TRIBOLOGICAL BEHAVIOUR OF FRP BY REINFORCING WITH A WASTE MATERIAL

[1]Prof .Samarendra Choudhury, [2]Assoc. Prof. Sunil Kumar Sahu, [3]Asst.Prof. Lakshmi Narayana Panda, [4]Sr.Lect Dati Jayaram, [5]Sr.Lect Sanjay Kumar Panigrahi
Dept. of Mechanical Engineering
Gandhi School of Engineering, Berhampur

ABSTRACT

Many of the engineers and researchers have done their research on composite materials and they found that the composite which are made from two different materials with different chemical and physical property that, when combined ,produce a material with characteristics different from individual components .Both artificial and natural fibers will be used for the preparation of samples. The samples will be made from epoxy, bamboo, flax, glass fibers by using hand layup method. Then tribological test of the material will be done by using those samples by using pin on disc apparatus. From the outcome the following result will be calculated i.e wear rate, co-efficient of friction, volume loss, frictional force, surface roughness.

I . INTRODUCTION

After making and controlling fire and inventing the wheel, spinning of continuous yarns is probably the most important development of mankind, enabling him to survive outside the tropical climate zones and spread across the surface of the Earth. Flexible fabrics made of locally grown and spun fibers as cotton; flax and jute were a big step forward compared to animal skins. More and more natural resources were used, soon resulting in the first composites; straw reinforced walls, and bows and chariots made of glued layers of wood, bone and horn. More durable materials as wood and metal soon replaced these antique composites**.**

A composite material is a material made from two or more constituent materials with significantly different physical or Chemical properties that, when combined produce a material with characteristics different from the individual components the individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional material.

.

- To get a new FRP that should have better characteristics than only epoxy polymer and that can be use in scientific applications and industry by giving all the test results.
- For the sample preparation hand layup method is adapted and the tests for getting the tribological characteristics are:

II. METHODOLOGY

2.1 Material Selection

2.1.1 Fibers

Bamboo fibers, Flax fibers and Glass Fiber (E Type) employed in this work were supplied by Go Green Products, Chennai, India. The fibers were extracted from the stem column of bamboo and flax plant.

(a) (b) (c)

Fig. 2.1 (a) Flax fibers , (b)Bamboo fibers , (c)E-glass fibers

2.1.2 Matrix

The epoxy resin was a product of Das Enterprise, Kharagpur, India. (LY556, viscosity: 1.13-1.16 gm/cc at 25^0C). Epoxy resin and hardener are mixed in a ratio of 10:1 at room temperature (25^0 C). Silicon Spray is bought from Das Enterprise, Kharagpur, India.

Fig. 2.2 Epoxy Resin (LY556)

Fig. 2.3 K-6 Hardener

Fig. 2.4 Silicon Spray

2.2 Die Preparation

The die which is used is having length=260mm , width =130 mm, height =4mm, volume=135 cm^3. The die cavity is filled with oil when not in use to avoid rusting and also prevent dust to settle on it.

Fig. 2.5 Die

2.3 Hand Layup Procedure

- Take 100ml of epoxy and 50 ml of hardener in a beaker (basically in a 2:1 ratio) and mix it at room temperature (i.e 25^0 C).
- Simultaneously prepare the fiber, comb and flatten them like sheets.
- Calculate the amount of fiber and epoxy needed as per the weight percentage i.e, for 10% fibre 15gm is required.
- Divide the fiber and epoxy accordingly and pour the solution in the die which was prepared by a layer of silicon spray, after that place the fiber then pour the solution.
- Then press the laminate by a roller and then place a metal sheet and place 50N load on it.
- Leave it for 24 hr after that remove the model by the help of ejector pin.

Fig. 2.6 Hand Layup Procedure

Fig. 2.7 Hand layup procedure step by step

2.4. Experimental Details

A pin on disc tribometer consists of a stationary pin under an applied load in contact with a rotating disc. The pin can have any shape to simulate a specific contact, but speriacal tips are often used to simplify the contact geometry .Two types of disc are mainly used that are tungsten alloy and mild steel. Mild steel is used for metals and tungsten alloy for polymers.

Technical specifications of pin on disc wear testing machine The machine should be able to carry out with testing as Standard ASTM G- 99 or equivalent.

Disc size: 165 mm x 8 mm Normal

Load: 5 to 200 N

Rotational Speed: 200 rpm to 2000 rpm

Frictional Force: up to 200 N

Wear measurement: range up to 2000 µm

Wear Track Diameter: 140 mm or variable

Pin/Ball Diameter: 3, 6, & 10 mm

Lubrication Module: with re- circulation system

Loading system: using dead weights.

One Personal Computer integrated data acquisition system for measurement of load and wear. Advanced comparative view reporting for comparison of multiple test results. Safety interlocks to ensure safe operations at all times within manufacture's permissible maximum limit shall be provided Easy to calibrate.

2.4.1 Procedure

At first the disk should be cleaned properly. If there is some load then that should be removed. Then Fix the specimen in the pin holder using align key. Note down the track radius. Apply the desired load .then switch on the power switch and set the timer. set wear and frictional force to zero. Start the wear testing machine and give some rpm as per requirement. Note down wear and friction force reading regularly in some definite interval. Frictional torque and coefficient of friction are continuously recorded on the computer as a function of time with the help of the supplied software.

Fig. 2.8. Pin on disc set-up

2.4.2Output Parameters

2.4.2.1 Wear Rate

Wear rate is volume loss per unit distance and its unit is m3/Nm .it is independent of load applied , specific wear rate depends on applied on to cause wear, it is volume loss per unit meter per unit load . its unit is m^3/Nm. this can be calculated as follows:

$K_0 = \frac{\Delta M}{\rho L D}$ (m^3/Nm)

ΔM = is the loss in weight (kg) of the pin

ρ =density (kg /m^3),

L = the load (N) and

D = sliding distance (m).

2.4.2.2 Frictional Force

The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it .There are at least two types of fiction force sliding and static friction. though it is not always the case ,the friction force often opposes the motion of an object .

Friction force can be calculated as :

F=µN,

F=the resistive force friction;

µ= co-efficient of friction;

N= normal force

III.RESULT AND DISCUSSION

3.1 Experimental Details

The experiment has been performed on a group of specimens for duration of 30 minutes, and load of 10N and 20N, with speed 286 rpm. The set up is connected to a Data Acquisition System which computes friction force and coefficient of friction of said material. By fixing any two parameters with one variable parameter experiment is performed. Graphical representation of wear rate along with friction force and coefficient of friction is given by WINDUCOM software and the results will show the coefficient of friction in relation with (time, speed and load) and the systematic comparisons of one material with the other. Friction is a force that resists sliding and is measured by a coefficient which is generally considered to be constant and specific to various material.

The setup of the method comprises of a pin with spherical surface as the tip and a circular rotating disk which is placed at a perpendicular with respect to the spherical pin surface. The diameter of the pin is 12mm and the length is 60mm.The disk is made of Tungsten on which the pin is held with a jaw in the apparatus and rotation is provided to disk which causes wear of the pin on a fixed path on disk. The pin is pressed against the surface of the disk with load being applied with the arm attachment provided to the apparatus. Machine is attached with a data acquisition system and WINDUCOM 2010 software which gives result values and graphs.

Fig. 3.1 Disc

Working Parameters
Wear track Diameter: 100mm
Load applied: 10N and 20N
Time Duration: 30 min
Rotation of disk: 286 rpm
Pin size: Width=12mm,
Length=60mm

Table 3.1 Tabulation for 20N Load

Sl No.	Sample name	Friction force 20	Wear 20	Density 20	K_0 20	µ20
1.	Glass20%+Epoxy 80%	2.3	354	1391.93	2.7946×10^{-3}	0.145
2.	Bamboo10%+Epoxy 90%	2.7	114	1286.89	2.9601×10^{-3}	0.125
3.	Epoxy100%	5.3	489	1250	1.952×10^{-3}	0.255
4.	Glass10%+Epoxy 90%	1.8	293	1317.15	1.7803×10^{-3}	0.128
5.	Flax10%+Epoxy 90%	0.5	163	1274.04	6.1614×10^{-4}	0.192
6.	Flax20%+Epoxy 80%	6.2	223	1298.98	6.1585×10^{-4}	0.141
7.	Bamboo20%+Epoxy 80%	2.0	117	1239.67	6.4129×10^{-4}	0.068

Table 3.2 Tabulation for 10N Load

Sl No.	Sample name	Friction force 10	Wear 10	Density 10	$K_0$10	µ10
1.	Glass20%+Epoxy 80%	1.6	197	1391.97	2.2895×10^{-3}	0.105
2.	Bamboo10%+Epoxy 90%	0.3	29	1286.41	3.5913×10^{-3}	0.013
3.	Epoxy100%	4.3	210	1250	9.12×10^{-4}	0.367
4.	Glass10%+Epoxy 90%	1.0	141	1317.1514	1.4500×10^{-3}	0.144
5.	Flax10%+Epoxy 90%	2.3	119	1274.03	1.6404×10^{-3}	0.100
6.	Flax20%+Epoxy 80%	2.0	107	1298.60	1.8943×10^{-3}	0.211
7.	Bamboo20%+Epoxy 80%	0.9	73	1239.69	1.5147×10^{-4}	0.034

3.2 Tribological Properties of Composites

For the experiment of 30 min for each composite under each load, data on coefficient of friction as a function of time were generated. From these data, stabilized value was selected as a µ on that load for that composite. Since approx 50 graphs were generated and it was not possible to include all of them here, only some of the graphs are given below.

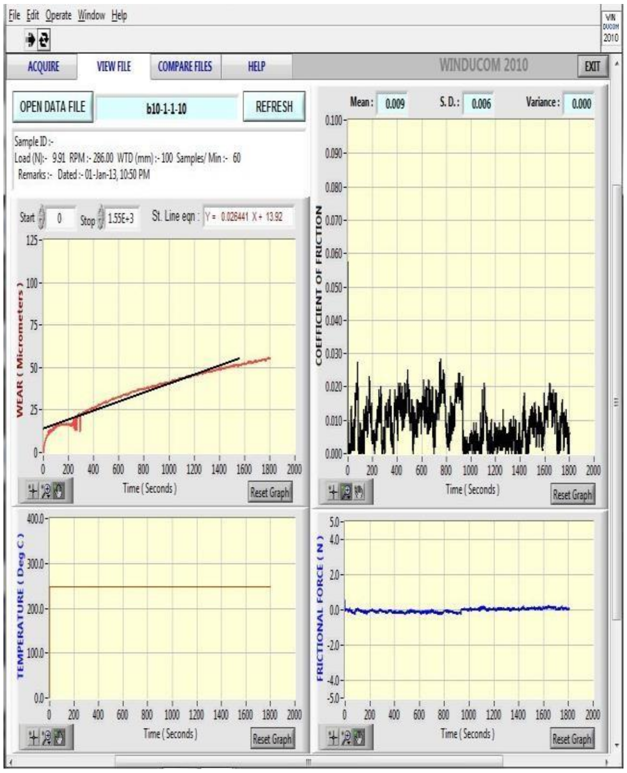

Fig. 3.2 Test for bamboo10 %(10N)

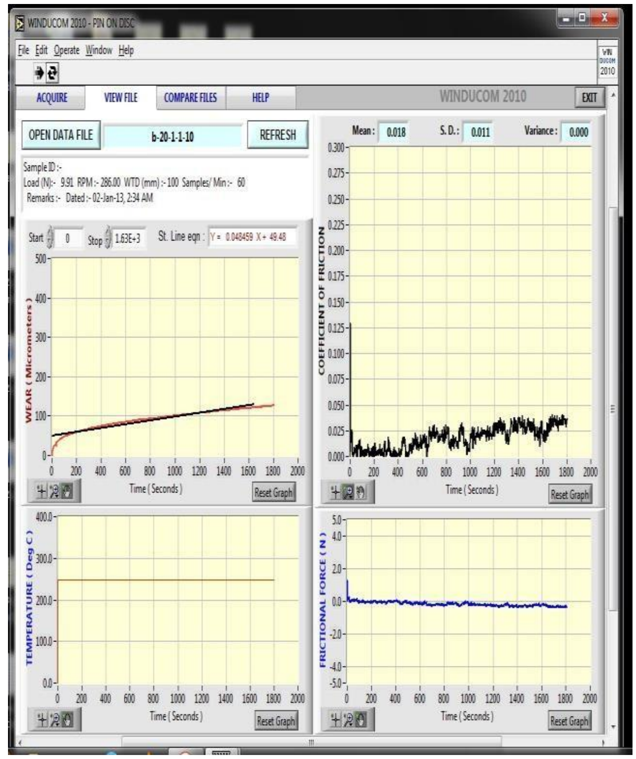

Fig. 3.4 Test for bamboo20 %(10N)

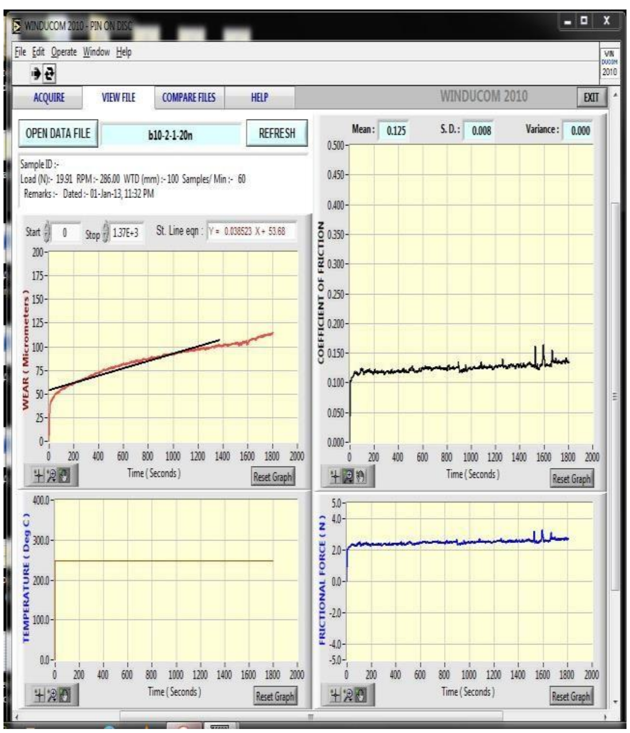

Fig. 3.3 Test for bamboo10 % (20N)

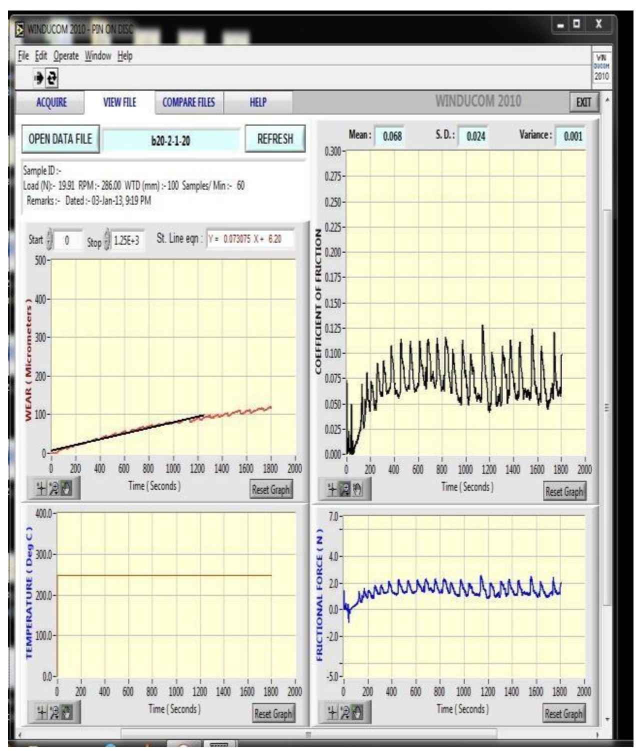

Fig. 3.5 Test for bamboo 20 %(20N)

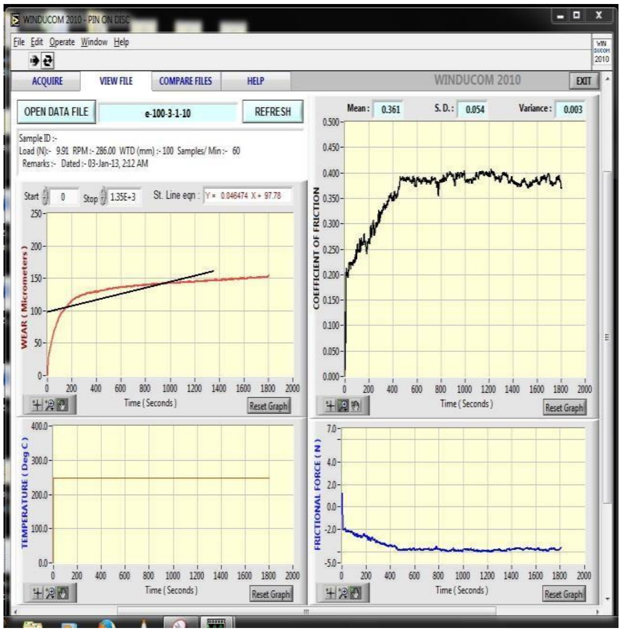

Fig. 3.6 Test for epoxy (10N)

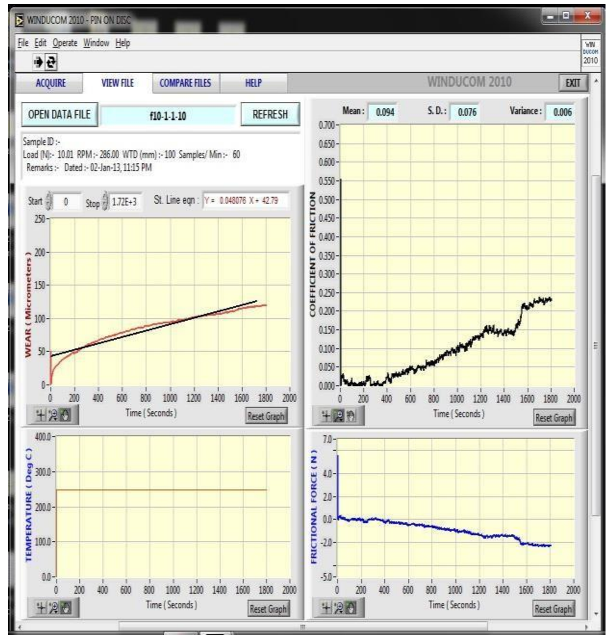

Fig. 3.8 Test for flax10 %(10N)

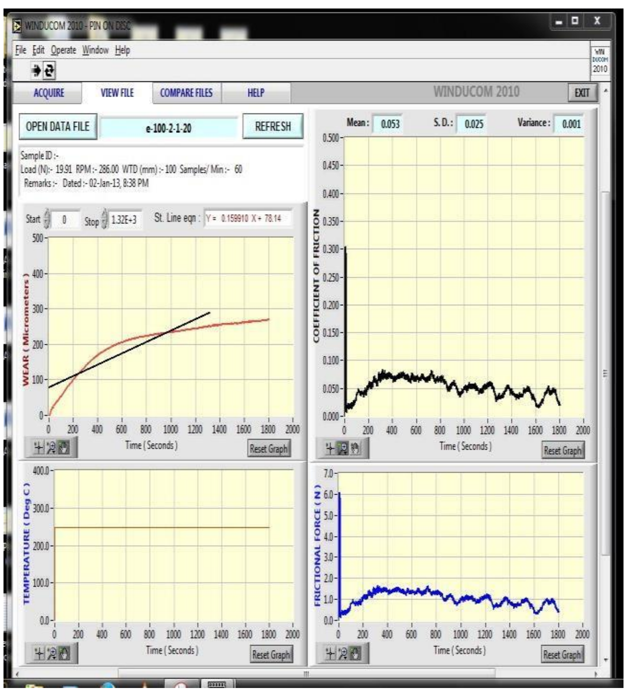

Fig. 3.7 Test for epoxy(20N)

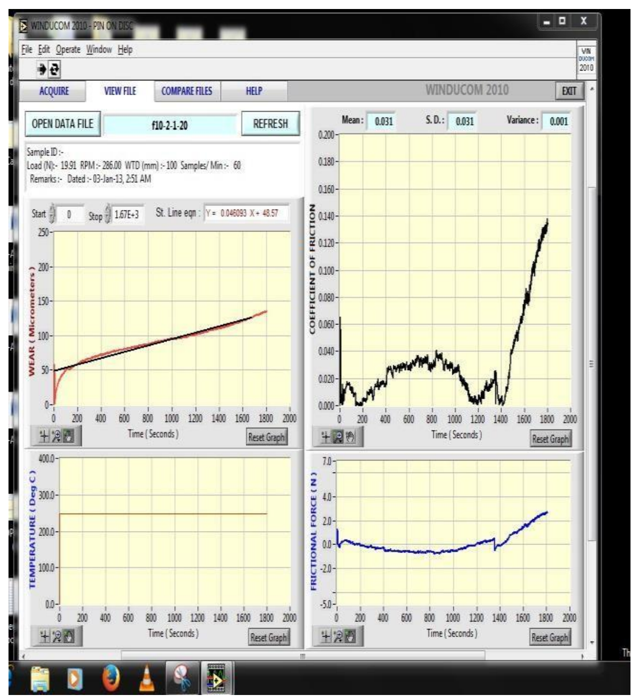

Fig. 3.9 Test for flax10 %(20N)

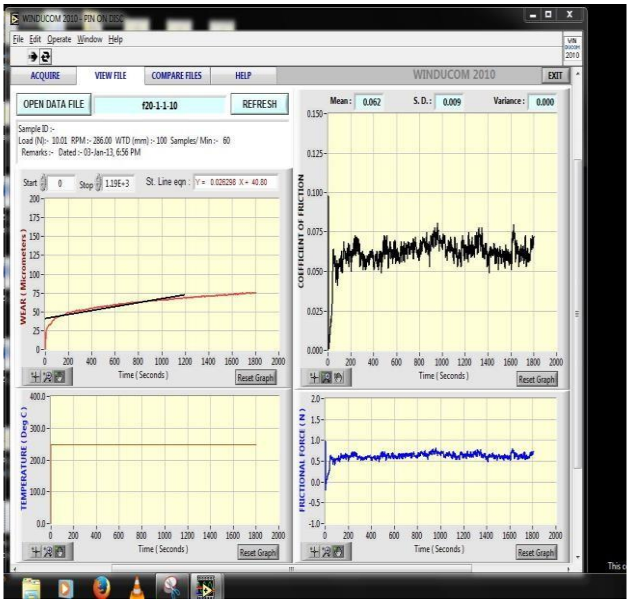

Fig. 3.10 Test for flax20%(10N)

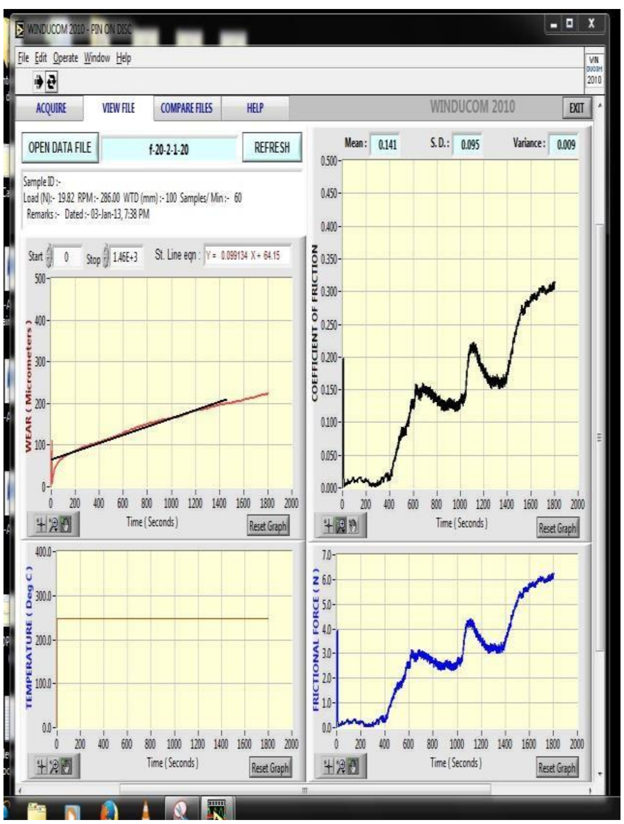

Fig. 3.11 Test for flax20 %(20N)

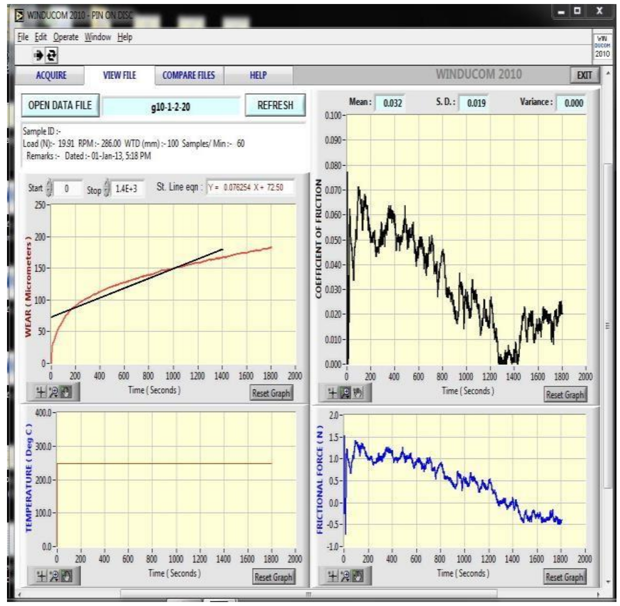

Fig. 3.12 Test for glass10%(20N)

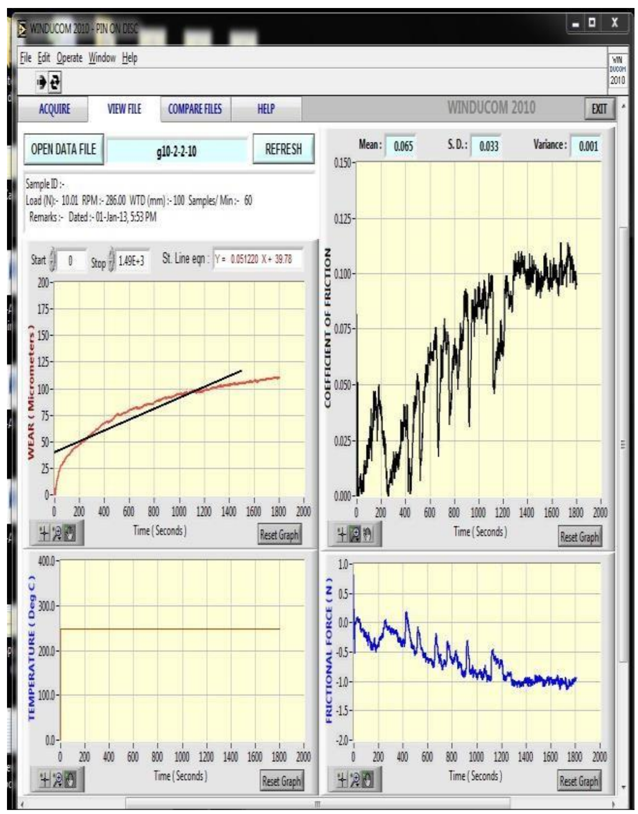

Fig. 3.13 Test for glass10 %(10N)

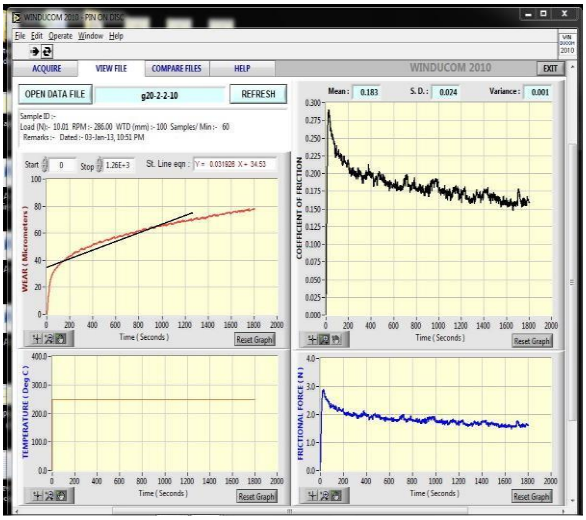

Fig. 3.14 Test for glass20 %(10N)

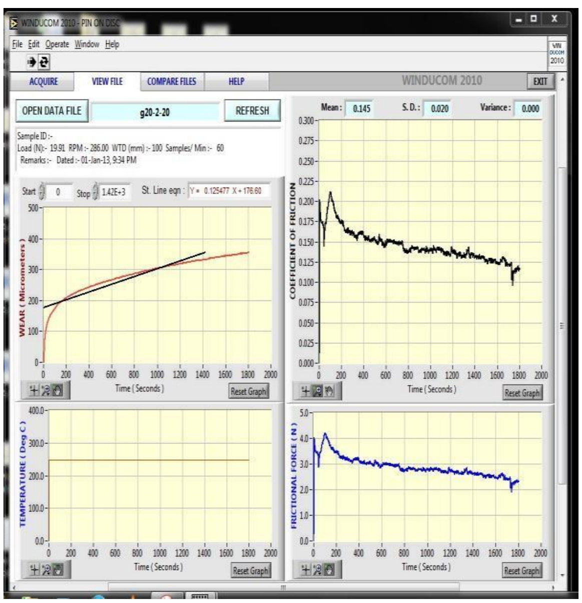

Fig. 3.15 Test for glass20%(20N)

IV.CONCLUSION

1. The main objective of our project was to develop a composite using waste material, we used flax fiber, bamboo fiber, glass fibers as waste material with epoxy as resin, and compared the result with epoxy.
2. We adapted hand layup method, which was cost effective and simple process for composite preparation.
3. At 10N epoxy has wear 210 micrometer and friction force 4.3 while co-efficient of friction is 0.367 and at 20N it is having wear 489 micrometer, friction force 5.3 and co-efficient of friction is 0.255.
4. From the above experiment when the load is 10N wear resistance of (bamboo10%+epoxy90%) is maximum with lowest frictional force and co-efficient of friction, when the load is 20N also (bamboo10%+epoxy90%) is having maximum wear resistance property.
5. Graph of (bamboo10%+epoxy90%) at 20N load is smooth curve in nature.

REFERENCES

[1] C. Steggall-Murphy et al. / Composites: Part A 41: A model for thermoplastic melt impregnation of fiber bundles during consolidation of powder-impregnated continuous fiber composites (2010) 93–100

[2] Wang, C., Li, J., Yu, J., Sun, S., Li, X., Xie, F., Jiang, B., Wu, G., Yu, F., Huang, Y.,Grafting of Size-Controlled Graphene Oxide Sheets onto Carbon Fiber for Reinforcement of Carbon Fiber/Epoxy Composite Interfacial Strength, *Composites: Part A* (2017)

[3] M.S. Chaudhry , A. Czekanski , Z.H. Zhu , Characterization of Carbon Nanotube Enhanced Interlaminar Fracture Toughness of Woven Carbon Fiber Reinforced Polymer Composites , *International Journal of Mechanical Sciences* (2017)

[4] Zhao Yan *, Duan Yuexin, Yuan Lu, Guan Fengxia, The dispersion of SWCNTs treated by dispersing agents in glass fiber reinforced polymer composites, Composites Science and Technology 69 (2009) 2115–2118

[5] Norshah Aizat Shuaib*, Paul Tarisai Mativenga, Energy demand in mechanical recycling of glass fibre reinforced thermoset plastic composites, Journal of Cleaner Production 120 (2016) 198-206