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Mechanical characterisation of rattan fibre polyester composite

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Abstract

This study investigates the mechanical properties including tensile, flexural, density and hardness of composite plate made from rattan fibre and unsaturated polyester resin GP-7150. The purpose of this study is to produce the light weight and cost effective composite laminates from renewable natural fibres using hand layup method. By using rattan fibre six types of laminates were made with using different quantity of rattan fibre. It has been found that addition of fibre leads to improvement in mechanical properties up to 12.5% fibre level after which there is decrement in properties as resin is not sufficient to transfer load between fibres.

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Key words: Rattan fibre, unsaturated polyester resin GP-7150 & Mechanical properties.

1. Introduction

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix.Reinforcing phase and the one in which the reinforcing phase material may be in the form of fibres, particles, or flakes. The matrix phase materials are generally continuous.Examples of composite systems include concrete reinforced with steel and epoxy reinforced with graphite fibres, etc.

C. W. Nguong et al. (2013)used chemically treated and untreated natural fibres as reinforcement for the preparation of composites and were micromechanically characterized using pull out and single fibre fragmentation test.

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A film stacking method was used for processing sisal, kenaf, hemp, jute and coir byPaul Wambua et al. (2003)Tensile, flexural and impact properties of prepared compositeswere determined and compared with each other.Maya Jacob et al. (2004) used natural rubber in reinforcement with untreated sisal and oil palm fibres chopped to different fibre lengths. The effects of concentration and modification of fibre surface in sisal/oil palm hybrid fibre reinforced rubber composites have been studied. They concluded that increasing the concentration of fibres resulted in reduction of tensile strength and tear strength, but increased modulus of the composites.

According to S. K. Garkhali et al. (2000) in the last decade, research activities in the area of thermoplastic composites have shifted from high-performance advanced composites towards the development of cost-performance engineering composites,especially, glass-mat-reinforced thermoplastic materials. These fibres do have some disadvantages. Glass fibres are non-renewable and give problems with respect to ultimate disposal at the end of a materials lifetime since they cannot be thermally recycled by incineration and are left behind as a residue that can damage a furnace. They are also very abrasive which leads to an increased wear of processing equipment such as extruders and moulds. Next to some ecological disadvantages, glass fibres can cause problems with respect to health and safety. For example, they give skin irritations during handling of fibre products, and processing andcutting of fibre-reinforced parts. In view of all this an interesting environmentally friendly alternative for the use of glass fibres as reinforcement in engineering composites are natural fibres based on lingo-cellulose such as rattan, flax, hemp, sisal and juteas discussed byLuisa Medina et al. (2009) These vegetable fibres are renewable and nonabrasive.

Natural fibres have the advantage that they are renewable resources and have marketing appeal. The Asian markets have been supplying natural fibres for many years, e.g., sisal, banana and Roselle are common reinforcement in India. D. Chandramohan et al. (2011) showed thatNatural fibres such as rattan, sisal, jute, banana and coil, have been used as not only toughness modifiers but also reinforcing fillers. It has emerged as a renewable and cheaper substitute to synthetics such as glass and carbon in making structural components. In addition, reinforcement plastics and cement using cellulose materials as filler are also lightweight enhanced with mechanical properties and free from health hazards while synthetics are high cost and high-energy requirement in their production. Natural fibres have been used to reinforcing materials for over 2,000 years. The necessity for renewable fibre reinforced composites has not been as prevalent as it currently isDr. Navdeep Malhotra et al. (2012), Hnin Yu Wai et al. (2011) and Hanafiismail et al. (2012) have shown that natural fibreslike rattan are emerging as cost effective and apparently ecologically superior substitutes to glass fibres in composites.Rattan is one of the most popular types of outdoor furniture and also can be used as indoor and outdoor furnishing. It is durable, versatile and easy to maintain. Rattan fibre furniture is available in various shapes, sizes and colors.

2. Materials

Natural Fibre composite plates are prepared using rattan fibre and unsaturated polyester resin GP-7150using hand layup technique. These plates are then tested to determine their mechanical properties

2.1. Material preparation

Most rattans differ from other palms in having slender stems, 2–5 cm diameter. Rattans are superficially similar to bamboo. Unlike bamboo, rattan stems are solid, and most species need structural support and cannot stand on their own. In forests where rattan grows, its economic value can help protect forest land, by providing an alternative to loggers who forgo timber logging and harvest rattan canes instead. Rattan is much easier to harvest, requires simpler tools and is much easier to transport. Reinforcing phase contains fibre partials 80 to 90% strength of laminates is depended on fabric material strength. Plates were made using woven type of arrangement. For hand layup in woven form first fabric material is prepared in thin strip with 1 mm thick, 8 mm width and 200 mm length.

(A)

(B)

Figure 1. Rattan strips in woven form

For applications where more than one fibre orientation is required, a fabric combining 0° and 90° fibre orientations is useful as shown in Figure (A) & (B).

Woven fabrics are produced by the interlacing of warp (0°) fibres and weft (90°) fibres in a regular pattern or weave style. The fabric's integrity is maintained by the mechanical interlocking of the fibres. Drape (the ability of a fabric to conform to a complex surface), surface smoothness and stability of a fabric are controlled primarily by the weave style.

One or more warp fibres alternately weave over and under two or more weft fibres in a regular repeated manner. This produces the visual effect of a straight or broken diagonal rib to the fabric. Superior wet out and drape is seen in the twill weave over the plain weave with only a small reduction in stability. With reduced crimp, the fabric also has a smoother surface and slightly higher mechanical properties.

Unsaturated polyester resins can be utilized in a wide range of manufacturing processes such as open mould laminating, bulk moulding compounding, sheet moulding compounding, resin transfer moulding and infusion. GP-7150 resin technology provides high mechanical and impact properties and good surface profiling. GP-7150 resins can be customized to meet fabricators needs for varying reactivity, viscosity and gel time. The matrix holds the fibres in their proper position, protects the fibres from abrasion, transfers loads between fibres, and provides inter-laminar shear strength. When the two are initially mixed they form a low-viscosity liquid that cures as a result of either internally generated (exothermic) or externally applied heat. The curing reaction forms a series of cross-links between the molecular chains so that one large molecular network is formed, resulting in an intractable solid that cannot be reprocessed on reheating. On the other hand, thermoplastics start as fully reacted high-viscosity materials that do not cross-link on heating. On heating to a high enough temperature, they either soften or melt, so they can be reprocessed a number of times.

3. Methodology

Laminates of rattan fibre are made by hand lay-up methodshown by C.S. Verma et al. (2012) Rattan fibre is added in woven type of arrangementis shown by N. Srinivasababu et al. For hand layup in woven form first fabric material is prepared in thin strip and arranged in woven form. Two layers are choosing for getting sufficient thickness of laminates. Layers of rattan strips are properly arranged in mould. Releasing agent is applied for properly release laminate from mould. Nextly resin is added with 2% cobalt as accelerator and 3% MEKP (methyl-ethyl-ketone-peroxide) as a hardener. Dilute solutions MEKP are used in industry and by hobbyists as the catalyst which initiates the Cross linking between resin and fibre.

(A) (B)

Figure 2. Sample plates

After adding resin curing process is there. In curing plate is left in mould for 24 hours than resin will become gel after being sufficient hard laminate is removed properly from mould. Now resin need more time to curing for getting hardness plate is cured in roomtemperature for 24 hours and 2 hours in Furnace at 70 ^{0} for post curing and again 2 hours in room temperature for cooling than plate is sufficient hard for use.

Laminatesare made with six different proportion of rattanfibre i.e. 5%, 7.5%, 10%, 12.5%, 15% & 17.5%. The various combination of fibre and resin for making plates are as shown inTable 1 and Figure (A) & (B). Now these plates are tested for different mechanical properties.

Table 1.Fibre and resin percentage in laminate

Plate No	% of resin	% of rattan fibre
1	95	5
2	92.5	7.5
3	90	10
4	87.5	12.5
5	85	15
6	82.5	17.5

4. Testing

Mechanical testing plays an important role in evaluating fundamentalproperties of engineering materials as well as in developing new materials and incontrolling the quality of materials for use in design and construction. If a material is to be used as part of an engineering structure that will be subjected to a load, itis important to know that the material is strong enough and rigid enough towithstand the loads that it will experience in service.As a result engineers havedeveloped a number of experimental techniques for mechanical testing ofengineering materials subjected to tension, compression, bending or torsionloading.

Laminates made with rattan fibre are tested for tensile strength, flexural strength, density and hardness. Test specimens are prepared with different weight fractions of rattan fibreand the improvement in mechanical properties (tensile strength, flexural strength, density and hardness) of the composite material as observedby Vasanta V Cholachagudda et al. (2013) and Amar singhsingha et al. (2008)

4.1. Tensile strength

The most common type of test used to measure the mechanical properties of a material is the tension test. Tension test is widely used to provide basic design information on the strength of materials and is an acceptance test for the specification of materials. The major parameters that describe the stress-strain curve obtained during the tension test are the tensile strength, yield strength or yield point, elastic modulus, percent elongation and the reduction in area. Toughness, Resilience, Poisson's ratio can also be found by the use of this testing technique.

For Testing Specimen are cut as per ASTM D-638 standards and tested for tensile Strength in Universal testing machine.

4.2. Flexural strength

With ever increasing demand for high quality and reliable electronic components and materials, flexural tests have become an important test method in both the manufacturing process and research and development to define a material's ability to resist deformation under load. A component's or material's flexural strength provides critical insight into the modulus of elasticity in bending, flexural stress and flexural strain. Bend testing of final assembly the rising popularity of human interface devices such as touch screens means that everyday devices such as mobile phones are subjected to many cycles of flexing during normal use. As a result manufacturers are committed to ensuring products do not fail within their planned lifetime and of guaranteeing performance across a range of usage scenarios. In order to achieve this, the manufacturing and quality control processes need to be optimized by testing the performance of the material or product.

For Testing Specimen are cut as per ASTM D-790-10 standards and tested for flexural Strength in Universal testing machine.

4.3. Density test

The density, or more precisely, the volumetric mass density, of a substance is its mass per unit volume. The symbol most often used for density is ρ (the lower case Greek letter rho). Mathematically, density is defined as mass divided by volume.This quantity is more properly called specific weight. Density of all laminates is measured as per ASTM D 792 Standard.

A rough estimationhas it that for every unit of weight reduction is directly proportional to reduction in density, and hence materials can be used forlight weight application as discussed by Sabeel Ahmed et al. (2006), Panthapulakkal et al. (2007), John K. (2003) andIdicula M. et al. (2005)

4.4. Hardness test

Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a force is applied. Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex therefore there are different measurements of hardness, scratch hardness, indentation hardness, and rebound hardness. Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness and viscosity.

Hardness of all laminates is measured in Barcol hardness tester as per ASTM D-2583 standard.

5. Result and Discussion

This studies of mechanical characterisation of rattan fibre composite laminates. It presents the physical and mechanical characterization of the class of polymer matrix composite developed for the present investigation. The result of various characterization tests are reported here. They include evaluation of tensile strength, flexural strength, density and hardness has been studied and discuss. All testing were conducted under ambient condition in an environmentally controlled room.

In the present work rattan fibre reinforced polyester composite has been prepared in laboratory and its mechanical properties have been conducted.

5.1. Tensile test result

Tensile test result is carried out in Universal testing machine of all laminates as per ASTM D-638 standards.Result of tensile test is shown in

Table 2 and Figure . From each laminates of different fibre proportion four samples are prepared for test and the average value is listed in table.It was observed that from the figure 3 that tensile stress of the woven rattan reinforced composite increase at fast rate up to 12.5% fibre after that tensile stress is decreased because resin content being small is not sufficient to transfer load between fibres. Also resin is not sufficient to cover up the fibre so that tensile stress decreases by increasing fibre proportion after 12.5%

The standard specimens for tensile stress measurements were cut in dumbbell shape. Test specimens were visually inspected before measurement and were found to be free from pores and nicks.

Table 2. Tensile test result

Plate No	Contain of fibre %	Tensile stress in Mpa
1	5	7.3
2	7.5	9.75
3	10	15.69
4	12.5	20.43
5	15	13.91
6	17.5	12.55

It shows that tensile stress of laminates is increased continuously with increasing fibre contains and after certain limit decrease. Tensile stress is maximum in 12.5% fibre laminate.

5.2. Flexural test result

Flexural test is carried out in Universal testing machine of all laminates as per ASTM D-790-10 standards.From each laminates of different fibre proportion three samples are prepared for test. Result of flexural test is shown in Table 3 and Figure 4. From each laminates of different fibre proportion three samples are prepared for test. It was observed that from the figure 4 that flexural strength of the woven rattan reinforced composite increase at fast rate up to 12.5% fibre after that is flexural strength decreased as fibre contains is increased resin contain will decrease i.e. resin is not sufficient to transfer load between fibre so that flexural strength decreases by increasing fibre proportion after 12.5%.

The standard specimens for tensile stress measurements were cut in dumbbell shape. Test specimens were visually inspected before measurement and were found to be free from pores and nicks.

Table 3 Flexural test result

Plate No	Contain of fibre %	Flexural strength in Mpa
1	5	30.07
2	7.5	31.48
3	10	48.19
4	12.5	57.65
5	15	37.36
6	17.5	31.48

Result of Flexural test is shown in

Table 3 and Figure . It shows that flexural strength of laminates is increased continuously with increasing fibre contains and after certain limit decrease. Flexural strength is maximum in 12.5% fibre laminate.

5.3. Density test result

Density test is carried out in density meter of all laminates as per ASTM D 792 Standard. Test specimens were visually inspected before measurement and were found to be free from pores and nicks.

Table 4 Density test result

Plate No	Contain of fibre %	Density in g/cm^3
1	5	1.165
2	7.5	1.162
3	10	1.130
4	12.5	1.098
5	15	1.048
6	17.5	1.016

Result of Density test is shown in Table 4 and Figure . It shows that Density of laminates is decrease continuously with increasing fibre contains it shows that laminates made from rattan fibre is comparatively lighter than other composite laminates.The density of all the laminates decreased with increase in volume fraction of rattan fibre. This is due to the low density of the rattan fibre than that of the matrix and thereby resulting composite densityobviously decreased.

5.4. Hardness test result

Hardness test is carried out in Barcol Hardness tester of all laminates as per ASTM D-2583 standard. Test specimens were visually inspected before measurement and were found to be free from pores and nicks.

Table 5 Hardness test result

Plate No	Contain of fibre %	Hardness in BHU
1	5	35
2	7.5	35.5

3	10	38
4	12.5	40
5	15	42
6	17.5	45

Result of Hardness test is shown inTable 5 and Figure . It shows that Hardness of laminates is Increase continuously with increasing fibre contains.

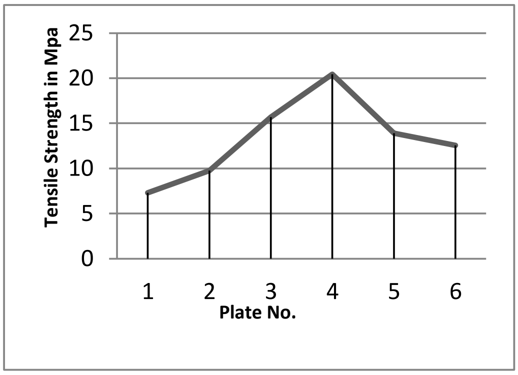

Figure 3. Tensile test result

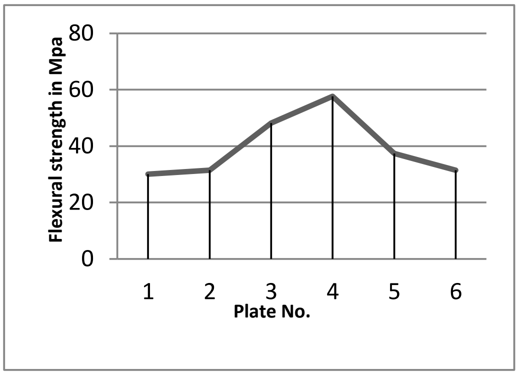

Figure 4. Flexural test result

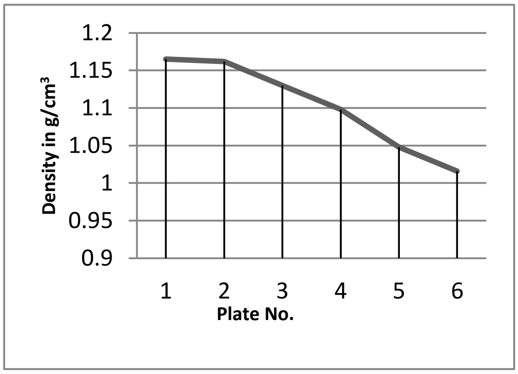

Figure 5. Density test result

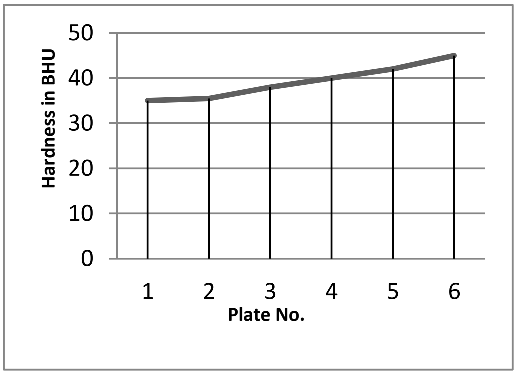

Figure 6. Hardness test result

6. Conclusion

The main conclusions drawn from this study were as follows:

- Tensile strength of laminates increase with increasing rattan fibre contains but it decreases after certain limit. It was observed that tensile stress of the woven rattan reinforced composite increase at fast rate up to 12.5% fibre after that tensile stress is decreased as fibre contains is increased resin contain will decrease i.e. resin is not sufficient to transfer load between fibre so that tensile stress decreases by increasing fibre proportion after 12.5%.

- Flexural strength of laminate also increase with increasing rattan fibre contains but it decreases after certain limit.Flexural strength of laminates increase with increasing rattan fibre contains but it decreases after certain limit. It was observed that flexural strength of the woven rattan reinforced composite increase at fast rate up to 12.5% fibre after that tensile stress is decreased as fibre contains is increased resin contain will decrease i.e. resin is not sufficient to transfer load between fibre so that flexural strength decreases by increasing fibre proportion after 12.5%.
- Density is lower in maximum fibre contained plate is shows composite made with rattan fibre is light in weight.The density of all the laminates decreased with increase in volume fraction of rattan fibre. This is due to the low density of the rattan fibre than that of the matrix and thereby resulting composite density obviously decreased.
- Hardness of Composite plates increase with increasing fibre contains in laminate.

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