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An Experimental Investigation of Mechanical Properties of Teak Wood Rust and Tamarind Kernel Powder Reinforced Polymer Composite

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ABSTRACT: The intention of the present experimental research aims at investigating the mechanical behavior of natural fiber composites. In the recent past, Natural fibers attracting the attention of engineers, researchers, professionals and scientists all over the world to use them as an alternative to conventional reinforcing materials, because of their superior properties such as high specific-strength, less weight, economical, availability, equitably decent mechanical properties, non-abrasive, eco-friendly and bio-degradable characteristics. In this experimental work an attempt is made to find the effect of teak wood and tamarind kernel as reinforced particulates on mechanical properties of composites with polyester resin. The analysis is carried out on the mechanical behavior of different combinations of composite material, with different tests such as tensile test, hardness test and flexural bend test. Finally, it is reported that more value in the combination of tamarind dust on flexural bend test. Coming to hardness test it reported more value in teak wood dust and at last in tensile test it varies at different combinations.

KEYWORDS: Natural Fiber, Polymer Composite, Mechanical Behaviour, Flexural Test, Tension Test, Hardness Test.

I. Introduction

Composites are made from a matrix that is reinforced with an engineered, man-made or natural fiber or other reinforcing material. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications.
The following are some of the reasons why composites are selected for certain applications:

- High strength to weight ratio (low density high tensile strength)
- High creep resistance
- High tensile strength at elevated temperatures
- High toughness

A. *Polymer Composites*

Most commonly used matrix materials are polymeric. In general, the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. These difficulties are overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites need not involve high pressure and doesn't require high temperature. Also, equipment's required for manufacturing polymer matrix composites are simpler. For this reason, polymer matrix composites developed rapidly and soon became popular for structural applications.

B. *Natural fiber reinforced composites*

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple, ramie, bamboo, rice husk, wood rust, banana, etc., as well as wood, used from time immemorial as a source of lignocellulose fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc.

C. Application of Natural fiber composites

The natural fiber composites can be very cost-effective material for following applications:
Building and construction industry: panels for partition and false ceiling, partition boards, wall, floor, window and door frames, roof tiles, mobile or pre-fabricated buildings which can be used in times of natural calamities such as floods, cyclones, earthquakes, etc.
Storage devices: post-boxes, grain storage silos, bio-gas containers, etc.
Furniture: chair, table, shower, bath units, etc.
Electric devices: electrical appliances, pipes, etc.
Everyday applications: lampshades, suitcases, helmets, etc.
Transportation: automobile and railway coach interior, boat, etc.

II. LITERATURE REVIEW

Natural fiber reinforced polymer composites have raised great attentions and interests among materials scientists and engineers in recent years due to the considerations of developing an environmental friendly material and partly replacing currently used glass or carbon fibers in fiber reinforced composites. They are high specific strength and modulus materials, low prices, recyclable, easy available in some countries, etc.

Pickering et al. [1] conducted a research to study the mechanical properties, especially interfacial performances of the composites based on natural fibers due to the poor interfacial bonding between the hydrophilic natural fibers and the hydrophobic polymer matrices. Two types of fiber surface treatment methods, namely chemical bonding and oxidization were used to improve the interfacial bonding properties of natural fiber reinforced polymeric composites. Interfacial properties were evaluated and analyzed by single fiber pull-out test and the theoretical model. The interfacial shear strength (IFSS) was obtained by the statistical parameters. The results were compared with those obtained by traditional ways. Based on this study, an improved method which could more accurately evaluate the interfacial properties between natural fiber and polymeric matrices was proposed.

Joshi et al. [2] compared life cycle environmental performance of natural fiber composites with glass fiber reinforced composites and found that natural fiber composites are environmentally superior in the specific applications studied. Natural fiber composites are likely to be environmentally superior to glass fiber composites in most cases for the following reasons: (1) natural fiber production has lower environmental impacts compared to glass fiber production; (2) natural fiber composites have higher fiber content for equivalent performance, 16

reducing more polluting base polymer content; (3) the light-weight natural fiber composites improve fuel efficiency and reduce emissions in the use phase of the component, especially in auto applications; and (4) end of life incineration of natural fibers results in recovered energy and carbon credits.

Rana et al. [3] in their work showed that the use of compatibilizer in jute fibers increases its mechanical properties. At 60% by weight of fiber loading, the use of the compatibilizer improved the flexural strength as high as 100%, tensile strength to 120%, and impact strength by 175%. The following conclusions may be drawn from this paper:

1. The sharp increase in mechanical properties and decrease in water absorption values after addition of the compatibilizer.

2. All these results justify that the role of jute fiber was not as a filler fiber but as a reinforcing fiber in a properly compatibilized system.

3. This system produced a new range of low-energy, low-cost composites having interesting properties and should be given priority over costly and high-energy synthesis reinforcing fiber wherever possible.

Shah and Lakkad [4] tries to compare the mechanical properties of jute-reinforces and glass-reinforced and the results shows that the jute fibers, when introduced into the resin matrix as reinforcement, considerably improve the mechanical properties, but the improvement is much lower than that obtained by introduction of glass and other high performance fibers. Hence, the jute fibers can be used as a reinforcement where modest strength and modulus are required. Another potential use for the jute fibers is that, it can be used as a filler fiber, replacing the glass as well as the resin in a filament wound component. The main problem of the present work has been that it is difficult to introduce a large quantity of jute fibers into the JRP laminates because the jute fibers, unlike glass fibers, soak up large amount of resin. This problem is partly overcome when hybridsing with glass fibers is carried out. Ray et al. [5] in their work, Jute fibres were subjected to alkali treatment with 5% NaOH solution for 0, 2, 4, 6 and 8 h at 300C. It was found that improvement in properties both for fibers and reinforced composites. The fibres after treatment were finer, having less hemicellulose content, increased crystallinity, reduced amount of defects resulting in superior bonding with the vinylester resin. As fibers, the improvements in properties were predominant around 6–8 h treatment whereas as composites, it was maximum when reinforced with 4 h-treated fibers at 35% fiber loadings. The modulus of the jute fibers is improved by 12, 68 and 79% after 4, 6 and 8 h of treatment, respectively. The tenacity of the fibers improved by 46% after 6 and 8 h treatment and the% breaking strain was reduced by 23% after 8 h treatment. For 35% composites with 4 h-treated fibers, the flexural strength improved from 199.1 to 238.9 MPa by 20%, modulus improved from 11.89 to 14.69 GPa by 23% and laminar shear strength increased from 0.238 to 0.283 MPa by 19%. The mechanical properties of natural fiber-reinforced composite depend extremely on the degree of adhesion between the natural fiber and the matrix [6]. There by, poor fiber/matrix interface leads to a weaker material with low strength and life span. In the last two decades, many researchers have focused on improving the interfacial adhesion by modifying the fiber surfaces via physical and chemical treatments to make them more compatible with matrix [7]. These surface treatments also enhance environmental durability (moisture and temperature) and wear resistance of the composite.

III. MATERIALS AND METHODOLOGY

A. Materials

This unit explains the details of processing of experimental process and the composite Followed by their mechanical characteristic features. The materials used in this work are

- Teak wood dust
- Tamarind kernel powder
- K-type polyester resin
- Hardener
- Catalysts

B. Method of Specimen preparation

Tamarind kernel powder and teak wood dust are reinforced with polyester k-type resin, this resin is belonging to the polyester family is utilized as the matrix material. Tamarind kernel powder made by us, first we took tamarind seeds and remove the shell/husk after roasting the seeds and at last grind the seeds according to required size particles. We got teak wood dust from a local supplier. Remove the moisture of teak wood and tamarind kernel powder. Also, the polyester k-type resin and hardener are provided by a local supplier. This manufacturing process is carried out by hand layup technique. Hardener and curing polyester resin is taken in the form of the ratio. Three types of composites have been produced with three different combinations.

- In the first combination out of 250gms wt the ratios of weight of materials taken as 15%Wt of tamarind kernel powder and 85%Wt of k-type polyester resin.
- In the second combination out of 250gms wt the ratios of weight of materials taken as 15%Wt of teak wood dust and 85%Wt of k-type polyester resin.
- Coming to the last combination out of 250gms wt the ratios o weight of materials taken as 10%Wt of tamarind kernel powder, 10%Wt of teak wood dust, and 80%Wt of k-type polyester resin.

While doing stir well without any lumps, and pour in mold. Here we took plastic box as a mold box and pour it after 24 hrs at room temperature it cured. Remove from the mold after process completed. And then cut the specimens according to required dimensions for mechanical testing. The composition of the composite material used for testing is presented in table 1. The reinforcing material is shown in fig 1 and fig 2.

Table 1: Designations of Composite Materials

Composites	**Compositions**
A1	Tamarind kernel powder (15wt %) + K-type polyester resin (85wt %)
A2	Teak wood dust (15wt %) + K-type polyester resin (85wt %)
A3	Tamarind kernel powder (10wt %) + Teak wood dust (10wt %) +K-type polyester resin (20wt %)

Fig.1. Tamarind Kernel Powder

Fig.2. Teak Wood Dust

C. Mechanical Testing

Types of tests done on specimens

- Hardness test (before heating)

- Hardness test (after heating at 150ºc)
- Flexural bend test
- Tensile test

Hardness Test (Before Heating)

The hardness test was done on the specimen by using shore hardness tester. A diamond indents in form of conical steel rod and having an angle 30ºc.

Hardness Test (After Heating)

This test is same as that of before heating but the difference is before testing the specimen it is heated up to 150ºc temperature. Then the process should be done.
The fig 3 and fig 4 presents the hardness test specimen and hardness test.

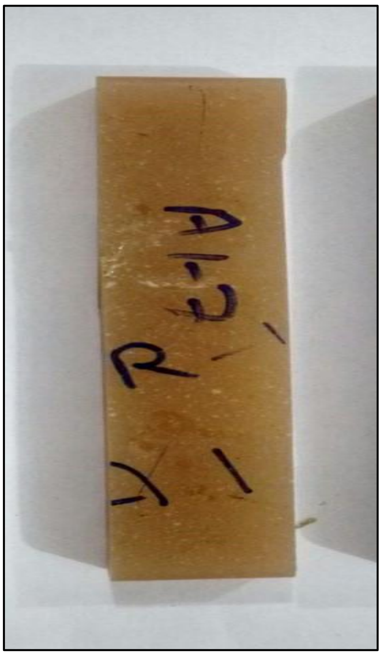

Fig.3. Hardness Test Specimen

Fig.4. Hardness Test

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Flexural Bend Tests

There are two types of flexural tests.

i. In the first scheme, the beam is centrally loaded & basically supported at two ends is called three points bending test.
ii. In the second method, there are two loading points and two end supports are called four points bending test.

In this experiment, we used three-point bending tests it gives result by recording the load applied and it outcomes the strain.The condition of stress depends on the distribution of bending moment and shear force, the specimen subjected to three points are four points bending tests.

Flexural Strengths

In the case of three points bending test, the stress is on the surface of the specimen at failure. The flexural modulus for three points bending tests is

$E_f = S^3m/4bh^3$

Where E_f = flexural modulus
S= support spam
m= slope of load deflection
b= width
h= thickness

Fig.5. Flexural Test Specimen

Tensile Testing

In tensile testing, the load is applied uniaxially and displacement is recorded. The strain and stress derive using stress-strain formula. The information thus collected is utilized to generate the stress-strain curve. In engineering applications, the magnitude of tensile stress is defined as load over the initial cross- section area.

Fig.6. Tensile Test Specimen

IV. RESULTS AND DISCUSSION

This chapter represents the mechanical properties of the teak wood dust, tamarind kernel powder. The test was done on here combinations the processing of test details has been explained in the previous chapter. The results of 3 combinations reported in this chapter. This test's results included flexural bend test, tensile test and, hardness tests before heating and after heating are discussed.

Effect of different types of combinations on hardness test before heating:

The three composites of measured hardness values are shown in the figure. The hardness value of teak wood dust filled K-type polyester resin is more as compared to tamarind kernel powder and the combination of tamarind + teak. Among three different types of combination, the tamarind kernel combination showed less hardness value.

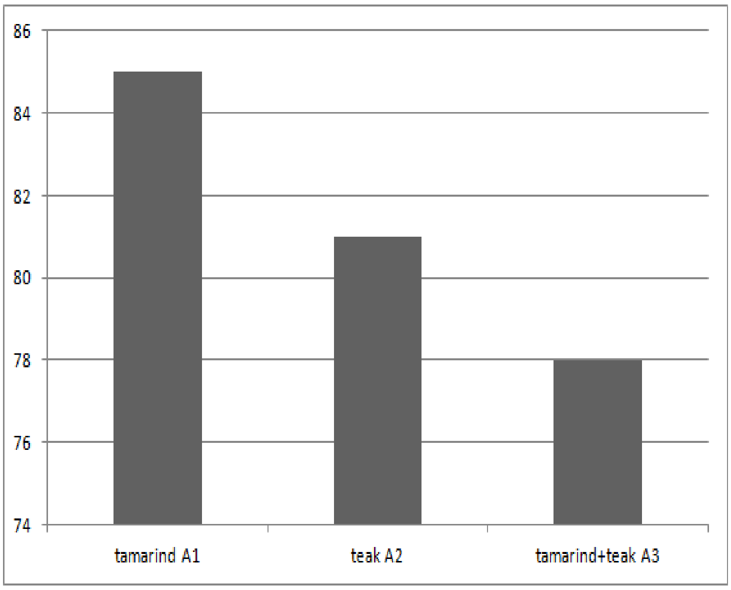

Fig.7. Comparison of Hardness of 3 specimens before heating.

Effect of different types of combinations on hardness test after heating:

Coming to the hardness values of the specimen after heating also is shown in the figure. In this, the combination of teak wood dust filled K-type polyester resin is more as compared to remaining two combinations.

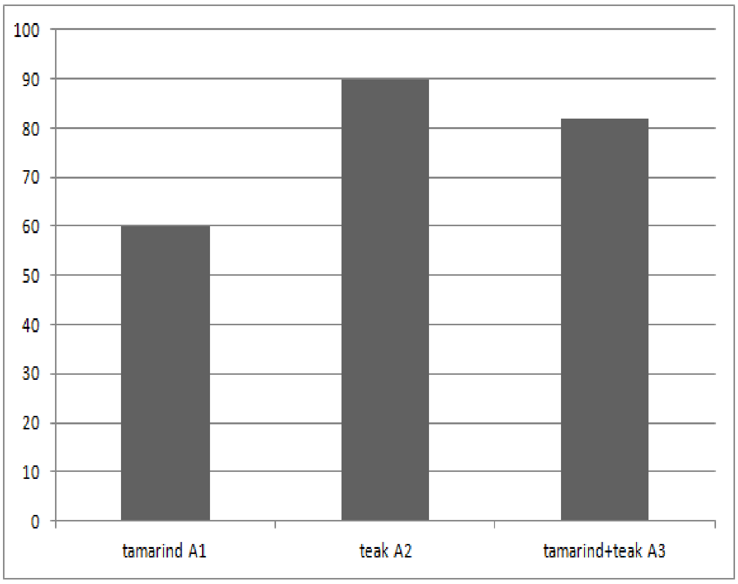

Fig.8. Comparison of Hardness of 3 specimens after heating

Effect of different types of combinations on flexural bend tests:

In this, flexural tests tamarind kernel powder with polyester resin reported more value than the teak wood dust and combinations of teak wood dust + tamarind kernel powder. The less value reported by the combination of tamarind and teak wood dust.

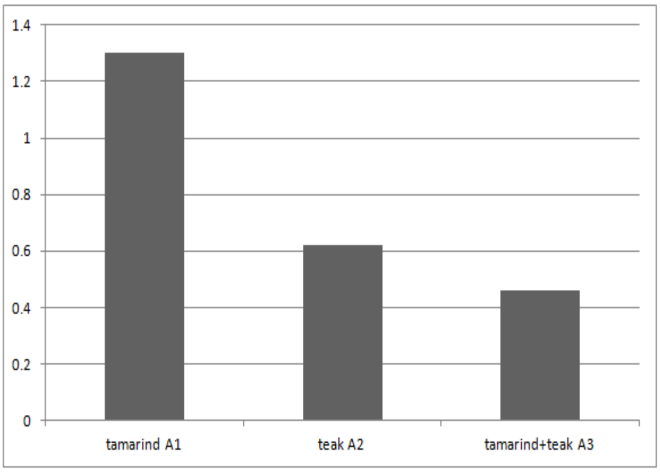

Fig.8. Comparison of Flexural Strength of 3 specimens

Effect of different types of combinations on tensile test:

In this experiment, the input data taken as

Combination of tamarind:

Specimen width mm: 13.72
Specimen thickness mm: 12.7
Cross-section area mm2: 174.244
Original gauge length mm: 50
Final gauge length mm: 50.9

In this, the result showed that ultimate load at 3.320KN, ultimate tensile strength at 19.054n/mm^2,elongation % = 1.800, yield load at 2.400KN and yield stress at 13.774 N/mm^2.

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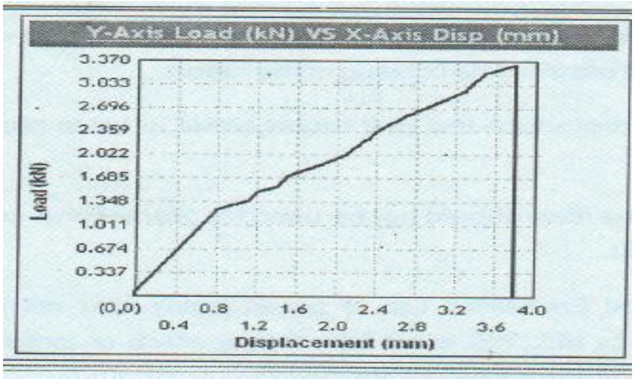

Fig.9. Results of Tensile test on Specimen A1.

Combination of teak:

Specimen width mm: 13.43
Specimen thickness mm: 13.4
Cross-section area mm2: 179.962
Original gauge length mm: 50
Final gauge length mm: 50.86
In this, the result showed that ultimate load at 3.360, ultimate tensile strength at 18.671N/mm^2, elongation % = 1.720, yield load at 3.200KN, yield stress at 17.782N/mm^2.

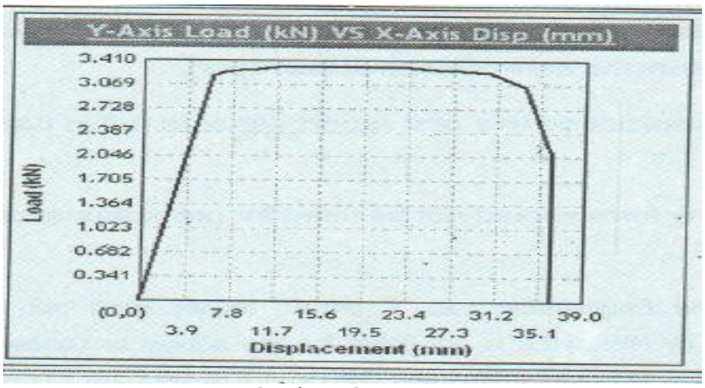

Fig.10. Results of Tensile test on Specimen A2.

Combination of teak + tamarind:

Specimen width mm: 14.9
Specimen thickness mm: 14.7
C/S area mm2: 219.03
Original gauge length mm: 50
Final gauge length mm: 51.4
In this, the result showed that ultimate load at 3.240KN, ultimate tensile strength at 14.792N/mm^2, elongation %= 2.080, yield load at 3.040KN, yield strength at 13.879N/mm^2.

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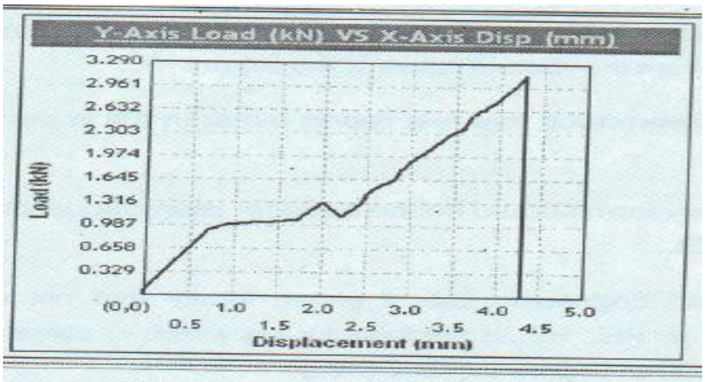

Fig.11. Results of Tensile test on Specimen A2.

V. CONCLUSIONS

The feasibility of use of teak wood rust and tamarind Kernel powder reinforcement in polymers composites is studied from the experiment. Both the reinforcements exhibited good bonding with the matrix. The polymer when reinforced with Teak rust and tamarind Kernel powder resulting in a composite with good tensile and bending strength to use in structural applications.

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