Experimental Investigation for Evaluation of Mechanical Properties of Rice Husk and Saw Dust Composites

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***Abstract* –** With the strong prominence on ecological awareness, much concentration has been brought in the development of recyclable and environmentally sustainable composite materials since the last decade. Environmental legislation as well as consumer demand in many countries is imposing higher pressure on manufacturers of materials to consider the environmental impact of their products at all stages of their life cycle, including recycling and ultimate disposal. These environmental issues have recently generated considerable interest in the development of recyclable and biodegradable composite materials. Therefore the use of natural fibers for technical composite applications has recently been the subject of intensive research in the World. Though the strength of natural fibers is not as great as glass, the specific properties are comparable. The following preliminary research has investigated the use of rice husk and saw dust (wood rust), as a possible glass replacement in fiber reinforced composites. The natural fiber epoxy composite has been made as per the ASTM standards by using hand lay-up method, and its mechanical properties are experimentally investigated by conducting tensile and impact tests.

Keywords: *Natural Fibers, Polymer Composite, Mechanical properties, Tensile strength, Impact strength.*

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. MATERIAL AND MANUFACTURING

This chapter describes the details of processing of the composites and the experimental procedures followed for their mechanical characterization. The raw materials used in this work are

- Polyester resin
- Hardener
- Natural Fibers (Rice husk, Wood rust)

Table 1: Properties of Fiber materials

Material	Density	length
Rice husk	0.34gm/cm3	3-6mm
Wood chips	0.29gm/cm3	-

A. Preparation of composite

The required quantity of polyester resin is measured and mixed with the hardener in the required proportion and stirred thoroughly to achieve the proper mixing of resin and hardener. For 100% of resin 2% of catalyst i.e. methyl ethyl ketone peroxide is needed to harden the composite.

Figure 1: Preparation of resin

It takes 10-20 minutes for the resin to harden when it is poured in to the die. The process of preparation of resin is presented in the figure 1.

The composite is made by using the hand lay-up process. After cleaning the die, first the Vaseline is applied on the surface of the die for easy removal of the composite.

Figure 2: Cleaning Of The Die

The resin thoroughly mixed with the hardener is poured in a container and the rice husk with 70% of resin and 30% of rice husk or wood rust will be mixed.

Figure 3: Measuring And Mixing Of Rice Husk With Resin

The mixture is poured in the die. The die is closed with the metal plate and four screws are tightened at four corners.

Figure 4: Filling and Closing The Die

It is allowed to cure for 3-4 hours and the composite is taken out from the die carefully.

Figure 5: Composite Made With Rise Husk

Wood rust composite also prepared by using the similar steps.

IV. EXPERIMENTAL PROCEDURE

The natural fiber reinforced polymer composite after successful fabrication is subjected tensile and impact tests to estimate the properties.

A. Specimen Preparation

From the composite laminate, the specimen is prepared by using a wire cut hacksaw as per the ASTM standard dimensions.

For impact test

- ASTMD256
- Length =63.5mm
- Width =12.7mm
- Thickness =3mm

For tensile test

- ASTMD3039
- Length =250mm
- Width =25mm
- Thickness =3mm

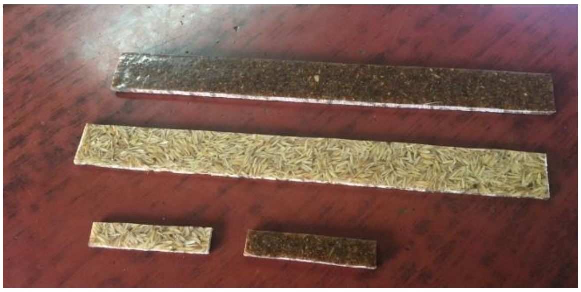

Figure 6: Specimen Used For Tensile Test and Impact Tests

B. Tensile Test

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the dog-bone type. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is (160x12x3)mm. Typical points of interest when testing a material include: ultimate tensile strength (UTS) or peak stress; offset yield strength (OYS) which represents a point just beyond the onset of permanent deformation; and the rupture (R) or fracture point where the specimen separates into pieces. The tensile test is performed on the universal testing machine (UTM) Instron

1195 and results are analyzed to calculate the tensile strength of composite samples.

Figure 7: Tensile Test As Per Astm Standards

C. Impact Test

Impact test is a test used in studying the toughness of material. The definition of toughness is defined as the capacity of material to absorb energy and deform plastically before fracturing. Toughness is associated with both ductility and strength of materials. Since the amount of plastic deformation that occurs before fracture is a measure of the ductility of the material and because the stress needed to cause fracture is a measure of its strength, it follows that toughness is associated with both the ductility and strength of the material.

Impact test involves the sudden and dynamic application of the load. For this purpose, in general, a pendulum is made to swing from a fixed height and strike the standard impact specimen. There are two types of method to test impact test which is Izod test and Charpy test. These two methods are different in placing the specimens. In Izod test, the specimen is placed in vertical position and the notch area is facing the pendulum. Meanwhile in Charpy test, the specimen is placed horizontally with unnotched area facing the pendulum. Moreover, Izod impact specimen only has a V-notch specimen while Charpy impact specimen has both U-notch and V-notch specimen. Charpy test result can indicate how brittle the materials are.The most common method for the measurement of impact strength that is Charpy tests is used in this experiment.

The specimen dimensions as per ASTMD256 (16.3x12.7x3) mm is used for impact test.

Figure 8: Impact Test As Per Astm Standards

V. RESULTS

The tensile and impact tests are being conducted on specimens manufactured by hand layup process with rice huskand wood rust as reinforcement. The resulting tensile strength and young's modulus of each specimen is tabulated in table 2 & 3.

A. Tensile test results

Table 2: Composite Material Rice Husk

Load at yield	0.16KN
Elongation at yield	2.250mm
Yield stress	2.098 N/mm^2
Load at peak	0.200KN
Elongation at peak	2.570mm
Tensile strength	2.622N/mm^2
Load at break	0.120KN
Elongation at break	2.630mm

B. Tensile test results of rice husk

Table 3: Composite Material Wood Chips

Load at yield	1.24KN
Elongation at yield	6.060mm
Yield stress	16.404 N/mm^2
Load at peak	1.580KN
Elongation at peak	7.430mm
Tensile strength	20.902N/mm^2
Load at break	0.040KN
Elongation at break	8.610mm

C. Impact test results Notch type (charpy V)

Composite material with rice husk

Impact energy value in joules = 2

Composite material with wood rust

Impact energy values in joules = 3

CONCLUSION

The feasibility of use of wood rust and rice husk fiber in polymers composites is studied from the experiment. Both the reinforcements exhibited good bonding with the matrix. The polymer when reinforced with wood rust and rice husk resulting in a composite with good tensile and Impact strength to use in structural applications.

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