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Review on Fabrication & Characterization of Green Composites using Natural Fibers

Dr.K.Sooryaprakash, G.Sathyamoorthy

Abstract— The growing global environmental awareness, ecological concern and preservation of non renewable natural resources have attracted researchers to develop new eco friendly bio fiber materials. This paper deals with the concept of natural fibers (banana and jute) reinforced with soybean resin to form a fiber matrix composites. In this process the banana and jute fibers are mixing in various weight ratios to get hybrid structure. These hybrid structures with resin are fabricated with the moulding process and to form new composites. It also discuss the various factors sample preparation, moulding process, temperature, pressure etc., on enhancing the mechanical properties of fiber matrix composites. The moulded components have more excellent properties like flexural, impact, tensile strength and elongation. The fabricated composites can be used in various fields for replacing plastics and to form light weight components used in automobiles.

Keywords- Fiber matrix composites, Natural fiber, Resins, Moulding process, Plate formation.

I. INTRODUCTION

Fiber matrix composites are the materials obtained from the fibers combined with resin. In this work natural fibers (fibers obtained from plants or living species) like banana and jute are present. The FRP contains high strength fibers and have good interfacial bond between them [1]. In this fiber acts as load carrying members and matrix as load transfer medium.[5].These fibers contains the lingo cellulosic property, which has many advantages compared to glass fibers like easily available, low cost, recyclable and biodegradability[2,3].

In this work, composite acts as a better alternative for replacing plastic material products [4]. The disposal of waste plastic products is more difficult and challenging due to lack of land in populated areas [6]. Moreover, it can be used for reducing weight, increasing strength in automobile parts, micro structure molecules and to develop it to bio-degradable product materials. Natural fiber based bio-composites are the recent techniques to fill the gap of biodegradable products as a part of the green revolution due to renewable, non-abrasive properties. In this process, the pretreatment on fiber like acid, alkali etc, are done to get good bonding between the resins [7] and to form composites. The materials like banana, jute and soybean resin are discussed briefly.

A. MATERIALS DESCRIPTION PROCESS

Dr.K.Sooryaprakash, G.Sathyamoorthy, are in Department of Mechanical Engineering, Anna University Regional Centre, Coimbatore.

BANANA FIBERS:

The fibers are obtained from the banana plant of the Musacease family. It is a ligno-cellulosic fiber which has good properties. It is also obtained from the "pseudostems" which is clustered in a manner [8]. It is fully of bio-degradable, no environment hazards and eco-friendly materials. Its average fineness is 2400Nm.it is
made up of thick walled cell tissue and bonded by natural gums.

Table1: Botanical composition of banana fibers.

Sl.No	Constitutents	Percentage
1.	Cellulose	31.27 ± 3.61
2.	Hemicellulose	14.98 ±2.03
3.	Lignin	15.07±0.66
4.	Extractives	4.46±0.11
5.	Moisture	9.74±1.42
6.	Ashes	8.65±0.10

It also possesses a good property when it is to be reinforced with the resins and to form good composites. It is to be employed in more cotton, textiles, and design process to produce products and acetylation process of this fiber will improve oil absorption [9].

Fig 1: A view of banana fiber.

Table2: Tensile properties of banana fibers.

Tensile strength (MPa)	Strain (%)	Young's modulus (GPa)	Density (g cm^{-3})
161.8 ± 11.8	2.0 ± 0.4	8.5 ± 0.9	0.8 ± 0.08

It also finds the applications in high quality security/currency paper, packing cloth for agriculture produce, wet drilling cables, ships towing ropes etc.,

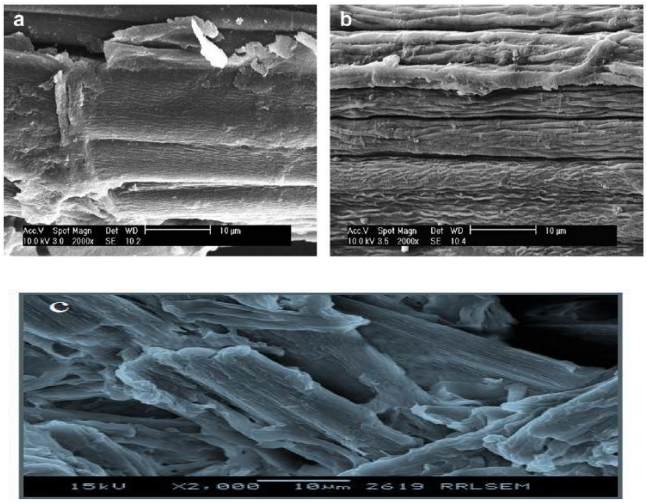

Fig 2: Shows the SEM images of a) surface morphology of the banana fiber. b) Acid treatment of banana fibers. c) out view of the banana fibers[9].

JUTE FIBERS:

Jute fiber is obtained from the plant of corchorus family. It is the second most cultivation of the natural fiber in the world. It possesses a good specific strength, modulus and stiffness with respect to lingo-cellulosic fiber to form composites [10]. It has the advantages of good insulating and antistatic properties and low moisture retention [11].

Table3: Properties of jute fibers.

Fibre	Density (g/cm^3)	Tensile Strength (MPa)	Young's Modulus (GPa)	Elongation At break (%)	Specific Tensile Strength ($MPa/g.cm^{-3}$)	Specific Young's Modulus ($GPa/g.cm^{-3}$)
Jute	1.3-1.45	393-773	13-26.5	1.16-1.5	286-562	9-19

Due to its uneven diameter and comparatively low cellulose content, jute fiber is about 90% is spun into yarn for fabrics; the better qualities supply burlap and the poorer grades are used for baling and sacking (e.g., gunny sacks). The fiber strands in the bark are 6 to 10 ft long (2-3m) and are separated from the woody stalk center by retting.

Fig 3: A view of jute fiber.

This fiber has good bond with the resin matrix to form a composites. The major use of the jute fiber is to make curtains, chair coverings, carpets, cosmetics, paints, medicines and other products.

Table4: Tensile strength of jute fibers in acid treatment.

Jute fibers	Tensile strength±SD* [MPa]
Untreated	250±119
2 wt% NaOH treated	325±132
5 wt% NaOH treated	389±150
2 wt% KH550 treated	326±145

It can be used to give the good bonding between resin matrixes to form composites [12].

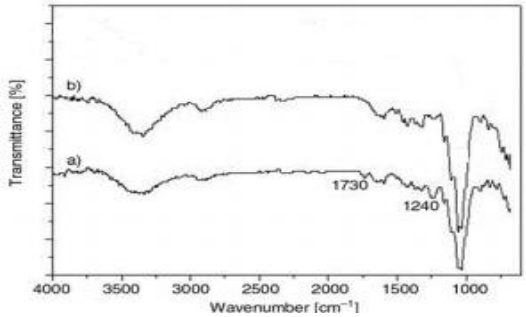

Fig 4: Shows the FTIR spectra of a) untreated jute b) acid treated jute.

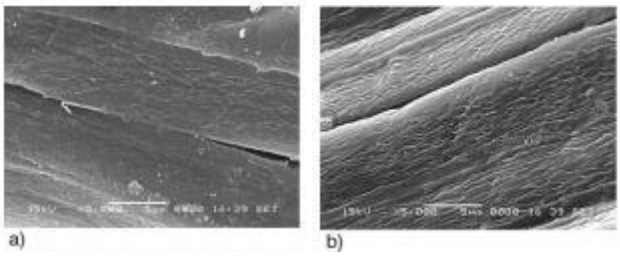

Fig 5: Shows the SEM images of a) surface morphology of jute fiber. b) Acid treated jute fiber.

SOYBEAN RESIN:

Soybean resin is a bio resin which is to be obtained from the vegetable soybean. These based hybrid composites will be degradable and eco-friendly manner [13].soybean resin is to be various forms like soy protein concentrate and oil to form the matrix material [10]. The proteins on this soybean may cross linked with the natural fibers (jute & banana) to form fiber matrix composites.

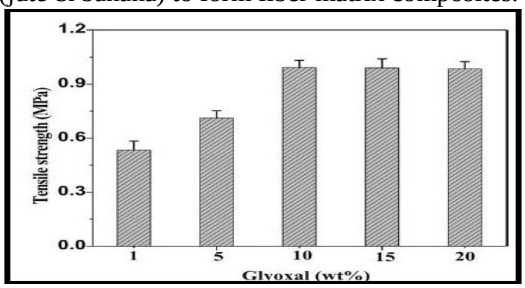

Fig 6: Shows the tensile strength of soybean resin with different % of glyoxal.

Soybean consists of a group of proteins (polypeptides) has the wide range of molecular structures and consists of

38% of non polar, non reactive amino acid residues where 58% are polar and reactive [14].

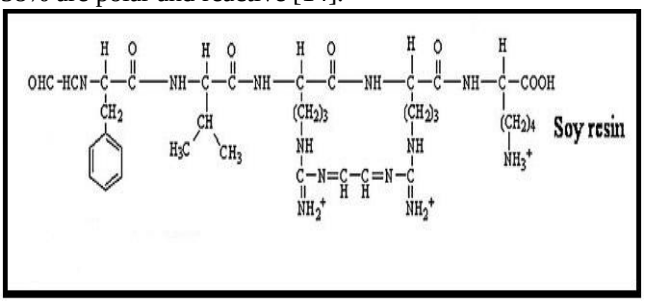

Fig 7: Shows the structure of soy bean resin

These resins will make the fiber to get tightly compact to form the fiber matrix composites [10]. The numbers of carbon-carbon double bonds present in vegetable oils make them a good target for manipulation into some other useful products. Soy proteins, which are complex macromolecular polypeptides containing 20 different amino acids, can be converted into biodegradables.

II. PREPARATION OF SAMPLE SPECIES

In this process, the fiber of banana and jute to be prepared and set to be hybridized in a cross piled manner. The ratios of the fibers are separated with the help of weight aspects. Hardener is to be used at the time of fiber to matrix formation [16].In this process the jute and banana are to be mixed with different (75/25, 50/50, 25/75) ratios and to get mixed with resin and hardener are to be mixed in the ratio of 4:1 level so that the formed composite plate will have good compact in manner. The mixing of hardener and resin are to be done using stirrer for 15 min continuously [17].

The natural fibers are cut according to the ASTM standards. The natural fibers are to be clean with the distilled water and then dry in sunlight. The cleaned natural fibers are to be in treatment with chemical process of NaOH contains 80% of sodium hydroxide and 20% of distilled water. The fibers are dipped into the solution and again dried in sunlight [16].

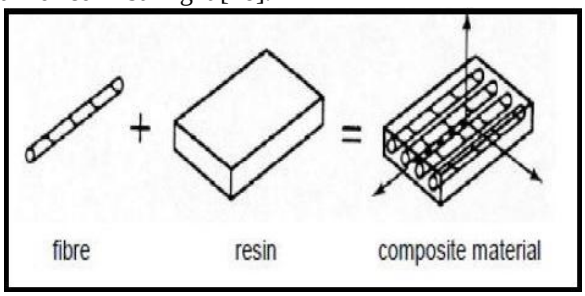

Fig 8: Outline of the material formation process [16].

Due to chemical treatment process, moisture content is to be removed and increase in strength, flexural rigidity of the fibers. The banana fiber and jute fiber are to be preparing in the above process and is to be placed on to mould pattern according to the specified weight ratios [10]. Then it is be mixed with resin and hardener place in the mould cavity. The process takes to formation of composites. In this work, we produce the plates according to weight ratios process.

Table5: Fibers mould ratios according to weight.

BANANA FIBER WEIGHT %	JUTE FIBER WEIGHT %	RESIN &HARDENER RATIO
75	25	4:1
50	50	4:1
25	75	4:1

The composite slabs are made by hand-lay-up technique in conventional manner and are to be followed by light compression moulding process [1]. The pattern is made of stainless steel having dimension of 250mm and 3mm thickness. For easy removal of the composite material silicon spray is to be used.

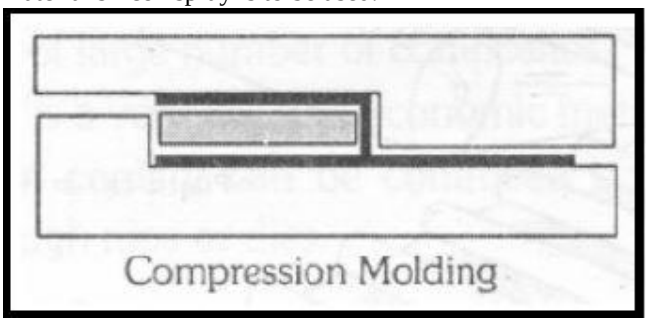

Fig 9: Simple layout of compression moulding technique.

To avoid the clump and tangle together of the composites when mixing care is to take to it. Then it tends to load of 25kg and 24 hours before removed from the mould and take to environment.

III. FORMATION OF COMPOSITE PLATES

With the formation of setup, the composite plates are made by the help of compression moulding process. Here the preparation of the sample of banana and jute fibers are to mix in hybridized manner such that it can combine with resin to form fiber matrix components [3]. These fibers are to be mixed with various weight ratios in order to get the composite plates of high strength products. Here the technique of compression moulding is employed for mass production of composite plates [10]. In comparison with injection moulding, it has the advantage of better physical and chemical process.

When the fiber and resin are to be hybridized with respective ratios place on the mould, the cavity is closed and the mould is heated. With the increasing pressure air is forced to out of the cavity. The pressure is based on focused part of ranges from 0.7 to 9 MPa [18]. The composite part will have a smooth surface on one side and a very rough surface on other. A mould must be used for hand lay-up unless the composite is to be joined directly to another structure. In this process, lower pressure results to

increase in porosity of the mould whereas higher pressure leads to sink marks [13].

Fig 10: Formation of composite plates.

From the above fig, banana and jute fiber are prepared with 75% and 25 % weight ratios and mixed with soybean resin to form composite plates. It is formed of the dimensions of 130x110mm and 3mm thickness. After the process of curing time, the composite plate is formed. With the help of this technique can produce large number of parts with little dimensional variations, variety of shapes, complexity and different sizes.

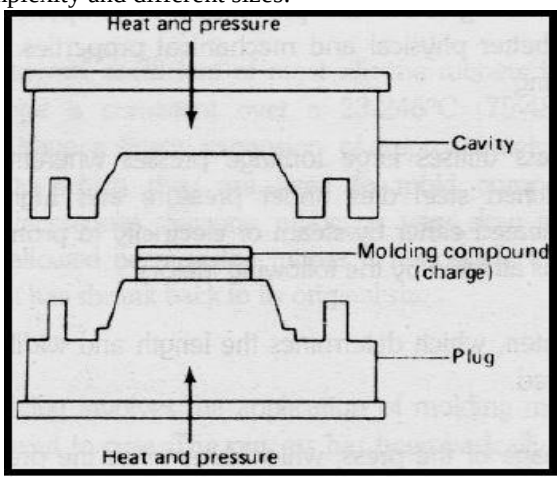

Fig 11: Working conditions of compression moulding.

With the help of compression moulding technique, the composite plates are formed and different plates are formed according to the weight ratios [1]. After that plates are subject to various tests. The specimen has to be cut according to the mechanical and physical characterization process. In order to maintain uniformity and homogeneity careful observation is needed.

IV. MATERIAL PROPERTIES OF THE SPECIMEN

After the preparation of the composite plates, obtained by the compression moulding process they are subject to various testing process in order to find out the mechanical properties as per ASTM standards [19]. It is an important element in quality control and quality assurance process as to find in these composite plates. In order to get the tensile testing results, the specimen is undergone in to the process of universal testing machine. The speed of testing is the relative rate of motion of test fixtures during the test [1]. The testing speed of the crosshead is 0.5 mm/min. The elongation of the specimen is continued until the full fracture occurs. It is to be record; average o three specimens have to be observed [20].

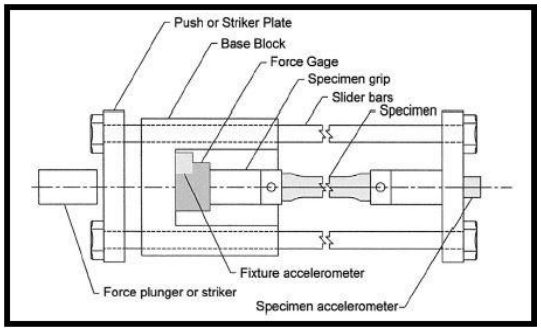

Fig 12: Working of tensile test specimen.

The most common specimen for ASTM: D-638-10 is used and to get the specimen dimensions of 165 x 13 x 4 mm [21]. Flexural test is to be identified with the composite plates. These are done to get the material stiffness and to get deformation value subject to loading. It is to be conducted as per ASTM: D790 using UTM to the dimensions of 127 x 13 x 4 mm [22]. It is about 10 to 20 percent of compressive strength depends on type, size and volume of coarse aggregate used.

The impact test is to be carried out to find the toughness of the material and used for quick, easy control check. In this the kinetic energy is needed to continue fracture until the specimen is broken. The standard specimen of dimension is ASTM: D256 (66 X 13 X 3) mm [23]. In order to find out the hardness tests the sample is subjected to intender load when force is applied. It is characterized by intermolecular bond; hence the dimensions are given as per ASTM: D790 (50 X 13 X 3) mm. Then the composite plates are subjected to thermal tests, these are observed by the thermo gravimetric analysis [1]. It measures the amount and rate of change in the weight of material as a function of time. The temperature deflected is recorded as heat defection temperature as per ASTM: D648 [24]. The composite plates are then subjected to water absorption tests and is identified in terms of weight increase for composite specimen immersed in water as per ASTM: D570 [25] of dimensions (5 x 5 x 3) [1]. The sample is taken out and dried to get the weight of the sample. The sample tests have to be observed with the help of scanning electron microscope, with this interfacial property such as fiber matrix interactions, fracture behavior and fiber pullout after the mechanical tests is identified. The fractured portions of the samples are cut and coated over the surface uniformly for examination process [10].

V. ANALYSIS AND FUTURE WORKING PROCESS

In this work, after the composite plates are formed and verified it is to be analyzed with the help of software techniques. These techniques are needed to show the material is fabricated to product how much strength it with stand when subject to failure process. In this process to

find the material analysis software will be used to obtain the results [26]. After the process of composite testing, Taguchi method has followed to test which of the hybrid composites will give the best result of increase in strength and good compact ratios. It will be easy to find the best result of producing the composites.

In the new trends the term bionics has to be mostly identified with the material structures and it relates to nature of the working environment in to scientific field. It is to be considered as gift of god that the modern development leads to copying of structure from plants and animals to get nice look and increase in efficiency process [27].In this process also bionics is introduced in to this field, as most of the living organisms after their live comes to degradability level in this process also the composite material tends to be biodegradable after their life. Hence it does not affect the environment, not to create pollution and no spending time on disposal process. It is eco-friendly material to be used in all fields of applications [28]. This bio-integrated field will leads to the environmental safety process. As the newer trends of this field gives more about biological concept to get more compactable to environment. Formation of the composite plates leads to bionic integrated honey comb plates which are to be subjected to wear and compressive tests properties.

VI. APPLICATIONS

Composite materials have found applications in almost all branches of engineering. A rough estimate indicates that more than 60,000 products are being made using these materials. For convenience, the usage of composites can be divided into few application areas and their interior applications are listed below. This division is based on the design and functional requirements.

- Automotive - Door panels, seat backs, headliners, dash boards, car door, Transport pallets, trunk liners, spare tyre covers, other interior trim.
- Aircraft Construction - Interior panelling, Railing and bridge.
- Household products and furniture - Table, chair, fencing elements, Window frames, doorframe profiles and food tray.
- Electrical and electronics - Mobile cases and laptops cases.
- Sports and leisure items - Tennis Racket, bicycle, Frames and Snowboards.

VII. CONCLUSION

The present investigation deals about the concept of reinforcement of natural fiber (jute and banana) with bio-based vegetable resin and it will be tends to form composites on the process of various weight ratios. In this process the best of the hybridized composites will be selected and compare it to other weight ratios. The study of this process is identified and it will be converted to practical work to find the mechanical properties of the composite materials. In the research field it is more suitable for biological zones for replacing plastic materials, low cost, light weight products such as in fertilizing and aircraft industries. In this work, it describes about the theoretical study on fiber reinforced composites with the mechanical properties influenced on it. It also reveals the various types of testing that tends to identify the composite structures and the software techniques to identify the analysis process.

In this area of bio-degradability of products most of products made by the synthetic and plastic will leads to affect the environmental zone specially for the process of biological environment. With the use of these synthetic things will leads to affect the soil, water and other source to development of hazardous, pollution environment. It also gives to reduction of source as low in groundwater source and this leads to next generation people a dangerous zone. Such that in order to fill the gap of biodegradability, pollution free environment has to be made. These eco-friendly materials has to be made with the help of fiber reinforced composite plates. In this area of applications gives car coverings, mirror area, front head of the bike, false sealing, roofing, micro gear structure, couplings etc., In this composite plates will give a good replacement for plastic zone and to the development of these composites will give more useful for mechanical industry leads to give more research on this field. Thus it forms a eco-friendly, useful products to environment and to development of next generation a good atmosphere is created.

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