ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.05 pp 371-382, 2016

Microstructure Observation and Analysis on Hybrid Composite of Basalt Fiber with Titanium Oxide, Barium Sulphate and Silicon Carbide

T. Narendiranath Babu*

School of Mechanical Engineering, VIT University, Vellore, India

Abstract : Modern microscopes are widely used in scanning a microscopically sharp probe across surfaces. Microscopes can be used not only for imaging in two or three dimensions, but for measurement of physical and chemical properties by diffraction, spectroscopy and other specialized methods. This paper briefly describes the microscope technique used to investigate fibre structure, including an overview of fibre identification. Today a significant growth is observed in the manufacturing of composite materials. Intensively developed polymer composite materials (PCM) are used in different sectors of industry and technology. They are successfully replacing traditional construction materials and also permit the conditions that exclude use of metals. By industrial production of basalt fibers on the basis of new technologies their cost is equal and even less than cost of glass fiber, moreover basalt fibers and materials on their basis have the most preferable parameter, a ratio of quality and the price in comparison with glass & carbon fibers, and other types of fibers. Though Basalt fiber has good wear resistance still increasing the wear resistance, decreasing friction coefficient, and increasing the hardness also gives more applications to basalt fiber like car brakes, interior decorations, car headliner, etc. more over increase in basalt fiber's tensile strength will give more applications to basalt fiber like bridges, underground tunnels, etc. From the results, it can be concluded that adding titanium oxide, silicon carbide and barium sulphate to the fiber matrix shows the increase in the above said properties, thus the above said mixture are added to the basalt fiber. The wear testing was conducted on the Pin on disc machine to predict the performance of material.
Keywords : Basalt fiber, microstructure analysis, wear behavior, pin on disc machine, wear resistance.

1. Introduction

Hybridization is a commonly used procedure to obtain properties, which are intermediate between the two originating materials. Dealing with polymer composites, hybridization may result in a compromise between mechanical properties and cost to meet specified design requirements, as one of the reinforcements is usually cheaper than the other one. A number of studies have been performed recently, which suggest that mechanical properties can be possibly tailored using hybridization based on glass or basalt fiber laminates and including other natural (aiming at a more sustainable material) or synthetic fibers. In particular, with respect to plant fibers, which equally show thermal and acoustic insulation properties, the higher specific weight of basalt fibers (around2700 kg/m 3) is widely compensated by their higher modulus, excellent heat resistance, good resistance to chemical attack and low water absorption. This suggests that hybrid laminates, based on basalt fibers and plant fibers, and/or glass–plant fiber hybrid laminates, the latter being particularly studied when it comes to the need for sufficient impact resistance, may have some interest. This would possibly result in a more sustainable end-of-life scenario without substantially affecting the structural performance of the laminates.

As a matter of fact, hybridization of basalt fibers has been attempted with ceramic fibers, to provide improved hot wear resistance to friction materials, with high tensile strength fibers, such as carbon and aramid, and with glass fibers. In these cases, basalt provided an impact and environmental resistance superior to that provided by the corresponding hybrids with glass fibers, coupled with a substantial reduction in costs, with respect to carbon and aramid fiber composites. In the case of basalt/Nylon fibers hybrid laminates, low tensile modulus of Nylon is improved by adding basalt fibers, whilst Nylon provides conversely a higher impact resistance. Also basalt hybridization with glass fibers has been attempted, which is based on the use of two fibers, which are chemically not very different: continuo us basalt fiber has a not very different con- tent in silica and alumina from glass fibers and also a comparable, if not superior, tensile strength[1].

Though Basalt fibers tensile strength is higher than other fibers but still increase in basalt fiber's tensile strength will give more applications to basalt fiber like post-earthquake strengthening, bridges, underground tunnels etc. Moreover reducing the wear resistance, friction coefficient, and increasing the hardness also gives more applications to basalt fiber. Thus to increase its tensile strength we are adding Titanium oxide and Aluminium oxide to basalt fiber in proportion of 5% weight[3]. We are also adding Barium sulphate to basalt fiber in 5wt%, we are also adding Silicon carbide in 5wt% to increase the hardness[2] and we are also adding 2wt% of graphite to reduce coefficient of friction[4].

Basalt originates from volcanic magma and flood volcanoes, a very hot fluid or semifluid material under the earth's crust, solidified in the open air. Basalt is a common term used for a variety of volcanic rocks, which are gray, dark in colour, formed from the molten lava after solidification. Basalt rock-beds with a thickness of as high as 200 m have been found in the East Asian countries. Russia has unlimited basalt reserves. There are large deposits of these rocks in the Ural, Kam, chatka, Far East, Sakhalin, Kola Peninsula, Northwest Siberia, and the Transcaucasia. Basalt fiber is a material made from extremely fine fibers of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine. Plagioclase is an important series of minerals within the feldspar family. The pyroxenes are a group of important rock-forming inosilicate minerals found in many igneous and metamorphic rocks. In silicates (from Greek, fiber), or chain silicates, have interlocking chains of silicate tetrahedra with either SiO3, 1:3 ratio, for single chains or Si4O11, 4:11 ratio, for double chains. Igneous rock is formed through the cooling and solidification of magma or lava.

Metamorphic rock is the result of the transformation of an existing rock type, the protolith, in a process called metamorphism, which means "change in form". The mineral olivine is a magnesium iron silicate with the formula (Mg,Fe)2SiO4. The mineral levels and chemical makeup of basalt formations can differ significantly from location to location. Moreover, the rate of cooling, when the original flow reached the earth's surface, also influenced the crystal structure. Its ready availability from mines and open-air quarries around the world, only a few dozen locations contain basalt that has been analyzed and qualified as suitable for manufacture of continuous thin filaments. Basalt formations in the Ukraine are particularly well suited to fiber processing.

Basalt Rock fibers have no toxic reaction with air or water, are non-combustible and explosion proof. When in contact with other chemicals they produce no chemical reactions that may damage health or the environment. It has good hardness and thermal properties, can have various application as construction materials. Basalt is a major replacement to the asbestos, which poses health hazards by damaging respiratory systems. Basalt base composites can replace steel (1 kg of basalt reinforces equals 9.6 kg of steel) as light weight concrete can be get from basalt fiber. As it is made of basalt rock is really cheap and has several excellent properties[5-7].The major advantages of Basalt fiber are

- 20-25% higher tensile strength than E-glass [8]
- 10-15 % higher tensile modulus than E-glass [9]
- Better chemical resistance than regular E-glass
- Extended temperature range up to 580°C
- Environmental friendliness and easy recycling/disposal of basalt-fiber-reinforced plastics (BFRP) compared to GFRP [10]

The main objective of the paper is to increase the tensile strength, hardness, wear resistance and decrease friction coefficient. Thus it will be used in many applications like post-earthquake strengthening, bridges, underground tunnels etc. Moreover basalt fiber is cheap when compared to glass fibers, thus if this purpose is satisfied this can bring a new revolution in the composites. The main purpose of the paper is to produce a composite with basalt fiber as the core material and adding other materials like aluminium oxide ,titanium oxide, Barium sulphate, silicon carbide and graphite to form a composite which has more tensile strength than basalt fiber, higher wear resistance than basalt fiber, lower coefficient of friction and higher hardness.

2. Experimental

Fabrication Process

1. The major component of basaltfiber is Epoxy LY556 (Resin).
2. Hardener HY951 is used for hardening and support.
3. Resin + Hardener are mixed in the ratio of 10:1 and the mixture made up is called
4. MATRIX.
5. Tool is prepared by standard method.
6. Apply the matrix on glass cloth which is wrapped around the mandrel.
7. Ensure proper weighing is done.
8. Clamp the tool die for 2 hrs at ambient temperature condition.
9. The sample is then furnace heated at 100celcius for 2 hrs for hardening.
10. Take out and cool the specimen until room temp. is achieved.
11. Flash is removed from the sample.
12. Demoulding i.e. clamp is removed from the specimen.
13. Cut to appropriate dimension as per experimental needs
14. Emery paper of grade 60 is used to provide necessary surface finish.

The Figure1, Figure 2 and Figure 3 shows the basaltfiber, mould cavity and hot air oven for preparing specimen.

Figure 1.Basalt Fiber

Figure 2.Mould Cavity

Figure 3. Hot Air Oven

3. Experimental Setup

This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disc test rig shown in Figure 4. Materials are tested in pairs under nominally non-abrasive conditions. A pin on discis an instrument that measures tribological quantity, such wear behaviour, between two surfaces in contact. Table 1 shows test rig parameters.

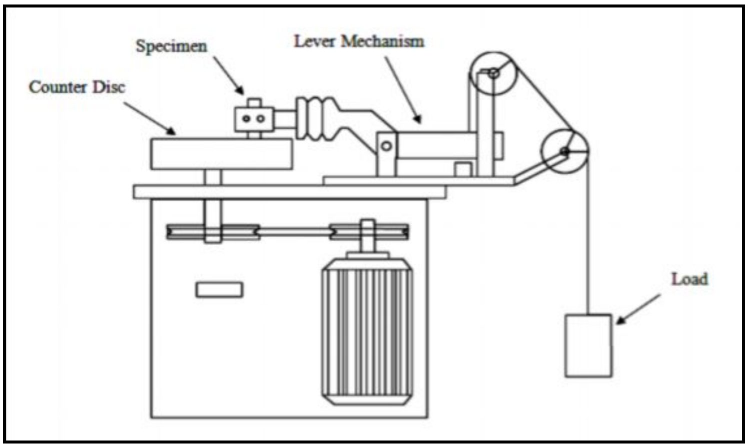


Figure 4. Pin-on-Disc Test Rig

Table 1 Test Rig Parameters

S.No	Description	Details
1	Speed	Min 200 rpm, max 2000 rpm
2	Normal Load	200N max
3	Frictional Force	200N max
4	Wear	± 2mm
5	Wear Track Diameter	Min 50mm, max 100mm
6	Sliding Speed	Min 0.3m/sec, max 10m/sec
7	Preset Timer	99/59/59 hr/min/sec
8	Specification Size (Pin)	Ø3,4,5,6,8,10 & 12mm
9	Wear Disc Size	Dia 165mm X 8mm Thick, EN-31 Hardened To 60hrc, Ground To Surface Roughness 1.6Ra
10	Environmental Chamber	This chamber prevents oil spillage and collects debris after test
11	Software	Winducom 2010
12	Software Interface	Comport

3.1 Procedure

A pin-on-disc test setup was used for slide wear experiments. The surface of the sample (5mm X 5 mm) glued to a pin of dimensions 10 mm diameter and 30 mm length comes incontact with a hardened disc of hardness 60 HRC. The counter surface disc was made of En31 steel having dimensions of 165 mm diameter, 8 mm thick and surface roughness (Ra) of1.6 µm. The test was conducted on a track of 115 mm diameter for a specified test duration,load and velocity. Prior to testing, the test samples were rubbed against a 600-grade SiCpaper. The surfaces of both the sample and the disc were cleaned with a soft paper soaked inacetone before the test. The pin assembly was initially weighed using a digital electronicbalance (0.1 mg accuracy). The test was carried out by applying normal load at different sliding velocities. At the end of the test, the pin assembly was again weighed in the same balance. A minimumof three trials was conducted to ensure repeatability of test data. The friction force at thesliding interface of the specimen was measured at an interval of 5 minutes using a frictionalload cell. The coefficient of friction was obtained by dividing the frictional force by theapplied normal force.The aim in the first group is to investigate the effect ofload and velocity on tribologicalbehaviours. The bearing velocities are kept in between 2.5-3 m/s and the bearing loading upto9 kgf.

4. Results and Discussion

The main objective of the paper is to increase the tensile strength, increase the hardness, increase the wear resistance and decrease the friction co efficient. Thus from the literature survey, a suitable solution has been proposed. The following materials are added to the basalt fiber,

- Titanium oxide
- Barium Sulphate
- Silicon carbide
- Graphite

The above given materials are added to the Basalt fiber in the given weight proportion. The figure 5 shows wear test specimen.

4.1 Specimen composition

Different samples prepared are :

- Sample 1
  - Basalt fiber – 40%
  - Epoxy Resin – 60%
- Sample 2
  - Basalt fiber – 23%
  - Titanium oxide – 5%
  - Silicon carbide – 5%
  - Barium sulphate – 5%
  - Graphite – 2%
  - Epoxy Resin – 60%
- Sample 3
  - Basalt fiber – 50%
  - Epoxy Resin – 50%
- Sample 4
  - Basalt fiber – 33%
  - Titanium oxide – 5%

- Silicon carbide – 5%
- Barium sulphate – 5%
- Graphite – 2%
- Epoxy Resin – 50%

• Sample 5

- Basalt fiber – 50%
- Aluminum oxide – 5%
- Titanium oxide – 5%
- Silicon oxide – 5%
- Epoxy resin – 35%

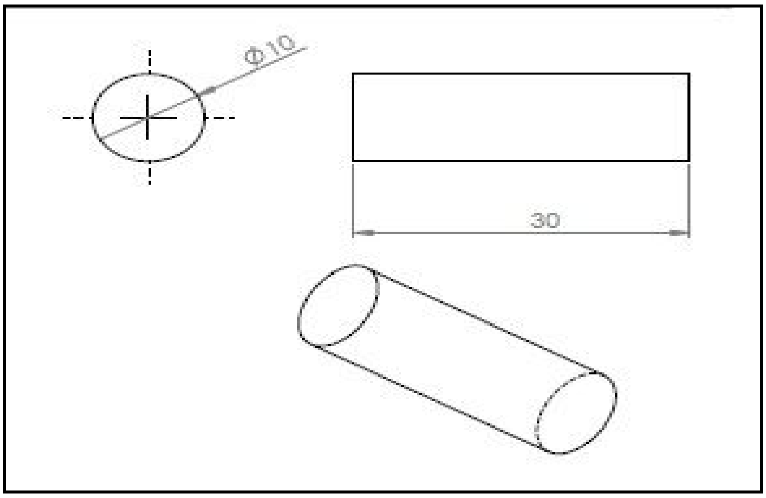


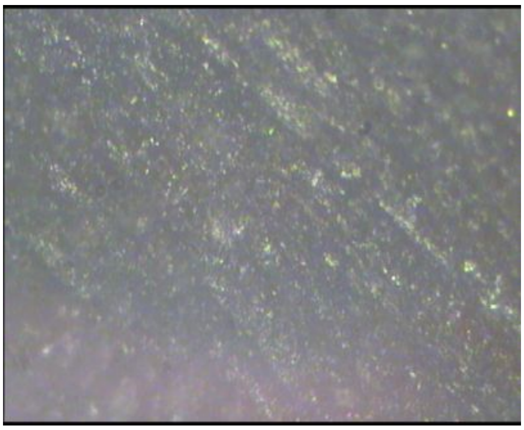
Figure 5 Wear test specimen

4.2. Microstructure Analysis

Specimen 1

Before wear testing

100 x zoom 400 x zoom



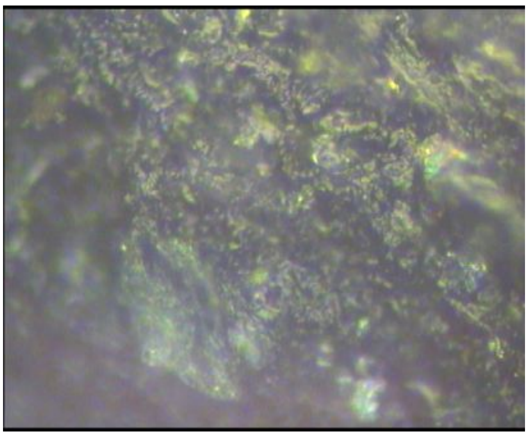


Figure 6 Microstructure of specimen 1 before wear test

From the figure 6-7 for specimen 1 it is observed that before wear test there is no visible scratches in the specimen, but after the wear test there is increase in the bonds and there are also many visible scratches. The fiber breakage in this specimen is also high compared to other specimens.

After wear testing (300mins)

100 x zoom 400 x zoom

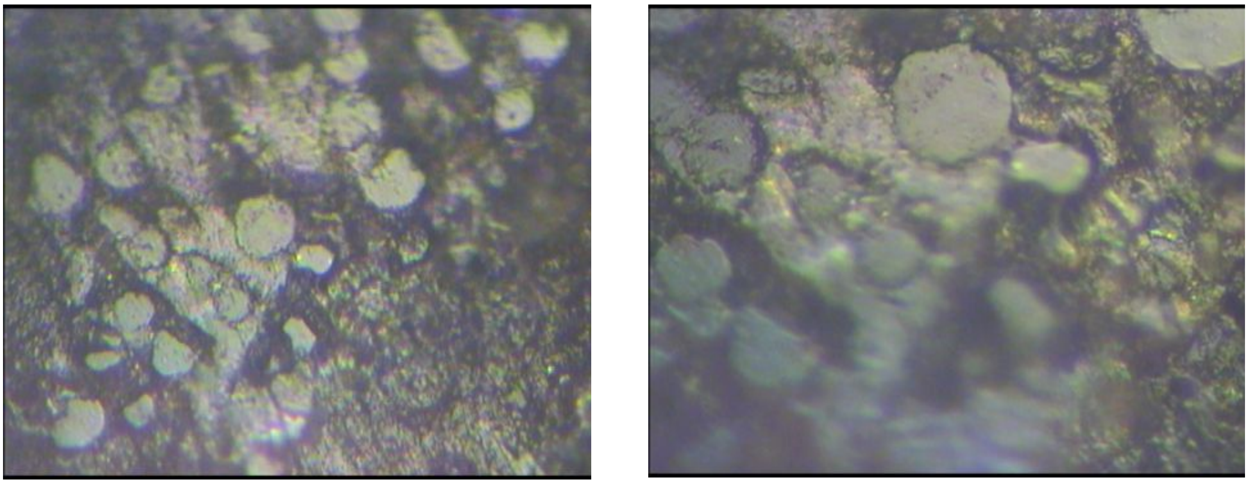


Figure 7 Microstructure of specimen 1 after wear test

Specimen 2

Before wear testing

100 x zoom 400 x zoom

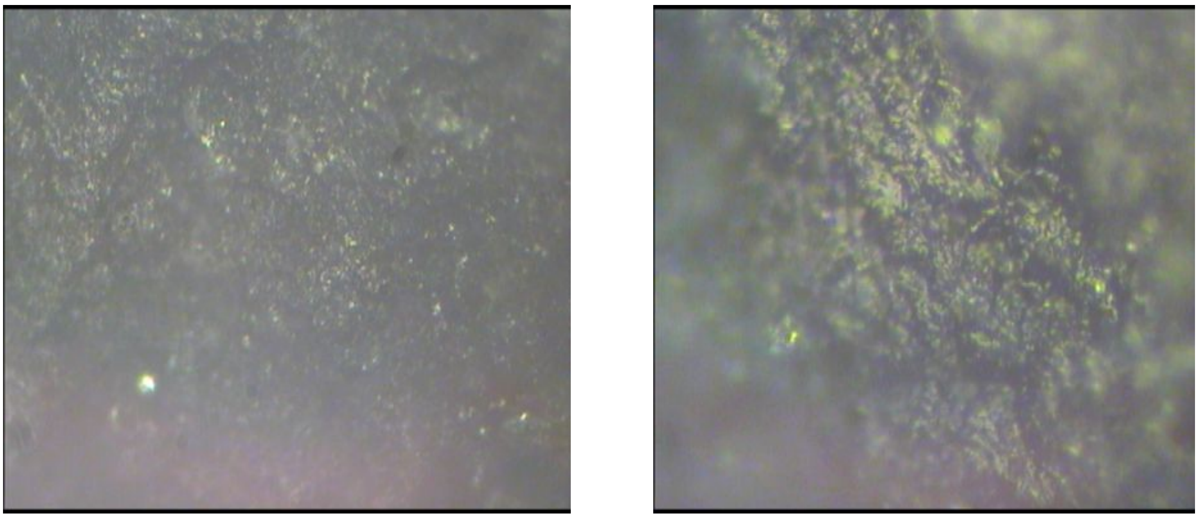


Figure 8 microstructure of specimen 2 before wear test

From the figure 8-9 for specimen 2 it is observed that the fiber breakage in this specimen is very less when compared to other specimens, thus the wear resistance of specimen 2 is high. Moreover before wear test there is no visible scratches in the specimen, but after the wear test there is increase in the bonds and there are also many visible scratches.

After wear testing (300mins)

100 x zoom 400 x zoom

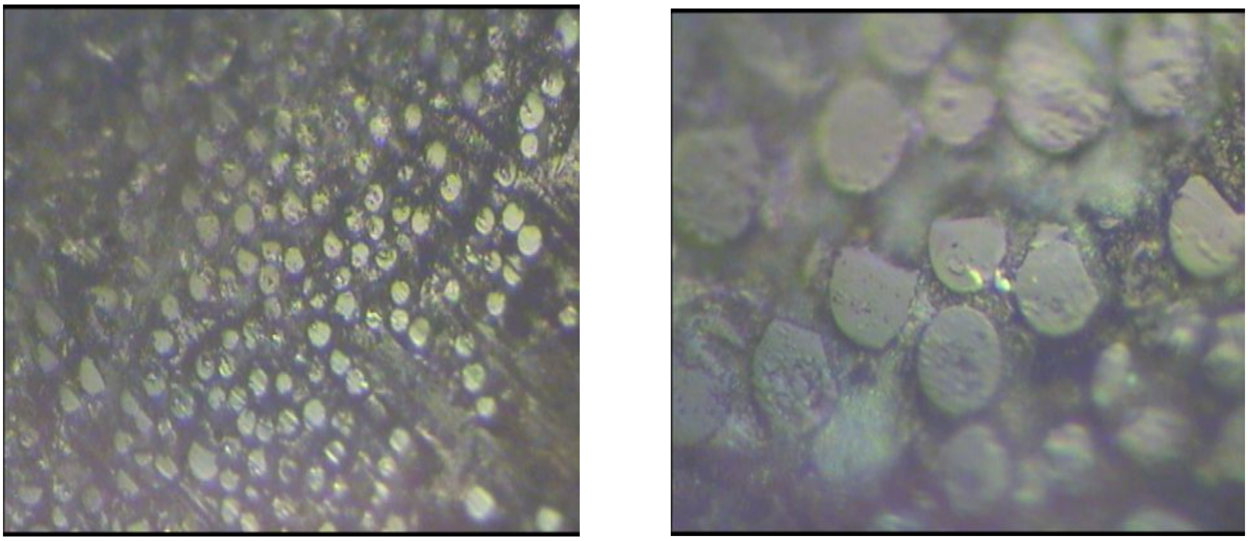


Figure 9 microstructure of specimen 2 after wear test

Specimen 3

Before wear testing

100 x zoom 400 x zoom

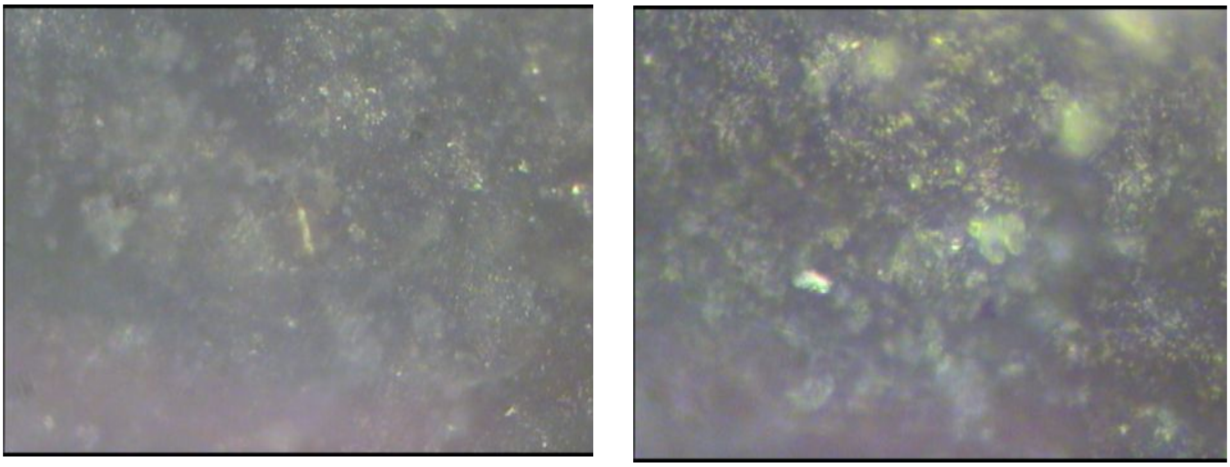


Figure 10 microstructure of specimen 3 before wear test

From the figure 10-11 for specimen 3 it is observed that the fiber breakage in this specimen is very high when compared to other specimens, thus the wear resistance of specimen 3 is less. Moreover before wear test there is no visible scratches in the specimen, but after the wear test there is increase in the bonds and there are also many visible scratches.

After wear testing (300mins)

100 x zoom 400 x zoom

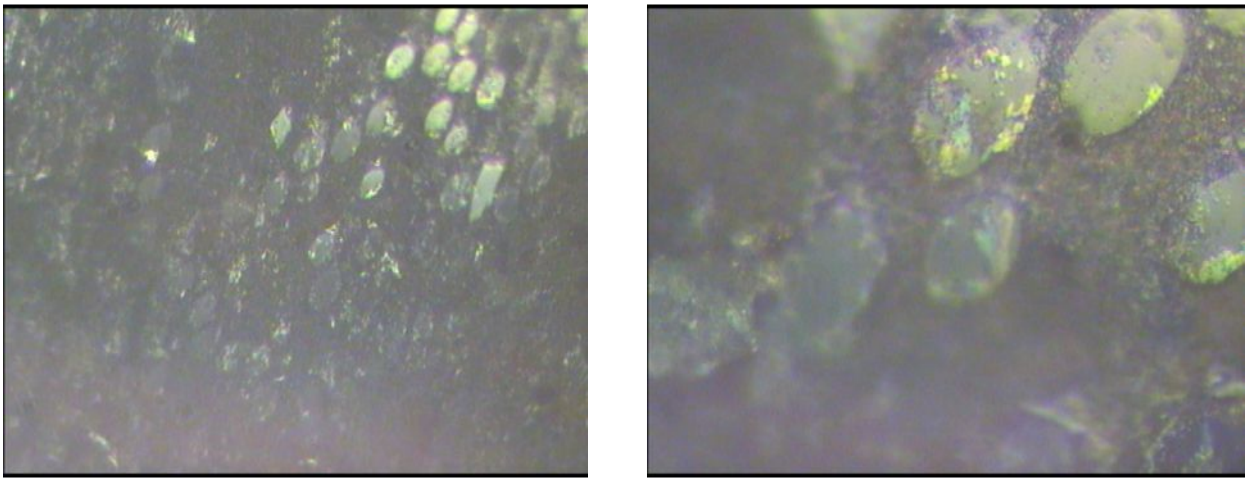


Figure 11 microstructure of specimen 3 after wear test

Specimen 4

Before wear testing

100 x zoom 400 x zoom

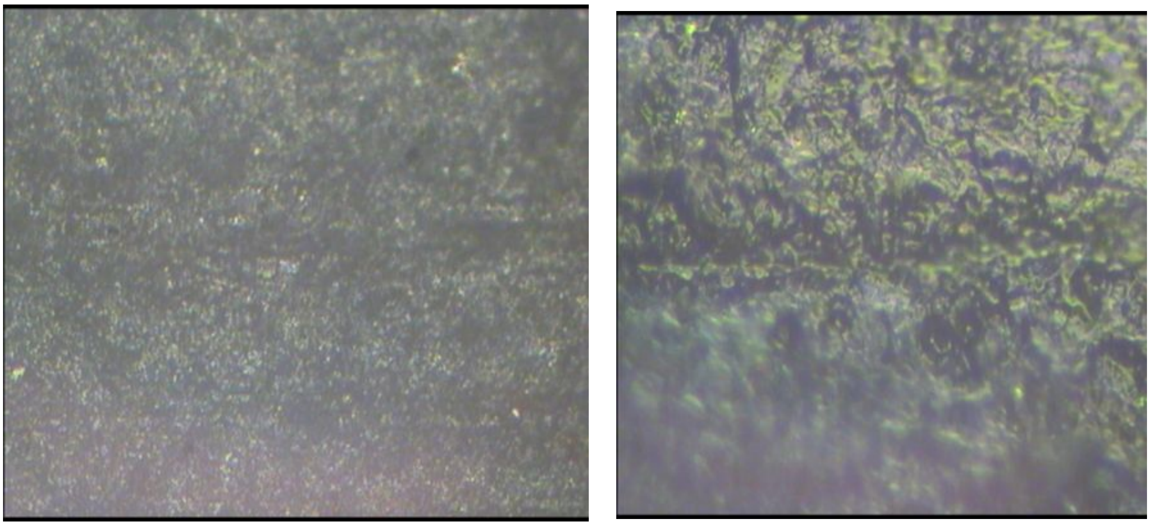
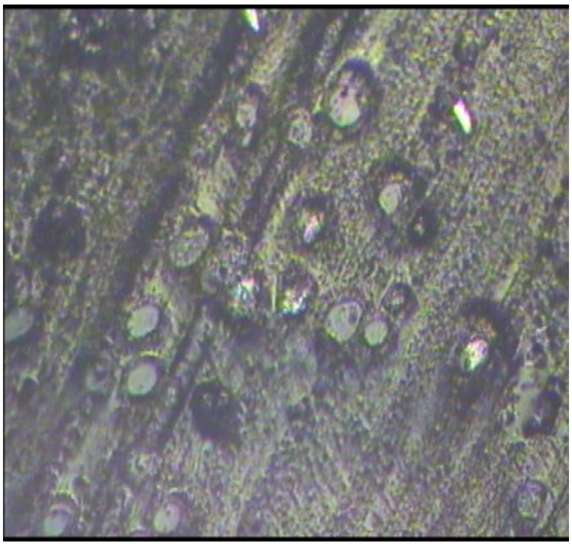


Figure 12 microstructure of specimen 4 before wear test

From the figure 12-13 for specimen 4 it is observed that before wear test there is no visible scratches in the specimen, but after the wear test there is increase in the bonds and there are also many visible scratches. The fiber breakage in this specimen is also high compared to other specimens.

After wear testing (300mins)

100 x zoom 400 x zoom



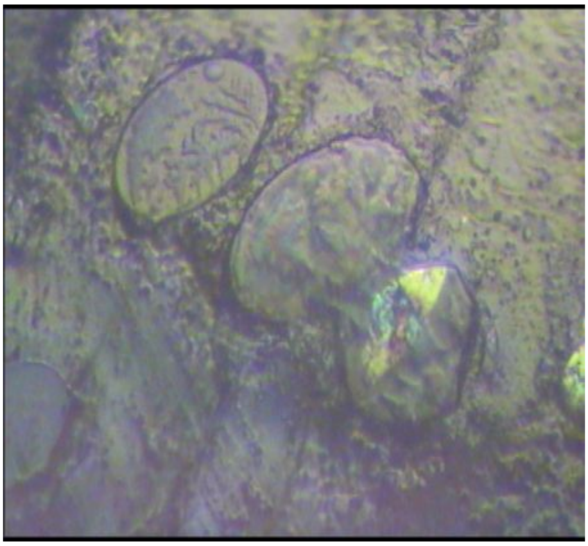
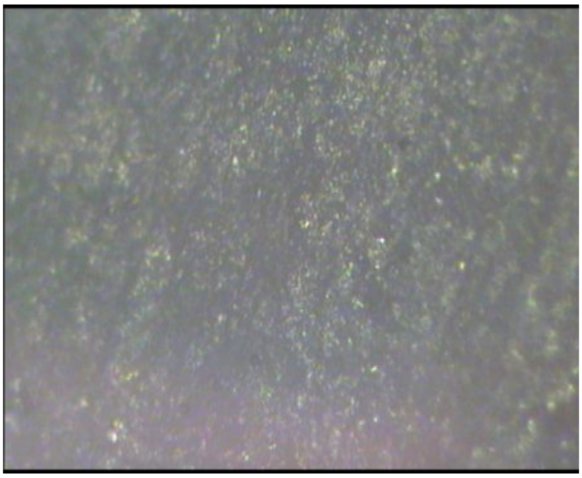


Figure 13 microstructure of specimen 4 after wear test

Specimen 5

Before wear testing

100 x zoom 400 x zoom



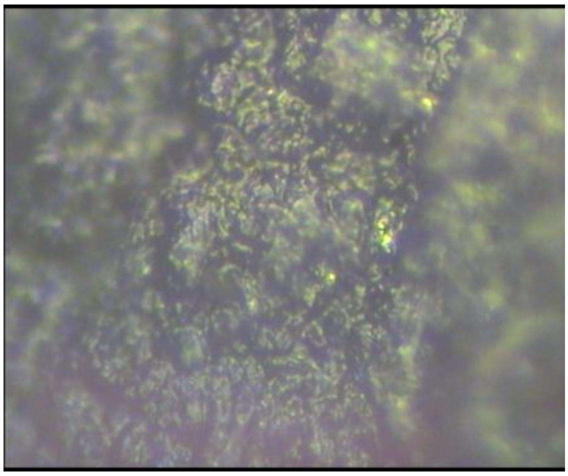


Figure 14 microstructure of specimen 5 before wear test

From the figure 14-15 for specimen 5 it is observed that the fiber breakage in this specimen is little higher when compared to specimen 2, thus the wear resistance of specimen 3 is less. Moreover before wear test there is no visible scratches in the specimen, but after the wear test there is increase in the bonds and there are also many visible scratches After wear testing (300mins)

100 x zoom 400 x zoom

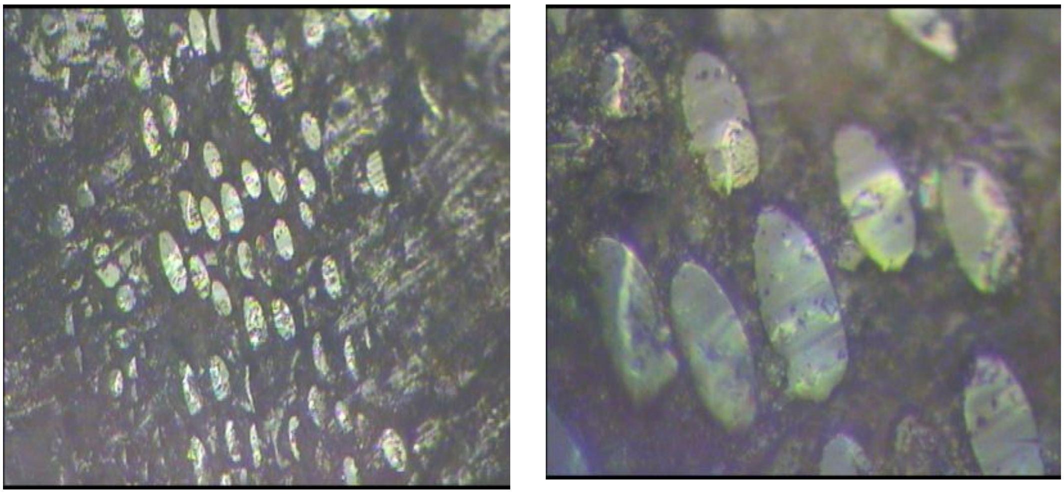


Figure 15 microstructure of specimen 5 after wear test

5. Conclusion

The wear rate of specimen 1 is the highest among the specimens for 700rpm and it gradually increases and maintains the same wear rate at increasing the speed and load. Specimen 1 has moderate coefficient of friction as compared to other specimens, thus it can be used in applications where coefficient of friction is neither high nor low is required. Thus specimen is a moderate sample with not so high and not so low properties, thus it can be used in applications where friction is not very high or not very low is required with medium hardness.

The wear rate of specimen 2 is the lowest and thus it can be used in applications were wear rate is high. Specimen 2 has less coefficient of friction as compared to other specimens, thus it can be used in applications where coefficient of friction is less required. Thus specimen 2 can be used in applications were high tensile strength and hardness is required, low fiction coefficient and, low wear rate. Thus the purpose of the paper of increasing the tensile strength, hardness, wears resistance and decreasing the coefficient of friction has been achieved. The specimen 2 has satisfied with good tribological performance.

From the microstructural analysis, it can be observed that the specimen 2 has less failure when compared to other specimens. Hence, this hybrid composite recommended to use in the manufacture of bearing liners, cams, etc.

Acknowledgement

Authors are thankful to VIT University, Vellore for their encouragements and support to complete this work.

6. References

1. A short Review on Basalt Fiber by KunalSingha international Journal of textile science, 2012, 1(4): 19-28.
2. Wei B, Song S, Cao H. Strengthening of basalt fibers with SiO2- epoxy composite coating, Mater Des 2011: 32:4180-6.
3. Fabrication and characterization of TiO2 particulate filled Glass Fiber reinforced polymer composite, S. SrinivasaMoorthy, K. Manonmani (2013)
4. The effect of illing and sintering techniques on mechanical properties of Cu-graphite metal matrix composite prepared by powder metallurgy route C.P. Samal, J.S. Paihar, D. Chaira (2013)
5. A review on basalt fiber and its composites, V.Fiorel ,T.scalicil, G. Di Bella2, A. Valenzal (2014)

6. Abrasion resistance and fracture energy of concretes with basalt fiber, NihatKabay, Yildiz Technical University, Department of civil Engineering (2013).
7. Mechanical characterisation of hybrid composite laminates based on basalt fibers in combination with flax, hemp and glass fibers manufactured by vacuum infusion, R. Petrucci, C. Santulli b, D. Puglia a, F.Sarasini b , L. Torre a, J.M. Kenny
8. Hancock, Paul and Skinner, Brian J. "basalt".The Oxford companion to the Earth, 2000.
9. "Continuos basalt fiber sector in shaping. (Statistics)" China Chemical Reporter. July 6, 2010.
10. Palmieri, A., Matthys S, and Tierens, M. "Basalt fibers: Mechanical properties and applications for concrete structures." Taylor and Francis Group. 2009.

*****