Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 8, August -2017

Processing and Characterization of Coconut Coir-Human Hair Reinforced Epoxy based Composites

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Abstract— *A composite material is a alliance of two or more materials arranged in the pattern of layerby layer using binding material through some prescribed methods. Recently there is a escalation in natural fibre based composites due to their many advantages like easily available, low cost etc. The mechanical behaviour of a composite material depends on many factors such as fibre content, orientation, types and length etc. The effect of fibre loading on the mechanical properties behaviour of fabricated composite is analysed.*

The objective of this research work is to manufacture a hybrid composite material with coir and human hair. To remove dirt particles initially fibre is weild with sodium hydroxide solution. The fabrication of composite will be done by hand layup process. Initially for trail formulations some preliminary tests are made. After the trail formulations, a maximum fibre placed in the mould is arrived and based on that distinct compositions are considered and casting is made on the glass mould stationed on the different compositions. After the mould is prepared using hand lay up process moulds are cutted stationed on the ASTM standards for the mechanical properties.

The mechanical properties such as tensile, flexural and impact strength, Rockwell hardness strength are determined by conducting tests for the samples sliced from the fabricated composite material as per ASTM standards.

Keywords— *coconut fiber; Human hair; hybrid composites; mechanical properties.*

I. INTRODUCTION

The development of composite materials and their related design and manufacturing technologies are now a days playing most prominent role in the history of materials. Composite materials are developed for a particular application used in different fields having demand with improved mechanical and physical properties. These materials has a more advantages compare to the other conventional materials in order to improve tensile strength, impact strength, flexural strengths, stiffness and fatigue symptomatic. Because of their numerous advantages they are wastly used in the aerospace industry, mechanical engineering applications and aircraft structures etc.

Composite materials are defined as the combination of discrete phase and continuous phase materials whereas discrete phase is reinforcing material and continuous phase is matrix material. Composites are again classifiedinto three types based on the type of matrix material used. Composites are classified into three types. They are metal matrix composites, ceramic matrix composites, and polymer matrix composites. In metal matrix composites metal materials are used as matrix with fibre as reinforcement. Commonly used fibres are graphite, boron, alumina, silicon carbide, molybdenum and tungsten. The most commonly used metal matrix is copper, lead, aluminium, titanium and super alloy. The main applications of metal matrix composites are in manufacturing satellites, helicopter structures, missile, jet engine fan blades, antenna structures etc. It is a ceramic matrix composite reinforced with fibre. Most commonly used fibre is carbon, boron, aluminium oxide etc… most commonly used matrix is silicon carbide, aluminium oxide etc. The various fields of applications are cutting tools, dies, pressure vessels, automotive engines etc.. In Polymer matrix composites polymer resin is used as Matrix with different type of reinforcement. Due to many advantages this type of composites is used in many applications such as ease of fabrication, good thermal and electrical insulator, low cost and low density. PMC composites consider the matrix from thermosetting or thermoplastic materials and these are embedded in glass, carbon and other synthetic fibres. Most of the composite materials are manufactured to improve the mechanical properties of materials.

Fibres are classified into two different groups i.e. Natural fibres and synthetic fibres. Synthetic fibres are manmade fibres and synthetic fibres possess more advantages when compare with the natural fibres. The main advantages of synthetic fibres are they possess strength, high elastic modulus, and resilience. Nature of synthetic fibre is hydrophobic. Examples of synthetic fibres are carbon fibre, glass fibre etc. The main disadvantage of synthetic fibre is high cost compare to the natural fibre. Due to this disadvantage natural fibres are used. Natural fibres possess comparable strength to synthetic fibres, low density, easily available, renewable resource, non-toxicity and biodegradable in nature. Based on the availability natural fibres are categorized into bast fibres, leaf fibres and seed hair. Example for seed hair is cotton fibre; ramie, jute and flax are the examples for bast fibres; examples for leaf fibre sisal fibre and abaca fibre. Most common fibres used for fabrication of polymer matrix composites are jute, coir, sisal, bamboo, flax, ramie, hemp etc. The mechanical properties of a natural fibres composite depend on so many factors such as such as fibre strength, fibre length, modulus, fibre matrix interfacial bond strength and orientation..

Human hair is a natural fibre that can be easily available in all over the world. It is a protein content fiber which is called as keratin chains.

II. OBJECTIVE

The main objective of the this project work is to fabricate the composite material by taking coconut coir and human hair as the reinforcement and Arldaite LY556 and hardener HY951 as the binding material.

Fabrication of the reinforcement and binding material will be fabricated by hand lay up process. This hand lay up process is a very easy for batch production and small quantity production.
After the completion of fabrication process, the mechanical properties such as tensile test, impact test, hardness test, flexural tests are tested.

III. MATERIAL

In this composite material human hair and coconut coir fibres are used as reinforcement and Araldite LY556 and hardener HY951as binding material by using this materials four disimilar compositions are fabricated such as 20%hair and 20%coir,20%hair and 40%coir,40%hair and 20%coir,40%hair and 40%coir. The materials properties are discussed below

3.1Coconut coir

It is naturally available fibre extracted from the coconut. It is mainly used in the form of ropes, mats and other house-hold applications. Its diameter varies from 12 to 24 microns. It is widely available natural resource mainly in the coastal areas of Western India.

Coconut fibre is extracted from the outer shell of a coconut. The common name , scientific name and plant family of coconut fibre is coir , cocos nucifera and Arecaceae respectively. Fig 1 shows the extracted fibres of coconut coir.

There are two different types of coir, brown fibre yank from matured coconuts and white fibres yank from immature coconuts. Here white coir fibres are used in this project.

Figure 1. Coconut coir

3.1.1Properties of coconut fibre

- Coconut fibre has the more ductile in nature compare to all the natural fibres.
- Coconut fibres can withstand even though after taking strain 4-6 times more than that of other fibres.
- Highly available in India the second highest in the world after philippiness.
- Because of high lignin content coir is more long lasting compare to the other natural fibres.
- Lignin is a polymer which is needs to a plant to transfer liquids through the plant.
- Coir provides excellent thermal insulation and it also have most insulation against sound.
- Coir provides excellent resistant to fungi and rot and flame retardant.
- Coir is unaffected by moisture and dampness.
- Coir springs back to shape even after continue use.
- Coir is static free and easy to clean.

4HUMAN HAIR

Keratin is a protein which is the main content to form hair and it is having more content of sulphur. The physical properties of human hair are elasticity, smoothness and softness. Hair is stronger and the main responsible for this is Cortex keratin and to form a regular structure its long chains are compressed, and it is also is flexible.

Figure 2. Human hair

This property is much used for making this composite material much flexible. Fig 2 represents the human hair collected from the barber shop.

4.1Properties of human hair

The unique properties of human hair such as

- Hair is having unique chemical composition.
- Its degradable rate is very slow.
- Hair is having high tensile strength.
- It is having excellent thermal insulation.
- It is having scaly surface and also has unique interaction with water and oils.
- Hair is having good elastic recovery.

Human hair has been used for reinforcing clay based constructions because of its high tensile strength and friction coefficient. Strength of hair-reinforced cement and fly ash concrete is highly useful in high pressure bearing structures such as petroleum wells and bridges..

5BINDING MATERIAL

In this project binding material is epoxy resin that is Araldite LY556 and hardener is Araldite HY951.

5.1Properties of Araldite LY556

- It has outstanding adhesion to different materials.
- It has abundant strength and toughness resistance.
- It has outstanding resistance to chemical attack and to moisture.
- Brilliant mechanical and electrical properties.
- Odourless, tasteless and completely nontoxic.
- Insignificant shrinkage.

Hardener Araldite HY951 is used because it has a viscosity in from 10-20 poise at 25 degree centigrade.

IV. SPECIMEN PREPARATION

The specimen will be fabricated by a method called hand-layup method which is suitable for batch production and small quantity production. It is a production method suitable for model making such as prototype andalso suitable for low volume production of fiber composite material. The hand lay-up process can be divided into four different steps such as mould preparation, gel coating, lay-up and finishing. Mould preparation is basic step involved in lay-up process. Moulds can be prepared by wood, plastics, metal whereas metals are used depending on the number of parts, curing temperature, pressure, etc. but for our research work glass sheet with glass frame is taken as mould. To separate the laminate easily from the mould coatings are used this process is called gel coating. Fig 3 shows the hand lay up process which is used to fabricate the laminates.

Hand Lay-up is the method in which the epoxy is poured into the mould, fabric in the form of reinforcement is brushed or applied to the gel coat surface. Here four types of laminates are fabricated in four different compositions by using hand layup method. The composite is cured at room temperature and with the aid of external load of minimum 25kgs for minimum of 24 hours duration.After the completion of curing process, post curing is done.

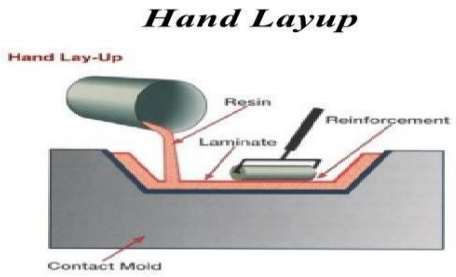

Figure 3. Hand layup process

post curing process is completed for the fabricated moulds then we go for the cutting process to make the specimen ready for the test. The test samples were cutted into the required sizes prescribed in the ASTM standards.
Based on the ASTM standards test samples are cutted in the required dimensions. After this testing process is done on the specimens.

V. METHODOLOGY

The materials has been collected, to remove the dirt particles from the fibres they are treated with sodium hydroxide (NAOH) solution. For one litre distilled water 10 grams of sodium hydroxide pillets are mixed and coir is placed in this mixture for 7hours and after this again coir is removed and placed in one litre distilled water. After this coir is removed from the distilled water and dried it in the closed room.
After the treating of coir again we have to treat the human hair in the same process, but human hair is treated for only 2hours.
After the completion of this process then coir and human hair is cutted into 3cms length for the preparation of hybrid composite material.

5.1Calculations for fibre loading

After curing the pure epoxy weight is 0.90 grams. To know that how much fibre have to place to fill the mould along with epoxy initially 4.4 grams of human hair and 4 grams of coconut coir is measured and place it in a cover. After this a glass mould is taken which is having dimensions 150mm*150mm*3mm then apply wax to the glass mould then pour a layer of epoxy into the mould then spread it with hand brush and then place a layer of coir and then next a layer of human hair until the mould is completely filled. After that measure the weight of the remaining fibre which is present in the cover. By doing like this maximum fibre content in the mould is found. Then subtract the fibre which is present in the cover from the overall fibre so that actual fibre present in the mould known. Remove the weight of the cover while calculating the actual fibre. Mould is prepared for knowing the capacity of maximum amount of epoxy fits into the mould. Fig 4 shows the fabricated pure epoxy laminate.

Figure 4.Pure epoxy

Total epoxy =0.90 grams,Cover weight=1.20 grams,

Coir initial weight =4grams-1.20grams=2.8grams ,

Hair initial weight =4.4grams-1.20grams=3.5grams,

Fig 4 shows the pure epoxy mould. In this 100% pure epoxy mould 90 grams epoxy is present

Coir final weight =1.69grams-1.20grams=0.499grams, Hair final weight=2.30grams-1.20grams=1.1grams
Coir weight =2.8grams-0.49grams=2.31grams,Hair weight=3.2grams-1.1grams=2.1grams,Total fibre weight=4.41grams
For 100% 0.90 grams epoxy and 4.41 grams total 94.41 grams. In this 94.41grams percentage of fibre is 4.67%. Fig 5 shows the maximum fibre mould which is fitted in the 150mm*150mm*3mm mould.
Maximum percentage of fibre present in the 15cm*15cm*0.3cm size mould is 4.41 grams
15cm*15cm*0.3cm=4.41grams

Figure 5.Maximum fiber

Maximum percentage of fibre present in the 20cm*20cm*0.3cm size mould is

20cm*20cm*0.3cm=?

To find the maximum percentage of fibre present in the 20cm*20cm*0.3cm size mould,

calculate for the one cm^3 then 1 cm^3=0.065 grams

Maximum fibre 0.065*20*20*0.3=7.8grams

5.2To find the individual weight composition of different fibre

15cm*15cm*0.3cm size mould,Weight of the coir =2.31grams,Weight of the hair =2.1grams,
Coir weight for 1cm^3=0.0342grams,Hair weight for 1cm^3=0.0311grams, For 20cm*20cm*0.3cm size mould
Coir weight =4.104grams,Hair weight=3.7332grams
For 20% of human hair weight of the fibre in 3.733 is 0.75grams,For 20% of coconut coir weight of the fibre in 4.104 is 0.8208 grams,For 40% of human hair weight of the fibre in 3.733 is 1.5 grams,For 40% of coconut coir weight of the fibre in 4.104 is 1.64 grams
Based on this measurements the following are the different compositions considered in the present research work tabulated below.

Table 1 Different compositions

Serial NO	Human Hair	Coconut coir
1	20%	20%
2	20%	40%
3	40%	20%
4	40%	20%

5.3Hand layup process for the preparation of required mould

The above calculations are used to prepare the moulds for testing the tensile strength, flexural strength, impact strength.The 20%hair,20%coir composition,20% hair,40% coir, 40%hair,20%coir composition and 40%hair,40%coir composition.After the completion of laminates, the laminates are cutted into required specimens based on the ASTM standards. For these 16 specimens mechanical properties will be tested on the universal testing machine for tensile strength and flexural strength, Impact testing machine for impact strength and Rock well hardness testing machine for hardness test. Fig 7 shows the specimens after testing.In this project work the main aim is to increase the impact strength. So human hair is considered as one of the reinforcement material. Human hair has more impact and tensile strength.

VI. RESULT AND DISCUSSION

In every mechanical test experimental values are compared with the base paper experimental values. Bar graphs are plotted in between the specimen numbers and the experimental values and then comparison graphs are plotted for the four compositions.

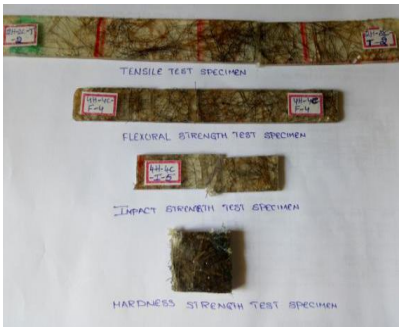

Figure 6.Specimens after testing

6.1Tensile Strength Test

Tensile test is carried out on universal testing machine which is shown in fig 7.

The tensile specimens are prepared as per ASTM-D638(200mm*20mm*3mm).

The experiment values are shown below table. From fig 8 shows the graph between tensile strength and specimen no. at different compositions. From fig 8 it is concluded that tensile strength decreases gradually when the fibre loading increases.

Table 2 Comparative tensile test

S.NO.	2H,2C	2H,4C	4H,2c	4H,4C
1	17.08	11.16	7.164	8.816
2	15.23	10.88	7.16	8.163
3	14.22	8.68	6.33	8.16
4	12.3	7.85	6.2	7.55
5	10.5	7.28	6.12	6.985

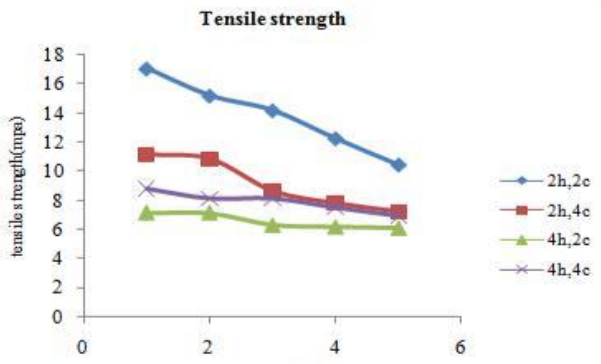

Figure 7.Tensile strength

6.2Flexural strength test

Flexural test is carried out on Universal testing machine. To perform this test specimen size is considered from the ASTM-D790 (127mm*13mm*3mm). the ratio of stress to strain in flexural deformation is known as Flexural Modulus. The experimental values are tabulated below. Fig 9 shows the graph between the specimen number and flexural strength and it is concluded that as the maximum fibre load increases flexural strength decreases. As the coir percentage increases flexural strength increases.

Table 3 Comparative flexural strength

S.NO.	2H,2C	2H,4C	4H,2c	4H,4C
1	12.57	23.92	12.57	22.67
2	12.69	25.27	13.69	24.37
3	12.69	26.1	13.51	25.27
4	12.57	22.57	13.42	20.54
5	12.56	20.57	12.44	18.56

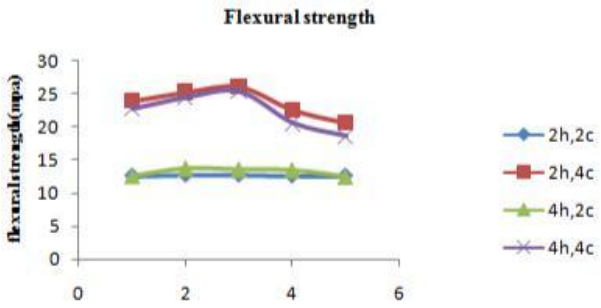

Figure 8. Flexural strength

6.3Impact test

Impact test is performed on Izod impact testing machine which is shown in fig 12. The dimensions used for making the specimen are based on the ASTM standard D256. The experimental values are tabulated below. Fig 10 shows the impact strength is increased when the fibre loading increases.

Table 4Comparative impact test

S.NO.	2H,2C	2H,4C	4H,2c	4H,4C
1	17.5	28.4	50.7	66.7
2	25.4	35.6	55.3	69.5
3	30.8	45.2	58.2	71.2
4	34.6	50.2	62.4	75.3
5	40	55.3	65.5	77.8

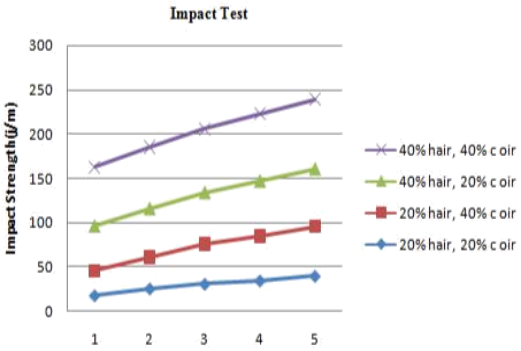

Figure 9.Impact strength

6.4Rockwell hardness test

Hardness test is carried out on Rockwell hardness testing machine which is shown in fig 13. The experimental results are tabulated below. Bar graphs are drawn in between the specimen number and the hardness strength for each and every composition. The experiment values are tabulated below. Fig 10 shows the hardness strength decreases when the maximum hair is reinforced when compare to the other compositions.

Table 5Comparative hardness strength

S.NO.	2H,2C	2H,4C	4H,2C	4H,4C
1	82	74	75	63
2	85	79	82	78
3	73	78	74	74
4	72	76	70	71
5	70	67	68	67

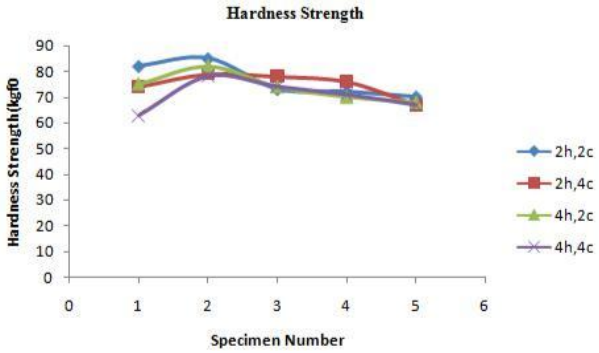

Figure 10.Hardness strength

Figure 11.UTM

Figure 12. Impact machine

Figure 13.Rockwell hardness machine

VII. Conclusion

From the experimental work carried out on coconut coir-human hair epoxy based rein forced composite it was concluded that, as the fibre loading increases tensile strength decreases. When compare with the base paper it is concluded that individual fibres has less strength than the composite fibres. When hair is reinforced with coir at the maximum percentage of fibre that is 40%hair and 40% coir has the more impact strength compared to the other compositions whereas at 20% hair and 20% coir has the maximum flexural strength and tensile strength compare to the other fibre loading and it is also concluded that hardness strength is more when the coir percentage is more. When the coir percentage has more flexural strength increases slightly, hardness strength is decreased when the hair percentage is increased.

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