TRIBOLOGICAL INVESTIGATION OF 8090 Al ALLOY METAL MATRIX COMPOSITE

A. Kalaiyarasan[1], S. Sundaram[2]

[1]Research Scholar, Department of Mechanical Engineering, Muthayammal Engineering College (Autonomous), Rasipuram, Namakkal, Tamilnadu, India. E-mail Id: kalaianbutamil@gmail.com
[2] Professor, Department of Mechanical Engineering, Muthayammal Engineering College (Autonomous), Rasipuram, Namakkal, Tamilnadu, India. Email Id: Sundaram1160@gmail.com

Abstract

Aluminum Alloy composites are used in engineering applications such as aircraft, aerospace, automobiles and various other fields due to having excellent mechanical properties such as high strength, high stiffness, high load to weight ratio and better wear resistance. In the automobile sector the components like brake drum, cylinder, cylinder liners, pistons, piston insert rings are manufactured by aluminum composites where dry sliding wear is a predominant process. In this examination, Aluminum Metal Matrix Composite was set up by fortifying disposed of waste particles like wet processor stone residue particles and waste tonner. Dry sliding wear test was led utilizing Pin-on-Disk wear testing contraption for the various blends of wear boundaries like burdens, sliding velocity and sliding separation. The sliding separation was the hugest boundary affecting the wear rate followed by applied burden, sliding velocity and level of fortification material separately.

Key words: *Aluminum metal matrix composites, boron carbide, stir casting, dry sliding wear test, al2o3..*

1. INTRODUCTION

The advancement of composite materials has turn into a defining moment in the historical backdrop of science and innovation as it allows the synergizing of clear properties of its fixings, namely the reinforcement phase and the bulk matrix phase and suppresses the deficiencies of each of them. The composite materials in light of metals and their alloys which are termed as metal matrix composites (MMCs) [1]. aluminum alloys are the most widely used because of their outstanding properties such as light weight, high strength, high modulus, low coefficient of thermal expansion and good wear resistance. Depending on final desired properties of composites, different reinforcement is used in aluminum matrix composites [2]. Aluminum is the most profuse material in the earth's crust. Aluminum alloys are light-weight, have relatively high strength, retain good ductility at subzero temperatures, have high resistance to corrosion, and are non-toxic. They have a melting range between 482^0 C and 660^0 C, depending upon the alloy [3]. Hard ceramic particulate reinforced AMCs are being proved as potential engineering materials for critical applications which demand light weights materials with highly wear resistant property, such as connecting rods, pistons, brake drums and cylinder liners etc. Presence of hard particles in the

AMCs protects them from severe wear conditions and results lesser wear and lower friction coefficient than those of their monolithic alloys [4]. In many applications which demand light weight and energy efficient materials, such as machine parts in automobiles, aluminum alloys are desirable due to their low density. However, their applications have been often restricted because of their extremely poor wear resistance. The development of improved wear resistant aluminum-based matrix composites is receiving considerable attention [5]. Composite materials are significant building materials because of their extraordinary mechanical properties. Composites are materials in which the alluring properties of independent materials are consolidated by precisely or metallurgical restricting them together. Every one of the segments holds its structure and trademark, yet the composite by and large has better properties. Composite materials offer superior properties to conventional alloys for various applications as they have high stiffness, strength and wear resistance [6]. Particle reinforced hybrid composite contains with low density and a low-cost reinforcement is an increasing demand for automotive and aerospace industries. Components with low density material has ultimately reduces the weight of the component. Less weight of component results with improved performance of the vehicle [7]. Aluminum metal matrix composites (AMMC) has gained more care as engineering materials because of their developed specific strength, stiffness and in addition to their better wear resistance associated to unreinforced aluminum alloys. Preparation of MMCs chiefly dependents upon the type of reinforcement and matrix materials. AMMCs are for the most part utilized in protection, aerospace, sports and in industries because of many desirable properties like higher stiffness, higher strength, thermal conductivity and combined properties like wear resistance, fracture toughness and corrosion resistance [8]. In recent days, the aluminum metal matrix composites have become the most eligible candidate in the field of structural applications because of their excellent wear resistance and strength. The processing of these materials was successfully carried out using stir casting technique which is most widely used due to its capability of producing large and complex shape castings [9]. Metal Matrix Composites (MMCs) have several advantages over monolithic alloys. Aluminum alloy matrix composites reinforced with hard ceramic particles shows better mechanical properties such as specific strength, specific modulus and increase in wear resistance than unreinforced aluminum alloy [10]. In this investigation we have followed liquid stir casting method to reduce the cost. It involves the incorporation of dispersed phase into a molten metal matrix, followed by its solidification. These aluminum matrix composites are drawing more attention in aviation, aerospace, automobiles and many structural applications due to their good wear resistance with the extraordinary hardness[11].Boron carbide B_4C is one of the most favorable ceramic materials due to its high strength, low density 2.52 g/cm3 , high hardness and good chemical stability [12].

2. MATERIAL SELECTION

2.1. Aluminum alloy series (8090)

Aluminum alloy 8090, metal matrix composite materials which is the main construction material for the production of air-to-air heat exchanger fins its having water wettability, surface roughness and frost formation in different psychometric parameters. Aluminum alloys are the predominant materials in modern industries. Expanded information about the surface qualities of uncovered aluminum can upgrade the comprehension about how to enhance the functioning conditions for the hardware including aluminum parts. This work focusses on the properties of local surface of aluminum composite 8090, which is the principle development material for the creation of aerial warmth exchanger balances. In this investigation, we address its water wettability, surface harshness and ice arrangement in various psychometric boundaries.

Table 1. Mechanical properties of Material.[13][14]

Material	Density (g/cm^3)	Young's modulus (Gpa)	Poisson ratio
Stainless steel 316L.	8000	193	0.30
Aluminum alloy 8090	2.54	77	0.30
Boron Carbide	2.52	362	0.21
Aluminum Oxide	3.95	215	0.30

2.2. Boron Carbide (B_4C)

The Boron Carbide is one of toughest materials known, ranking third behind shape and cubic boron nitride. It is the hardest material produced in tonnage amounts. Hot-squeezed boron carbide is perhaps the hardest material accessible in business shapes, and gives exceptional protection from rough wear.

2.3. Aluminum Oxide (Al_2O_3)

Because of its incredible mechanical, compound and warm characteristics, alumina stands apart from numerous practically identical materials by conveying equivalent or better answers for ease creation and assembling. Aluminum oxide is a hard material, nearly to the degree of jewels, so it has phenomenal wear obstruction properties. It has high consumption continuance and high temperature strength, low warm extension and a great solidness to-weight proportion. Since aluminum oxide has a brilliant electrical resistor, it is regularly utilized in capacitors as the dielectric, the part keeping charges in the gadget isolated.

3. EXPERIMENTAL PROCEDURE

3.1. Stir Casting

The composite materials were fabrication by using Stir casting is a liquid state technique, in which a dispersed phase (ceramic or reinforcement particles, short fibers) is mixed with a melted metal matrix by means of mechanical stirring. Stir casting is the simplest technique and the most cost-effective technique of liquid stat fabrication. The composite material is a liquid state then cast by the conversional casting tactics and may also be processed by conversional metal forming machineries liquid stat fabrication of metal matrix composite involves integration of single phase into a melted matrix metal, followed by its solidification.

Figure 1: Stir Casting Machine and Pre heating Setup

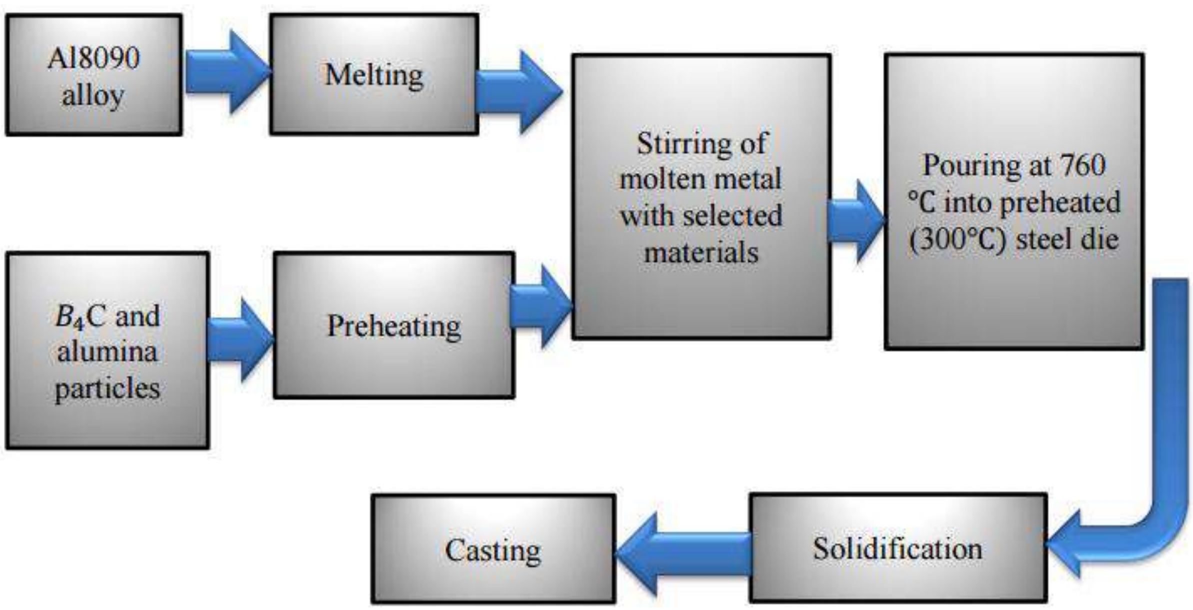


Figure 2: Synthesis of composite

The stir casting methods used to fabricate the process of synthesis of composite materials with a homogeneous materials or monolithic materials. The stirring of molten or melted metal with selected materials after pouring at 760^0C into preheated at 300^0C of steel die with solidification to casting the suitable or selected materials or matrix.

3.2. Pin on Disc

Wear is a method of removal of composite material from one or both of two solid surfaces in solid state contact. As the wear is a surface removal singularity and happens mostly at outer surfaces, it is more suitable and economical to make surface alteration of existing alloys than using the wear resistant alloys. Wear is connected to interactions between surfaces more specifically the removal and total deformation of material on a surface as a result of mechanical actions of the reverse surface. Wear test was carried in Pin on disc for ASTM G99 standard with the samples.

Table 2: Wear test setup standard Parameters on ASTM G99

PARAMETERS	VALUE
Track diameter	*100mm*
Room Temperature	*28 C*
Applied load	*10N,20N,30N*
RPM	*750rpm*
Sliding velocity	*3.14,3.76,4.39m/s*

Figure 3: Pin on Disc Setup Machine

3.3. Scanning Electron Microscope

The SEM study of the post mechanical tests was carried out to study the worn-out surfaces under the applied different loads. The fractured test pieces were examined with the help of a Scanning Electron Microscope (JSM-6480LV). The fractured surfaces were calculated for modes of fracture, the failure of the Interface, failure of the matrix, failure of the reinforcement etc.,

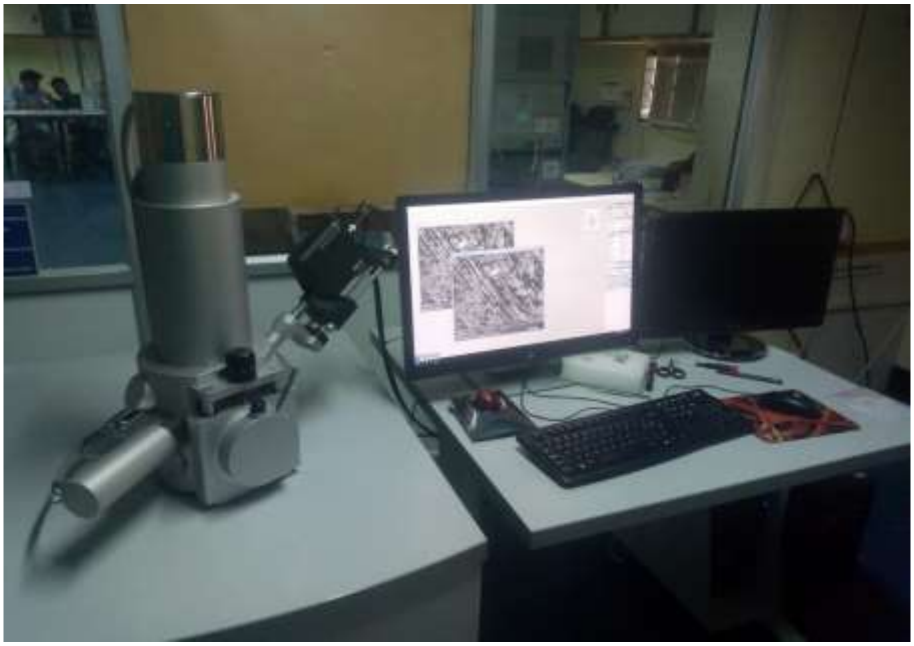


Figure 4: Scanning Electron Microscope setup

4. RESULTS AND DISCUSSION

In this chapter presents the mechanical properties of the Al8090 and Al_2O_3 and B_4C composites material prepared for this present investigation. Details of processing of these composites and the tests shown on them have been described in the previous chapter. The results of various description tests are reported here. This includes evaluation of wear and SEM analysis has been studied and discussed. The understanding of the results and the comparison among various composite samples are also presented.

4.1. Wear Test

The most common tests performed on metal contain the wear properties i.e. wear loss and wear rate. Uniform dispersal of the particles is a pre-requisite to improve the tribological properties of the matrix. This test provides a sensibly good baseline for a metal sample assuming that it is large enough to do tests, is uniform in composition, and is uniform in wear resistances.

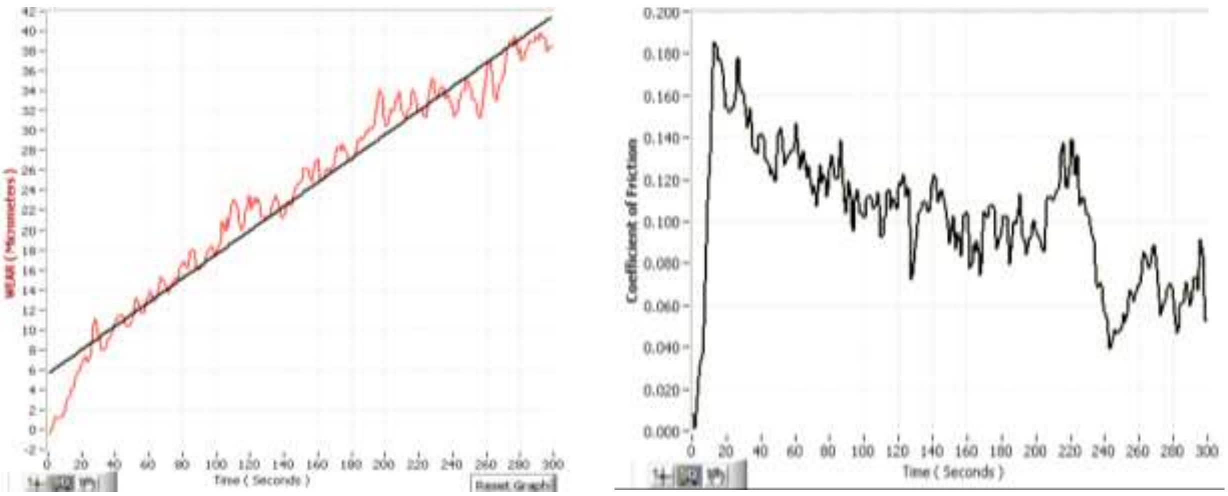


Figure 5: Load 10N, Speed 750 RPM, Track diameter 100mm.

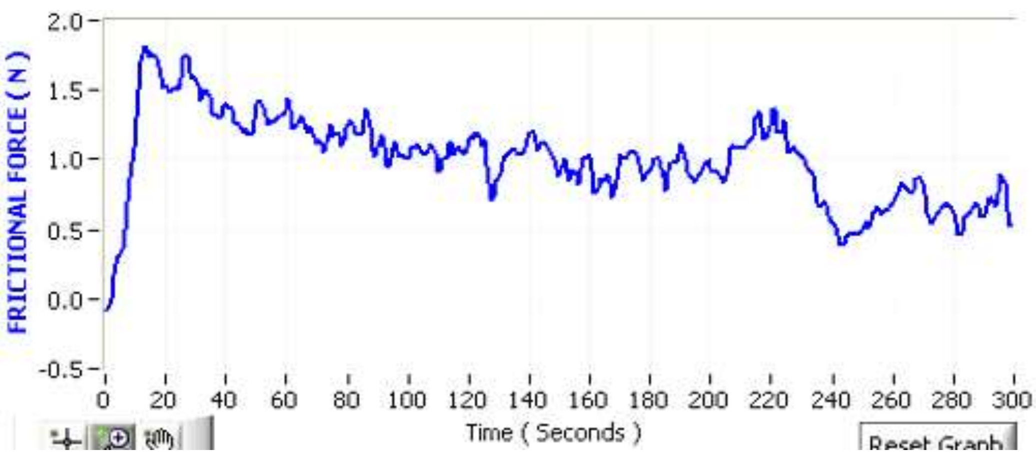
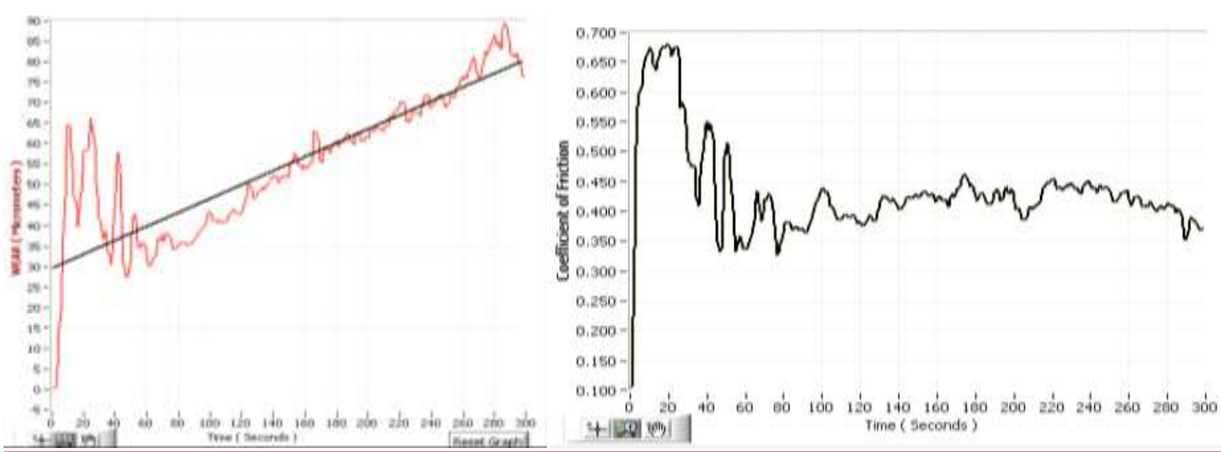


Figure 6: Load 20N, RPM 750, Track diameter 100.



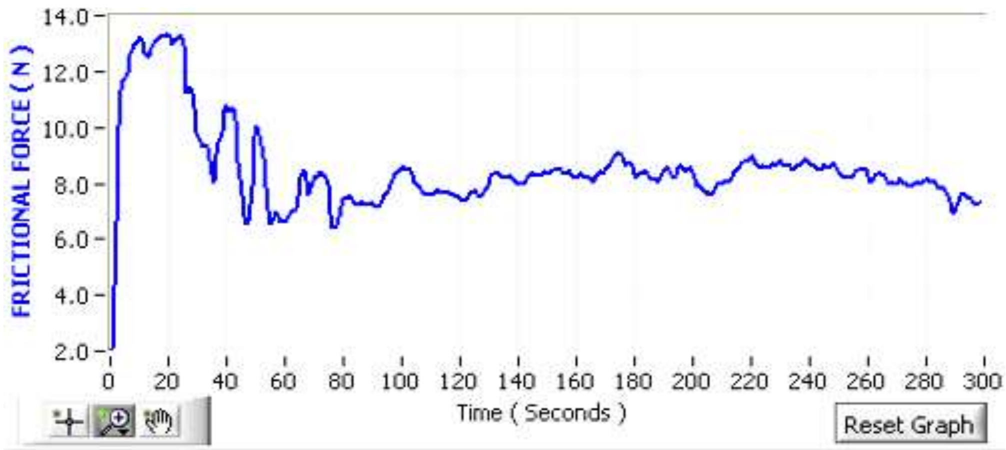


Figure 7: Load 30N, Speed 750 RPM, Track diameter 100mm.

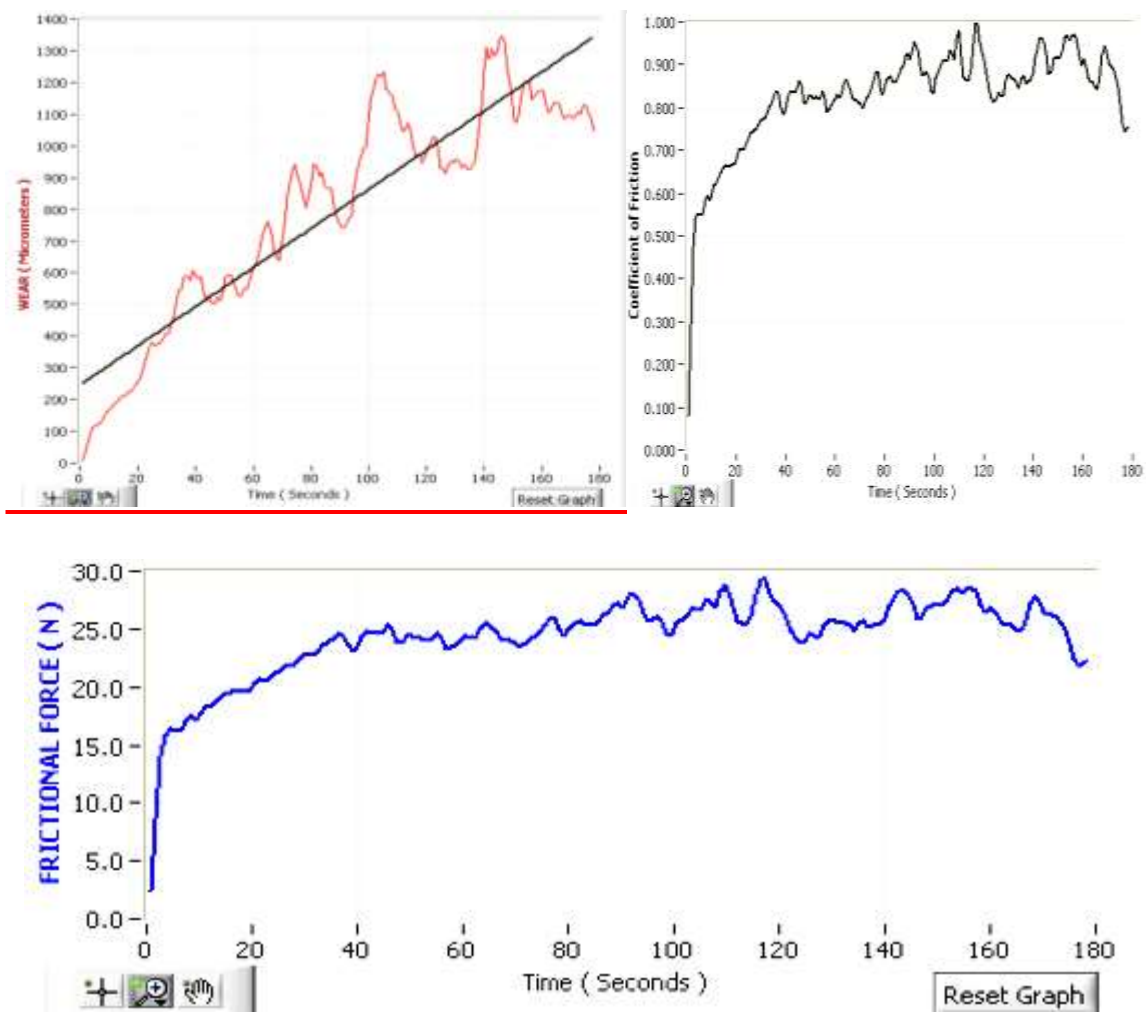
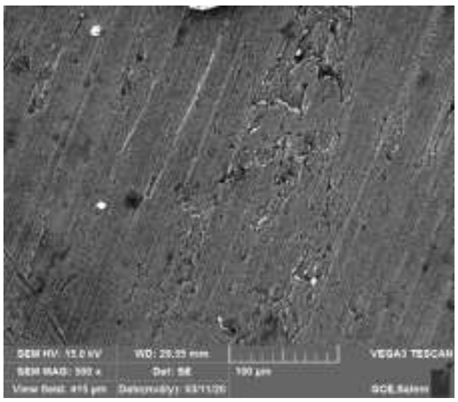


Figure 8: Load 40N, Speed 750 RPM, Track diameter 100mm

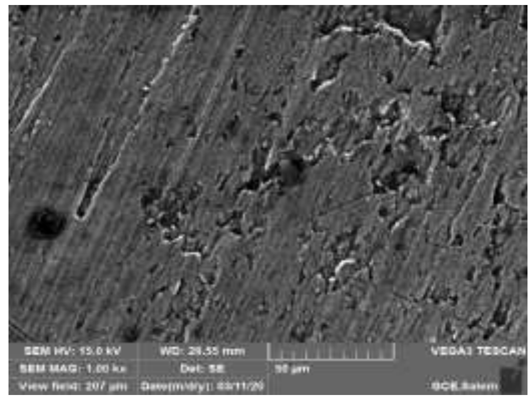
4.2. SEM Image

The scanning electron microscope used to combination of metal matrix and reinforcement composite materials with the homogeneous materials. The different specimen test has taken the micron level of combination materials like matrix and reinforcement materials (see figure 9. As shown in below).

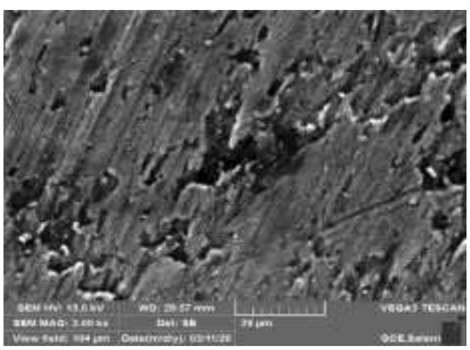
Specimen 1:



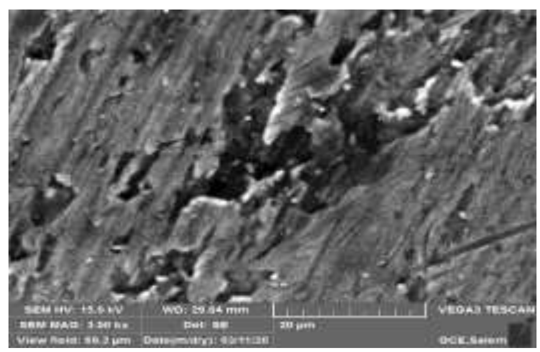
a) Specimen 1 at 500x



b) Specimen 1 at 1000x

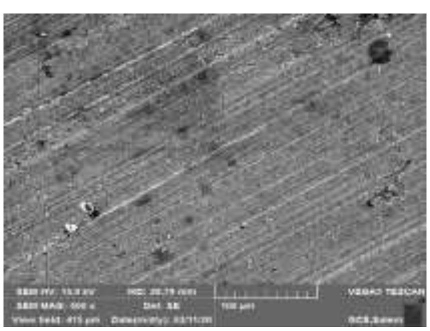


c) Specimen 1 at 2000x

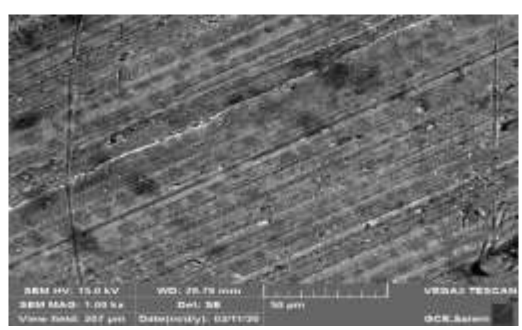


d) Specimen 1 at 3000x

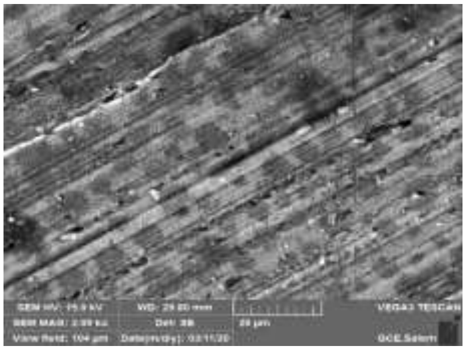
Specimen 2



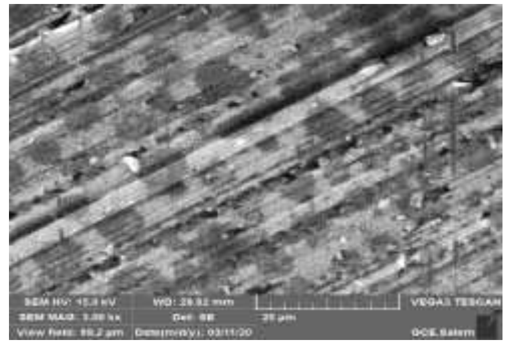
a) Specimen 2 at 500x



b) Specimen 2 at 1000x

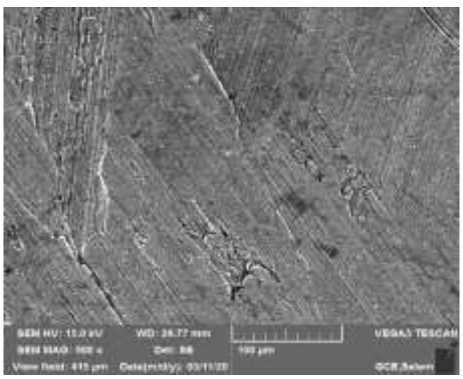


c)Specimen 2 at 2000x

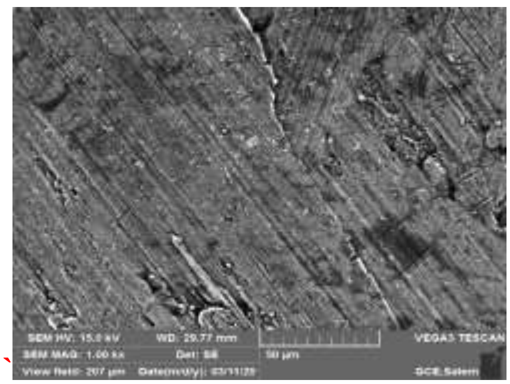


d) Specimen 2 at 3000x

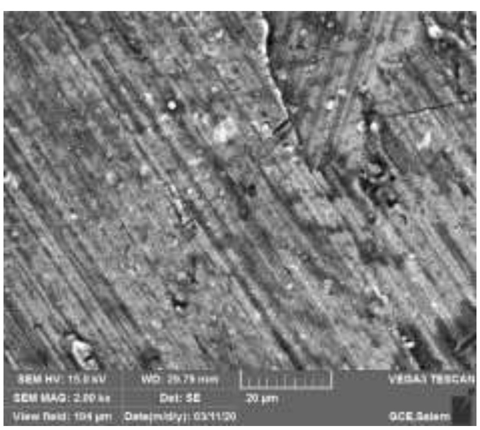
Specimen 3:



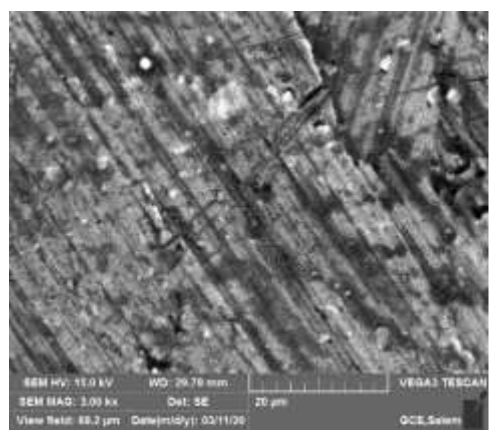
a) Specimen 3 at 500x



b) Specimen 3 at 1000x



c)Specimen 3 at 2000x



d) Specimen 3 at 3000x

Figure 9. SEM Image of different Combination of reinforcement materials

5. CONCLUSION

The uniform distribution and refinement of reinforcement media helps to attain better wear resistance in surface composites. The best material of boron carbide and aluminum dioxide materials are used for automotive parts and other different applications. The reversal of direction of processing passes further increases the uniformity of distribution of reinforcement media. This certainly can be preferred, as in terms of fabrication, reversal of direction of processing passes is absolutely easy and frugal. Surface composites can make mechanical components lighter without compromising on function and eventually contribute to energy savings and allied benefits, which apparently is welcome in today's world.

Acknowledgments

The authors of the paper like to acknowledge the Principal, Dean (TL), HOD, Staff members of Department of Mechanical Engineering in Muthayammal Engineering College (Autonomous) Rasipuram for their support and valuable suggestion in preparing the present paper.

Reference:

[1] Vicky Kumar, Jitendra Kumar, Sunil Kumar, Sandeep – "Wear behavior of Aluminum Metal Matrix Composite Reinforced with Sic", International Research Journal of Engineering and Technology- Volume: 03 Issue (2016)573-577.

[2] Manjunatha A, Dr. P. Sampath Kumaran, Dr. H B Niranjan, Dr. Prashanth Banakar, Basavarajappa V N- "Study of Wear Properties on Aluminum alloy Composite Reinforced with Graphene", International Journal for Research in Applied Science & Engineering Technology - Volume 6 Issue III (2018) 447-452.

[3] K. Vijaya Bhaskara, S. Sundararajan, B. Subba Rao, K. Ravindrad – "Effect of Reinforcement and Wear Parameters on Dry Sliding Wear of Aluminum Composites", Materials Today: Proceedings 5 (2018) 5891–5900.

[4] Diptikanta Dasa, Swati Pattanaika, Bharat Chandra Routaraa, Purna Chandra Mishraa and Chandrika Samalb – "Dry sliding wear behavior of Sic reinforced Zn-Mg-Cu based aluminum matrix composite", Materials Today: Proceedings 4 (2017) 2965–2974.

[5] T.S.A. Suryakumari, S. Ranganathan – "Preparation and Study the Wear Behavior of Aluminum Hybrid Composite", Materials Today: Proceedings 5 (2018) 8104–8111.

[6] Ramesh B, Dr. Arun Kumar M, Dr. R. P. Swamy – "Dry sliding wear test conducted on pin-on-disk testing setup for Al6061-SiC metal matrix composites fabricated by powder metallurgy" -- International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 6, (2015)264-270.

[7] Anandha Moorthy Appusamy, Prakash Eswaran, Madheswaran Subramaniyan – "Investigation on Dry Sliding Wear Behavior of Self-Lubricating Metal Matrix Composites Reinforced with Fly ash and Solid Lubricant"- International Journal of Recent Technology and Engineering - Volume-7 Issue-4S, (2018)413-416.

[8] L. Francis Xavier, P. Suresh – "Studies on Dry Sliding Wear Behavior of Aluminum Metal Matrix Composite Prepared from Discarded Waste Particles"- International Journal of Advanced Engineering Technology Vol. VII-Issue (2016)539-543.

[9] K V Sreenivas Rao, Ga S Shivashankar, b Sanman S, Vineeth Kumar T V – "Effect of Standoff Distance on Solid Particle Erosion Wear Behavior of Chill Cast Aluminum - Boron Carbide Composites"- Materials Today: Proceedings 4 (2017) 10015–10019.
[10] V.M. Ravindranath, G.S. Shiva Shankar, S. Basavarajappa, Siddesh Kumar N.G – "Dry sliding Wear Behavior of Hybrid aluminum Metal Matrix composite reinforced with Boron carbide and graphite particles"- Materials Today: Proceedings 4 (2017) 11163–1116.
[11] C. Karthikkumar, R. Baranirajan, I. Premnauth, P. Manimaran – "Investigations on Mechanical properties of AL 8011 reinforced with micro B4C / Red Mud by Stir Casting Method"- International Journal of Engineering Research and General Science Volume 4, Issue 2 (2016)405-412
[12] S. Magibalan, P. Senthil Kumar, A.V. Balan, N. Shivasankaran, S.P. Sankar, M. Prabu, S. Saravanan – "Wear loss of stir cast aluminum alloy 8011"- Materials Today: Proceedings 4 (2019).
[13] A Kalaiyarasan, K Sankar, S Sundaram, "Finite element analysis and modeling of fractured femur bone" Materials Today: Proceedings (2020). Volume 22, Part 3, 2020, Pages 649-653
[14] Kalaiyarasan A, Sakthivel k, Santhosh M, Subaash R, Rajkumar S, "Experimental Behavior & Analysis of Connecting Rod Metal Matrix (8090-B4c) Composite" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 14, Issue 2 Ver. IV (Mar. - Apr. 2017), PP 123-129