Mechanical Characteristics of Coir/Jute fibers polymer composites

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Abstract

Natural Fibers composites are considered to have potential use as reinforcing material in polymer matrix composites because of their good strength, stiffness, low cost, environmental friendly and biodegradable.In present study, mechanical properties for natural fiber composites were evaluated.Composite were prepared with randomly orientated fibers with different proportions of fibers and matrix ratio.Mechanical tests i.e. impact and hardness tests were performed and the results are reported.

Keywords: *Natural fibers, mechanical properties, Coir, Jute fibers*

1. Introduction

The advantage of composite materials over conventional materials stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. By definition, composite materials consist of two or more constituents with physically separable phases However, only when the composite phase materials have notably different physical properties it is recognized as being a composite material. Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load.The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone. The reinforcement may be platelets, particles or fibers and are usually added to improve mechanical properties such as stiffness, strength and toughness of the matrix material. Long fibers that are oriented in the direction of loading offer the most efficient load transfer. This is because the stress transfer zone extends only over a small part of the fiber-matrix interface and perturbation effects at fiber ends may be neglected. In other words, the ineffective fiber length is small. Popular fibers available as continuous filaments for use in high performance composites are glass, carbon and aramid fiber.

2. Literature review

Kumar et al [1] in their paper, Mechanical properties of Coir/Glass fiber Phenolic resin Based composites was investigated. Here phenolic resin based Coir/Glass hybrid composites were developed by hand lay-up technique. The mechanical properties such as tensile and flexural properties have been analyzed. This study is focused on the mechanical performance of coir based and its hybrid composites. The main aim of the work is to find high mechanical performance composites. Khanam et al. [2] in their paper, Tensile, Flexural and Compressive Properties of Coir/Silk fiber-reinforced hybrid compositeswas analyzed. Here the hybrid composites of Coir/Silk unsaturated polyester based hybrid composites with different fiber length (1, 2 & 3 cm) were prepared. Hussain et al. [3] in their paper, Mechanical Properties of short Bamboo fiber Reinforced Polyester composites filled with Alumina Particulate was analyzed. This paper deals with the evaluation of mechanical properties namely Tensile strength and flexural strength of short bamboo fiber reinforced polyester composites filled with alumina particulates. Specimens were prepared by hand lay-up technique and are cut as per ASTM standards to perform test. Gowda et al. [4] in their paper, some mechanical properties of untreated Jute fabric reinforced Polyester composites was investigated. This research work was concerned with the evaluation of the mechanical properties of Jute/Polyester Composites. Reddy et al. [5] in their paper, A Study on Hardness and Flexural Properties of Kapok/Sisal Composites was analyzed. In this paper hardness and flexural properties of kapok/sisal composites were determined with reference to fabrics content and varying the volume ratios of fabrics. The properties of kapok/polyester composites are found to be better than those of kapok/sisal polyester composites. At the end of my literature survey, I concluded that the most composites are made by different natural fibers and matrices. Mostly single natural fiber is used as reinforcement element and their mechanical properties are studied. But one or two hybrid composites are made by the combination of natural fibers. So, I wish to do my project in the area of hybrid composites which includes the coir fiber, Jute fiber and Alumina particulate are mixed in different weight percentage with polyester polymer matrix. Then the mechanical properties such as tensile, flexural and impact strength are to be tested. The methodology used in this research work is shown in Figure 1

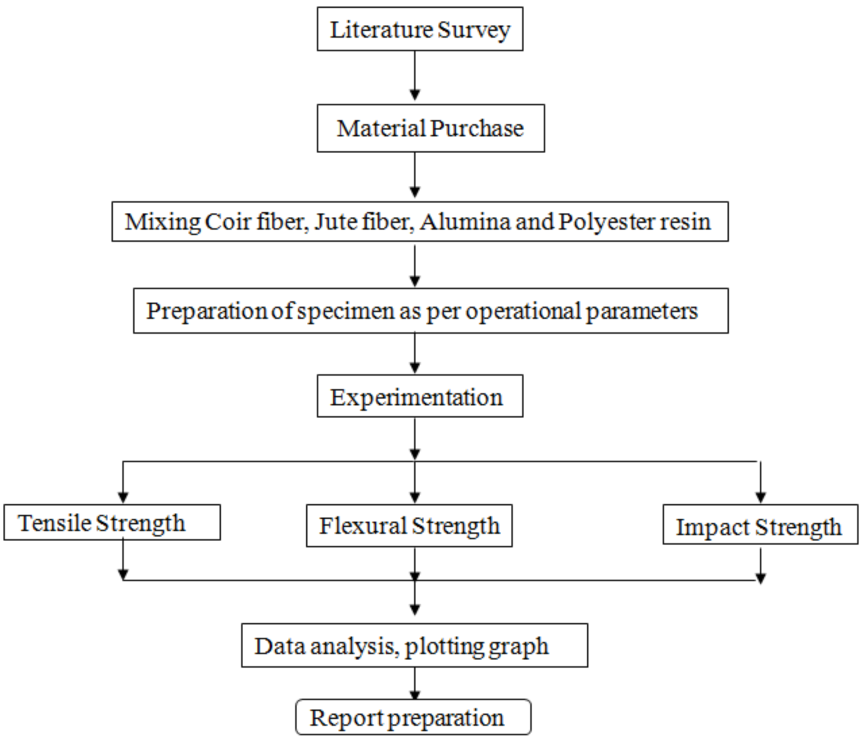

Figure 1 Methodology

2. Materials and Methods

This research work details the materials and methods used for making the hybrid composites. The following raw materials which are used in the experimental work such as Natural Fibers of Coir and Jute, Polyester resin, Alumina Al_2O_3, Hardener. Coir is a lino-cellulose natural fiber. It is a seed hair fiber obtained from the outer shell, or husk, of the coconut, the fruit of Cocosnucifera (Palmae). The individual fiber cells are narrow and hallow, with thick walls made of cellulose, Brown coir fiber is a matured one contains more lignin and less cellulose than fibers such as flax and cotton and is thus stronger but less flexible. Jute is 100% bio-degradable & recyclable and thus environment friends. .It is a natural fiber with golden & silky shine and hence nicknamed as the Golden Fibre. Jute is a long, soft, shiny plant fiber that can be spun into coarse, strong threads. Alumina is nothing but an aluminium oxide, which is the engineering ceramic. Alumina is produced from bauxite (Al_2O_3 $2H_2O$) which is the main ore from which metallic aluminium is manufactured. This is purchased from NICE CHEMICALS Pvt.Ltd, Kochi. Code No A15129, Net Quantity 500gm. For the sample preparation the first and foremost step is the preparation of the mould which ensures the exact dimension of the composite to be prepared. We have to prepare moulds for the preparation of 10%, 15%, 20%, 25%, 30% fiber of the composite. A clean smooth surfaced wooden board is taken and washed thoroughly. The wooden board was covered with a mould release sheet.

The preparation of the mould is done in open space in atmosphere conditions. The size of the mould is 300*30*3mm as shown in Figure 2. It takes nearly one hour for mould to come precipitate. The coir & Jute fibers prepared in the above steps were put on the already designed mould. After putting the coir & Jute fibers in the mould, the polyester resin-hardener mixture was slowly poured over it. The coir & Jute fiber due to its light weight and high volume gets swelled up. For that reason only we roll a roller gently till the sample fits in the mould. Then we cover the sample with a non-reacting plastic cover and place the glass on it such that no voids or air gaps leave behind. These voids weaken the composite and makes testing difficult. For the composite of perfect dimension weight should be carefully put above it. Weight should be put in such a way that no polyester resin- hardener mixture seeps out of the glass. The composite sheet takes 12 hrs for curing in room temperature. Then the samples were cut into desired dimensions for experimental purposes depending on the standards.

Figure 2 Hybrid composite materials 300×300mm

3. Results and discussion

In this work, the following three mechanical properties of fabricated composites were tested and analyzed. They are tensile strength, flexural strength and impact strength. Sample prepared for testing is shown in Figure 3. Tensile strength (TS) is the maximum stress that a material can withstand while being stretched or pulled before necking, which is when the specimen's cross-section starts to significantly contract. The TS usually found by performing a tensile test and recording the stress versus strain. It is an intensive property; therefore its value does not depend on the size of the test specimen. However, it is dependent on other factors, such as the preparation of the specimen, the presence or otherwise of surface defects, and the temperature of the test environment and material. Tensile strengths are rarely used in the design of ductile members, but they are important in brittle members. They are tabulated for common materials such as alloys, composite materials, ceramics, plastics, and wood. The tensile behavior of prepared samples was determined at room temperature using Universal testing machine in accordance with ASTM D3039. Test specimen having dimension of length 250mm, width of 25mm and thickness of 5mm. The specimen was loaded between two manually adjustable grips.

Figure 3 shows specimen (250mm × 25mm × 5mm) of 25 mm fiber length

Flexural strength is the ability of the composite material to withstand bending forces applied perpendicular to its longitudinal axis. The inter-laminar shear strength (IILS) is the maximum shear stress existing between layers of laminated material. Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three point flexural test technique.The flexural strength represents the highest stress experienced within the material at its moment of rupture.Flexural test were performed using 3-point bending method according to ASTM D790 standard procedure. The specimens were tested at a crosshead speed of 0.5 mm/min. The loading arrangement in the specimen was shown in figure. The value of gauge length (L), width (d) and thickness (t) of the test specimen used in the experimentation as 130 mm, 25 mm and 5 mm. This test method determines the flexural properties of fiber reinforced polymer composites. Impact strength is defined as the ability of the material to resist fracture under stress applied at high speed. The impact properties of composite materials are directly related to overall toughness and composite fracture toughness is affected by inter laminar and interfacial strength parameters.The impact performance of the fiber reinforced composites depended on many factors including the nature of the constituent, fiber/matrix interface, the construction and geometry of the composite, and test conditions. The impact failure of a composite occurs by factors such as matrix fracture, fiber breakage, fiber/matrix deboning, and fiber pull-out. The Charpy impact strength of composites was tested using a standard impact machine as per ASTM E23 standard. The standard test specimen 55mm long 10 x 5mm^2 cross section, having 45˚ V-notch and 2mm deep were used for the test.

The test results for tensile strengths and graph are shown in Figures 4. It is seen that the tensile strength of the composite increases with increase in fiber length. There can be two reasons for this increase in the strength properties of these composites compared. One possibility is that the chemical reaction at the interface between the filler particles and the matrix may be too strong to transfer the tensile. From Figure 4, is clear that with the increase in fiber length the tensile moduli of the coir/Jute fiber with alumina reinforced polyester composites increases gradually.

Table 1 Tensile Strength of Coir/ Jute fiber with Alumina particulate 25mm fiber Length Hybrid Fibers Polyester Composites

Composite Materials	Weight % of Coir Fiber	Weight % of Jute Fiber	Weight % of Al_2O_3	Tensile Strength MPa
CJA_1	10	10	10	15.26
CJA_2	15	15	15	16.80
CJA_3	20	20	20	18.40
CJA_4	25	25	25	15.60
CJA_5	30	30	30	14.40

From the Table 1, tensile strength of coir/ jute fiber with Alumina particulate& 25mm fiber length, polyester composite was shown. Here from CJA_1 to CJA_5 the fiber % will gradually increase and polyester resin will decreased CJA_3will shown superior tensile strength properties i.e., 18.40Mpa and after that it will decreased because due to high fiber content and low polyester resin in the composite material it will losses strength and increase void and decrease bonding strength.

And also from the above Table 1, it will result of two different fiber lengths i.e., 25mm. Because the 25 mm short length hybrid fibers leads to greater fibrillation, Owing to the relatively large quantity of fiber ends available for crack initiation. This could lower the effective stress transfer at the interface. But the 50 mm fiber length composites have less quantity of fiber ends available due its more length than the 25 mm fiber length. So, there is a lesser chance for making crack initiation.

From the Figure 4 Tensile Strength of Coir/ Jute fiber withalumina particulated 25mm fiber Length Hybrid Fibers Polyester Composites will shown. From CJA_3 it will loses the tensile strength. Before that it will increased due to high bonding strength and increase of fiber content. The test results for Flexural strengths and graph are shown in Figures 5. It is seen that the tensile strength of the composite increases with increase in fiber length.

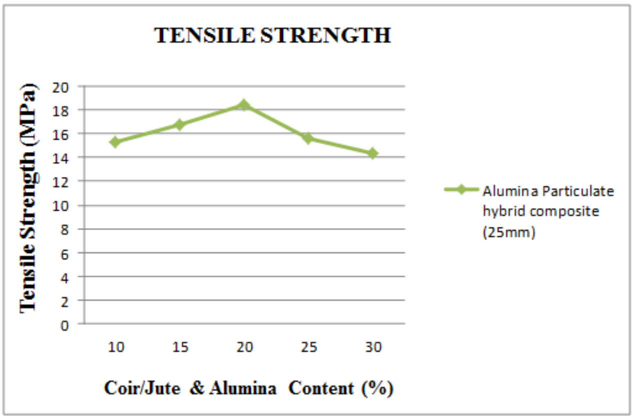

Figure 4 Tensile Strength of Coir/ Jute fiber with Alumina particulated 25mm fiber Length Hybrid Fibers Polyester Composites

There can be two reasons for this increase in the strength properties of these composites compared. One possibility is that the chemical reaction at the interface between the filler particles and the matrix may be too strong to transfer the flexural. From Figure 5, it is clear that with the increase in fiber length the flexural moduli of the coir/Jute fiber with alumina reinforced polyester composites increases gradually

Table 2 Flexural Strength of Coir/Jute fiber with Alumina particulated 25 mm Length Hybrid Fibers Polyester Composites

Composite Materials	Weight % of Coir Fiber	Weight % of Jute Fiber	Weight % of Al_2O_3	Flexural Strength MPa
CJA_1	10	10	10	555.36
CJA_2	15	15	15	773.76
CJA_3	20	20	20	789.36
CJA_4	25	25	25	755.04
CJA_5	30	30	30	661.44

From the Table 2, flexural strength of coir/ jute fiber with Alumina particulated & 25mm fiber length, polyester composite was shown. Here from CJA_1 to CJA_5 the fiber % will gradually increased and polyester resin will decreased CJA_3will shown superior flexural strength properties i.e., 789.36 Mpa and after that it will decreased because due to high fiber content and low polyester resin in the composite material it will losses strength and increase void and decrease bonding strength.And also from the above Table 2 it will result of two different fiber lengths i.e., 25mm.Because the 25 mm short length hybrid fibers leads to greater fibrillation, Owing to the relatively large quantity of fiber ends available for crack initiation. This could lower the effective stress transfer at the interface. But the 50 mm fiber length composites have less quantity of fiber ends available due its more length than the 25 mm fiber length. So, there is a lesser chance for making crack initiation.

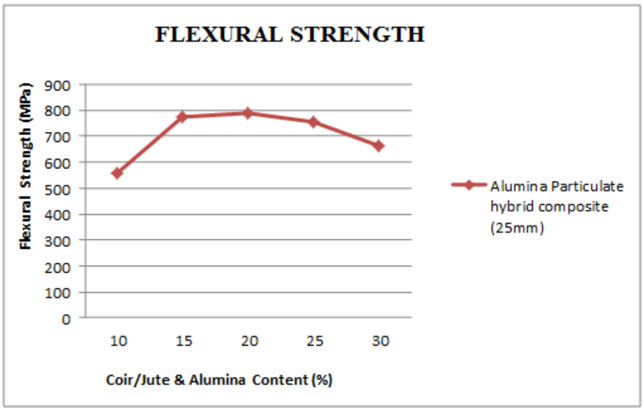

Figure 5 Flexural Strength of Coir/ Jute fiber with Alumina particulated 25mm fiber Length Hybrid Fibers Polyester Composites

From the Figure 5, Flexural Strength of Coir/ Jute fiber with alumina particulated 25mm fiber Length Hybrid Fibers Polyester Composites. From CJA_3 it will lose the flexural strength. Before that it will increased due to high bonding strength and increase of fiber content.

The test results for impact strengths and graph are shown in Figures 6 respectively. It is seen that the impact strength of the composite increases with increase in fiber length. There can be two reasons for this increase in the strength properties of these composites compared. One possibility is that the chemical reaction at the interface between the filler particles and the matrix may be too strong to transfer the impact. From 6, it is clear that with the increase in fiber length the impact moduli of the coir/Jute fiber with alumina reinforced polyester composites increases gradually.

Table 3 Impact Strength of Coir/Jute fiber with Alumina particulated 25 mm Length Hybrid Fibers Polyester Composites

Composite Materials	Weight % of Coir Fiber	Weight % of Jute Fiber	Weight % of Al_2O_3	Impact Strength J/mm^2
CJA_1	10	10	10	0.26
CJA_2	15	15	15	0.32
CJA_3	20	20	20	0.44
CJA_4	25	25	25	0.38
CJA_5	30	30	30	0.26

From the Table 3, Impact strength of coir/ jute fiber with Alumina particulated & 25mm fiber length, polyester composite was shown. Here from CJA_1 to CJA_5 the fiber % will gradually increased and polyester resin will decreased CJA_3 will shown superior Impact strength properties i.e.,0.44 J/ $mm^2$and after that it will decreased because due to high fiber content and low polyester resin in the composite material it will losses strength and increase void and decrease bonding strength.

And also from the above Table6, it will result of two different fiber lengths i.e., 25mm. Because the 25 mm short length hybrid fibers leads to greater fibrillation, Owing to the relatively large quantity of fiber ends available for crack initiation. This could lower the effective stress transfer at the interface. But the 50 mm fiber length composites have less quantity of fiber ends available due its more length than the 25 mm fiber length. So, there is a lesser chance for making crack initiation.

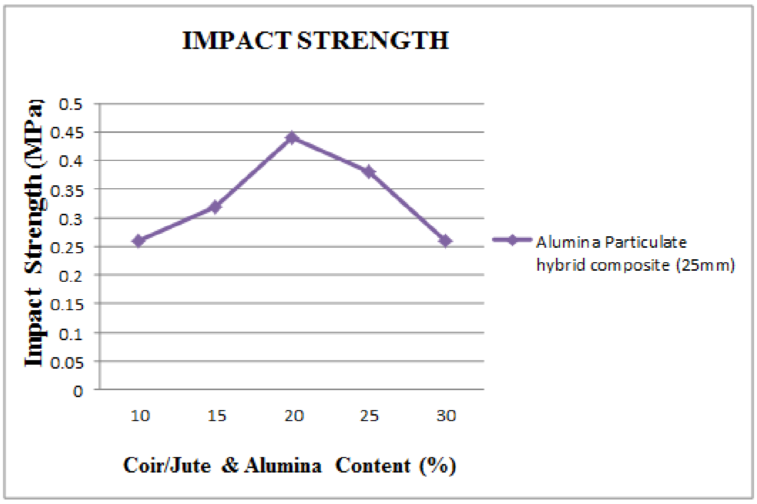

Figure 6 Impact Strength of Coir/ Jute fiber with Alumina particulated 25mm fiber Length Hybrid Fibers Polyester Composites

4. Conclusion

This experimental investigation of mechanical behaviour of coconut coir/Jute /Alumina particulate reinforced Polyester composites leads to the following conclusions: This work shows that successful fabrication of a coir / Jute / Alumina particulate fiber reinforced Polyester composites with different fiber lengths is possible by simple hand lay-up technique. It has been noticed that the mechanical properties of the composites such as micro-hardness, tensile strength, flexural strength, impact strength etc. of the composites are also greatly influenced by the fiber lengths. The fracture surfaces study of coir Jute/Alumina particulate fiber reinforced epoxy composite after the tensile test, flexural test and impact test has been done. From this study it has been concluded that the poor interfacial bonding is responsible for low mechanical properties.

5. Conclusion

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