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DEVELOPMENT OF COCONUT COIR AND PLASTIC REINFORCED COMPOSITE MATERIAL FOR HOME UTILITIES.

P.M. Ajay Gokul [(a)], M. Aswin [(a)], K. Suresh [(a)], P.S. Sampath[(b))]

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Abstract

In the past decades, due to population and technical development, the pollution in the world has increased. Most of the products are developed from petroleum derivatives. The petroleum-based derivatives have some problems like pollution, availability, and cost of products. So, this research is work focused on the composite materials for petroleum derivative-based materials which are used in home appliances. The primary aim of the research is developing suitable natural fiber composite for the right application. For preparing composite material, the coir fiber has been selected for good mechanical strength, availability and low cost. In this research, mechanical testing named tensile, impact, flexural and water absorption testing were examined. The specimen for the experiment was prepared in different ratios of coir and polypropylene. The coir fiber is finely chopped in 3mm length and mixed with polypropylene. The pressure and temperature are applied through compression moulding machine, it creates high pressure on the fiber. The coir fiber mixed with polypropylene with the ratio of 0% coir and 100% polypropylene, 10% coir and 90% polypropylene, 20% coir and 80%, 30% and coir 70%, 35% coir and 65% polypropylene. Finally, the best ratio is picked from the examined results

[(a)] Final Year student, Mechanical Engineering, K.S.Rangasamy College of Technology, Tiruchengode-637215 , Namakkal, Tamil Nadu

[(b)] Professor, Mechanical Engineering, K.S.Rangasamy College of Technology, Tiruchengode-637215 , Namakkal, Tamil Nadu

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1. INTRODUCTION

The use of composite materials has greatly risen over the years, and they are now competing with plastic and ceramics for household and industrial consumer markets. Although their low weight is a key selling point that helped them gain market share, making composites affordable is a difficulty. Numerous cutting-edge production processes have been developed in response to the rising demand for economically appealing composites, yet manufacturing alone cannot get over the cost barriers. For a competitive advantage that is also cost-effective, resources are diverted towards design, material, process, tooling, quality, and program management. Due to the low weight advantage, the aerospace industry uses composites more frequently, but there has been a paradigm shift in how widely they are used in other commercial applications. Due to its better qualities in chemical resistance, corrosion resistance, impact loads, damping qualities, heat properties coir fiber widely used in explosive gas cylinders, windmill fans, pump impellers, drive shafts, house hold products. Newer polymers with improved resin matrix materials, high performance glass fibers like carbon and aramid, as well as the introduction of natural fibers were produced as a result of broader composite use. Engineering requirements determine the type of composite to be used, and elements affecting composite formation include application lifespan, shape complexity, cost restraints, manufacturing expertise, and composites' potential. For outstanding performance, composite polymers rely heavily on epoxy resin, which is particularly advantageous for low-weight fibers such as bamboo, coir, and jute. Although biodegradable, these natural fibers are not as strong, have a lower modulus, and are less resistant than composites reinforced with synthetic fibers like glass, carbon, or aramid. [1-3].

Composite material especially natural fiber reinforcement composite are most welcome materials in engineering industries and home appliances industries. The reason for the demands is natural fibers mostly non-pollutant, low in price, good availability threw out the year.The other mechanical and thermal qualities can be strengthened in order to create hybrid fiber reinforcement. To process hybrid composites that use a range of production techniques to reinforce different fibers, a suitable matrix is required. Coir fiber offers greater flexibility in design compared to other hybrid composites and is also known for its good thermal properties. Additionally, coir fiber is easily obtainable and cost-effective.

The multi cellular coconut fiber possess low thermal conductivity and high density compare than remaining natural fibers. These properties lead to implement the coir fiber into eco-friendly application as well as other structural and thermal applications.

Crystalline cellulose is structured helically within a matrix of lignin and non-crystalline cellulose found within the cells of coconut fiber. Coir fiber has the maximum elongation at the point of breakage when compared to other natural fibers and can withstand 4 to 6 times greater strain. [2- 5].

2. COMPOSITE MATERIAL

Generally, more than one material bonded with one to one and producing a composite material. The both materials essentially have unique physical or chemical properties. In the completed structure of fiber-based composite materials, the individual segments remain isolated and distinct. Typically, a bonding agent, such as resin and hardener, is also necessary.

3. LITERATURE REVIEW

Natural fiber-reinforced composite materials have drawn attention on a regular basis because of its potential for industrial use. Natural fibers are consistently replacing synthetic ones because they are more affordable, renewable, fully/partially recyclable, biodegradable, and environmentally beneficial. Natural fiber composites were the subject of numerous studies.

Prassanna Kattimani[1] carried out research on coconut coir reinforced polymers. Despite natural fibers having poor compatibility with the matrix and exhibiting a high moisture absorption rate, their advantageous characteristics, such as low cost, low density, non-abrasiveness, strong thermal properties, and improved energy recovery and biodegradability, outweigh these limitations. Coir, a notable lignocellulosic fiber, is utilized in the production of various products including floor furnishings, yarn, and rope, although these items comprise only a relatively small proportion of the total coir production. Therefore, researchers are looking for novel applications for coir as a reinforcement polymer composite. The natural fiber used in this experiment, coconut coir fiber, has been chemically treated using alkaline solution. Here, polyester, vinyl ester, and epoxy resins are mixed separately with chemically treated and untreated fibers. The reinforced composite material is then hand-laid up and shaped into a box shape. Nine specimens will be created using three different resins (polyester, epoxy, and vinyl ester) and altering the volume percentage of coir fibers in order to acquire more precise findings.

Yadvinder Singh [2] characterized the hybrid composite developed from coir fibers and epoxy resin. This article details the production of a hybrid composite consisting of coir fiber, woven carbon fiber, and epoxy resin, as well as an analysis of its mechanical and thermal properties. Composite samples were fabricated using the hoover bagging technique, with varying fiber weight percentages of 30%, 20%, and 10%. The mechanical behavior of the coir fiber/carbon fiber/epoxy resin hybrid composites, including tensile, compressive, flexural, and impact strength, as well as their thermal behavior via thermogravimetric analysis, were evaluated in accordance with ASTM standards. Scanning electron microscopy (SEM) was utilized to examine the fiber/matrix bonding of the surface before and after alkaline treatment, as well as the morphological characterization of tensile fractography specimens. The results indicate that the treated fiber exhibits good matrix binding and minimal fiber pull-out, outperforming single fiber-reinforced composites in terms of mechanical loading.

P.N.E. Naveen [3] Evaluation of Coconut Coir Fiber Reinforced Polymer Matrix Composites' Mechanical Characteristics. In this current work, the creation and characterization of a new series of polyester composites utilizing coir as reinforcement and epoxy resin are detailed. When five various volume fractions of coir composites were tested, their mechanical properties were assessed, and the results were given. The findings of the experiments demonstrated that adding reinforcement to composite materials has a significant impact on their tensile, static, and dynamic properties. This suggests that coir could be employed as a viable reinforcement material in a variety of structural and non-structural applications. According to the findings, there is a significant correlation between the dynamic features and the mechanical qualities. The volume proportion of fibers has a big impact on both of the attributes. Compared to composites with higher fiber loading, the composite containing 5% coir fibers produced a notable result due to the impact of material stiffness.

P Sakthivel [4] investigating the properties of coir and tamarind fiber reinforcement composite materials. Epoxy and the three distinct coir fibers combinations are used to manufacture the composite materials. The first combination consists of 60% epoxy, 30% coir, and 10% tamarind; the second is 60% epoxy, 20% coir, and 20% tamarind; and the third is 60% epoxy, 10% coir, and 30% tamarind. In reinforced plastic materials, the fiber used as reinforcement is typically synthetic or natural. According to investigations in the literature, fiber-reinforced polymers have been made using synthetic fibers including carbon, glass, and others. Various tests, including tensile, impact, and hardness tests, are conducted on composite materials with different combinations to assess their mechanical characteristics, such as load carrying ability, elongation, and hardness. The results of the tests demonstrate that the addition of natural fibers improves load bearing capacity. The combination of 10% coir and 30% tamarind had the highest flexural strength, with a maximum load carrying capacity of 9.1kN and a deflection of 16.8mm. The combination of 30% coir and 10% tamarind had the highest tensile strength, with a load carrying capacity of 8.35kN and a deflection of 9.014mm. In terms of impact strength, the combination of 10% coir and 30% tamarind had the highest score of 76. Comparing the three composite material combinations, the combination of 60% epoxy, 10% coir, and 30% tamarind exhibited good mechanical properties.

Shubham Bankar [5] The variety of uses for composite materials has steadily grown thanks to their strength and tenacious expansion into new areas. Modern composite materials make up a considerable component of the engineering materials market, being used in anything from commonplace goods to complex specialist applications. Although it has long been established that composites are materials that reduce weight. Making composites affordable is a difficulty for researchers in the current situation. The primary topic of this article is the utilization of natural coconut fiber, with a particular emphasis on the mechanical properties of coconut fiber composites.

R. Shrivastava [6] investigated almost all of the mechanical properties. The main objective of this study was to create coir fiber-reinforced polypropylene composites (PPC) that possess properties comparable to those of synthetic composites currently in use, and to investigate their fracture toughness behavior and other mechanical characteristics. The specimens were fabricated using the injection molding technique, and Compact Tension (fracture toughness) testing was conducted according to ASTM D-5045 standards. Mechanical properties were assessed through tensile, impact, flexural strength, and hardness tests. The results indicate that, in comparison to neat polypropylene, natural coconut coir fiber-reinforced composites exhibit higher fracture toughness values and improved mechanical properties.

4. MATERIALS AND METHOD

4.1 MATERIALS SELECTION

In generally polypropylene has been used for major plastic material application. In order reduce the usage of polypropylene the natural fiber going do replace the polypropylene.

4.2 COIR FIBER

Coir fiber is one among the natural fiber which is available in through out of the year. India is the most major coir producer in globally. Yearly 2,80,000 metric ton coir produced by India. So, it easily available and cheapest fiber. Coir has good mechanical properties.

Fig no: 1- Coir fiber

S.NO	PROPERTIES	VALUE
`1	Density (g/m^3)	1.2
2	Modulus (GPa)	4-6
3	Tensile strength (MPa)	175
4	Elongation to failure (%)	30
5	Water absorption (%)	130-180

Table no: 1- Properties of coir

4.3 POLYPROPYLENE

Polypropylene is mostly used in plastic material application for making house applications like chairs, tables and other applications. Coir has been used in this spot in place of polypropylene. The matrix material is made of the thermoplastic polymer polypropylene (PP), which is produced when the monomer propylene undergoes chain growth polymerization. Polypropylene is offered in a number of low-cost, low-density grades and has excellent stiffness, enhanced tensile strength, fatigue resistance, and chemical resistance. It has a melting point of approximately 170°C. [1]. Polypropylene will serve as a bonding agent in this work. Polypropylene powder of a technical grade was employed for this project.

Fig no:2- Polypropylene

4.4 SODIUM HYDROXIDE

For this work sodium hydroxide used for increasing the roughness of the coir [7,9,10]. And also, its help to increase bonding strength with polypropylene. Boiling point of the sodium hydroxide 1390°C. Soluble sodium hydroxide used for this work.

5.EXPERIMENTAL WORKS

5.1 FIBER PREPARATION

Fiber preparation for this work consists two set of work. One is fiber washing and another one is chemical treatment.

5.2 WASHING OF FIBER

To get rid of the dust and plant matter, coir fibers obtained from coconut husk are cleansed using water. The cleaned fibers were allowed to dry in the sun for two days.

5.3 CHEMICAL TREATMENT

The dried fiber is used in the subsequent chemical processing step. Chemical therapy involves the use of sodium hydroxide. 16 liters of water and 800 grammes of sodium hydroxide are combined. The fiber was dried and then finely steeped in this mixture for one day.

5.4 MOULD PREPARATION

Generally composite products were developed by using compression mould or injection mould. For this work 20 tonnes compression moulding machinery used to develop the composite plate. The mould was prepared with 12 mm mild steel plate. The size of mould is 28*29cm.

5.5 STEPS INVOLVED IN SPECIMEN PREPARATION

The finely washed and chemical treated fiber chopped in to small length pieces. The size of piece approximately 3-5mm. for this work there are 5 numbers of plates prepared using compression moulding. The 5 plates are prepared with variable fraction ratio of coir and polypropylene. The details faction ration of coir and polypropylene showed in table no:

S.NO	COCONUT COIR (%)	POLY PROPYLENE (%)
1	0	100
2	10	90
3	20	80
4	30	70
5	35	65

Table no: 2- volume Fraction of fiber

The above-mentioned fraction ratio of fibers perfectly mixed with required amount of water for bonding. The finely mixed fibers placed in side of the mould and it kept in compression machine under the 1500Psi pressure. This pressure maintains for 3-4 hours for obtaining good bonding and drying. Then other four plates were developed by this same step repeatedly. After the plate preparation the testing specimens cut from the plate with dimensions of ASTM standards.

6. RESULTS AND DISCUSSION

ASTM STANDARDS

ASTM standard is an important engineering field controlling the material testing. This committee providing guidelines for investing the properties of materials. So, our research also following ASTM guidelines to test out prepared materials.

INTRODUCTION OF TESTING

Metals testing is crucial for demonstrating the various properties of metals and any flaws that might have developed during manufacture or use. Metals testing is crucial for demonstrating the various properties of metals and any flaws that might have developed during manufacture or use. The research involved performing six types of tests, including tensile, impact, flexural, shear, compression, and water absorption tests, in accordance with the relevant ASTM standards.

6.1 TENSILE TEST

Tensile strength of the material is crucial in structural applications to uncover the fundamental mechanical properties. A key test for structural applications is the tensile test. The specimen was created in accordance with ASTM specifications [8]. The load was gradually increased and find out the ultimate load of the specimen. From the ultimate load and specimen area the other properties were calculated.

Fig no:3- Universal testing machine

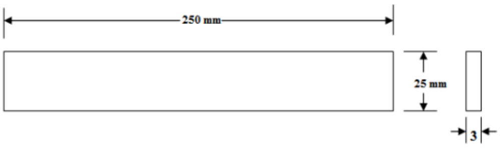


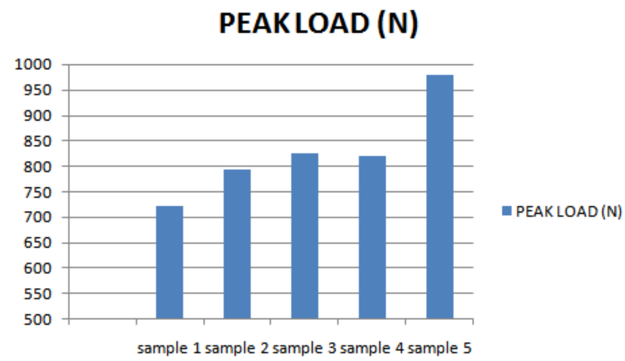
Fig no:4- Dimension of tensile test specimen

Fig no:4 - Tensile tested specimen

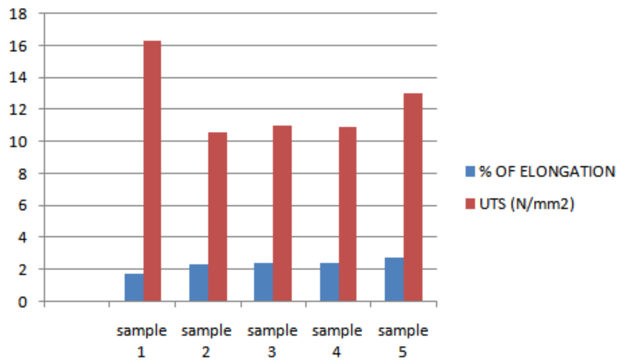
The natural fiber composite of coir with polypropylene where tested and results are tabulated.

S. N	Material		PEAK LOAD (N)	% OF ELONGATION	UTS (N/m^2)
	CC	PP			
1	0	100	722.48	1.66	16.300
2	10	90	792.28	2.24	10.562
3	20	80	825.78	2.4	11.010
4	30	70	818.89	2.39	10.918
5	35	65	978.19	2.68	13.040

Table no: 3- Tensile test results



Graph no: 1- Peak load in tensile test



Graph no: 2- ultimate strength

6.2 IMPACT TEST

The impact strength of the material defines the material resistance to shock or impact loads. For this test specimen placed on the work holding fixture. The pendulum with hammer is released from the certain height and it broke the specimen. During the hammer and specimen collision the energy is shown by the scale which placed on machine. That is called as impact test machine there is two types of impact testing machines widely used one is Izod and another one is Charpy.

The mechanical response of a material to sudden shock loading resulting in deformation, fracture, or complete rupture is evaluated using an impact test. A known weight, often in the form of a pendulum, is dropped from a known height to impart sudden force on the sample. The dimensions and orientation of the holding fixture are determined by the particular test being run. The energy exchange is employed to ascertain the material's fracture mechanics even though the specimen is normally destroyed after the contact. The Izod and Charpy machines are two types of impact testing equipment that are often utilized.

This test illustrates the impact performance of a composite comprised of polypropylene and coir fiber (CC with PP). The impact test was carried out using the Izod Impact testing equipment in line with ASTM regulations, and test specimens were created using ASTM D-256. Impact testing was performed on each specimen, and the findings were recorded. In the image above, a specimen for the Izod impact test is displayed with dimensions that comply with ASTM guidelines. Size of the specimen 65X13X3mm

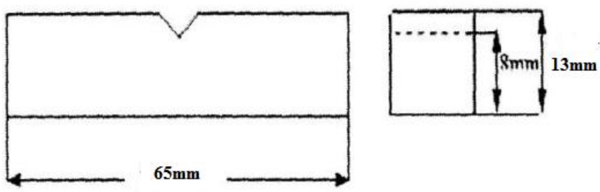
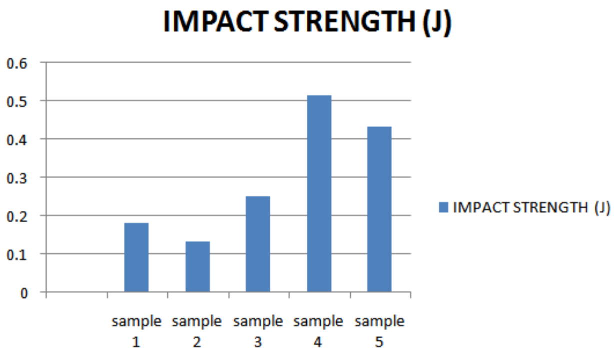


Fig no:5 - Dimension of Impact test specimen

S. N	MATERIAL		IMPACT STRENGTH (J)
	CC	PP	
1	0	100	0.183
2	10	90	0.133
3	20	80	0.25
4	30	70	0.516
5	35	65	0.433

Table no: 4- Impact test results



Graph no:3- Impact results

6.3 FLEXURAL TEST

The purpose of the flexural test is to determine the flexural characteristics of the prepared specimen. This test is carried out using ASTM D790. The results of the analysis guide the selection of materials for the application. It has to do with how stiff the substance is. To gauge a plastic's flexural qualities, use ASTM D790. The specimen is 125X13X3mm.

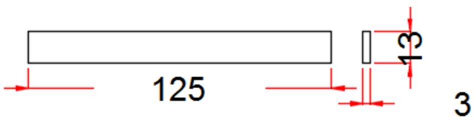
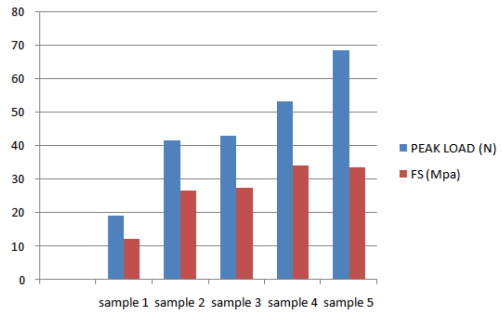


Fig no:6- Dimension of flexural test

Fig no:7 - Flexural tested specimen

S. N	Material		PEAK LOAD (N)	FS (MPa)
	CC	PP		
1	0	100	19.133	12.26
2	10	90	41.597	26.66
3	20	80	42.912	27.50
4	30	70	53.18	34.09
5	35	65	68.395	33.50

Table no: 5- Flexural test results



Graph no: 4- Flexural strength

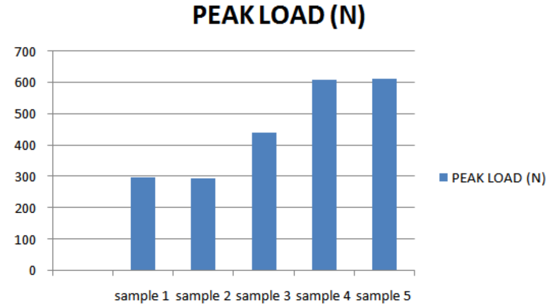
6.4 COMPRESSION TEST

The compressive characteristics of a polymer are measured in accordance with ASTM D-3410, and the compressive strength test is carried out using the CTM (Compression Testing Machine). Put the specimen between the testing device's two plates. In this test, an axial load was applied. The uniform gradual load applied. The used homogeneous progressive load. As soon as a failure occurred in the specimen, the loads were applied and noted. The compressive stress can be estimated from this maximum compressive load. The specimen is 150X25X3mm.

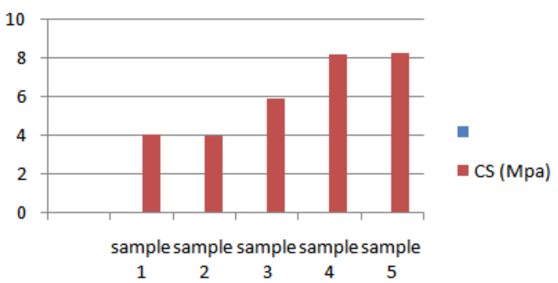
Fig no: 8- Compression tested specimen

S. No	Material CC	Material PP	PEAK LOAD (N)	CS (MPa)
1	0	100	299.58	3.99
2	10	90	294.80	3.92
3	20	80	442.189	5.89
4	30	70	609.92	8.13
5	35	65	613.64	8.18

Table no: 6- Compression test results



Graph no: 5- Peak loan in compression test



Graph no: 6- Compression strength

6.5 WATER ABSORPTION TESTING

The test technique for polymer water absorption qualities is ASTM D-5229 (Test technique for Water Absorption qualities of Polymers). The water absorption test is very important to fiber-based composites. This test conducted for find out water absorbing rate of coir fiber composite. In this experiment, the material was dried in an oven at a predetermined temperature and duration. The specimens are promptly weighed after being placed in desiccators to reach natural temperature. The material is then maintained at 23°C for 24 hours to achieve equilibrium. The specimens are taken out, dried with a loose cloth, and weighed. 20x20x3mm is the size of the specimen.

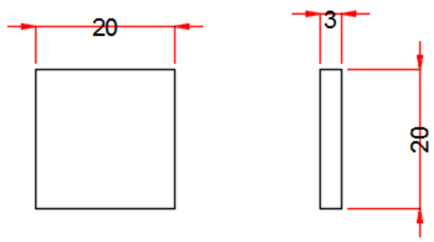
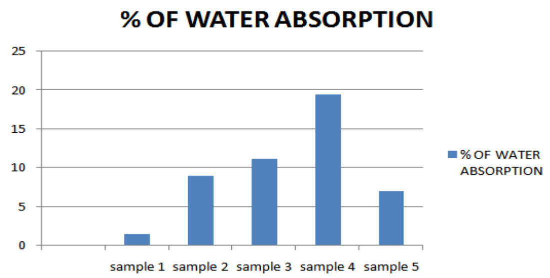


Fig no:9- Dimension of water absorption test

S. No	MATERIAL CC	MATERIAL PP	WEIGHT OF SPECIMEN (gms) BEFORE	WEIGHT OF SPECIMEN (gms) AFTER	% OF WATER ABSORPTION
1	0	100	1.4	1.42	1.4
2	10	90	1.24	1.35	8.9
3	20	80	1.17	1.3	11.1
4	30	70	1.28	1.53	19.5
5	35	65	1.57	1.68	7.0

Table no: 7- Water absorption test results



Graph no: 7- water absorption results

7. CONCLUSION

The goal is to evaluate the coconut coir fiber reinforced natural fiber composite. The preparation of the specimens was done by hand layup. The samples were examined, and the results were tallied. According to studies, coir combined with 35% of coir and 65% of polypropylene develops stronger materials than other ratios. This coir composite material providing good flexibility reducing weight. Same as this material posses some more addition qualities like low corrosion, less pollutant, good mechanical properties.

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