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Wear Resistance Behavior Study of AZ 31b Mg Alloy

G. Vijay Bhaskar [1]
Department of Automobile Engineering,
Vel Tech Dr. RR & Dr.SR Technical University,
Chennai, India.

B. Sharmila[2]
Department of Mechanical Engineering,
Vel Tech Dr. RR & Dr.SR Technical University,
Chennai, India.

P. Nanjappa Chetty[3]
Department of Automobile Engineering,
Vel Tech Dr. RR & Dr.SR Technical University,
Chennai, India.

Abstract: **Magnesium alloys have been increasingly used in the aerospace and automotive industries in recent years due to their lightweight. The density of magnesium is approximately two thirds of that of aluminum, one quarter of zinc, and one fifth of steel. As a result, magnesium alloys offer a very high specific strength among conventional engineering alloys. This paper is dealt with the sliding wear behaviour of AZ31b Mg alloy at room temperature. Experiments were conducted by using pin on disc test rig apparatus, considering the parameters like applied load, sliding distance and sliding velocity. The study includes sliding wear behaviour of the AZ31b Mg in adhesive wear using EN31 as counter face disc. It was observed that wear rate of the alloy increased with the applied load, sliding distance and sliding speed.**

Keywords: wear resistance, AZ31b, Pin on disc, applied load, Sliding distance.

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I. INTRODUCTION

A contemporary technological development makes it necessary to look for new constructional solutions that aim at the improvement of the effectiveness and quality of a product, at the minimization of dimension and mass as well as the increasing of reliability and dimension stability in the operation conditions. These demands belongs production of research for newer and newer materials including magnesium alloys. The desire to create as light vehicle constructions as possible and connected with it low fuel consumption have made it possible to make use of magnesium alloys as a

constructional material in car wheels, engine pistons, gear box and clutch housings, framing of doors, pedals, manifolds, housings of propeller shafts, differential gears, brackets, radiators and others, number of companies as well as the use of magnesium and its alloys are still growing alloys are still relatively expensive, however customers get high quality products, advanced both Generally they are applied in motor industry and machine building, but they find application in a helicopter production, planes, and air navigation, chemical, and nuclear power industries.

Mg–Al-based alloys such as the AM and AZ series offer high specific stiffness and strength at room temperature. However, the AM and AZ type Magnesium alloys exhibit low creep strength and hence, are not suitable for service at temperatures of 150–200°C. Generally, aluminum and zirconium are main alloying elements of magnesium alloys. Alloying elements have an influence on the mechanical, physical and chemical properties of magnesium alloy. Aluminum is the most important alloying element and can significantly improve the tensile strength. Hiratsuka et al.[1] examined the dry sliding of pure magnesium against alumina at room temperature, and observed two different types of wear mechanism, namely oxidational wear severe plastic deformation at higher wear rates that was observed in vacuum. S.Das et al. [2].Studied the microstructure evolution during high temperature sliding wear of Mg-3% Al-1% Zn (AZ31) alloy and found that AZ31 magnesium alloy exhibited high wear rates when tested at 623K and material layers transferred to the counter face, indicating that adhesion was main material removal process.

In recent trends, attention is being paid to the use of high strength Al-Zn-Mg alloys for structural applications in aerospace and general engineering sectors. However these materials are of poor weldability. A.F.Normam et al.[3] Examined that Most of the materials are joined either by riveting or bolting, and hence there is a greater possibility of vibration/oscillation in these regions, which in due course might be leading to fretting and sliding type of wear in dry conditions. This demands the need to examine the dry sliding wear behavior of these alloys. [4].R.A. Saravanan and M.K. Surappa worked on Fabrication and characterization of pure Mg-30 vol.% Sic particulate composite and studied the dry sliding wear behavior of the composite.[5] Umeda junco et al. studied the tribological response of powder metallurgy magnesium composite containing amorphous silica particles.

In the present investigation wear resistance properties of Magnesium AZ31b alloy have been studied by using various parameters such as applied load, sliding distance and speed using pin on disc with the counter part of EN31 steel.

II. EXPERIMENTATAL WORK

A. *Characterization of as-received alloy*

The magnesium alloy AZ31b specified as (Al-3 wt%, Zn-1 wt% b graded) pin was purchased from ducom industries, Bangalore. The hardness of the samples tested was measured as 64±2.2 HV on the Vickers's scale using a load of

1.0 N. Tensile strength measured showed 262 MPa. The compositions of the as-received alloy are listed in Table1.

B. Sliding wear tests

Sliding wear tests were conducted using a pin on disc. The magnesium AZ31b alloy pin with 40mm length and 60mm diameter were machined and EN31 heat treated steel with the diameter of 100mm was used as a counter face. Tests were conducted by varying the applied load, sliding velocity, sliding distance, against EN31 steel.

Table 1.Composition of Mg alloy AZ31b

Chemical name	Wt%
Aluminum	2.5 - 3.5
Copper	0.05 max
Iron	0.005 max
Magnesium	Balance
Manganese	0.2 min
Nickel	0.005 max
Silicon	0.1
Zinc	0.6 - 1.4

Fig. 2(a) Test specimen AZ31b

During sliding, the load is applied on the specimen through cantilever mechanism and the specimens brought in intimate contact with the rotating disc at a track radius of 100m.the samples were cleaned with acetone and weighted up to an accuracy of 0.01 mg using micro balance prior to and after each test The wear rate was calculated. A set of four tests was conducted in every experimental condition. The sample is held such a way that 3mm of sample remains outside the holder (the distance between the contact surface and the sample holder is maintained to almost 3mm). Wear tests were conducted maximum up to 20 N of applied load, 350rpm of sliding speed and 2000m of sliding distance for EN 31 counter face disc. The sliding velocity, sliding distance and track radius are kept in constant.

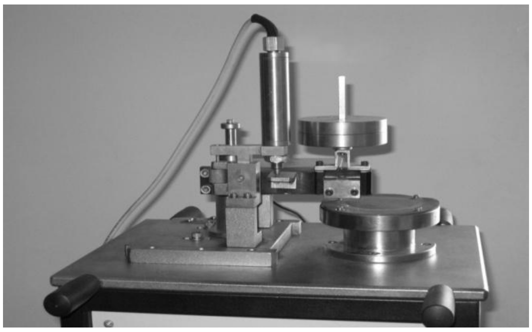

Fig. 2(b) Pin on disc tribometer

For each sliding condition, a total of 5 min test were carried out prior to each test. And the readings of wear rate and friction force were noted from the digital meter of apparatus. The occurrence of seizure was defined by the generation of abnormal sound and vigorous vibration during the test, and sudden increase in frictional force. Sticking of material was also noted on the steel disc by naked eye inspection.

III. RESULTS AND DISCUSSION

A. Sliding Wear Behaviour

- Effect of Applied Load on wear Rate

The wear rate of samples as a function of load at a sliding speed of 350rpm and a sliding distance of 500 m and Track radius of 70 mm is depicted. The Fig 3 shows that the wear rate increases with applied load. When the applied load reaches to a critical value the frictional heating becomes significantly high and thus the localized adhesion of pin surface with counter face has been increased. It is noted that the wear rate increases gradually with increased applied load from 5 to 15N. Suddenly the wear rate increases rapidly from 15 to 20N and again the wear rate becomes gradual for higher applied loads. It also noted that the wear rate of the alloy is found to be higher at 20 N. From the graph wear rate (weight loss) of the alloy at an applied load of 5 N is 0.009 gms and it increased to 0.014 gm at an applied load of 10 N. Maximum wear rate of 0.137gm was experienced by 20N applied load.

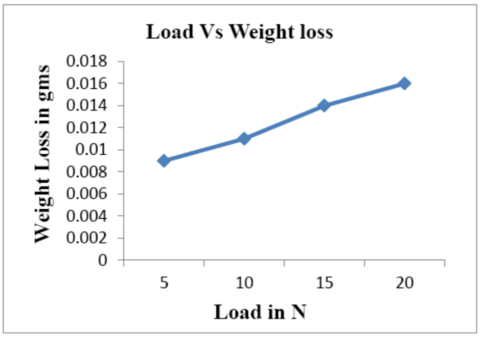

Fig.3.Effect of applied load on wear rate (weight loss)

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- Effect of load on coefficient of friction

Fig.4.shows the co-efficient of friction as a function of applied load. From the graph the coefficient of friction increases with increasing applied load. When the coefficient of friction reaches the critical value and tends remains constant for higher applied loads. Hence the surface of the alloy becomes self-lubricating phenomenon. The constant parameters include Track radius, sliding distance, sliding speed.

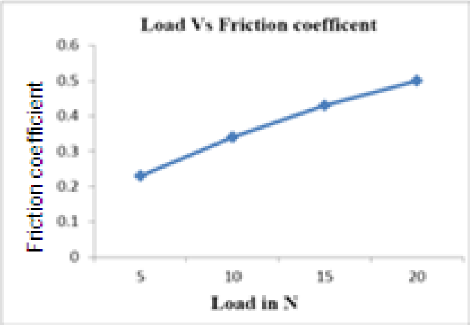

Fig.4. Effect of applied load on coefficient of friction.

- Effect of sliding distance on wear rate

The wear rate of samples as a function of sliding distance at a sliding speed 350 rpm and at a load of 15N and track radius of 70 mm is depicted by varying the sliding distance.

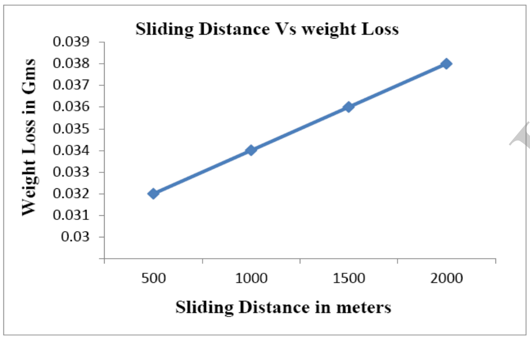

Fig.5 Effect of sliding distance on wear rate

Fig.5 shows that the wear rate in all the samples increases not only with increase in sliding distance but by the applied load also. It is observed that the wear rate initially increases slowly with increase in sliding distance. The maximum sliding distance increases up to 2000 during sliding, frictional force acts between the counter face surfaces, which cause frictional heating of the counter surfaces. Because of combined actions of load, sliding speed, and sliding distance subsurface micro cracks are generated which finally leads to removal of wear debris, especially from asperity contacts. As a result, it is expected that weight loss will increase with increase in sliding distance.

- Effect of sliding distance on coefficient of friction

Fig.6. shows that coefficient of friction increases with increase in sliding distance in all samples. The co-efficient of friction becomes very higher at 2000m.

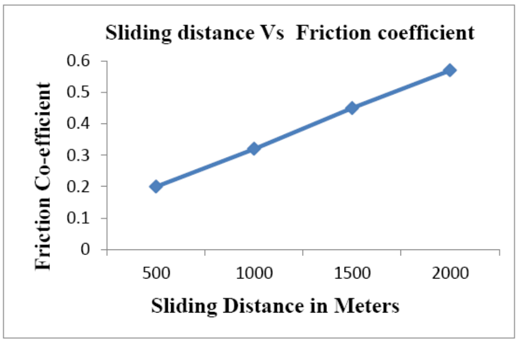

Fig.6. Effect of sliding distance on coefficient of friction.

- Effect of Speed on wear rate

In the fig.6. the graph shows that increasing the speed there is a decrease in the wear rate.

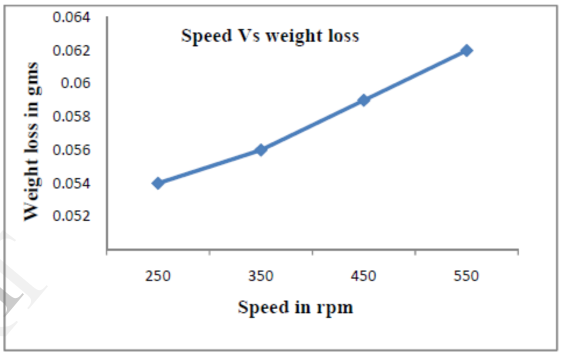

Fig.6.Effect of sliding velocity on wear rate

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During the tests load, sliding distance and track radius were kept constant for the test samples. At the sliding speed of 1500 rpm the wear rate decreases gradually.

- Effect of speed on coefficient of friction

Fig.7.clearly indicates that coefficient of friction increases with increases in sliding speed. The temperature rises significantly and then temperature gradient increase; this results in higher rate of heat dissipation. And greater flowability of the material on the specimen surface is depicted. The curve shows that the weight loss of the material decreased with the increase in sliding velocity. Worn surfaces may also have characteristics of smearing and scratches visible to naked eye.

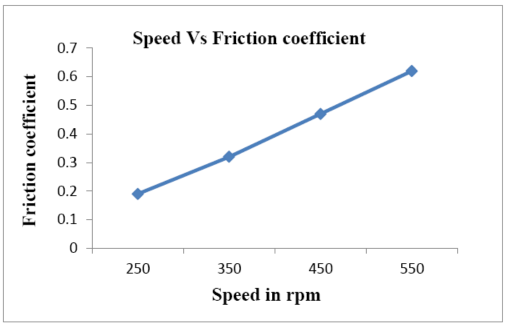

Fig.7. Effect of sliding velocity on coefficient of friction

- SEM WORN SURFACES

A worn surface of AZ31b alloy at an applied pressure of 0.2MPa is shown in the figure 8.Form the worn surface the alloy has undergone little wear with its counterpart. Small amount of debris and pits are shown some places.

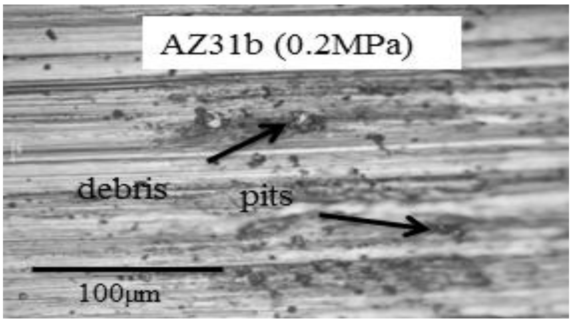

Fig.8.SEM-Worn Surface of AZ31b with applied 0.2 MPa

The wear mechanism associated with the magnesium alloy is slight plastic deformation.The worn surface of AZ31b magnesium alloy with the applied load of 0.5MPa shown in the fig 9.The worn surface indicates formation of continuous wear grooves and relatively smoother and some damaged regions. However the degree of formation of cracks on the wear surface is not much. The formation of grooves along the sliding direction. The wear surface of the alloy at relatively higher applied pressure (1.0) is depicted as a serious of parallel transverse as well as longitudinal cracks exhibits relatively smoother surface and grooves due to delamination layer (Fig .10).

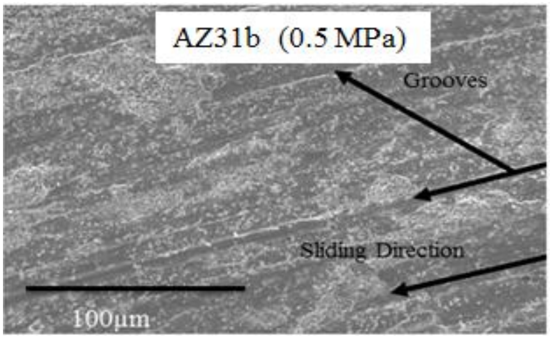

Fig.9. SEM – worn Surfaces of AZ31b with applied load 0.5 MPa

This indicates the simultaneous occurrence of formation of delamination Layer. The propagation of longitudinal and transverse cracks resulted in the formation of flaky shaped debris.

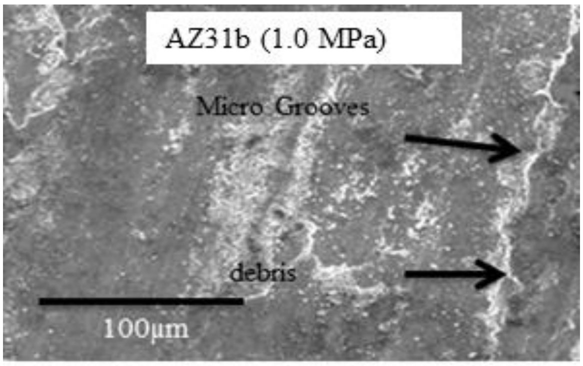

Fig 10.SEM- Worn surfaces of AZ31b with the applied load 1.0 MPa

Worn surface of AZ31b alloy with the applied load of 2.0 MPa is shown in the figure 11. From the worn surface the material under gone severe plastic deformation and delamination with the applied load.The worn surface contains the delamination layer and deep debris along the sliding direction.

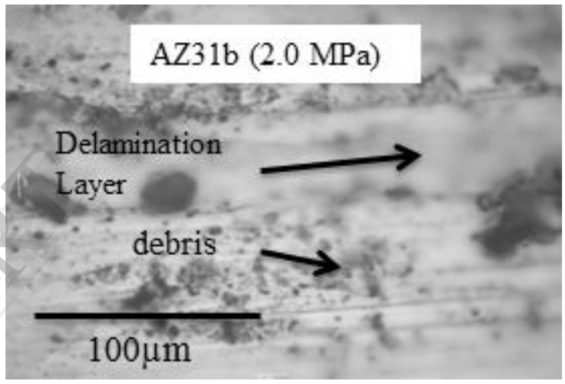

Fig.11.SEM- Worn Surfaces of AZ31b with the applied load of 2.0 MPa

IV. CONCLUSION

1. The wear rate is increased with increased applied pressure.
2. The wear rate increases marginally up to 1500 m after that abrupt increase in wear rate with the applied load.
3. The coefficient of friction increases slightly with increased applied pressure.
4. SEM worn surface of AZ31b Mg alloy shows deep debris and delamination layers with the applied load of 2.0 MPa. This confirms that the material has under gone severe plastic deformation.

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