There are various types of alloy formed in the AL-Si system but the point to be noted was that for AL-Si System Eutectic alloy had the lesser wear rate when we take account of all other alloys in the Al-Si system. The third observation that had evolved from the experiments shows that there was no sign of the plastic deformation when hyper eutectic alloys was observed. Lastly the key observation of the researchers were that when the researchers studied the spheroid particles evolved from the sub surface layer, they observed that the combination of mechanical and thermal process occurred in that layer only.

Chiao et al. [3] Used the method of X-ray Difactromettry (XRD) , EDS (Energy-dipresive spectrometry) and scanning electron microscopy to study the surface formed after conducting a dry sliding wear test in which the researchers uses pin (15% A1203 (p)-6061 Al composites) and the disc of (52100 steel) was used and made the following conclusions. Firstly iron was the main constituent of the phase of composite surface which was worn out. But after service wear sliding aluminium was the chief constituent of the worn surfaces. the next point of observation was that when the surface was under cross sectional microstructure analysis ,It was observed that A and O particles were combined when there were mild wear conditions but when they went for severe wear condition, the particle near the surface got fractured. when the researchers went for the XRD result, they concluded that the for the mild wear the composition of the debris was mainly Fe2O3 and for the severe wear the composition of the debris was AL2O3.

The key point of observation was that Al2O3 particles could not kept the strength of the surfaces as they were broken in the severe test and thus it was inferred that the wear behavior of the composite depends upon the ability of the particle to withstand the wear action. Johnson et al. [4] conducted the pin on disc experiment on a compound composed of nickel and aluminium alloy. The researchers took three different type of composition mainly 45, 48 and 50 percent of aluminium content in it and the pin was made up of this alloy which was tested at room temperature. The material of the disc was zirconium which was partially stabilized.

After the successful completion of the dry sliding test the researchers concluded the following points Firstly it was found that the wear rate is inversely proportional to the hardness. From this point the researchers concluded that the higher hardness of the material, higher would be the grain size of the material and lower would be the wear rate. The second point of consideration was about the brittle cracking, the researchers observed that on the worn surfaces brittle cracking was not observed. The next point of observation was that the plastic deformation was present throughout the surfaces and in all compositions mainly the mechanical debris and the plastic deformation was there on the surface of the wear pin. it was also observed that the coefficient of friction so found out varied from alloy to alloy and also since the composition had varied the coefficient of friction also varied. The researchers also argued that the presence of NiO which is an anti-Ferro magnetic oxide, metallic Ni made the dust magnetic in nature.

Lin et al.[ 5] studied the tribological effect of the composite made by the cast aluminium alloy A356.0 AL and fine graphite particle mixed with 6061 aluminium alloy powder by means of cold pressing and sintering. The researchers tested the self lubricating alloy so formed for the dry and wet analysis and concluded that the wear on the disk increases when the content of graphite present in the aluminium increases which is also subjected to the condition that the sliding speed increases and the nominal pressure decreases. but The researchers also observed that when the graphite content increased the wear rate suddenly decreased when the high load is applied.

The second observation of the researchers were that when graphite is added to the aluminium alloy than it lead to the surface seizure. The surface seizure also started when the dry pin on disc stated with the high nominal contact pressure which in turn increases the frictional contacts. the researchers emphasised on the fact that at speed of 2.12 m/s will effectively last for longer before the seizure of the surfaces. the next observation of the researchers was that as the coefficient of friction increases the oil temperature decreases also when there is surface seizure,

There will be an abrupt increase in the friction coefficient which results in the increase in the oil temperature. the next observation of the researchers was that when the total content of the graphite was 2 percent in the aluminium alloy, the Hersey number associated with the transition is reduced as the transition occur from mixed to boundary lubrication. It was also observed that in both the mixed and in boundary condition the friction coefficient is more for the alloy with 4 percent graphite as compared with the 2 percent graphite content. But when we increase the content from 4 to 6 or 10 percent than the coefficient of friction increases in all regimes. Lastly the researchers concluded that the boundary lubrication would not be generated by adding phosphorous based additive.

Gui et al. [6] studied dry sliding wear of alloy of Al – 6 CU mn. The researchers used the load of 5-400 N And identified four regions on the worn surfaces After applying the load. These four regions were on the basis of debris analysis and friction coefficient the researchers concluded that The two regimes mild and severe wear what's there in all all four regions out of which there are transition zones between the reason 3 and 4 and in rest in all regions mild wear was present. The second point was that there was oxidative wear in region 1 ,The reason to have the deal lamination wear and the Three head surface cracking assistive adhesive wear. When the researcher talked about the reason for this, they concluded that there is a formation of wear debris which is due to the shear fracture of the subsurface material.

Lastly the researcher concluded that the transition from the mild to severe had certain factors on which it depended; these factors were pin's strength of material strain and shear stress by pin load and if this is strain-induced shear stress is larger than the strength of the material then the severe wear is high. Yasmin et al. [7 ] Forget the weird behaviour of Al- Si Alloy input the cast and heat tempered material form. The researcher made the cylindrical specimen from a cast ingot and the pen was prepared and heat was supplied and the specimen was prepared according to the American Society of testing machine standard (ASTM). The weight loss technique was used to carry pin on disc experiment and following points were concluded firstly the increase in wear is proportional to the input weight former rotational speed and sliding distance in both the cast and he treated aluminium Silicon alloy. The next observation was that the rotational speed increases both the volumetric and specific wear rate for both the types of alloys. also the wear rate decreases with increase in input wait and sliding distance.

Wang et al.[8] studied three alloys of Al-20 Si and Al-25Si which were made using the deposition and spray atomization technique. the researcher used various load such as 8.9 17.8 26.7 and 35.6N. researchers analyzed the debris of the worn out surfaces by scanning electron microscope and found that when the load applied on the pin on-disk was 8.9 - 35.6 Newton , spray deposition Al-Si alloy have been found. For the load up to 8.9 Newton the wear rate depends upon Si content. When the SI content increases the Wear decreases and the wear mechanism so forms an oxidative mechanism.

When the load is 35.6 Newton there is superior wear resistance for Al-20Si. And for Al-12 Si and Al-25Si alloy, dormant wear mechanism was delamination and third body abrasion respectively. Quio et al. [9] found an alloy of Nanometre size with Alumina and Polyetheretherketone And rubbed it against medium carbon steel disc (AlSi 1045 Steel) with the sliding velocity of 0.42 to metre per second and at a load of 196 Newton the average diameter of PEEK powder is 240 um with 15 on 90 nm Alumina particles. after the dry sliding test the researchers concluded the following ,wear Coefficient was reduced by Nanometers and Micron particle of Alumina when used as filler ,the wear coefficient was not reduced. in fact the researchers obtained the lowest feed value of wear rate when the composition of filler was 5% 15 NM of Alumina.

The second point of activation was that a tenacious transfer film was found on a steel surface when 15 NM particle were used. the researchers noticed the scuffing between the transfer film and the composite surface. the next observation was that with 90nm Alumina filled PEEK abrasive wear was dominant and with 500 NM on PEEK adhesive wear was dominant. the next observation was when PTFE (10 % by mass) what filled in PEEK ,wear and friction Coefficient decreases but when 10% of PTFE got into PEAK composite , friction Coefficient decreases and wear Coefficient increases. Rodriguez et al. [10] Conducted several experiments varying the pressure and temperature of Al-8090 and Al8090 +15% by volume SiCp.

The researcher used SEM and EDX technique and examine the dominant wear mechanism and made the following conclusion which was that there was a change of two order of magnitude of the wear rate from mild to severe wear and the temperature change is proportional to it the next point of observation was that when the reinforcement are added its their rate is lower than the composite wear rate in mild wear regime .the mild beer was controlled by the newly formed mechanical mixed layer. Ghazali et al [10 ] studied wrought aluminium alloy (2134,3004 5056 ,6092) and did sliding wear test against 99.9% pure Alumina at at a fixed speed of 1 metre per second against the load range of 23 to 140 Newton and concluded that severe wear was present for all the alloy with a formation of layer which was mechanically mixed. the researchers concluded that the morphology of hardness of MML was based on alloy composition but no relation could be formed between hardness and wear rate. it was also noticed that work hardening of different alloy was different except for 5056 alloy.

A linear relationship was there between pressure and wear rate.

## 2.0 Wear Mechanism of Aluminium Alloys

In order to use Aluminium in the actual form , the machining of aluminium is required and in order to do the machining there must be a physical contact between the tool and the work piece and whenever there is a physical contact between the work piece and tool, the property of wear comes into the existence. It is evident from the literature review that aluminium is used in various form as an alloy and the machining of these alloy leads to the development of the wear. There are various type of wear for instance whenever there is contact between the two surfaces ,Sliding wear, Rolling wear, impact wear, Fretting wear and the slurry wear is there.

Moving one step further when the material comes into the Deformation states, there are two ways of classification , Plastic contact in which two types of wear predominates mainly adhesive wear and the abrasive wear.

The second type of the wear is the elastic wear in which again two type of wear predominates which are Fatigue wear and the corrosive wear. If we talk about in view of mechanical point of view than we can classify the wear into the Mechanical wear, thermal wear and the tribo-chemical wear. Again mechanical wear contains Adhesive wear, abrasive wear and the fatigue wear.

When we talk about the thermal wear it is the wear which is caused by frictional heat. Tribological wear contains two type of wear which include wear due to oxidation and the other is the wear due to the diffusion. The classification of the wear is physical separation, Molting wear and chemical dissolution. There is another type of wear which predominates when the repetitive contacts are there.

These contact are best represented by the curve shown in figure 1. In the type 1 wear, the wear volume is proportional to the sliding distance or the number of cycles. So the wear rate remains constant throughout the process type 2 wear shows the transition from high wear rate to steady wear rate at low rate.

The next type of wear is sudden transfer from a region of low wear rate to high wear rate. It is evident from the figure 1.

**Fig 1: Three Representative Types of Wear Curves in Repeated Contacts**

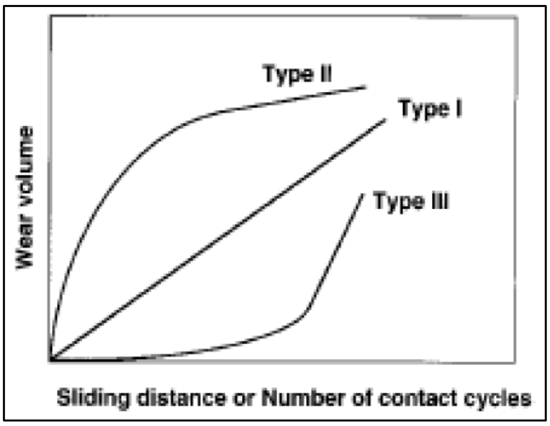
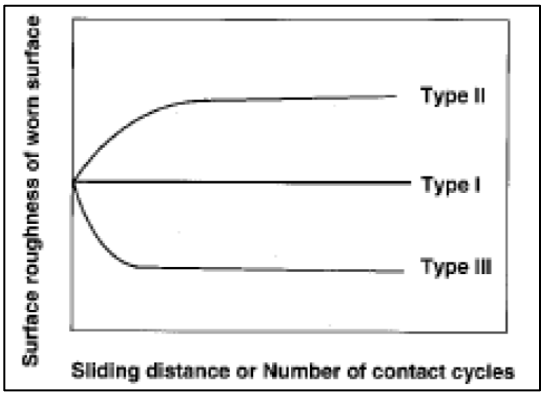



**Fig 2: Three Representative Types of Surface Roughness Changes in Repeated Contacts**




The next figure shows the roughness curve in which type1 curve shows the steady wear in which the roughness values do not change, Type 2 shows the steady wear where the values first increases to certain value and stays there.

The next is the type three value where the value decreases to certain value and stays there. This can be observe readily from figure 2.

There are four main wear pre dominates for the aluminium alloys which will be discussed, These four are Abrasive wear, Adhesive wear, Fatigue wear and corrosive wear. Adhesive wear and abrasive wear are wear modes generated under plastic contact. In the case of plastic contact between similar materials, the contact interface has adhesive bonding strength. When fracture is supposed to be essentially brought about as the result of strong adhesion at the contact interface, the resultant wear is called adhesive wear, without particularizing about the fracture mode. When the fracture is supposed to be brought about in the manner of micro-cutting by the indented material, the resultant wear is called abrasive wear. In the case of contact in the running-in state, fatigue fracture is generated after repeated friction cycles.

When surface failure is generated by fatigue, the resultant wear is called fatigue wear. In the case of contact in corrosive media, the tribochemical reaction at the contact interface is accelerated. When the tribochemical reaction in the corrosive media is supposed to be brought about by material removal, the resultant wear is called corrosive wear.

## 3.0 Conclusions

After the effective review, it can be concluded that

- Aluminium is most useful metal with advantageous properties.
- Most of the aluminium alloys are subjected to the wear.
- There are many ways for classification of wear.

- Aluminium alloys shows mainly four wear Abrasive wear , Adhesive wear, Fatigue wear and Corrosive wear.
- In general cases ,The wear depends upon the Load applied and the sliding speed and it is proportional to it.

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