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Dry Sliding Wear Behavior of Aluminium Hybrid Metal Matrix Composite At Temperature Condition

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ABSTRACT
Aluminum hybrid metal matrix composites (Al-HMMCs) are a class of materials that have gained significant attention due to their excellent mechanical and thermal properties. In this study, the hardness and wear resistance of Al-HMMCs for different temperature is investigated. The results showed that the hardness of Al-HMMCs were significantly higher than those of pure aluminum. The improved hardness and wear resistance were attributed to the presence of the hard reinforcement particles, which were dispersed throughout the matrix material. The results of this study demonstrate the potential of Al-HMMCs as a durable material for a wide range of high temperature applications, including structural components.To further evaluate the wear resistance of Al-HMMCs, a series of tests were conducted using both indentation and sliding wear method. The results showed that the Al- HMMCs sliding wear tests, a pin-on-disk setup was used to simulate sliding wear between for the Al-HMMCs The results showed that the Al- HMMCs had a significantly lower wear rate compared to pure aluminum, indicating improved wear resistance and the high temperature such as 453K ,473K,493K and 513K to calculate the wear rate of the material for the mentioned high temperature and to compare the each material for particular temperature to evaluate the wear rate for the particular material and consolidate the results .This improved wear resistance was attributed to the hard and abrasive nature of the reinforcement particles, which prevented the formation of wear debris and reduced the wear rate the results of this study demonstrate that Al-HMMCs have excellent hardness and wear resistance properties for different temperature, making them suitable for a variety of applications scanning electron Microscope and Energy Dispersive X- ray Spectroscopy.
***Keywords**: Increase in hardness, Wear for different temperature, Tic, MOS2, Dry sliding pin on disk wear, High Temperature, EDS and SEM analysis.*

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I. INTRODUCTION

Aluminum hybrid metal matrix composites (Al-HMMCs) are a class of materials that have gained significant attention due to their excellent mechanical and thermal properties. In this study, the hardness and wear resistance of Al-HMMCs of different temperature is investigated. The results showed that the hardness and wear resistance of Al-HMMCs were significantly higher than those of pure aluminum.

The improved hardness and wear resistance were attributed to the presence of the hard reinforcement particles, which were dispersed throughout the matrix material. The results of this study demonstrate the potential of Al-HMMCs as a durable material for a wide range of high temperature applications.

Evaluate the hardness and wear resistance of Al-HMMCs, a series of tests were conducted using both indentation and sliding wear methods. In the indentation tests, a diamond indenter was used to apply a load to the surface of the Al-HMMCs and the resulting indentation depth was measured. The results showed that the Al-HMMCs had a higher hardness than pure aluminum, with the hardness increasing as the volume fraction of the reinforcement particles increased.

sliding wear tests, a pin-on-disk setup was used to simulate sliding wear for high temperature the Al-HMMCs The results showed that the Al- HMMCs had a significantly lower wear rate compared to pure aluminum, indicating improved wear resistance of the composite material.

The improved wear resistance was attributed to the hard and abrasive nature of the reinforcement particles, which prevented the formation of wear debris and reduced the wear rate. The results of this study demonstrate that Al-HMMCs have excellent hardness and wear resistance properties, making them suitable for a variety of high temperature applications.

Using pin on disk dry sliding wear by treating the material with high temperature such as 453k, 473k,493k and 513k for each material and to consolidate the wear rate for particular material for certain temperature in order to have material for certain temperature application to reduce the wear for the material.

Further research is needed to fully understand the mechanisms behind the improved hardness and wear resistance of Al-HMMCs and to optimize their composition and processing for specific applications.

Tests were conducted using both indentation and sliding wear methods. In the indentation tests, a diamond indenter was used to apply a load to the surface of the Al-HMMCsfor a wide range of high temperature applications.

Dry sliding pin on disk wear test has been conducted under the influence of temperature such as 180℃,200℃ , 220℃ and 240℃ with speed 750 rpm , time of 6 minutes and load of 2 Kg with sliding distance ,sliding velocity as 2120.58m and sliding velocity as 5.89 m/s.

To evaluate wear behavior of Aluminum hybrid metal matrix composites for different temperature based on the wear rate the material has to be used for certain temperature condition to increase the wear rate of the material as well as application of material at the certain temperature in order to reduce the wear rate occur for certain application for certain temperature and SEM, EDS technologies to determine the wear behavior of the material.

II. PROJECT OVERVIEW

2.1 Problem Identification:

In the automobile manufacturing industries usage and application of composite materials especially aluminum hybrid metal matrix composites usages are at maximum level. To manufacture the brake drum and disc brake aluminum hybrid metal matrix composites material is used in order to that wear rate and hardness of the material gets reduce while continuous usage and sudden braking due to heat is occur and it will damage the material as well as life is also get reduced. To avoid these problems by adding the reinforcement material with the aluminum hybrid metal matrix composites to increase the wear rate as well hardness of the material.

2.2 Scope of the Project:

In order to improve the hardness and reduce the wear rate of aluminum hybrid metal matrix composites by adding the reinforcement material such as Titanium carbide (Tic) and Molybdenum disulfide ($M0s_2$) to drastically increase the hardness and reduction of wear of the material through the stir casting process due to the manufacturing of composite material by using the optimization technique reinforcement of the material is added to that aluminum hybrid metal matrix composites and to validate the material through the Rockwell hardness test machine and wear test machine for various percentage of the test specimen with high temperature involved to evaluate the withstand capacity of each material can be easily identified.

2.3 Objective:

- To improve the hardness and reduce the wear rate of material.
- Stir casting of the materials using Al 6061, Tic and Mos_2 material by using optimizing technique.
- To validate the hardness through Rockwell hardness test machine.
- To evaluate wear rate using dry sliding pin on disk wear test machine.
- To determine the material at different temperature condition.
- To Identify the wear rate of material at high temperature at high speed.
- To evaluate the SEM, EDS technologies to study the structure of the material.

ABBREVIATION:

S.NO	Abbreviated Form	Material Name
1.	Tic	Titanium Carbide
2.	Mos_2	Molybdenum disulfide
3.	Al 6061	Aluminum pure metal
4.	Al HMMC’S	Aluminum Hybrid Metal Matrix Composites
5.	SEM	Scanning Electron Microscope
6.	EDS	Energy Dispersive X-ray Spectroscopy

III. LITERATURE REVIEW

1.Ansar Kareem,increasing mechanical and tribological characteristics of hybrid aluminum metal used for casting. Aluminum was created to improve the efficiency of materials. Aluminum alloy Al 6061 has a wide range of uses because of its excellent material properties

2.Satyam Tiwari, the surface roughness, degree of accuracy, and fine surface finishes of the work piece are taken into consideration when calculating the WEDM's material removal rate using the Taguchi method.

3.**Chandra Sekhar Manda & Surendra Babu,**The AMMC is created by stir casting, which is followed by immediate quenching. To test the material and determine its mechanical characteristics, scanning electron microscopy and X-ray diffraction analysis were used to examine its microstructure and the distribution of its reinforced particles.

4.**Anupkumar Bongale**'due to increased tool wear and surface roughness, these alloys are difficult to machine using conventional techniques. The goal of the study is to determine whether Sic reinforced Al 6061 composite is Machinable. Microstructural analysis of the sliced surface showed that there are craters with a wave pattern on its surface.

5. **Maibam Bindya Devi, AnilKumar, BirruPraveenKumar, Bannaravuri**;Electro discharge machining is not only used for the standard precision material removal process; it is also used for micromachining, microimpressions, and the machining of hard-to-machine materials. Aluminum-based materials are one of the materials that electro discharge machining is used to control.
5

6.Avinash Lakshmikanthan, Santosh Angadi, Vinayak Malik;Also included are the mechanical and tribological properties performed, as well as the different matrix materials and particles used in Al-based MMCs Dual particle size reinforced composites, heat treatment of Al alloys, and tempering marks used in heat treatment.

7.Materialsimur Rizovich Ablyaz,EvgenySergeevich Shlykov;Composite materials are the effect of processing process parameters. Cutting Width PCM (Polymer Composite Material) processing precision affects the cutting width of the polymer composite material and even improves the process of the material.

8.M. Asif, K. Chandra, P.S. Misra;Sliding wear behavior of composites based on aluminum alloys using scanning electron microscopy (SEM) to characterize the microstructure of the worn surface and triangulate the composites. The proposed composite materials have a lower friction factor, lower temperature rise and low noise level; however, they have a slightly higher wear and tear. The hybrid composite has an acceptable level of tribological properties.

9.J. Jenix Rino, D. Chandramohan, K.S. Sucitharan;Aluminum alloys are widely used in the aerospace and automotive industries due to their low density and good mechanical properties, better corrosion and wear resistance, and low coefficient of thermal expansion compared to common metals and alloys. The goal of designing metal matrix composite materials is to combine the properties of metals and ceramics.

10.**S.T. Mavhungu, E.T. Akinlabi, M.A. Onitin, F.M. Varachia;**Composite material dominates industrial requirements for weight reduction, high efficiency and material performance. In the automotive industry, AMMCs are mainly used to improve high specific stiffness, high strength and long life parts, high speed rotating shaft, extreme material brake parts.

11. S Gopinath, M Prince and G. R. Raghav;Enrichment of mechanical, wear and corrosion properties of aluminum 6061 matrix composite with hybrid reinforcements Al alloy caused the highest surface damage resulting in poor wear and the worn surfaces are examined by scanning electron microscope. adhesive wear has occurred.

12.**J. W. Luster, M. Thumann and R. Baumann;**The stiffness and hardness of the resulting composites increase as the volume fraction of the particles increases, while the toughness also decreases accordingly. A balanced combination of tensile strength, durability, creep resistance, durability and fatigue resistance must be achieved.

13. **Rinki Yadav, Jai Prakash Sharma, Gianender, Rekha Yadav**;Effect of Molybdenum Disulfide (MoS_2) on Wear and Mechanical Properties of Aluminum Alloy 6061 Molybdenum Disulfide for Wear Reduction. The

study showed that the tensile strength and wear resistance of the Al 6061/MoS2 composite increases with 5 wt.% of MoS2.

14. H. C. Ananda Murthy, Somit Kumar Singh;Al-Tic particle composition has better high temperature potential. The observed increase in corrosion resistance of composites reinforced with Tic particles is attributed to the excellent bond integrity of the Tic particles to aluminum and possible electrochemical debonding between the Tic particles and the Al 6061 matrix alloy.

15. lbayomi A. Akinwande,Adeolu A.Adediran,Oluwatosin A.Balogun;Alloy casting faces certain challenges, including segregation, the presence of intermetallic phases, agglomeration, and the induction of residual stress. Mixing optimization, the responses evaluated are tensile strength, compressive strength, impact strength and hardness.

16.**PRAMANIK, A.K. BASAK, M.N. ISLAM, G. LITTLEFAIR;**The material removal rate increases over time as the pulse increases, although the thread tension does not affect the material removal rate. Higher wire tension facilitates a smooth machining process, resulting in less wire electrode wear and better surface quality.

17. **K. Umanath, K. Palani kumar, S.T. Selvamani ;** wear behavior of Al6061-T6 discontinuously reinforced with silicon carbide (Sic) and aluminum oxide (Al2O3) composite. Tests are performed using a pin wear test. The results showed that the wear resistance of the 15% hybrid composite is better than that of the 5% composite. The fracture surface of the composites shows ductile tear edges and cracked Sic and Al2O3 particles, indicating both ductile and brittle fracture mechanisms.

18.**D.Jeyasimman,R.Narayanaswamy,M.Kamaraj,V.Anadhakrishnan,R.Ponalaguswamy;**Dry sliding behavior of AA 6061 nanocomposites reinforced with different nanoscale reinforcements such as titanium carbide (Tic), gamma-phase aluminum (γ-Al2O3) and hybrid (Tic Al2O3) nanoparticle test was carried out by pin-on-disk wear test. sliding these pin samples at sliding speeds of 0.6, 0.9, and 1.2 m/s and under normal loads of 5, 7, and 10 N at different sliding speeds at room temperature. To observe the wear characteristics and the wear mechanism, the worn surfaces were analyzed with a scanning electron microscope (SEM). The formation of the oxide layer on the worn surface was investigated using energy dispersive spectroscopy (EDS).

19.P.R.S.Kumar,S.Kumaran,T.Srinivasa Rao,S.Natarajan; Effect of Fly Ash Particles on High Temperature Dry Sliding Wear Resistance of AA6061 The dry sliding wear behavior was investigated using the pin-on-disk method under a load of 14.6 N at different temperatures (100, 200 and 300 °C). For comparison, the study was also conducted at room temperature. The results showed a transition of the unreinforced alloy from mild to severe wear in the temperature range of 200-300 °C.

20.Mehak Nisar, M.S.Charoo; Al 6061 alloys are used in many industrial applications. The dry sliding wear behavior of Sic-based Al6061 composites has been extensively studied over the past decade, while its wear behavior at high temps. The scratch parameters of Al6061 alloy and Al 6061 reinforced with 2 wt.% Sicwere optimized and the wear behavior of the scratch was analyzed.

21**.Vyjainto Kumar Ray, Payodhar Padhi, B. B. Jha, Tapas Kumar Sahoo;**the aluminum metal matrix was reinforced with 1.5 wt.%. % Al2O3 nanoparticles metal matrix nanocomposite. A microstructural showed a uniform distribution of alumina particles. The sliding wear behavior of the as-cast MMNC was investigated in the dry state under different test conditions by varying the load and sliding speed, and it was found that the sliding resistance was significantly improved by the addition of alumina nanoparticles.

22.N.Saleema,D.K.Sarkar,R.W.Paynter,D.Gallant,M. Eskandarian;Aluminum structural bonding is widely used in the aerospace and automotive industries. Surface roughness, surface wettability and surface chemistry are controlled primarily by appropriate surface treatment methods. using various surface analysis tools such as scanning electron microscopy and energy dispersive X-ray analysis (SEM/EDX), X-ray diffraction. Excellent adhesion properties involving the use of strong acids and multiple processing steps.

23. P. S. Samuel Ratna Kumar, Peter Madindwa Mashinini;Materials were evaluated at various temperatures (313 K, 353 K, 393 K, and 433 K, respectively) to assess AA7075 (aluminum alloy) and its nanocomposites reinforced with (SiO2+Al2O3) Al2SiO5 layered nanoparticle as potential materials for high temperature wear condition. Testing for high temperature wear was done with a constant load of 24.5 N,2000 m of sliding distance at a speed of 3.14 m/s. This made it possible to comprehend how reinforcing at high temperatures affects the wear mechanisms of materials like AA7075 and nanocomposite materials. With the use of a field emission scanning electron microscope, an optical metallurgical microscope, and X-ray energy-dispersive spectroscopy, the worn surface topography was thoroughly examined. Wear resistance of the nanocomposites is increased as compared to the AA7075 matrix material at the testing temperature range of 433 K.

24. S.T. Mavhungu, E.T. Akinlabi, M.A.onitiri,F.M.varachia;Composite materials metal matrix composites requirement for weight reduction high efficiency and performance in the material AMMC'S with high specific and high strength could be used in long term application such as robots ,high speed machinery, rotating shafts and brakes parts . composite materials are high strength and light weight component advance material parts with improved performance and efficiency.

IV. METHODOLOGY

In order to overcome the problem following steps are to be involved in cast of the material, accurate weight of reinforcement using the optimizing technique to cast the composite with varying the percent of reinforcement for each samples and to test the hardness and wear rate, SEM and EDS.

1. **Problem Identification**:

Life of the material reduces due to continues usage of the material due to high temperature occurs wear rate and increase the hardness of material.

2. Literature survey:

Mechanical, Chemical properties and tribology of the material is to survey and identify the characteristics of the component, high temperature for wear rate, SEM and EDSis also determined.

3. Selection of the material:

Material is to select for the casting process in order to calculate hardness and reduce in wear rate of the material at the high temperature.

4. **Optimizing technique**:

Materials to be cast based on the optimization in order to vary the percentage of composition of the reinforcement material to increase the mechanical properties.

5. **Stir casting:**

For casting the composite material stir casting is used to manufacture the component.

6. **Testing of the component**:

Hardness and wear rate, SEM and EDSof the component has to be taken to view the mechanical properties and chemical properties.

7. Evaluate the result& generate report:

Result to be evaluate and based on that report has to be generated.

11

Methodology:

Problem Identification is to increase the hardness and decrease wear rate of high temperature involved for application purpose.

Literature Survey is to determine the wear behavior, SEM and EDS technologies for high temperature of Al 6061, Tic and Mos$_2$

Selection of material is based on the increase hardness and decrease wear rate of the material at high temperature.

Optimizing technique is to cast by varying the percentage of material to increase the mechanical properties.

By using the stir casting machine Al composite material is casted based on varying the percentage of

Evaluate the component using hardness, Wear test, SEM and EDS test to verify structure and wear rate of the material.

Based on test result the suitable material is to be used for the application purpose to increase the life of the material.

Generate the Report to establish the detail record of the material has to be noted further process.

V. COMPONENTS

5.1 Aluminum 6061 pure metal:

Fig: 1 Aluminum 6061 pure rod

SPECIFICATIONS:

- Elongation: 12-25%
- Thermal Expansion co-eff: $2.32x10^{-5}K^{-1}$
- Melting Temperature: 585℃
- Specific heat capacity: 897 j/kg k.
- Thermal conductivity: 202 W/mk.
- Good corrosion resistance.
- Good weldability.
- Medium fatigue strength.

5.2 Titanium Carbide (Tic):

Fig:2 Titanium Carbide (Tic) 100g

Fig:3 Tic with varying proportion

SPECIFICATIONS:

- Molar mass-59.89 g/mole
- Density – 4.93g/cm3
- Melting point: 3160℃
- Boiling point :4820℃
- Extreme hard refractory Ceramicmaterial.
- Increase hardness of material.

5.3 Molybdenum disulfide (Mos_2):

Fig: 4 Molybdenum disulfide (Mos_2) with varying proportion

SPECIFICATIONS:

- Molar Mass – 160.07 g/mole
- Boiling point – 2375℃
- Appearance – Black crystal.
- Excellent dry lubricant.
- Insolubility in water.

5.4 STIR CASTING MACHINE:

Fig:5 Stir casting setup

SPECIFICATIONS:

- Furnace Capacity - 2Kg
- Max. Temp. - 1000℃
- Manual Bottom Pouring
- Stirrer - 0 to 1000 rpm with SS Blade
- Temperature Control - PID
- MS Die - 30 diameter x 300 mm Length.

5.5 Composite Material Process:

Fig:6 Pouring casting Material into mold

Fig: 7 Curing of casting material in mold

Fig: 8 Casted composite material

5.6 Casted materials:

Percentage of composition: (750g)

1. Aluminum 6061 pure metal(750g).
2. 2% Mos2 (15g), 3% Tic(23g) and 95% Al 6061(713g).
3. 2% Mos2 (15g), 4% Tic(30g) and 94% Al6061(705g).
4. 2% Mos2 (15g), 5% Tic(38g) and 93% Al6061(698g).

Fig:9 Casting Material by varying proportional

5.7 Test sample Specimen:

Fig:10Test Samples are kept to distinguish varying proportional

1.Pure Aluminum 6061
2.S_1 - 2% Mos_2 + 3% Tic + Al 6061
3.S_2 - 2% Mos_2 + 4% Tic + Al 6061
4.S_3 - 2% Mos_2 + 5% Tic + Al 6061

5.8 Rockwell hardness Machine:
It is used to calculate the hardness of the material by applying the constant load for the specimen of varying proportional.

Fig:11 Rockwell Hardness Test Machine

SPECIFICATIONS:

- For Aluminum Alloys - Load is 100kg
- Indenter used - 1/16”
- Scale - ‘B’ Scale.

5.9 Wear Test Machine:
Dry sliding wear pin on disk is used to evaluate wear rate of the material as well by applying high temperature in order to determine the wear loss for the material.

Fig:12 Pin on disk Wear Test Machine

SPECIFICATIONS:

- Maximum Speed - 1000 rpm
- Maximum Temperature - 300℃
- Pin diameter -10mm
- Sliding distance - 2120.58m
- Sliding Velocity – 5.89049m/s
- Time - 6 Minutes.
- Pin Length- 30mm.

CHAPTER 6

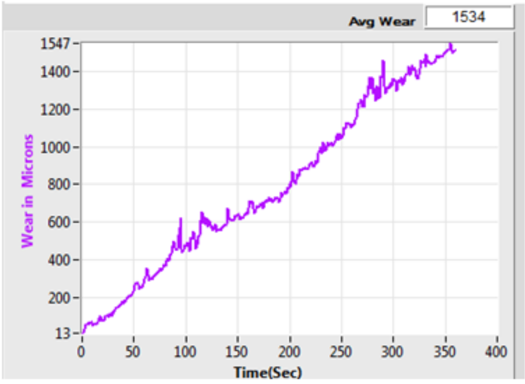
6.1Rockwell Hardness Test Table:

S.NO:	Composition	Hardness(HRB)
1.	Al pure 6061	74
2.	2%Mos_2+3%Tic+Al 6061	97
3.	2%Mos_2+4%Tic+Al 6061	109
4.	2%Mos_2+5%Tic+Al 6061	114

For pure Aluminum hardness is 74 N/mm^2but for the following materials components hardness are gradually increases as 97,109,114 N/mm^2 due to addition of Titanium carbide (Tic) in the component as 3% ,4% and 5% and 2% Molybdenum disulfide($Mos_{2)}$ as constant for each component.

6.2Dry sliding pin on disk wear test:

1. Aluminum 6061 pure metal(750g):



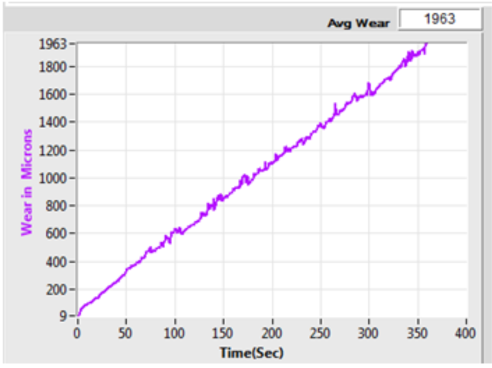
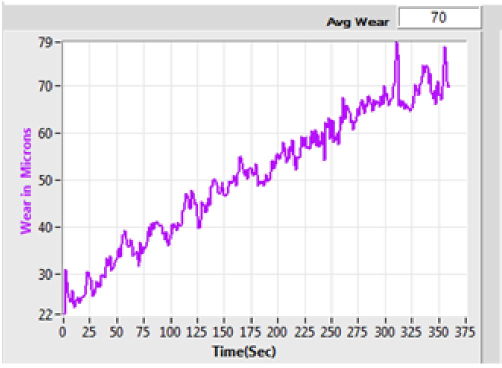


Fig:13 Pure Al 6061 at 180°C Fig:14 Pure Al 6061 at 200°C



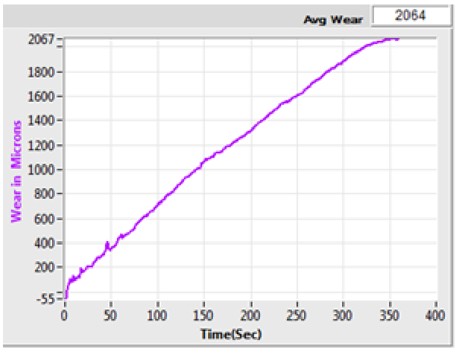
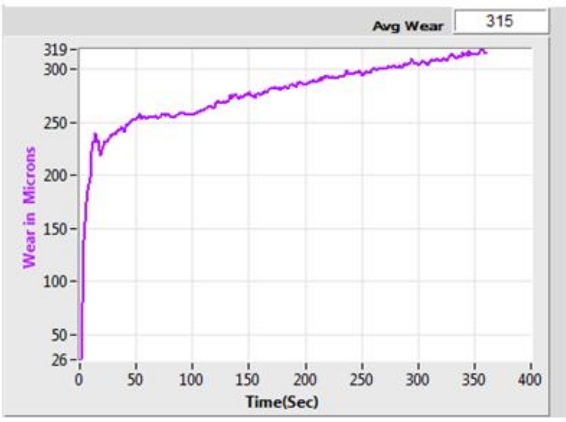


Fig:15 Pure Al 6061 at 220°C Fig:16 Pure Al 6061 at 240°C

- Pure Aluminum 6061 is to evaluate the wear rate under the influence of different high temperature 180°C,200°C,220°C ,240°C in order to keep track
Of wear rate of material at different temperature condition.
- Wear test can be done on dry sliding pin on disk with speed of 750 rpm with load as 2Kg as time as 6 minutes with sliding distance as 2120.58m and sliding velocity as 5.89m/s.
- Different wear rate is occurring at different temperature condition.

2.S_1 ⟶ 2% Mos2 (15g), 3% Tic(23g) and 95% Al 6061(713g):



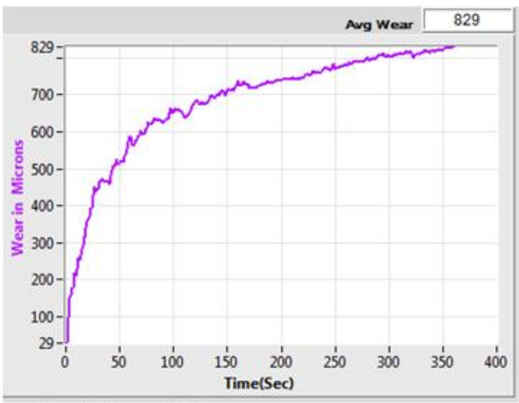


Fig:17 S_1at 180°C Fig:18 S_1at 200°C

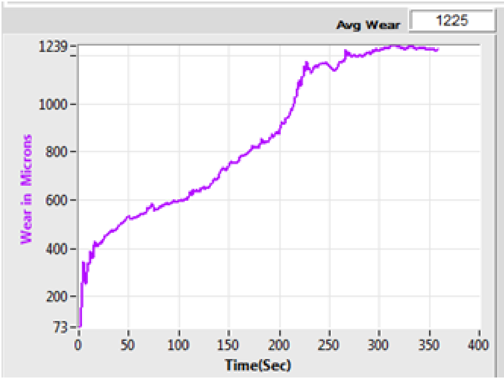


Fig:19 S_1at 220°C

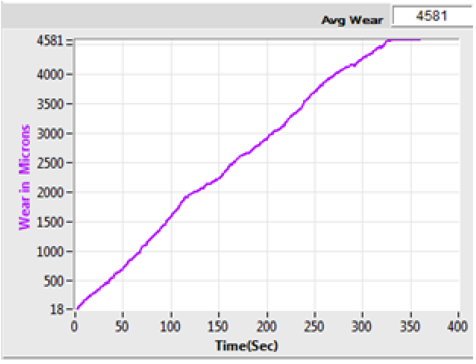


Fig:20 S_1at 240°C

- S_1 is to evaluate the wear rate under the influence of different high temperature 180°C,200°C,220°C ,240°C in order to keep track of wear rate of material at different temperature condition.
- Wear test can be done on dry sliding pin on disk with speed of 750 rpm with load as 2Kg as time as 6 minutes with sliding distance as 2120.58m and sliding velocity as 5.89m/s.
- As the temperature increases the wear rate for the material also increases due to which material is severely influence on the temperature, so there is variation in the wear of the material.

3. $S_2$2% Mos2 (15g), 4% Tic(30g) and 94% Al6061(705g):

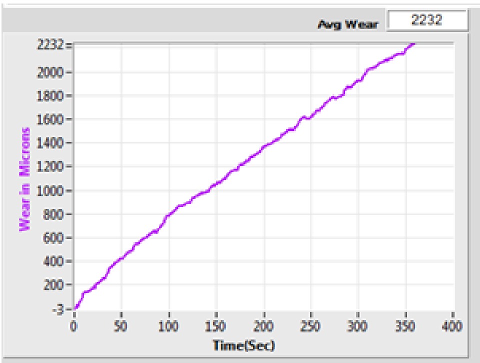


Fig:21 S_2at 180°C

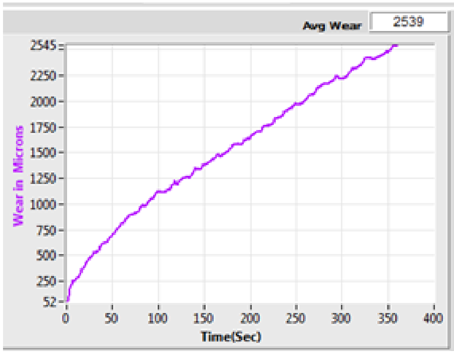


Fig:22 S_2at 200°C

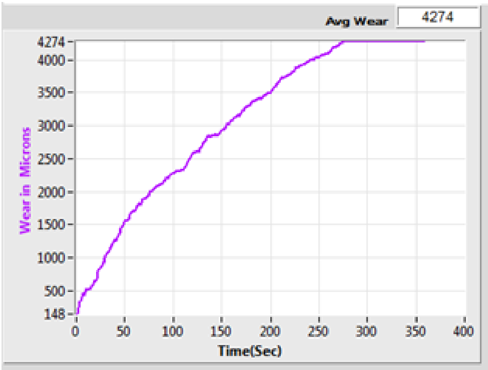


Fig:23 S_2at 220°C

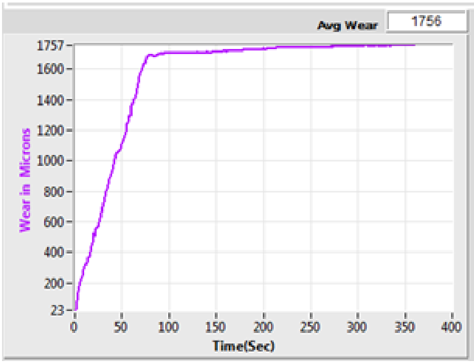


Fig:24 S_2at 240°C

- S_2 is to evaluate the wear rate under the influence of different high temperature 180°C,200°C,220°C ,240°C in order to keep track of wear rate of material at different temperature condition.
- Wear test can be done on dry sliding pin on disk with speed of 750 rpm with load as 2Kg as time as 6 minutes with sliding distance as 2120.58m and sliding velocity as 5.89m/s.
- As the temperature increases the wear rate for the material also increases due to which material is severely influence on the temperature, so there is variation in the wear of the material.

- Wear rate of the material gradually rises with rise of temperature so wear depends upon the rise of the temperature.

4. $S_3$2% Mos2 (15g), 5% Tic(38g) and 93% Al6061(698g):

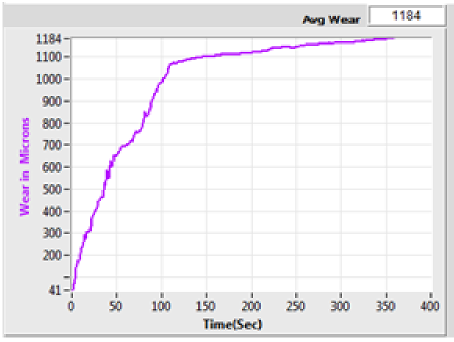


Fig:25 S_3at 180℃**23**

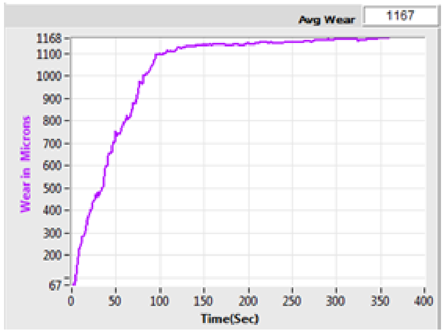


Fig:26 S_3at 200℃

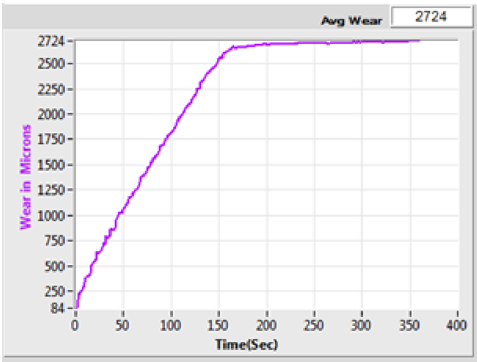


Fig:27 S_3at 220℃

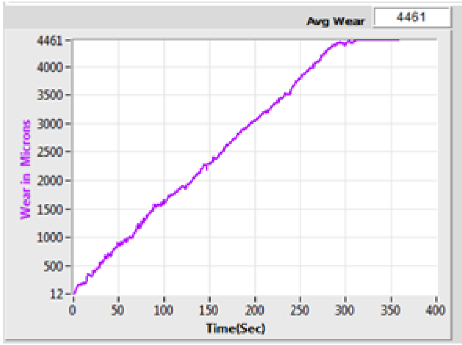


Fig:28 S_3at 240℃

- S_3 is to evaluate the wear rate under the influence of different high temperature 180℃,200℃,220℃ ,240℃ in order to keep track of wear rate of material at different temperature condition.
- Wear test can be done on dry sliding pin on disk with speed of 750 rpm with load as 2Kg as time as 6 minutes with sliding distance as 2120.58m and sliding velocity as 5.89m/s.
- As the temperature increases the wear rate for the material also increases due to which material is severely influence on the temperature, so there is variation in the wear of the material.
- Wear rate of the material gradually rises with rise of temperature so wear depends upon the rise of the temperature.
- c

6.3 CO-EFFICIENT OF FRICTION:

Co-eff of friction of the material at 180℃ to compare and analysis of all the material under the particular temperature to determine the mechanical properties of the each specimen.

1. COMPARISION OF CO-EFF OF FRICTION AT 180°C:

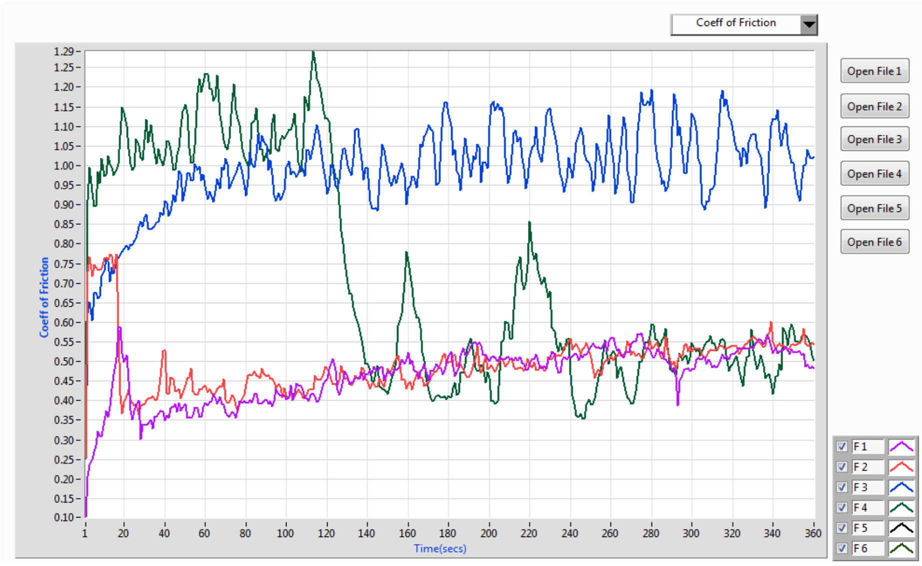


Fig:29 comparison co-eff friction of all specimen under 180°C

In this graph pure Aluminum has higher co-eff of friction about 0.46, s_1 sample increases at particular time and there is variation of co-eff of friction at 0.54, S_2 sample gradually co-eff friction trends to decline 1.02 and S_3 sample co-eff of friction tends to variation about 0.51.

2. COMPARISION OF CO-EFF OF FRICTION AT 200°C:

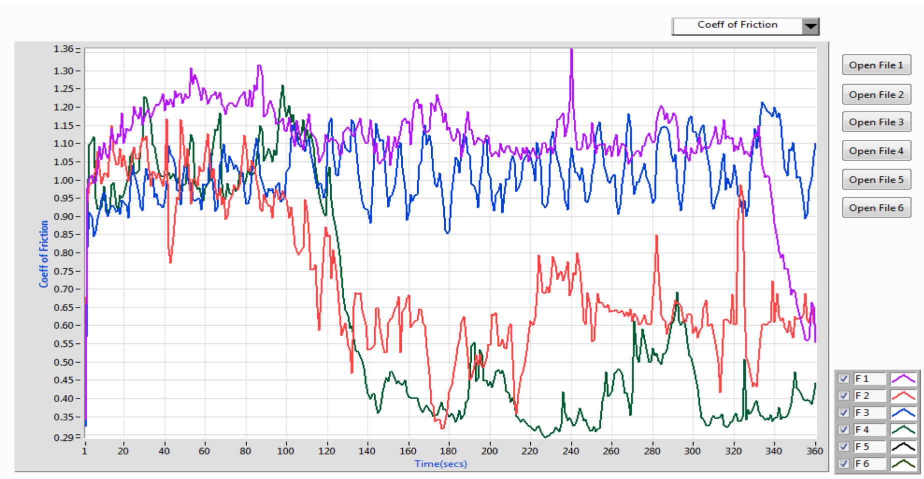


Fig:30 comparison co-eff friction of all specimen under 200°C

In this graph pure Aluminum has higher co-eff of friction about 0.54, s_1 sample increases at particular time and there is variation of co-eff of friction at 0.6, S_2 sample gradually co-eff friction trends to decline 1.11 and S_3 sample co-eff of friction tends to decline at 141 secs about 0.4.**25**

3.COMPARISION OF CO-EFF OF FRICTION AT 220℃:

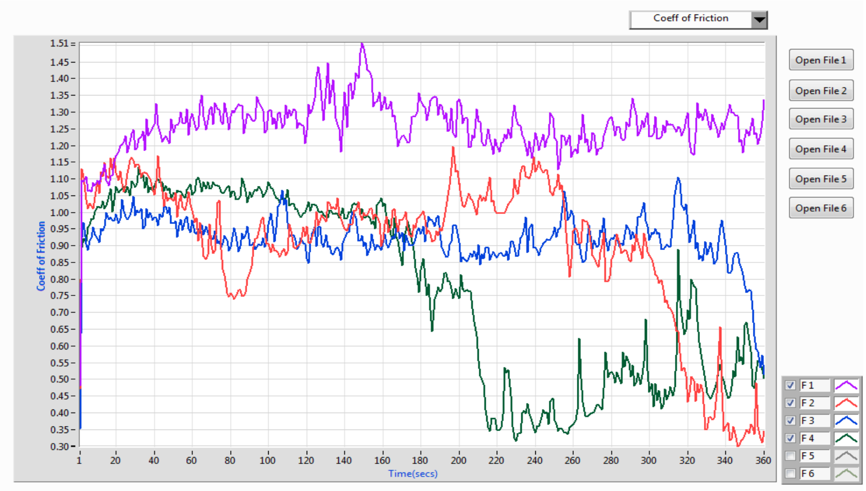


Fig:31 comparison co-eff friction of all specimen under 220℃

In this graph pure Aluminum has higher co-eff of friction about 1.35, s_1 sample increases at particular time and there is variation of co-eff of friction at 0.32, S_2 sample gradually co-eff friction trends to decline 0.53 and S_3 sample co-eff of friction tends to decline at 200 secs about 0.5.

4.COMPARISION OF CO-EFF OF FRICTION AT 240℃:

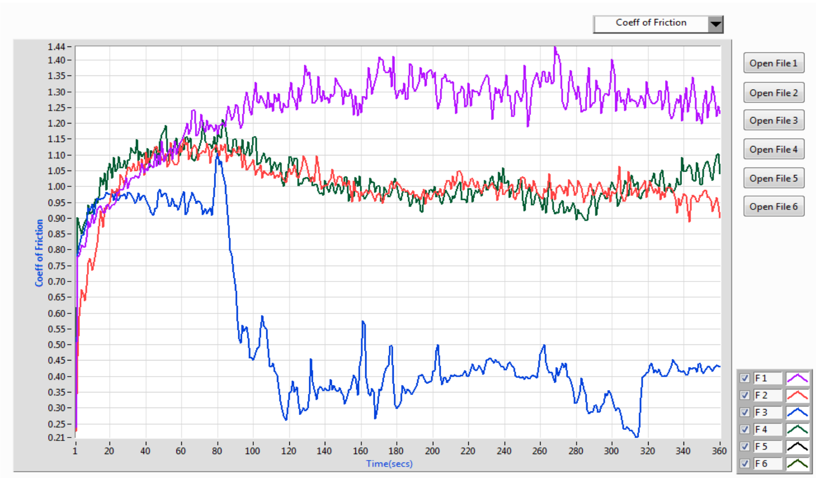


Fig:32 comparison co-eff friction of all specimen under 240℃

In this graph pure Aluminum has higher co-eff of friction about 1.23, s_1 sample increases at particular time and there is variation of co-eff of friction at 0.9, S_2 sample gradually co-eff friction trends to decline 0.4 and S_3 sample co-eff of friction tends to sudden rise at 220 secs about 1.10.

1. COMPARISION OF WEAR RATE AT 180℃:

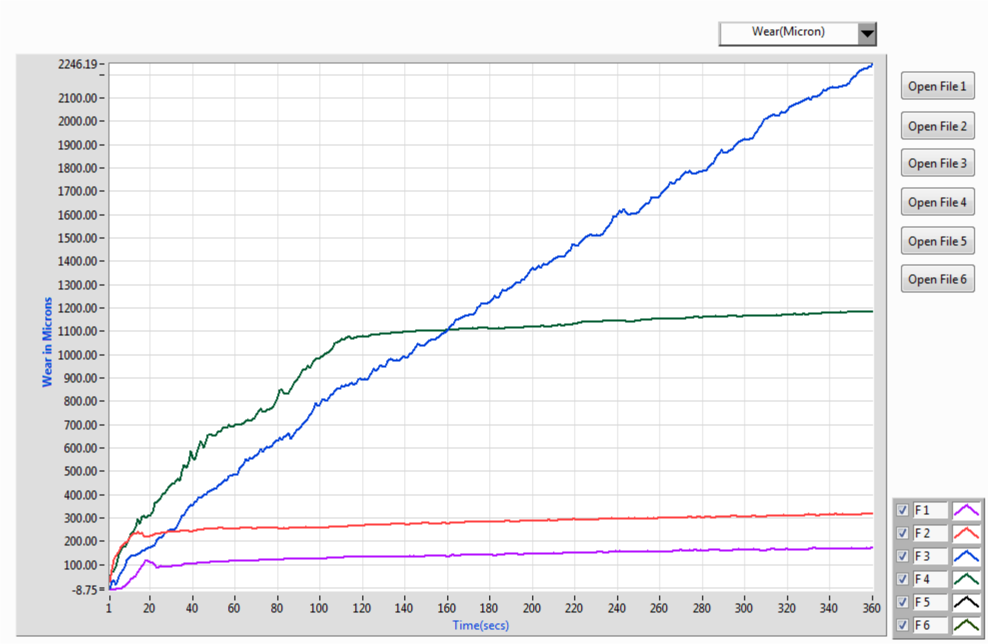


Fig:33 comparison wear rate of all specimen under 180℃

Graph depicts that the pure aluminum wear rate rises gradually about 220 microns, S_1 Sample has higher wear rate than the pure about 300 microns, S_2 Sample drastically rises up to 2246 micron and S_3 average wear rate about 1200 microns.

2. COMPARISION OF WEAR RATE AT 200℃:

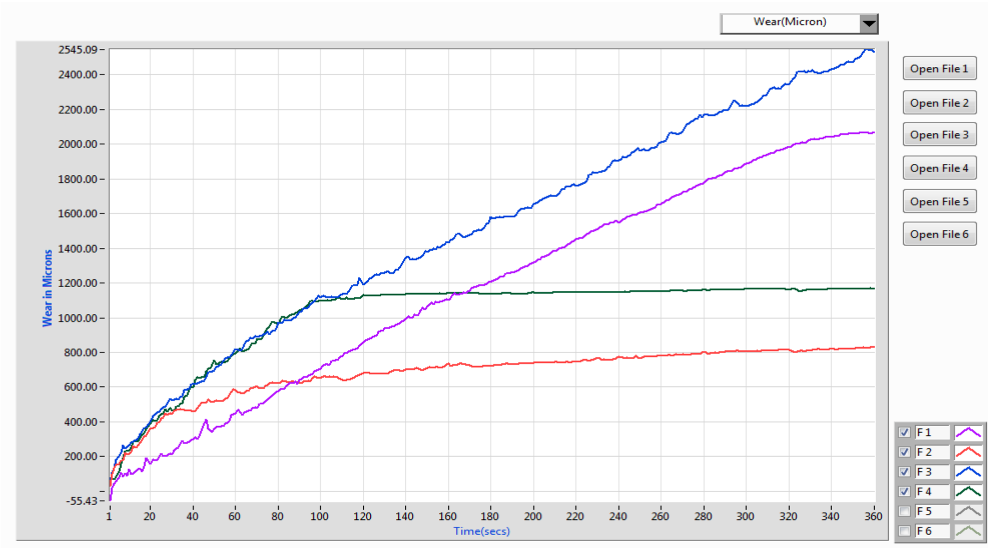


Fig:34 comparison wear rate of all specimen under 200℃

Graph depicts that the pure aluminum wear rate rises gradually about 2100microns, S_1 Sample has lower wear rate than the pure about 800 microns, S_2 Sample drastically rises up to 2545 micron and S_3 average wear rate about 1190 microns.

3. COMPARISION OF WEAR RATE AT 220℃:

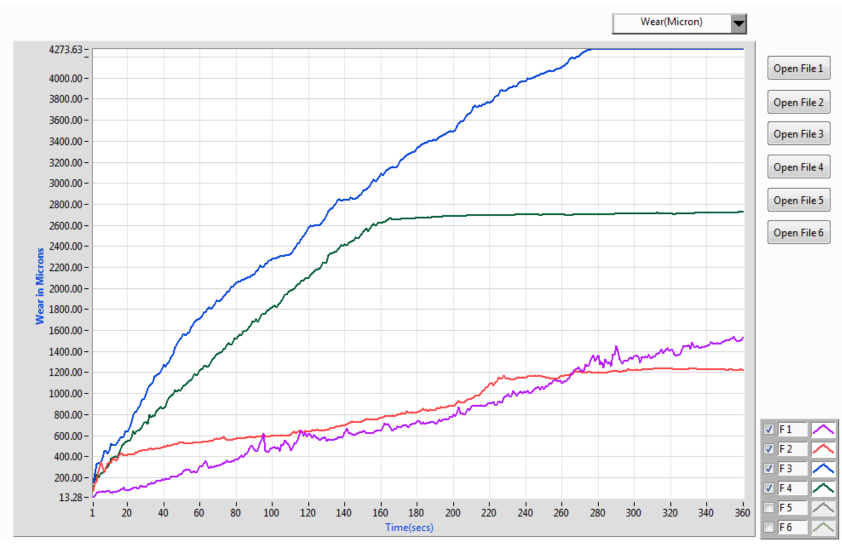


Fig:35 comparison wear rate of all specimen under 220℃

Graph depicts that the pure aluminum wear rate rises gradually about 1600microns, S_1 Sample has lower wear rate than the pure about 1100 microns, S_2 Sample drastically rises up to 4273 microns and S_3 average wear rate about 2600 microns.

4.COMPARISION OF WEAR RATE AT 240℃:

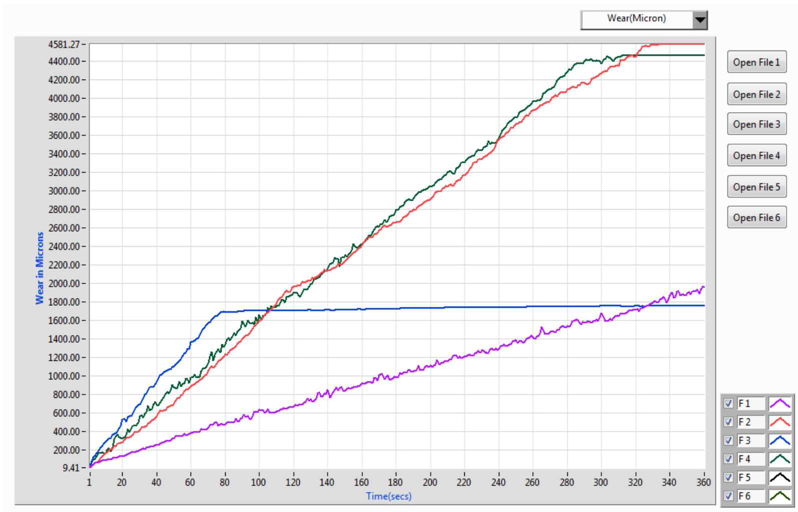


Fig:36 comparison wear rate of all specimen under 240℃

Graph depicts that the pure aluminum wear rate rises gradually about 1800microns, S_1 Sample has drastically higher wear rate than the pure about 4581 microns, S_2 Sample wear rate lower up to 1700 microns and S_3 sample slightly lower wear rate than S_1 Sample about 4600 microns.

6.4 Table for wear and co-eff of friction:

S.NO:	COMPOSITION	WEAR RATE				CO-EFF OF FRICTION			
		453K	473K	493K	513K	453K	473K	493K	513K
1.	Pure Aluminum 6061	70	2064	1534	1963	0.46	0.54	1.35	1.23
2.	2% Mos_2 + 3% Tic + Al 6061	315	829	1225	4581	0.54	0.6	0.32	0.9
3.	2% Mos_2 + 4% Tic + Al 6061	2232	2539	4274	1756	1.02	1.11	0.53	0.4
4.	2% Mos_2 + 5% Tic + Al 6061	1184	1167	2724	4461	0.51	0.4	0.5	1.10

- From the inference of test result shows as the temperature increases wear rate of the material also increases.
- Wear rate is gradually rise due to rise of temperature as well at speed of 750 rpm with load of 2Kg.
- Time is to be 6 minutes to determine the wear at high temperature with maximum load as maximum speed.
- To calculate wear rate temperature used are 180℃,200℃,220℃ ,240℃,Hardness also increases due to Tic present in the material and co-eff of friction also calculated for particular material.
- As the wear rate increases co-eff of friction of the material also increases due to which it satisfies relation between them.
- Mos_2 set has to be constant but varying the Tic of the component by the optimizing technique.**29**

6.5 SEM (Scanning Electron Microscope):

- It is used to infer the microscopic structure of the material to study the wear behavior of the material and to know about the detail structure of the component.
- Wear behavior can infer only at certain magnification it clearly depicts the wear happens at the 82, 150 and 250.
- Only above mentioned magnification the wear behavior is clearly identified and to clear state of the material.

1. S_1 sample SEM Analysis:

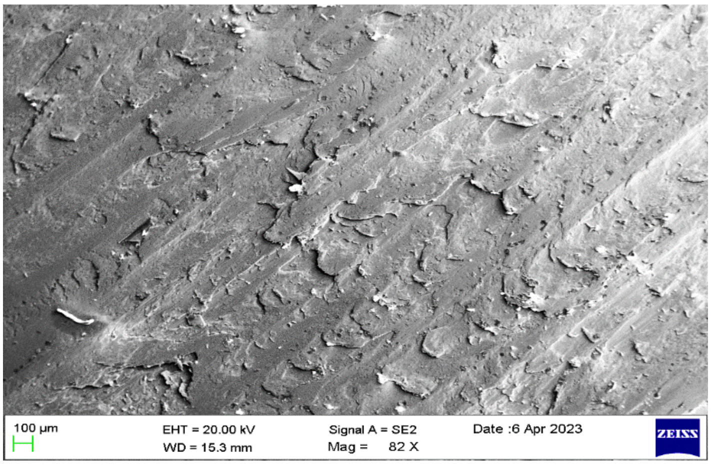


Fig: 37 S_1 at 82 magnification

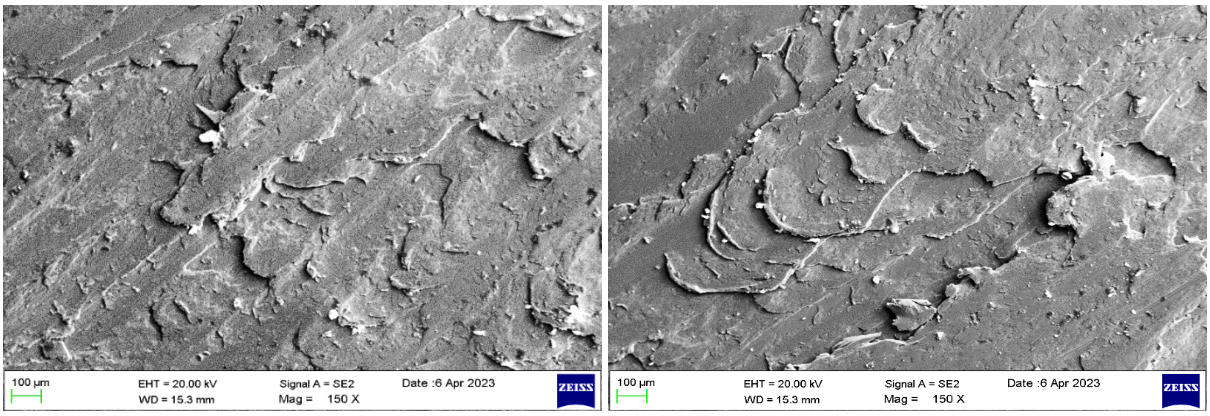


Fig: 38 S_1 at 150 magnification

2. S_2 Sample SEM Analysis:

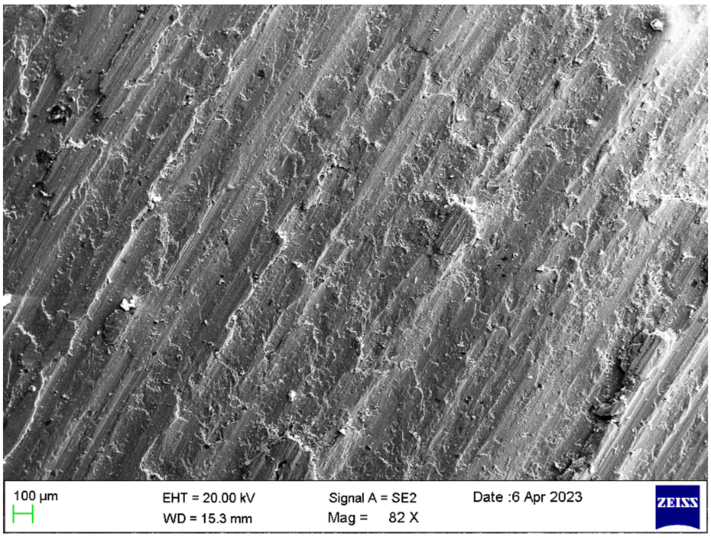


Fig:39 S_2 at 82 magnification

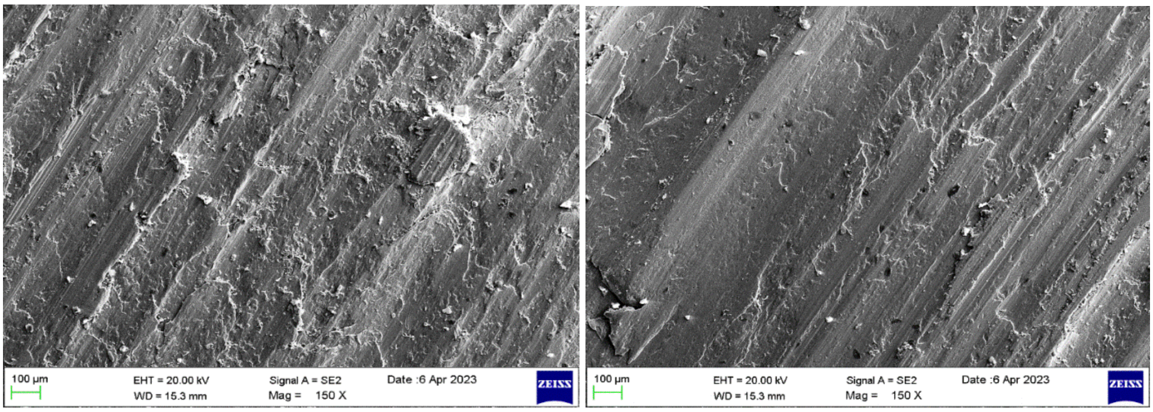


Fig:40 S_2 at 150 magnification

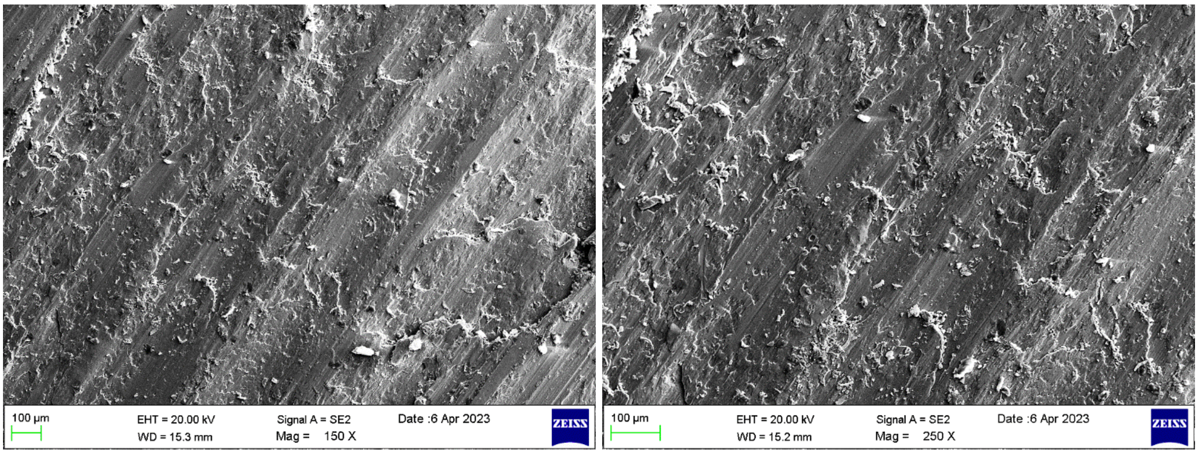


Fig:41 S_2 at 250 magnification

3. S_3 Sample SEM Analysis:

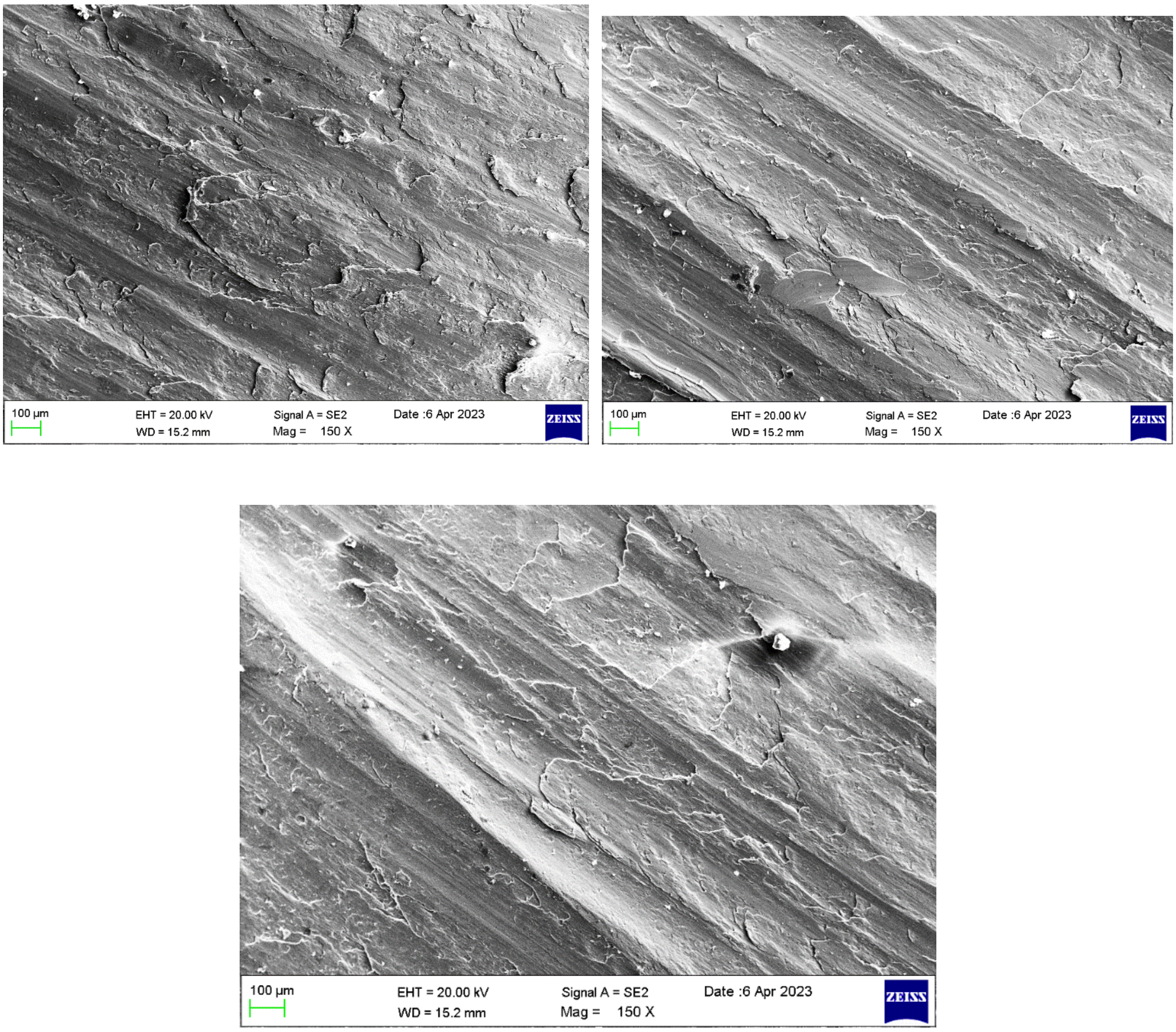


Fig:42 S_3 at 150 magnification

6.6 EDS (Energy Dispersive X-ray Spectroscopy):

- EDS is used to determine percentage of elements present in the component in order to evaluate the varying ratio of elements are clearly identified through this EDS technology.
- This technology used to determine correct proportional of elements whether present on the component.
- It is clearly depicting percentage are added to the component through casting.

- It also states that each element present in the component are with correct proportional as mentioned.
- It is technique that enables chemical characterization of the material.

1.S_1 Sample EDS Image:

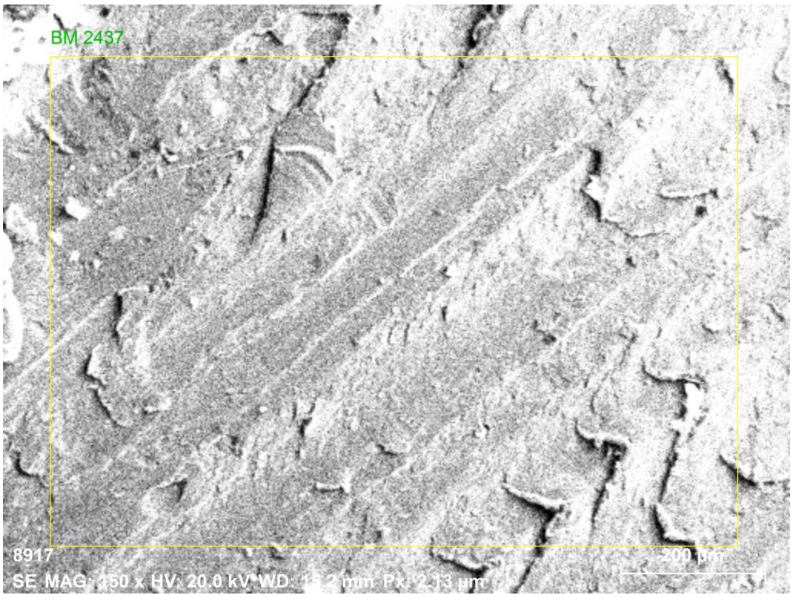
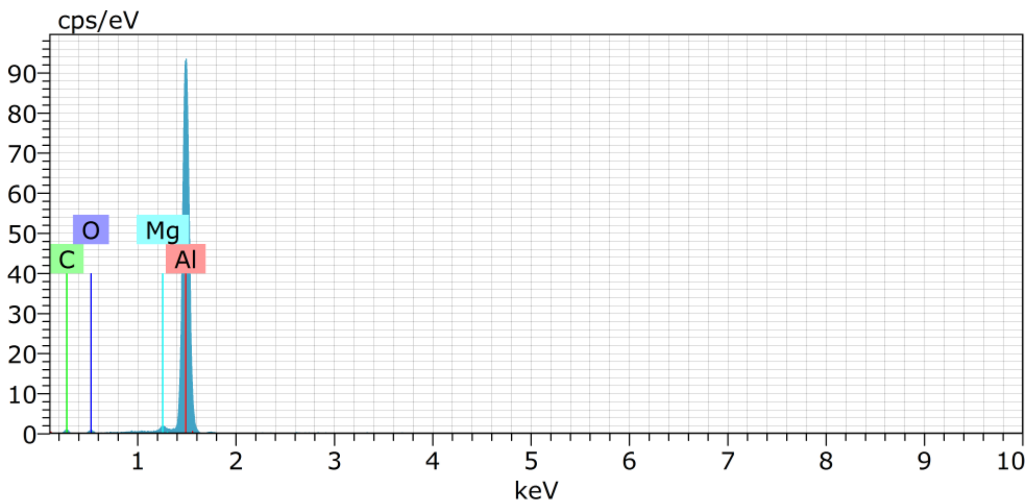


Fig:43 EDS Image of S_1 Sample

S_1 Sample composition in EDS:



El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
Al	13	K-series	99.18	77.69	62.43	4.77
C	6	K-series	22.26	17.44	31.48	4.67
O	8	K-series	4.82	3.78	5.12	1.10

Mg	12	K-series	1.39	1.09	0.97	0.11
		Total:	127.65	100.00	100.00	

2.S_2 Sample EDS Image:

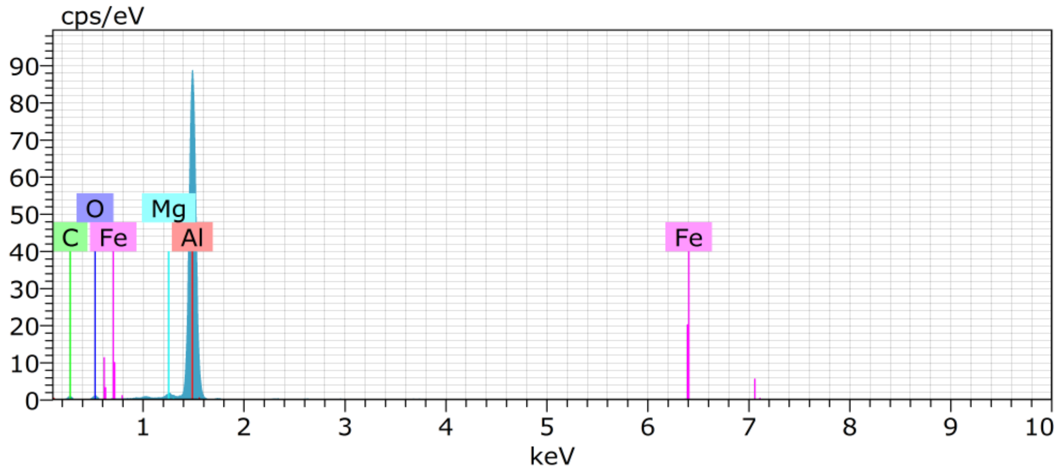


Fig:44 EDS Image of S_2 Sample

S_2 Sample composition in EDS:

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
Al	13	K-series	86.74	75.88	61.01	4.17
C	6	K-series	19.08	16.69	30.15	4.01
O	8	K-series	6.47	5.66	7.67	1.31
Mg	12	K-series	1.10	0.96	0.86	0.09
Fe	26	K-series	0.93	0.82	0.32	0.07
		Total:	114.31	100.00	0	

3.S_3 Sample EDS Image:

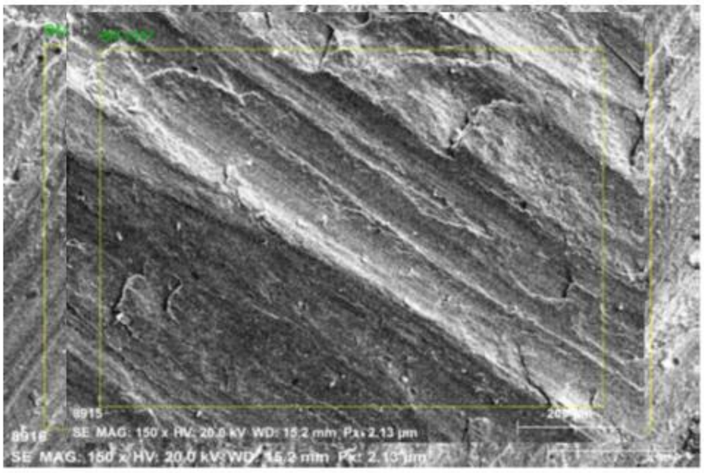
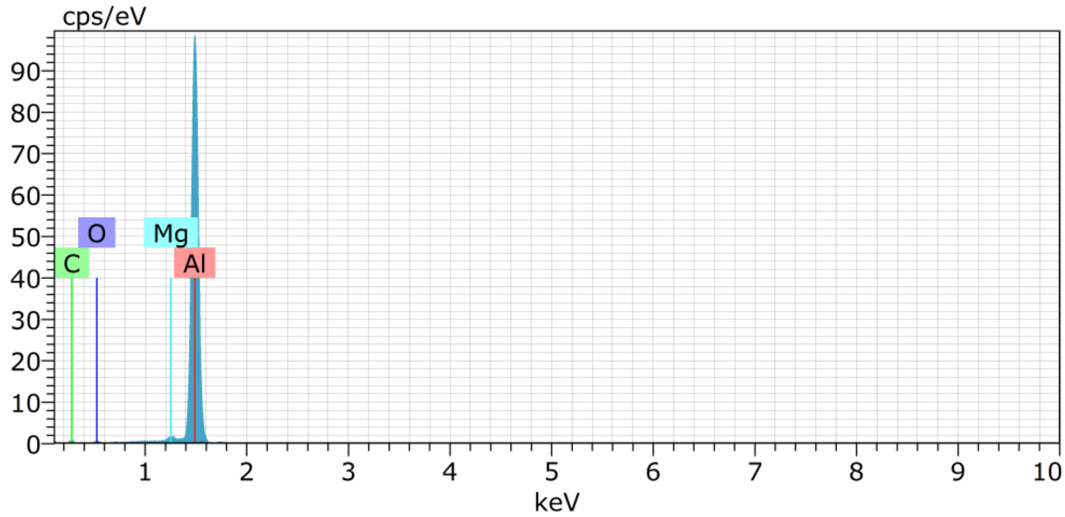
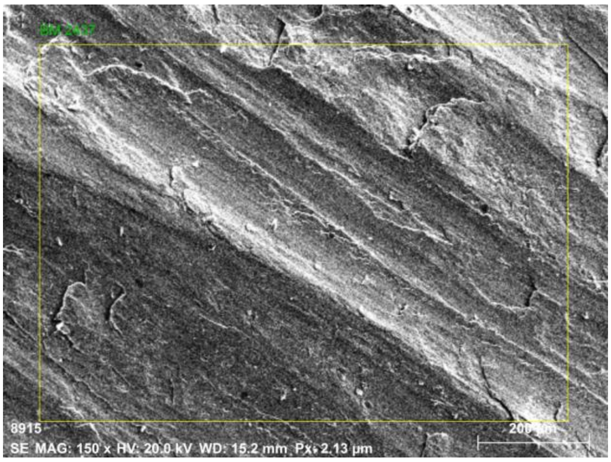


Fig:45 EDS Image of S_3 Sample

S_3 Sample composition in EDS:





El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
Al	13	K-series	82.29	82.72	69.52	3.96
C	6	K-series	13.58	13.65	25.78	3.14
O	8	K-series	2.74	2.75	3.90	0.70
Mg	12	K-series	0.87	0.87	0.81	0.08
		Total:	99.48	100.00	0	

VII. CONCLUSION

In this project Aluminum hybrid metal matrix composite is used in the automobile industry to manufacture brake drum and disc drum in which aluminum hybrid metal matrix composite material is used because aluminum has good mechanical and chemical properties as well as life of the material is also so long compare to the other material. In these material also continuously usage of material leads to reduce the hardness and wear rate of material drastically. To avoid the problem in order to increase the hardness and wear of the material adding the reinforcement material such as Titanium carbide which provide higher hardness than other reinforcement and Molybdenum disulfide provide lower wear rate comparative to other reinforcements and the material is to be casted in the way such that by optimizing technique materials are casted varying proportion as well to test in Rockwell hardness machine for hardness and wear rate can be calculated by applying high temperature and SEM analysis is used to infer the wear on other ways EDS technology is also used to read the composition of the material added to it and increase the strength as well as life of the material also increases and casting the material by varying the percentage of the reinforcement material .

7.1 FUTURE SCOPE:

Optimizing technique by varying the percentage of the reinforcement to increase hardness and weariness also increases as well as life of the component also increases and these material is implemented in the place where there is need of high hardness and wear resistance material also life of material not reduces by adding Tic and Mos2 are used for application of the material.

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