A Comparative Study of The Effect of Abrasive Wear Rate of the Material Al-6082 Alloy on Various Loads

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ABSTRACT

Wear is a very important factor for various types of application in automobile industries and also in aeronautical industries. Many researches are going on to renovate the wear by either alloying the material or by using composite material. Wear is a surface damage. It may be due to removal of material from the solid surface in sliding, rolling or by impact motion of surface relative to one another. Wear occurs when a mechanical contact take place between surfaces and more specially the removal and disfigurement of material on a surface as a result of mechanical action of opposite surface. The investigation summarized in this thesis present a comparative study on the effect of abrasive wear rate of the material Al-6082 alloy on various load. This investigation was carried out in the laboratory using an experimental set up for inquiring the wear rate of selected material. The experiment for analyzing the wear rate conducted on various load as well as various orientation against grinding disc. Here we perusal a comparative analysis of wear at different orientation against various load for investigating the useful or working life of a component before the expire. A component is unusable when dimensional losses exceed the specified tolerance limits. The abrasive wear behavior of selected material is analyzing at different loads and three different orientations. In the above paper I have analyzed the abrasive wear of selected material, which shows the estimated life of said material

KEYWORDS: Al-6082, Abrasive Wear, Load, Weight Loss, Orientation

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INTRODUCTION

Wear is related to interactions between surfaces and more specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface.

Wear may include loss at the inner surfaces between two sliding surfaces. But when a plastic deformation such as yield stress is omitted from the wear definition if it does not incorporates a relative sliding motion and contact against another surface despite the possibility for material removal, because it then lacks the relative sliding action of another surface. Impact wear is a short sliding motion where two solid surfaces come in contact at an exceptional short time period. When a fast execution, the contact found in impact wear was directed to as an impulse contact by the nomenclature.

A friction is generated between moving surfaces relative to each other and friction converts kinetic energy into heat. Friction is the component of science of tribology.

Some factors affecting wear rate such as Coefficient of friction, Specific energy of material, Material removal rate. This includes the width of the grinding wheel, Depth of cut, Feed rate of the specimen, power unit- torque & speed.

OBJECTIVE OF THE STUDY

To analyzing the Maximum and minimum wear rate position by comparing the material loss in abrasive wear at different load and different orientation for a selected material. This shows the material life against the selected load.

Aluminum (Al-6082):

By the appropriate treatment, mechanical properties of Al composites can be improved. Gradual wear occurs in machine element, in result of friction. Therefore, we have to search for the possibilities to prevent it thus extending the technical and tool life of component.

In present time aluminum alloy based metal matrix has an important role in several engineering application.

AL-6082 alloy has good formability, excellent mechanical properties and manufacturing properties.

Chemical compositions of the Al-6082 alloy:

Element	% Present
Silicon (Si)	0.70-1.30
Magnesium (Mg)	0.60 - 1.20
Manganese (Mn)	0.40 - 1.00
Iron (Fe)	0.0 - 0.50
Chromium (Cr)	0.0 - 0.25
Zinc (Zn)	0.0 - 0.20
Titanium (Ti)	0.0 - 0.10
Copper (Cu)	0.0 - 0.10
Others (Total)	0.0 - 0.15
Aluminum (Al)	Balance

Physical Properties of the Al-6082 alloy:

Property	Value
Density	70 g/cm^3
Thermal Expansion	x10^{-6}
Modulus of Elasticity	Gpa
Thermal conductivity	0 W/mK
Electrical Resistivity	038x10^{-6}Ωm

LITERATURE REVIEW

- *D.Z. Wang, H.X. Peng, J. Liu, C.K. Yaoet. al 1985.* In their investigation of wear behavior of al composite that with that increase of normal load and/or speed during dry sliding, the wear behavior of the SiCw-Al composites transforms from mild wear to severe wear and then to expropriation. The mild wear is characterized by mild oxidation while the severe wear is dominated by abrasion or adhesion and delamination.

- *C.C. Garcia, J. Narciso, E. Louiset. al 1996* – The tribological properties of these materials were determined for different ceramic particle sizes and volume fraction, and the result compared with those of conventional grey cast iron, a material commonly used in the fabrication of automotive brake discs.

- *C. B. Lin, R.J. Chang, W. P. Wenget. al 1998* results showed that tensile properties of these composites have been reduced. However, the hardness is remaining practically unchanged. In the wear microstructure of the unreinforced alloy, we can observe the ploughing generated by the hard Al chip clusters on the wearing material. The tribological behavior of the composites in the

T6 heat-treated condition is better than in the annealed condition or than that of the unreinforced alloy. The wear weight loss is reduced with increasing content of graphite particulates and sliding speed.

- *Y.B. Liu, S.C. Lim, S. Ray, P.K. rohatgiet. al 1997*-The wear resistance can be improved by the addition of graphite, which causes a corresponding reduction in the coefficient of friction, reaching about half that of the base alloy when the volume fraction of graphite particles reaches 50 vol.%. The reduction in friction and wear of this group of aluminum-graphite composites is a result of the smearing of the embedded graphite particles during sliding, forming a lubricating film on both the tribosurface of the composite sample and the steel counter face.

- *Chandramohan G., et. al* Reported that the sliding distance has the highest effect on the dry sliding wear behavior of MMCs than that of the load and sliding speed.

- *Y. Reda et.al* Vol.9, No.1 Studies on Al6061-SiC and Al7075 - Al2O3 Metal Matrix Composites 45 and **R. Clark et. al**. In their studies on Al7075 reported that, pre-aging at various retrogression temperatures improves the hardness, tensile properties and electrical resistivity.

- *Surappaet al 1982.* Noted that aluminum reinforced with 5 % alumina possessed an adhesive wear rate comparable to that of Al-11.8Si or AI--S1 hypereutectic alloys. Other work published by the same workerss4 involving Al, Al-11.8Si, Al-16Si alloys and Al reinforced with A1203p (5%) indicated that increased silicon content reduced the wear rate.

- *Hoskingset al.1982* reported a decrease in adhesive wear rate with increasing particle content (at constant particle size) and dimension (at constant volume fraction) for Al 2014 and 2024 alloys reinforced with Al,O,p and SiCp (1-142 pm) of various weight fractions (2-30 %). SIC was shown to be more effective than alumina in resisting wear, when tested in a ball-on-disc rig. These findings were in disagreement with those reported by Surappa.54 However, it should be noted that the former work involved only a small reinforcement content (5 %).

Abrasive wear:

It occurs when a hard surface moves or slide across a softer surface. Abrasive wear is a phenomenon of losing of material due to hard particles that forced against and move along a solid surface.

It is commonly classified on the basis of type of contact and the contact environment. The type of contact of moving or sliding surface determines the mode of abrasive wear. Two-body wear and three-body abrasive wear are the common modes of abrasive wear.

When the grits or hard particles remove material from the opposite surface then it is known as two-body abrasive wear. In this the common analogy is that the material being removed or displaced by cutting or plowing operation.

In three-body wear the particles are not constrained. They are free to roll and slide down a surface.

The contact environment determines, the wear is open or closed. If surfaces are sufficiently displaced to be independent of one another, then it is an open contact environment.

There are three commonly identified mechanisms of abrasive wear.

1. Plowing
2. Cutting
3. Fragmentation

Plowing-In the grooves formation when the material do not involve direct material removal and the material is displaced to the side, away from the wear particle. This mechanism is known as plowing. The displaced material forms ridges adjacent to grooves, which may be removed by subsequent passage of abrasive particles.

Fragmentation occurs when material is separated from a surface by a cutting process and the indenting abrasive causes localized fracture of the wear material. These cracks then freely propagate locally around the wear groove, resulting in additional material removal by spalling.

Abrasive wear can be measured as loss of mass by the Taber Abrasion Test according to ISO 9352 or ASTM D 1044.

EXPERIMENTATION:

In this paper we are going to discuss about the details of material used in the present investigation and its preparation has been described and the details of the experimental work. This investigation is consist formation of the L-18 orthogonal array which based on Taguchi design. Orthogonal array is reduces the total number of experiment. In this experiment total 18 run.

Experimental set up and selection of work piece:

In order to carry out the experimental work the procedure is as follows.

    (i) Material Selection

    (ii) Wear Behavior

    (iii) Taguchi design

All the investigations for analyzing the abrasive wear rate at different load and orientation, done at an experimental setup.

Experimental setup consist of – D.C. Motor, Regulator, Flange coupling, Bearing, Frame, Acrylic Sheet, Grinding Wheel, Shaft, Tachometer, Weighing Machine, Load cell.

Test procedure:

Before the test the weight of the test specimen was taken accurately using an Electronic balance with an accuracy of 0.001g. The maximum weighing capacity of the electronic balance was 320g. After a traveling two different times 04, 06 minutes against the grinding disc, the sample was taken out carefully so that the debris's were removed from the valleys of the specimen and exact wear materials can be measured. Once again weight was taken carefully using the above balance and the difference in weight was noted.This was continued for five times with same specimen and same position at fix rpm (2000).After that next specimen was taken for next test condition i.e. 0° angle and 5 N applied load and wear test was conducted using same procedure as discussed above and again the next specimen is taken for next test condition and so on . The cumulative effect of weight loss was taken for calculating the wear mass and wear rate. A pin on disc wear test technique was adopted to test the wear behavior of specimens. Wear rate and wear mass were evaluated at 0° orientation of the specimen. The tests were conducted for three different orientations namely 0°, 30°, 45°. Wear mass of above said specimen was evaluated at three different applied loads i.e. 5 N to 15N with a variation of 5 N. After the measurement of were mass, a comparative study is done among different weight loss at different angle against the different load.

Selection of applied load and the position of the specimen:

In this investigation of wear of a selected material against specified load, three loads are selected 5N,10N,15N

For each load the orientation of the specimen was kept at 0°, 30°, 45° respectively.

For each load and orientation the machining time are 4, 6 min.

Taguchi design:

Dr. Genichi Taguchi is regarded as the foremost proponent of robust parameter design.

Dr. Genichitaguchi design an engineering method for product or process design that focuses on minimizing variation and/or sensitivity to noise. Taguchi designs provide an efficient method for designing products that operate consistently and optimally over a variety of conditions. Taguchi describe several approaches to experimental designs that are sometimes called "Taguchi Methods."

These methods used for two, three, four, five, or mixed-level fractional factorial designs. Taguchi refers to experimental design as "off-line quality control" because it is a method of ensuring good performance in the design stage of products or processes.

A Taguchi design or an orthogonal array is the method of designing the experimental procedure using different types of design such as- two, three, four, five, and mixed level. In this study, a three factor mixed level setup is chosen.In this total eighteen numbers of experiments to be conducted and hence the L18 was chosen.

Levels of parameters:

Wear Parameter	Unit	Level		
		Level 1	Level 2	Level 3
Time	Min	4	6	
Load	N	5	10	15
Orientation	Degree	0°	30°	45°

Experiments were conducted according to Taguchi method by using the machining set up. The control parameters like Load, Orientation, and Time duration of Wear were varied to conduct 18 different experiments and the weights of the work piece before machining is 14.040gm.

Design matrix and Observation table:

Time	Load	Angle	Mean(Average Weight loss)
4	5	0	0.749
4	5	30	0.697
4	5	45	0.657
4	10	0	0.862
4	10	30	0.801
4	10	45	0.769
4	15	0	0.880
4	15	30	0.833
4	15	45	0.799
6	5	0	1.069
6	5	30	0.987
6	5	45	0.967
6	10	0	1.250
6	10	30	1.151
6	10	45	1.099
6	15	0	1.257
6	15	30	1.193

6	15	45	1.129

Influences on weight loss:

The S/N ratios for Mean (Average value) are calculated as given in Equation. This method is used to analysis the result of response of machining parameter for smaller is better criteria.

$$\boldsymbol{\eta = -10\log\left(\frac{1}{n}\sum_{i=1}^{n} Y_i^2\right)}$$

Where η - S/N ratios calculated from observed values,

Yi - experimentally observed value of the ith experiment

n =1 repeated number of each experiment.

RESULTS AND DISCUSSION:

Variation of mean of s/n ratio at different load, time, angle:

From observational result the S/N ratio is calculate with the help of Taguchi design method. The graph of variation of mean of S/N ratio at different load, angle shows that the mean of S/N ratios is increase with the increasing the angle.

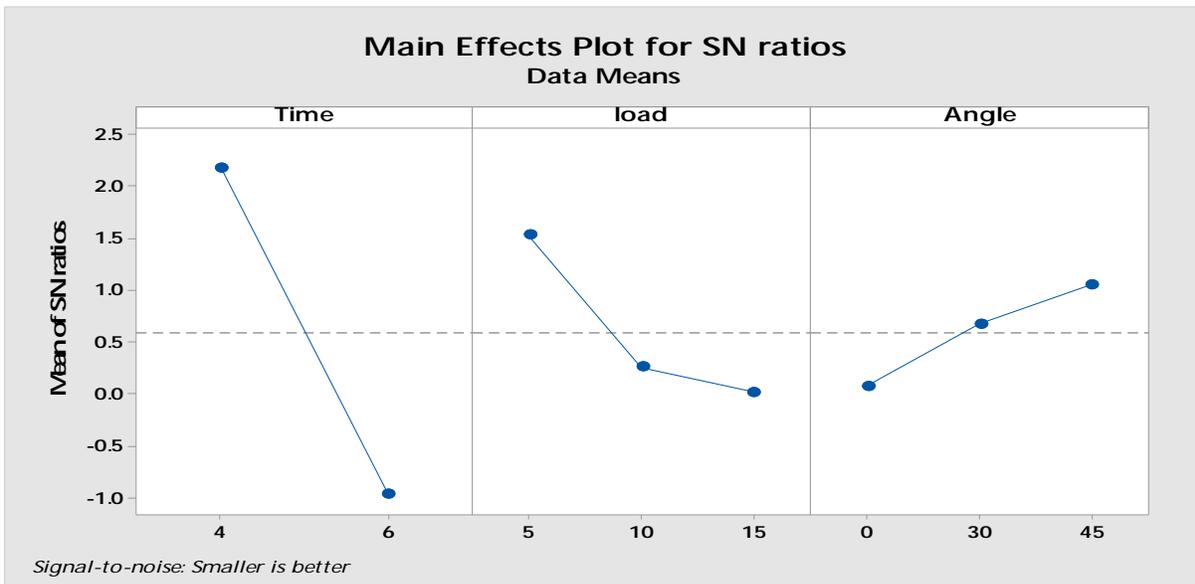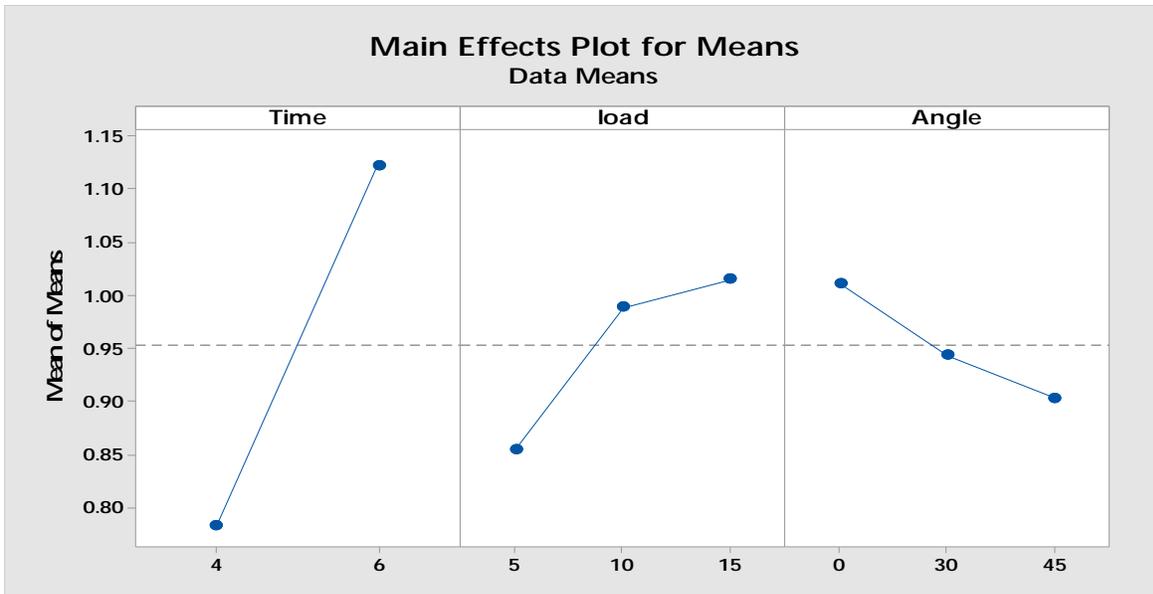Mean of S/N ratios is decrease with increasing the loadas shown in the graph of Main effects plot for SN ratio.

Fig. Variation of mean of SN ratio at different load, time, angle

Variation of mean of weight loss at differentload, angle, time:

Variation of Mean of weight loss at different load, angle, time

Fig. represents that the wear rate is highly influence by the angle. Weight loss is higher at 0° angle and decrease with increasing the angle.

Variation of weight loss at 0° angle is higher in both duration of time.

As the load increases the mean of weight loss is increases.

Comparison of abrasive wear rate at different orientation:
When the running time = 4 min:

- From the analytical study it is observed that, the orientation of the specimen changes from 0° to 45°, the wear mass (Wt. Loss) decreases from 0.749 gm to 0.657 gm when applied load is 5N.

- When the applied load is 10N and 15N, it is observed that wear decreases from 0.864gm to 0.767gm and 0.887gm to .803gm respectively when the orientation changes from 0° to 45°.

When the running time = 6 Min:

- From the fig it is observed that, the orientation of the specimen changes from 0° to 45°, the wear mass (Wt. Loss) decreases from 0.1.069 gm to 0.967 gm when applied load is 5N.

- From Fig it is observed that the wear mass follows the same pattern as in graph.The wear mass decreases from 1.25 gm to 1.099 gm as the orientation changes from 0° to 45°. From Fig it is observed that when the wt. loss maximum then orientation is minimum at a given load.

- The wear mass decreases from 1.257 gm to1.129 gm as the orientation changes from 0° to 45°.From the analytical study it is observed that when the wt. loss maximum then orientation is minimum at a given load.

Comparison of abrasive wear rate at different load:
When running time = 4 min:

- From the experimental study it is observed that, at a fixed orientation of specimen 0° the wear mass is increases from 0.749gm to 0.880gm as the applied load increases from 5N to 15N.

- When the orientation of specimen is fix at 30° then the wear mass increases from 0.697gm to 0.833gm as the load increases from 5N to 15N.

- When the orientation of specimen is again fix at 45° then wear mass increases from 0.657gm to 0.799gm as the load on specimen increases from 5N to 15N.

When the running time = 6 Min:

- From Fig it is observed that the wear mass increases from 1.069 gm to1.257 gm as the applied load on the specimen increases from 5N to 15N when orientation of the specimen is 0°.

- From Fig it is observed that when the load is maximum then wt. loss is maximum and when load is minimum then wt. loss is minimum at a 0 degree of orientation.

- From Fig it is observed that the wear mass increases from 0.987 gm to 1.193 gm as the applied load on the specimen increases from 5N to 15N when orientation of the specimen is 30°.

- From Fig it is observed that when the load is maximum then wt. loss is maximum and when load is minimum then wt. loss is minimum at a 0 degree of orientation.

- From Fig it is observed that the wear mass increases from 0.967 gm to 1.129 gm as the applied load on the specimen increases from 5N to 15N when orientation of the specimen is 45°.

- From Fig it is observed that when the load is maximum then wt. loss is maximum and when load is minimum then wt. loss is minimum at a 45 degree of orientation.

CONCLUSION

In the present comparative study of abrasive wear rate at different angle and load for the material aluminum alloy (AL-6082). The investigations were conducted under various parameters setting as

the Load(N), Time(min), angle or orientation. Minitab software is used for analysis the result and their responses which are based on Taguchi design method.

Taguchi design is used to obtaining the S/N ratio of mean(average) of weight loss with the help of mini tab. The value of S/N ratio for the mean is calculated under the condition of smaller is better. Value of S/N ratio is larger when mean is smaller.

The comparison of abrasive wear rate at different angle and different load at running time of 4 Min and at 6 Min are as follows:

- Fig. shows that the wear rate is highly influence by the angle. Weight loss is higher at 0° angle and decrease with increasing the angle. Weight loss at 0° angle is higher in both duration of time. As the load increases the mean of weight loss is increases.

- The graph of Variation of mean of SN ratio at different load shows that the mean of S/N ratio is decrease with increasing the load.

- The Mean of S/N ratio is increase with increasing the angle. The time verses mean graph shows that the mean of S/N ratio is higher at the time of 4 min and linearly decreases when the time increases from 4 to 6 Min.

- Maximum wear occur when the test specimen is held at 0° angle for given applied load.

- Minimum wear occur when the specimen is held at 45° angle for given applied load.

- As the orientation of the specimen changes from 0° to 45° the wear mass decreases from 0.749 gm to 0.657 gm when applied load is 5N and running time is 4 Min.

- When the running time is 6 min, the orientation of the specimen changes from 0° to 45° the wear mass decreases from 1.069 gm to 0.967 gm when applied load is 5N.

- The wear mass decreases from 0.862 gm to 0.769 gm as the orientation changes from 0° to 45° when applied load is 10N and the running time is 4 min.

- When the running time is 6 min the wear mass decreases from 1.250 gm to 1.099 gm as the orientation changes from 0° to 45° when applied load is 10N

- Wear mass decreases from 0.880 gm to 0.799 gm as the orientation of the specimen changes from 0° to 45° when applied loads is15N and running time is 4 min.

- When the running time is 6 min, the wear mass decreases from 1.257 gm to 1.129 gm as the orientation of the specimen changes from 0° to 45° when applied loads is15N

- The maximum and minimum wear occurs when the orientation of test specimen changes from 0° to 45° respectively.

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