DRILLING PROFILE CHARACTERISTICS OF NATURAL FIBERS REINFORCED COMPOSITES ON MECHANICAL PROPERTIES

P. Sivasubramanian*
*Asst Professor, Department of Mechanical Engineering, Saintgits College of Engg, Kottayam-686532 Kerala, India, siva948@yahoo.com

M.Thiruchitrambalam**
**Professor and Dean, Department of Mechanical Engineering, Tamilnadu College of Engineering, Karumathampatty, Coimbatore, Tamilnadu

A.G.Suresh***
***Asso Prof, Department of Mechanical Engineering, Odayappa College of Engg & tech, Theni. Tamilnadu

1. ABSTRACT

Natural fibers are now considered as a suitable alternative to glass fibers due to their advantages like low cost, high strength-to-weight ratio, recyclables, etc. Combining natural fibers with glass fiber also decreases the usage of glass fiber. In this investigation, natural fibers like sisal and hybrid glass fiber composites were fabricated using Hand-lay method. The tensile, flexural and impact strength of the fabricated composites were tested using Universal Testing Machine (UTM) under the with and without moisture condition. The load – Displacement graph obtained from UTM, the effect of fibers and its combinations on the Ultimate stress and the percentage elongation were determined. The impact strength of the composites was determined using un-notched charpy Impact tester from the experimentations it was concluded that the sisal-glass hybrid composites exhibit better strength. Sisal and glass fiber is used as reinforcement and the polymer based resin is used as a matrix. The mechanical properties like Tensile, Flexural and Impact strength are analyzed in detail. The drill hole profile is analyzed by using profile projector with 20x magnification.

Key words: Natural Fiber, Hand lay, Tensile strength, Flexural strength, Impact strength.
Corresponding Author: P.Sivasubramanian, siva948@yahoo.com , +91-97462 51316

2. INTRODUCTION

This chapter deals with the literature reviews. The various literatures are reviewed in this chapter.

Roger M. Rowell, et.al presented a paper on Utilization of natural fibers in plastic composites [1]. Results suggest that agro-based fibers are a viable alternative to inorganic/material based reinforcing fibers in commodity fiber-thermoplastic. Composite materials as long as the right processing conditions are used. These renewable fibers have low densities and high specific properties. Kenaf fivers, for example, have excellent specific properties and have potential to be outstanding reinforcing fillers in plastics. In our experiments, several types of natural fibers were blended with polypropylene (PP) and then injection molded, with the fiber weight fractions to 60%. The specific tensile and flexural moduli of a 50% by weight (39% by volume) of kenaf-PP composites compare favorably with 40% by weight of glass fiber (19% by volume)-PP injection molded composites.

H.Y.Sastra, et.al presented a paper on flexural properties of Agenta Pinnata fiber reinforced Epoxy composites [2]. The aim of this study is to determine the flexural properties of Arenga pinnata fiber as a natural fiber and epoxy resin as a matrix. The Arenga pinnata fibers were mixed with epoxy resin at the various fiber weight percentages of 10, 15 and 20% Arenga pinnata fiber and with different fiber orientations such as long random, chopped random and woven roving. Results from the flexural tests of Arenga pinnata fiber reinforced epoxy composite by Hand lay up method are that the 10% wt of woven roving Arenga pinnata fiber showed the highest value for maximum flexural properties.

The results above indicate that woven roving Arenga pinnata fiber has a better bonding strength compare to long random and chopped random Arenga pinnata fiber. Natural fiber composites enjoy excellent potential as wood substitutes in buildings industry in view of their low cost, easy availability, savings in energy and pollution free production. This paper also describes the advantages of using Agro-Fibers in plastics. The primary advantages of using annual growth lignocellulosic fibers as fillers/reinforcements in plastics are listed below:
Property Advantages:

- Low densities
- Non abrasive
- Easily recyclable & Biodegradable.
- Wide variety of fibers available through out the world
- Low cost

Mikko Hautala, et.al represented a paper on various methods for producing strong composites from high quality fibers [3]. There are increasing new industrial areas in Europe where agricultural fiber materials are used as raw materials instead of glass fiber. In natural fibers there is clearly more action in research than in established industrial production. However natural fiber semi products like roving and non woven mats. Also this paper explains about the various methods such as dry-line method and frost-line harvesting method for producing strong composites from high quality fibers. By these methods strong composite structures have been achieved with very simple processing technology. In this paper some technical properties of the natural fibers/plastic strong composites are reported. From this reports the stiffness and strength of the strong composites are clearly better than the values of plywood. On the other hand, extrusion and injection molding damages the properties of the natural fibers[4]. In contrast, Wanjun Liu[5] et al suggested the molding method, which neither damages nor orients the fibers during processing, which preserves the isotropic properties of the composites and reduces the changes in the physical properties. The type of fiber plays a vital role in the properties of composites.

H.Y.Sastra, et.al[6] discussed the flexural properties of Agenta Pinnata fiber reinforced Epoxy composites. The aim of this study is to determine the flexural properties of Arenga pinnata fiber as a natural fiber and epoxy resin as a matrix. Kazuya et.al[7] studied the tensile properties of bamboo based polymer composites and reported that there was an improvement in the tensile strength and modulus by 15% and 30% than that of matrix. The effect of incorporation of sisal fiber content in high impact polystyrene on stiffness was found to be increasing where as the tensile strength decreases [8].In literature, many natural fibers like jute [9], sisal [10], hemp [11], coir [12] and banana [13] have been tried and showed their suitability to form a composite.

2. OBJECTIVES

Based on the above literature reviews, natural fiber composites gain more importance. The sisal fiber is selected as it is easily available, low cost and less density. The objectives of the present work is as follows,

1. To fabricate sisal and glass fiber reinforced composites with varying layers.
2. To determine the properties like Tensile strength, flexural strength and impact strength both dry and wet conditions.
3. Analyses of drilled holes, to assess the elastic re-bounce on stresses.

3. FABRICATION OF COMPOSITE MATERIALS

The following fabrication incrediance are done in order to obtain the composite materials. The materials used in our fabrication process are

- General Purpose Resin (G.P.Resin chemically Polyester)
- Accelerator (Cobalt)
- Catalyst (Methyl Ethyl Ketone)
- Poly Vinyl
- Polythene Sheets & Glass Plates
- Sisal Fibers & Glass Fibers

The various types of layers in the fabrication process are

- Double Layer
- Triple Layer
- Layer with Hard Particle dispersion.

3.1 Double Layer

Double Layer consists of both sisal as well as glass fiber acts as reinforcement and polymer based resin acts as matrix. In the fabrication of double layer, polythene sheet is placed in which resin mixture is poured. And above which Sisal fiber is placed and again resin mixture is applied, and over which the glass fiber is placed, then the mixture is poured and finally it is covered by a polythene sheet.

Fig. 3.1 One Sisal and One Glass Fiber Composite

3.2 Triple Layer

Triple Layer consists of two layers of sisal and a layer of glass fiber in between the two layers (Or) two layers of glass fiber and a layer of sisal fiber act as reinforcement and polymer based resin act as matrix.

Two sisal fibers and a glass fiber composite

This composite consists of two sisal fiber layer and a glass fiber layer. In the fabrication of two sisal fiber and a glass fiber composite, first the resin mixture is applied over the polythene sheet. Then sisal fiber is placed and again resin is applied over it. Then a layer of glass fiber is placed over it, and again the resin mixture is applied. Then another sisal fiber is placed, then the resin mixture is applied, and it is finally covered by a polyvinyl applied polythene sheet.

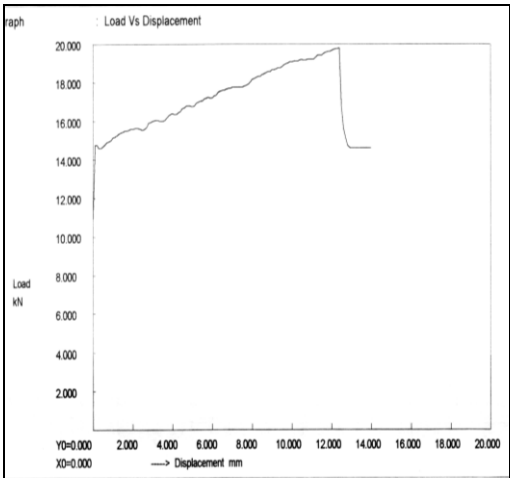
Two Glass Fiber and a Sisal Fiber Composite

This composite consists of two glass fiber layer and a sisal fiber layer. In the fabrication of two glass fiber and a sisal fiber composite, first the resin mixture is applied over the polythene sheet. Then glass fiber is placed and again resin is applied over it. Then sisal fiber is placed over it, and again the resin mixture is applied. Then another glass fiber is placed, then the resin mixture is applied, and it is finally covered by a polythene sheet.

Fig. 3.2 Two Glass Fiber and a Sisal Fiber Composite

4. RESULTS AND DISCUSSIONS

Tensile test is done on a dried and wet specimen with a size of 24cm X 3cm X 0.5cm. The figure 4.1(a)(b) depicts that when the load is applied above 14 KN, the composites begin to deform. As the load increases, the deformation begins to increase. The fluctuations in the figure are due to the breaking of fiber particles and the composite material breaks at the point of breaking load.



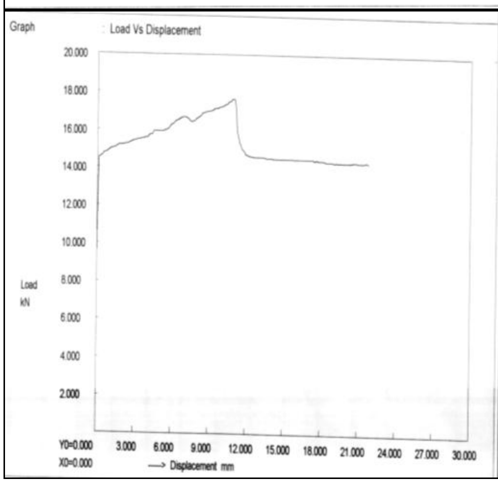


Fig. 4.1(a) Two Sisal & One Glass Fiber Composites (wo)
Fig. 4.1(b) Two Sisal & One Glass Fiber Composites(w)

4.1 Tensile test

Tensile Test is done by applying tensile load on the body. The various readings taken are

- Peak Load
- Displacement at Peak Load
- Breaking Load
- Maximum Displacement
- Ultimate Stress

Tensile Tests are done in composites with moisture and also without moisture.

The above figure shows the fracture of composite material when a tensile load is applied on it. The fracture mechanism is brittle fracture mechanism.

Comparison Between With and Without Moisture

The following figures explain the comparison between with and without moisture conditions for tensile test.

When it is tested, the fig 4.2 shows that two sisal and a glass fibers withstands high load for both with and without moisture conditions. This is mainly due to the presence of glass fiber in the composite. And also under the moisture conditions the sisal fiber will expand cylindrically, this phenomenon helps this composite to withstand high loads than the other layer of composites. The other two layers when tested exhibits almost the same properties when tested due to the presence of sisal fiber as it is ductile in nature.

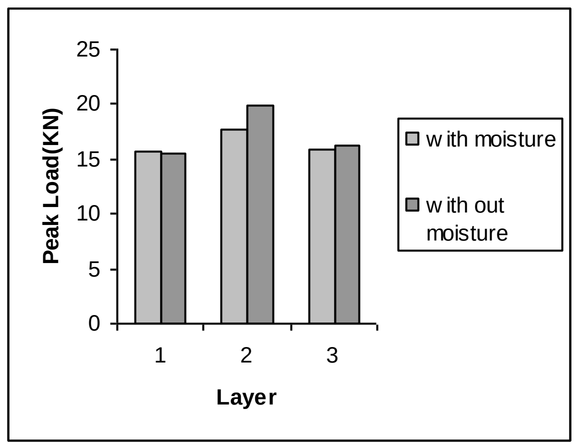


Fig 4.2 Effect of layer on Peak Load (Comparison)

But when tested with moisture, the results are reversed as the sisal fiber gets cylindrically expanded. This phenomenon provides the composite to withstand high loads. Therefore under moisture conditions the two sisal and a glass fiber composites provides better result.

Fig. 4.1(c). Fracture due to Tensile Load

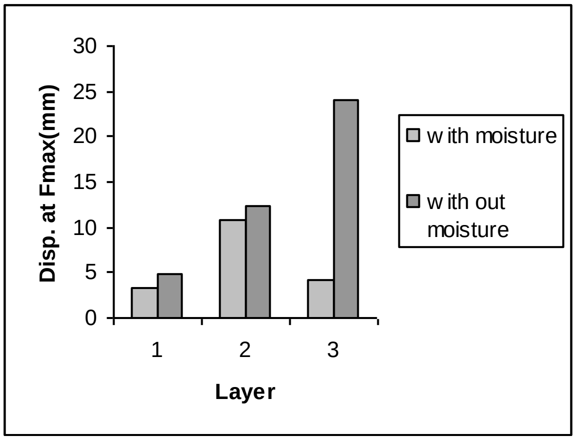


Fig 4.3 Effect of layer on Displacement at F_{max} (Comparison)

The displacement for the two glass and a sisal fiber composites is maximum when tested without moisture. This is due to the presence of glass fibers. The two sisal and a glass fiber composite show good property than one sisal and a glass fiber composite.

The displacement for the two sisal and a glass fiber composites is maximum when tested with moisture. This is due to the presence of sisal fiber as it cylindrically expands when exposed to moisture. The other two composites show worse results compared to two sisal and a glass fiber composites.

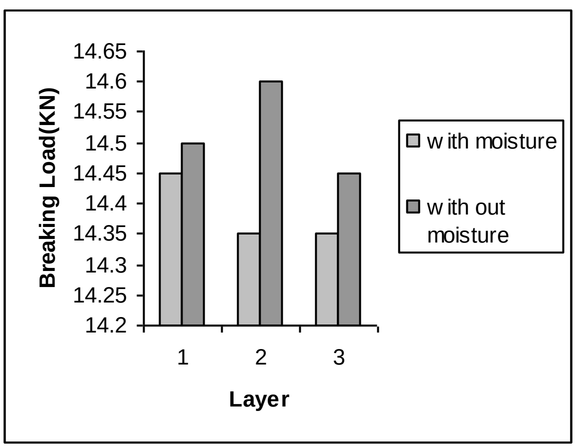


Fig 4.4 Effect of layer on Breaking Load (Comparison)

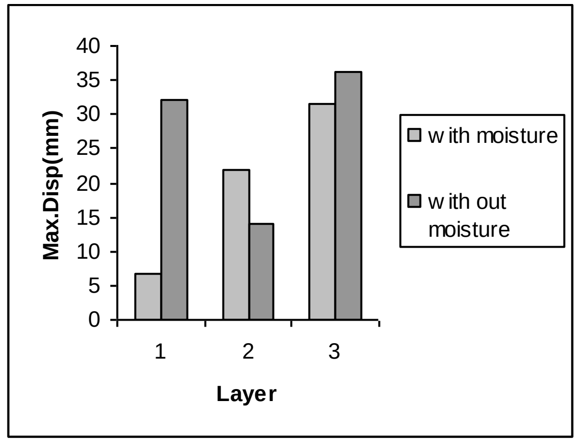


Fig 4.5 Effect of layer on Maximum Displacement (Comparison)

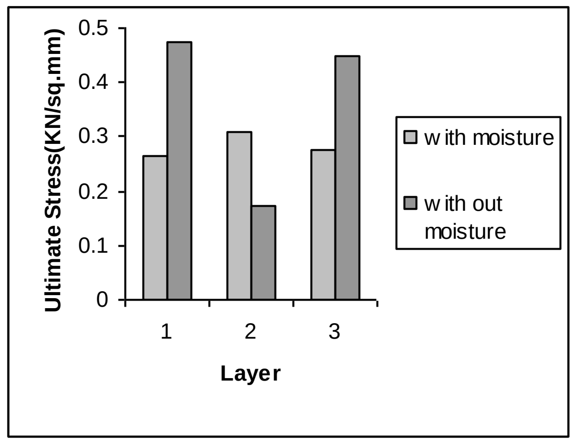


Fig 4.6 Effect of layer on Ultimate Stress (Comparison)

4.2 Flexure Test

Flexure test is done on a specimen of size 15cm X 2.5cm X .4 cm thick. It is done in UTE (100) Universal Testing Machine. The following figure shows the failure of the specimen when a load is applied.

Fig. 4.7.Fracture due to Flexure Test

Comparison between With and Without Moisture

The following figures illustrate the effect of layers on various parameters. In general, composites with moisture exhibits better mechanical properties than without moisture as the fibers get cylindrically expanded and it can withstand more loads. The resin matrix distributes the load equally and so it exhibits better mechanical property. When it is tested, the fig 4.8 shows that one sisal and a glass fibers withstands high load for both with and without moisture conditions. This is mainly due to the presence of glass fiber in the composite. And also under the moisture conditions the sisal fiber will expand cylindrically, this phenomenon helps this composite to withstand high loads than the other layer of composites. The other two layers when tested exhibit almost the same properties when tested due to the presence of sisal fiber as it is ductile in nature.

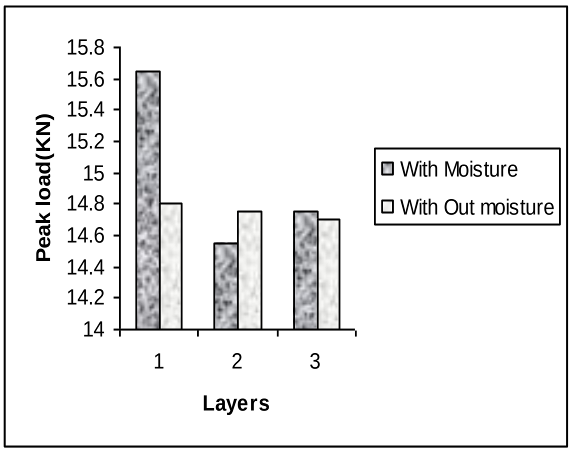


Fig 4.8 Effect of layer on Peak Load (Comparison)

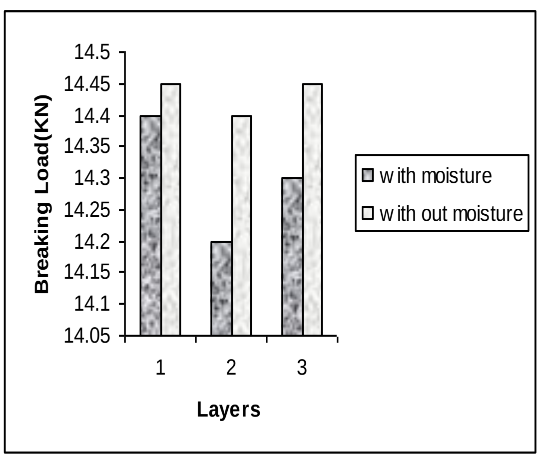


Fig 4.9 Effect of layer on Breaking Load (Comparison)

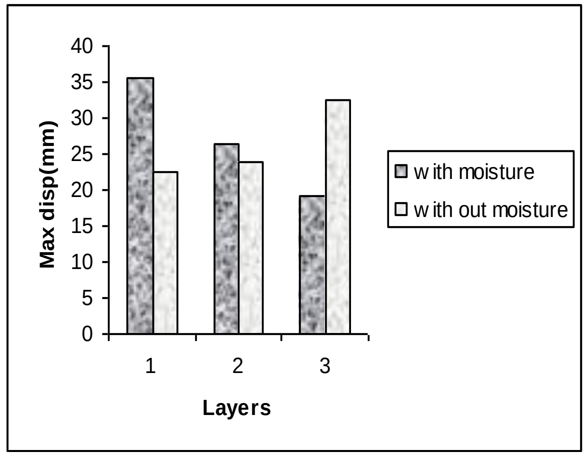


Fig 4.10 Effect of layer on Maximum Displacement (Comparison)

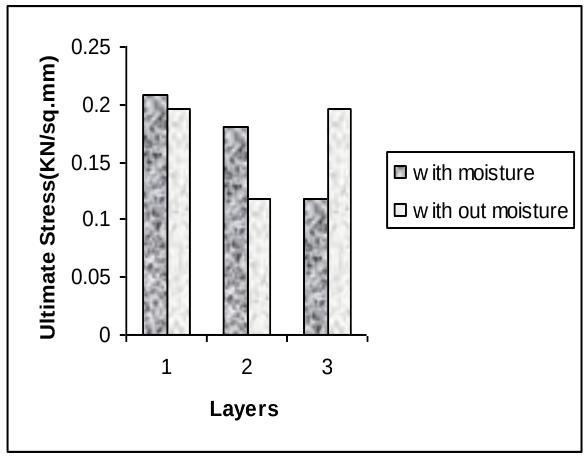


Fig 4.11 Effect of layer on Ultimate Stress (Comparison)

4.3 Impact Test

Impact test is done in Charpy Impact test bed. The specimen size is 9cm X 1.5cm. The impact test results show that the impact strength is increased with increase in layer. The glass fibers resist more to the impact loading. Therefore glass and sisal fiber composites have high impact strength. The impact strength increases with moisture. Also the resin matrix distributes the impact load evenly and it increases the impact strength of the composites.

The impact test results with and without moisture shows that the two glass and a sisal fiber shows better impact strength as the glass fibers is brittle in nature and it absorbs more energy till it breaks completely. The two sisal and a glass fiber composites has good impact toughness due to the presence of three layer and it absorbs more energy.

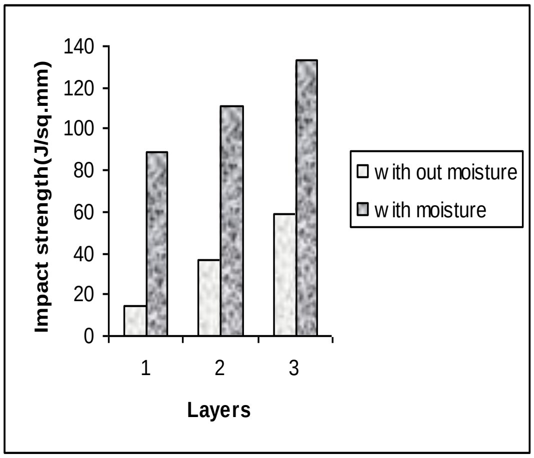


Fig 4.12 Effect of layer on Impact Strength (Comparison)

5. DRILLING CHARACTERISTICS

The holes are made in the composite materials and the hole profile is studied by using profile projector. The property of fiber composite is studied when a drill is made. The wear loss of the drill tool is also studied after the hole is drilled. The drill hole is made in the fiber composite material by using 2mm HSS drill bit. 30 holes are drilled on composite. The hole profile is analyzed by using profile projector with 20x magnification. The magnified hole is measured for its diameter in different areas. The holes are selected randomly and studied and their average diameter is analyzed for various layers.

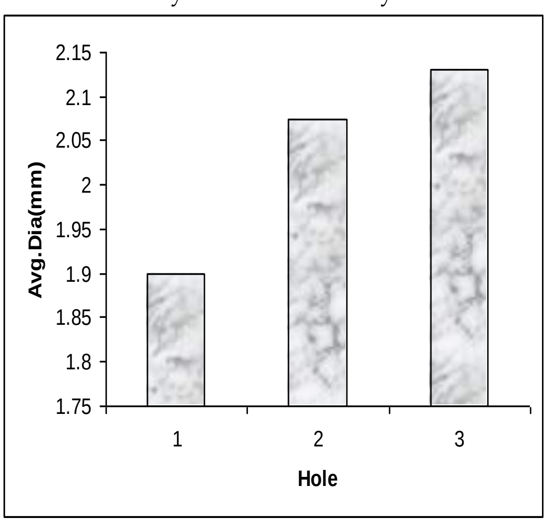


Fig. 5.1 one Sisal and one Glass Fiber

The figures shows that the hole profile of the glass fiber composites vary drastically due to the tensile nature of glass fibers.

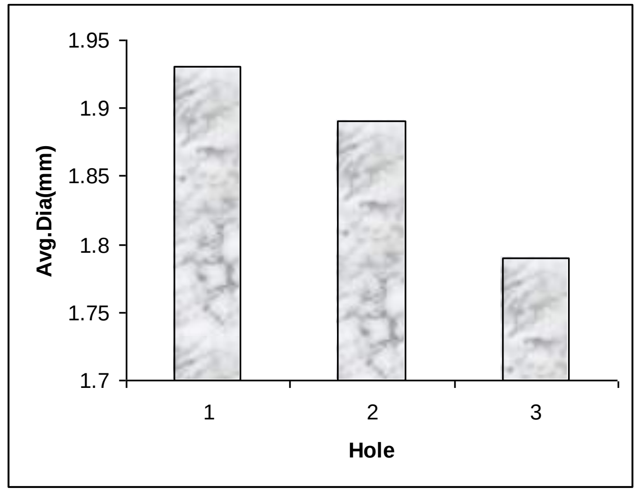


Fig. 5.2 Two Glass and One Sisal fiber

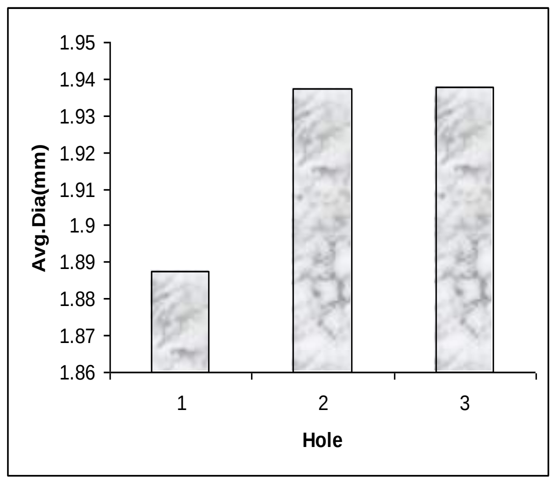


Fig.5.3 One glass & two sisal Fiber

The drilling characteristics of sisal fiber composites. The hole profile analysis is performed.

6. CONCLUSIONS & SCOPE FOR THE FUTURE

From the experimentation and analysis of sisal and glass fiber composites the following conclusions are derived.

This work presents a procedure to fabricate resin reinforced sisal and glass fiber composites. The tensile testing of fiber composites without moisture proves that the two sisal and a glass composites shows better mechanical strength. The tensile testing of fiber composites with moisture proves that the two sisal and one glass fiber composites shows better mechanical strength. The flexure testing of fiber composites without moisture proves that the one glass and one sisal composite show better mechanical strength. The flexure testing of fiber composites with moisture proves that the one glass and one sisal fiber composites shows better mechanical strength. The Impact testing results of fiber composites with and without moisture show that the two glass and a sisal fiber composites produces high impact strength. The drill hole profile analysis shows that all the fabricated composites have poor dimensional accuracy.

6.1 Scope For The Future

The scope of this work in the future are
Fabrication can be done by using compression moulding method.
Fibers can be used in the form of powder and it can be used to form composites.
Corrosion testing can be done in the future.
Fatigue analysis can be done in the future.

7. REFERENCES

1. Roger M. Powell (1994), "Utilization of Natural Fibers in Plastic Composites" in Lignocellulosic: Plastic Composites, Vol. 4(27).

2. H.Y.Sastra (2005), "Flexural Properties of Agenta Fiber Reinforced Composites", in American Journal of Applied Sciences, (Special Issue): 21-24,

3. Mikko Hautala (2002), "Agro Fiber Research and Industrial Development", Harvesting and processing of fibre hemp as raw material for pulp, mft -products and strong composites. Potsdam, Deutschland.

4. OS Carneiro and JM Maia, Rheological baviour of carbon fiber / Thermoplastic composites. Part 1: The influence of fiber type, processing conditions and level of incorporation, PolymCompos, 21 (6), 2000, 960-969.

5. L Wanjun, LT Drazal, AK Mohanthy and M Misra, Influence of processing methods and fiber length on physical properties of kenaf fiber reinforced soy based biocomposites, Composites: Part B, 38(11), 2007, 352-359.

6. H. Y Sastra, J. P Siregar, S. M Sapuan and M. M Hamdan, Tensile Properties of Arenga pinnata Fiber-Reinforced Epoxy Composites, Polymer-Plastics Technology and Engineering, 45 (11), 2006, 149 – 155

7. Kazuya Okubo, Toru Fujii and Yuzo Yamamoto, Development of bamboo-based polymer composites and their mechanical properties, Composites Part A: Applied Science and Manufacturing, 35 (3), 2004, 377-383.

8. P Antich, A Vazquez, I Mondragon and C Bernal, Mechanical behaviour of high impact polystyrene reinforced with short sisal fibers, Composites: Part A, 37, 2006, 139-150.

9. Thi-Thu-Loan Doan, Shang-Lin Gao and Edith Mäder, Jute/polypropylene composites I. Effect of matrixodification Composites Science and Technology, 66, 7-8, 2006, 952-963

10. Xun Lu, Ming Qiu Zhang, Min Zhi Rong, Da Lei Yue and Gui Cheng Yang Environmental degradability of self-reinforced composites made from sisal Composites Science and Technology, 64, 9, 2004, 1301-1310.

11. Shinji Ochi, Development of high strength biodegradable composites using Manila hemp fiber and starch-based biodegradable resin Composites Part A: Applied Science and Manufacturing, 37, 11, 2006, 1879-1883

12. V.G. Geethamma, G. Kalaprasad, Gabriël Groeninckx and Sabu Thomas, Dynamic mechanical behavior of short coir fiber reinforced natural rubber composites: Composites Part A: Applied Science and Manufacturing, 36, 11, 2005, 1499-1506

13. A Laly Pothan, Sabu Thomas and G. Groeninckx, The role of fibre/matrix interactions on the dynamic mechanical properties of chemically modified banana

fibre/polyester composites Part A: Applied Science and Manufacturing, 37, 9, 2006, 1260-1269.