# Study of Wear Rate on Al5083 /SiCp Composite Material

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***Abstract-*** *At present automobile industries are looking for the components that can sustain wear while they are in use . To know about the various parameters that effect he wear of a material this paper explains reasons for wear and also suggests what parameters influence wear of a material. In this Wear test is carried out to predict the wear of a material and to investigate the wear mechanism of Al5083/SiCp. The test is performed to evaluate the wear characteristics of a materials and also to determine on what factors the selected material is affected. To know the wear of a material pin and disc apparatus was followed with load acting on material ,sliding distance and sliding speed as parameters. Experiments are designed by Taguchi method and ranking also given for parameters and percentage influence are also calculated based on variance of analysis. Coefficient of friction is also noted to understand the material wear rate.*

***Keywords***- Pin on disc method, wear rate,Al5083/SiCp, Taguchi method, Analysis of variance.

## I. INTRODUCTION

**1.1 Wear rate:** Wear rates are calculated results reflecting wear mass loss, volume loss or linear dimension change under unit applied normal force and/or unit sliding distance. Wear rate can be expressed in many different ways. Wear resistance is a term frequently used to describe the anti-wear properties of a material. Wear test is carried out to predict the wear performance and to investigate the wear mechanism. From a material point of view, the test is performed to evaluate the wear property of a material so as to determine whether the material is adequate for a specific wear application.

**1.2 Wear Mechanism:** Wear mechanisms in these two systems are now described. In the first case, wear observations are performed on a plain carbon steel pin rubbing against a disk of the same material in air as a function of load under dynamic but otherwise steady-state conditions. When the applied normal load is relatively small, fine metal particles are removed from the rubbing surfaces and at least some of them are rapidly oxidized while dispersed in the gap between the contacting surfaces. The oxide particles then act as abrasive medium producing further wear. However, the observed wear rates are relatively small, and this is called mild wear. As the load increases, larger metal particles are torn from the rubbing surfaces. The oxidation rate induced by flash temperature is not large enough to fully oxidize the wear particles and many particles are ejected from the gap and discarded as wear debris. Because the wear rates involved are larger, this is called severe wear. For the highest loads, the resulting high flash temperatures lead to rapid formation of oxides and a hard, tempered layer on the contact surfaces. Fine metal particles are formed, oxidized and removed from the gap between the rubbing surfaces as wear debris. Since the contacting surfaces harden rapidly, the resulting wear rate is relatively small. This is known as the high temperature regime of mild wear.

**1.3 Evaluation of Wear Processes:** The most commonly used techniques to evaluate wear are weighing and measurement of changes in dimensions. Weighing may often be difficult if the worn volumes are small compared to the weight of the component, as is further discussed in the later section on mild wear. The wear may also be unevenly distributed over a surface, making the measurement of local wear damage more relevant than the total mass loss.

**1.4 Wear Measurement**: Quantification Wear measurement is carried out to determine the amount of materials removed (or worn away) after a wear test, (and in reality after a part in service for a period of time). The material worn away can be expressed either as weight (mass) loss, volume loss, or linear dimension change depending on the purpose of the test, the type of wear, the geometry and size of the test specimens, and sometimes on the availability of a measurement facility.

## II. LITERATURE SURVEY

**2.1 Metal Matrix Composites (MMC)** is widely used composite materials in aerospace, automotive, electronics and medical industries. They have outstanding properties like high strength, low weight ,high modules, low ductility, high wear resistance, high thermal conductivity and low thermal expansion. [1]These desired properties are mainly manipulated by the matrix, the reinforcement element and the interface. Some of the typical applications are bearings, automobile pistons, cylinder liners, piston rings, connecting rods, sliding electrical contacts, turbo charger impellers, space structures. The most popular reinforcements are Silicon Carbide (SiC) and Alumina(Al2O3). Aluminum, titanium and magnesium alloys are commonly used as the matrix phase. The density of most of the MMCs is approximately one third that of steel, resulting in high-specific strength and stiffness. [2]Composite materials are materials made from two or more constituent materials with significantly different physical and chemical properties. Composites materials offer high strength to weight ratio, good fatigue resistance and corrosion resistance which make them highly competitive against conventional materials. These composites materials are widely used in construction, aerospace and transportation industries as well as military application. In today's engineering world many classes of composites materials have emerged, including polymers matrix composites, metal matrix composites, ceramic matrix composites hybrid metal matrix. Composites materials in general exhibit inhomogeneity, anisotropy and non- ductile behavior. [3]In many developed countries and developing countries there exists continued interest in metal matrix composites (MMCs).[4] Composites are materials in which two phases are combined, usually with strong interfaces between them. They usually consist of a continuous phase called the matrix and discontinuous phase in the form of fibers, whiskers or particles called the reinforcement. Considerable interest in composites has been generated in the past because many of their properties can be described by a combination of the individual properties of the constituent phases and the volume fraction in the mixture

**2.2 Aluminum alloys** :[5]The aluminum alloys are represented by 1XXX, 2XXX, 3XXX up to 8XXX. The first digit gives basic information about the principal alloying elements. The second digit gives the information about the alloy modification. If the second digit is zero, it indicates the original alloy: digits 1 through 9, which are assigned consecutively, indicate alloy modifications. The last two digits have no special significance, serving only to identify the different alloys in the group. The 1xxx, 3xxx and 5xxx series are so called as non-heat-treatable alloys which gain their strength by alloying and work hardening. The 8xxx series designations are for miscellaneous types of alloys (i.e. Fe alloys) which cannot be grouped in the other families. The 2xxx, 6xxx and 7xxx series are heat-treatable alloys, which gain their strength by alloying but make use of precipitation hardening as the main mechanism. Al 5xx indicates presences of magnesium. It finds vast applications in the fields of construction, marine, automotive, aerospace and other fields. [6,7]The material selection criteria involves the requirement of high strength and good corrosion resistance aluminum alloys for the matrix materials, and the inexpensive reinforcement particles which can result in increased yield strength and elastic modulus at little expense of ductility. The matrix materials used in the present work are Al 5083 alloys. reinforcement materials are SiCp particulates. [8] The author explains wear rate of two specimens prepared by the molten matrix for 5 vol %SiCp and its matrix alloy against SiC and Al2O3emery papers on a steel counterface at fixed speed. It is observed that wear rate increased with increasing applied load, abrasive size particle and sliding distance for SiC paper, where as wear rate increased with applied load, abrasive size particle and decreased with sliding distance for Al2O3 paper. The interaction effect of the variable exhibited a mixed behavior towards the wear of the material. [9] The author explains impact of two reinforced particles in this aluminum metal matrix composites reinforced with SiC and graphite (Gr) particles was prepared by liquid metallurgy route. Dry sliding wear behavior of the composite was tested and compared with Al/SiCp composite. A plan of experiments based on Taguchi technique was used to acquire the data in a controlled way. An orthogonal array and analysis of variance was employed to investigate the influence of wear parameters like as normal load, sliding speed and sliding distance on dry sliding wear of the composites. The objective was to investigate which design parameter significantly affects the dry sliding wear. It shows that graphite particles are effective agents in increasing dry sliding wear resistance of Al/SiCp composite. [10] The author studied the wear behavior of SiCp –reinforced composites on different grit size. When a sample is loaded and slid on the different grit sizes it was observed wear rate increased with applied load, followed by abrasive size and decreased by sliding distance[11,12] The authors compared wear rate of abrasive wear behaviors of aluminum alloyed Hadfield steel at the high and low stress wear conditions were studied and compared with non-Al alloyed Hadfield steel. The wear tests were done with the pin on disc method using the abrasive wheel. The main parameters such as alloy compositions, normal load, sliding speed and distance were evaluated. It is shown that at the low stress condition, the aluminum alloyed Hadfield steel has higher wear resistance than the non-Al alloyed Hadfield steel. But at the high stress wear conditions, the non-Al alloyed Hadfield steel is more resistant than the Al alloyed.

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Problem Identification: From the survey it is essential to prepare the composite material by using aluminum as matrix phase and silicon powder as reinforcement material and it can be used to improve the performance of the components made form it for automobile and aerospace industry and wear test should be performed for the prepared composite.

3. Sample preparation for wear test

Then samples are used to investigate the dry sliding wear characteristics of composite as per ASTM G99 -95 standards. The specimen is prepared with stir casting process with I micron as particle size. The specimen is of 10mm in diameter and 30mm height with surface grounded to test it. The wear test is on pin on disc apparatus with sliding distance, load, and sliding speed as input parameters to find wear rate and coefficient of friction for the specimen .The experiment is carried on Al 5083 SiCp composite material with 5% silicon particulate particles in aluminum alloy. Pin on disc method was used to find the wear rate by weight method. Coefficient of friction can be obtained directly while conducting wear test. Wear rate by using the formula. For tasting orthogonal L9 is selected and levels of the values are in the table 1.

Procedure for Wear rate on Pin on Disc method

1. 1. Prepare the specimen as per experiment set up with dimensions 30mm length and 10 mm as diameter.
2. Note the weight of the specimen
3. Fix the sample on the disc and add load as per the test to be conducted.
4. Start the apparatus and note down the duration for the wear of the specimen.
5. Once again weigh the sample and difference of weight to be noted .
6. By calculating the sliding distance of the specimen, load on the specimen, and time of operation gives sliding speed of specimen.
7. wear rate is obtained by formula that is Wear rate = Volume of Wear/applied load* Sliding distance
8. Volume of wear is obtained from the weight of the specimen before and after operation
9. From the experimental values the ranking system is given by mathematics of statistics to find the parameter which is affecting more on wear rate of the specimen.
10. For remaining specimens perform the procedure from 2 to 8.
11. Number of experiments can be decided based on orthogonal array for three levels and three factors total 9 set of experiments are designed.
12. The factors and levels for which experiments are conducted
13. From the obtained results regression equation is developed to get the parameter coefficients
14. Predicted values are obtained from the regression equation to know the limits.
15. Conclusions are drawn based on the experimental values


Figure1 (a)Specimens for wear test

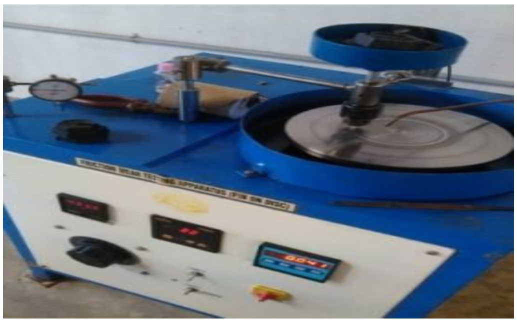


Figure1 (b)Wear test Equipment

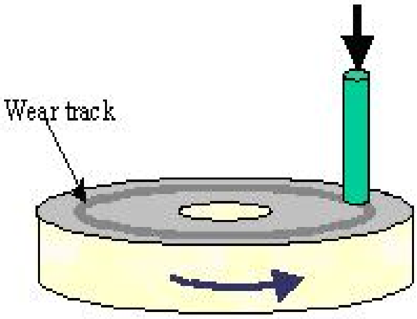



Figure 1(c) Wear Testing Process


Figure1 (d) Weighing after wear test

Figure 1: Wear testing process on Pin On Disc equipment

**Table 1** Input parameters to conduct Wear Rate of Al5083/SiCp

| Level/Parameter | Sliding Speed(m/sec) | Load(N) | Sliding Distance(m) |
|---|---|---|---|
| 1 | 2.09 | 16 | 1130 |
| 2 | 3.09 | 20 | 1500 |
| 3 | 3.92 | 28 | 1900 |

## III. RESULTS AND DISCUSSIONS

**Table 2 :** wear rate of Al/SiCp

| S.No | Sliding speed(m/s) | Load (N) | Sliding distance(m) | Difference of Mass before and after test | Coefficient of friction (cd) | Wear rate $mm^3$/N-m $10^{-06}$ | Predicted Wear ratemm$^3$/Nm $10^{-06}$ |
|---|---|---|---|---|---|---|---|
| 1 | 2.09 | 16 | 1130 | 0.0981 | 0.010 | 5.42 | 6.192 |
| 2 | 2.09 | 20 | 1500 | 0.1962 | 0.036 | 6.54 | 5.762 |
| 3 | 2.09 | 28 | 1900 | 0.245 | 0.075 | 4.6 | 4.695 |
| 4 | 3.14 | 16 | 1500 | 0.1471 | 0.015 | 6.12 | 6.022 |
| 5 | 3.14 | 20 | 1900 | 0.2207 | 0.024 | 5.8 | 5.610 |
| 6 | 3.14 | 28 | 1130 | 0.122 | 0.06 | 3.8 | 3.833 |
| 7 | 3.92 | 16 | 1900 | 0.1716 | 0.18 | 5.64 | 5.972 |
| 8 | 3.92 | 20 | 1130 | 0.1226 | 0.39 | 5.42 | 4.850 |
| 9 | 3.92 | 28 | 1500 | 0.1422 | 0.73 | 3.38 | 3.765 |

**Regression Equation**

Wear rate (k) = 0.00844843 - 0.000306534 sliding speed - 0.000149405 load (N) + 5.93392 sliding distance (M)---- 1

The equation 1 is used to calculate the predicted values which are in the table 4.1 which shows the values are within the limits.

**Table 3: Coefficient Values**

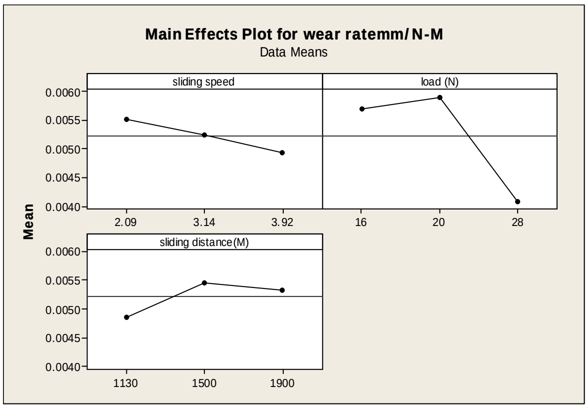
| s.no | Parameter | Coefficient | SE coefficient | T | P |
|---|---|---|---|---|---|
| 1 | Sliding Speed | 0.0003065 | 0.0002504 | 1.22399 | 0.275 |
| 2 | Load | 0.0001494 | 0.0000376 | 3.96937 | 0.011 |
| 3 | Sliding Distance | 0.0000006 | 0.0000006 | 0.99362 | 0.366 |

The table 3 is obtained from the Minitab in which p value is low means it has more influence on wear parameter. From the table load is more influencing factor followed by sliding speed and sliding distance in order.

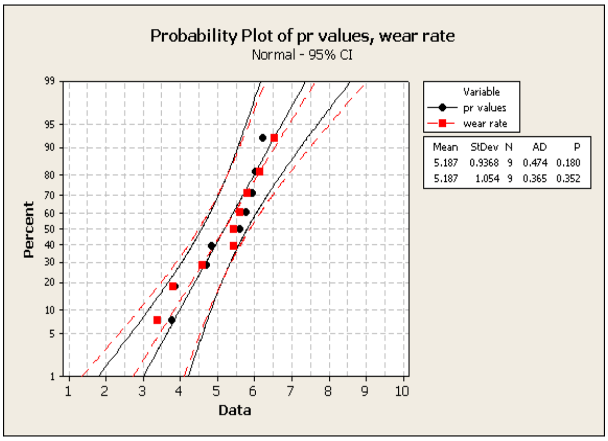
**Table4:Analysis of Variance**

| S.No | Parameter | Degrees of freedom | Seq SS | Adj SS | Adj MS | % of influence |
|---|---|---|---|---|---|---|
| | **Regression** | **3** | **0.0000058** | **0.0000058** | **0.0000019** | |
| 1 | **Sliding Speed** | **1** | **0.0000005** | **0.0000005** | **0.0000005** | **6.7** |
| 2 | **Load** | **1** | **0.00000050** | **0.00000050** | **0.00000050** | **67.7** |
| 3 | **Sliding Distance** | **1** | **0.0000003** | **0.0000003** | **0.0000003** | **4.05** |
| 4 | **Error** | **5** | **0.00000016** | **0.00000016** | **0.0000003** | **21.06** |
| | **Total** | **8** | **0.0000074** | | | |

Table 4 is exhibits input parameter percentage of influence on the wear rate of the material ,load is influencing 67.7% ,sliding speed is influencing 6.7% and sliding distance 4.05%




Graph :1 Mean effects on wear rate




Graph:2 Predicted value Vs Actual Values

**Observations of Al/SiCp Composite**: From graph 1 it reveals that load has more contribution on wear of a specimen because load acts directly on the specimen and falls on the rubbing surface in this material silicon is reinforced to aluminum so it resisted upto certain extent as material is still loaded the material wear increased due to abrasion wear. It is observed that when sliding speed increasing friction between sample and rubbing surface has less contact than compared with low sliding speed as material is having hard silicon particles hard materials posses less friction than soft material it showed less wear rate than, due to this as sliding speed increases wear rate of specimen decreased. Sliding distance increases wear rate also increases because if distance covered increase life of the component gradually decreases, in Al5083/SiCp silicon presence increases wear resistance. From the analysis of variance table 4 load has more influence followed by sliding speed and lastly by sliding distance on wear rate. From graph 2 predicted values and experimental values are within limits.

## VI. CONCLUSION

Al/Sicp has more resistance to load followed by sliding speed and sliding distance. This is due to reinforcement of silicon particles in aluminum matrix

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