Synthesis and Characterization of Epoxy Based Hybrid Composite

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***Abstract* - In the present investigation a new hybrid composite with epoxy as a resin and reinforcing both wood powder, peanut husk powder and coconut shell powder random oriented composites were used by keeping the compositions of epoxy L12 K6 70%, 77.5% and 85% and specimens were prepared by hand layup technique for different volume fractions and were prepared according to ASTM standards. To determine the mechanical properties such as Impact strength, tensile, compression, hardness and bending tests were conducted. Charpy impact test was conducted for different specimens having 5mm notch depths to determine toughness. Tensile test was conducted using UTM to determine mechanical properties using stress-strain curves of specimens. Bending test is conducted to determine the flexural modulus and flexural strength of bending specimen by applying bending load. Rockwell hardness test was conducted to determine the hardness of the specimen**

INTRODUCTION:

In the past few decades, research and engineering interest has been shifting from monolithic materials to fiber-reinforced polymeric materials. These composite materials now dominate the aerospace, automotive, construction and sporting industries. The composite material has been used from centuries ago, and it all started with natural fibers. Natural fibers have become important items in the economy and in fact, they have turn out to be a significant source of jobs for developing countries. Natural fibers can be easily obtained in many tropical and available throughout the world. Today, these fibers are assessed as environmentally correct materials owing to their biodegradability and renewable characteristics. For example, natural fibers like sisal, jute, coir, oil palm fiber have all been proved to be good reinforcement in thermoset and thermoplastic matrices (Geethamma et al. 1998; Joseph et al. 1996; Sreekala et al. 1997; Varma et al. 1989). Nowadays, the increasing interest in automotive, cosmetic and plastic lumber application has heightened the need of natural fibers reinforced composites in these regimes as it offers an economical and environmental advantage over traditional inorganic reinforcements (Rao and Rao 2007). Therefore, many industrial companies are looking for new composites material which has good and specific properties like mechanical, chemical and dynamic characteristic. In searching for such new material, a study has been made here coconut shell powder, wood powder and peanut husk is compounded with epoxy. Coconut shell is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, and Sri Lanka. Many works have been devoted to use of other natural fillers in composites in the recent past and coconut shell filler is a potential candidate for the development of new composites because of their high strength and modulus properties [1, 2, 3, 4]. Composites of high strength coconut filler can be used in the broad range of applications as, building materials, marine cordage, fishnets, furniture, and other household appliances.

LITRATURE SURVEY:

PMC's are designed to replace conventional monolithic alloys and metals, but they soften and ignite at very low temperature than alloys and metals. When polymers are ignited produce toxic gases and non-healthy smoke, which limits the full implementation of composites in many engineering applications. Sufficient literatures have mentioned that polymers are made wear resistance by the addition of ceramics. But very few have notified the addition of various size fillers into the PMC's to increase its wear resistance. Retrospection on the previous literatures of wear resistance polymers and their composites has been discussed

Salleh Z et al. This research is to develop the natural Activated Carbon (AC) composites prepared from carbon coconut shell reinforced with polypropylene (PP). Carbon coconut shell were selected from in-productive of coconut shell specifically namely as carbon Komeng coconut shell (CKCS) with different weight percentages of AC (6, 4 and 2 wt %) and PP (4, 6 and 8 wt %) contents. The specimens were then encapsulated with epoxy resin. The entire specimens were prepared using SRM (Silicon Rubber Moulds) with dumbbell shape and rectangular shape according to the standard ASTM D2099 and ASTM D256 respectively. The mechanical properties of all samples were investigated to characterize the quality of the samples. The morphological studies of reinforced samples were observed by using SEM machine. The results showed that the tensile stress was increased when AC is increased specifically for sample 4 wt% and 8 wt%. Maximum tensile stresses lead by sample 4 wt% with 30 MPa [1].

Hajime Kishi et al: Wood-based epoxy resin was synthesized from resorcinol-liquefied wood. First, wood components were depolymerized and liquefied by reaction with resorcinol. The resorcinol-liquefied wood with plenty of hydroxyl groups could be considered as a precursor for synthesizing wood-based epoxy resin. Namely, the phenolic-OH groups of the liquefied wood reacted with epichlorohydrine under alkali condition. By the glycidyl etherification, epoxy functionality was introduced to the liquefied wood. The wood-based epoxy resin was cured with 4, 4'- diaminodiphenylsulphone (DDS) and the thermal and mechanical properties were evaluated. The flexural modulus and strength of the cured wood-based epoxy resin were comparable to those of the petroleum-based bisphenol-A type epoxy resin (diglycidyl ether of bisphenol-A: DGEBA). The mechanical and adhesive properties of the wood-based epoxy resins suited well for matrix resins of fiber reinforced composites. Therefore, biomass composites consist of ramie fibers and the wood-based epoxy resin were fabricated. The flexural modulus and strength of the biomass composites were equivalent to those of the same fiber reinforced bisphenol-A type epoxy composites [2].

Agunsoye J. O et al: The mechanical, morphological and thermal stability of the recycled waste polypropylene composite reinforced with treated and untreated coconut shell particulate have been investigated under two coconut shell particulates sizes of 80 and 150µm. The thermal stability, microstructure and water absorption capacity were characterized using TGA 701, Scanning Electron Microscope model EVOMA 10 LaB6 Analytical VP-SEM at 20KV, Instron Testing Machine and Brinell Hardness Tester respectively. The surface treatment enhanced significantly the mechanical properties of the developed composites. At 10% coconut shell particulates addition, the impact energy of the developed composites and thermal stability of the treated coconut shell reinforced composite started decreasing [3].

IzzuddinZaman et al. The utilization of coconut fibers as reinforcement in polymer composites has been increased significantly due to their low cost and high specific mechanical properties. In this paper, the mechanical properties and dynamic characteristics of a proposed combined polymer composite which consist of a polyester matrix and coconut fibers are determined. The influence of fibers volume fraction (%) is also evaluated and composites with volumetric amounts of coconut fiber up to 15% are fabricated. In this work, the tensile test was carried out to determine the strength of material, while modal testing was used to obtain the dynamic characteristics of the composite material. Results were found that the strength of the composites tends to decrease with the amount of fiber, which indicates ineffective stress transfer between the fiber and matrix. The dynamic characteristic of composite was also having a same effect where the natural frequency decreased with increase of coconut fiber volume. However the damping ratio was found to be increased by the incorporation of fiber. When higher fiber content of 15% was used, the damping ratio shows the maximum value for almost all the frequency mode. It was observed that the effects of reinforcing polyester matrix with coconut fibers lead the composites more flexible and easy to deform due to high strain values and low stiffness. In fact, it may also be used to reduce high resonant effect [4].

PetrValasek, PetrChocholous:They carried out the experiment to evaluate the properties of epoxy resin with organic filler-wood flour such as hardness,impact strength, tensile strength, shear strength of lap solid adhered and resistance to abrasive wear. Adding wood flour into resin creates composite systems. For carried out experiments the two-component epoxy resin ECO-EPOXY 1200/324 with the curing agent P11 was chosen. The curing time of this resin is 24 hours at 23 ºC. The total curing occurs after 7 days. As guide for the hardness determination of the composite systems the standard CSN EN ISO 2039-1 was used. The two body abrasion was tested on a rotating cylindrical drum device with the abrasive cloth of the grain size P220 (Al2O3 grains) according to the standard CSN 62 1466. According to the standard CSN EN ISO 527 (Determination of tensile properties) the destructive tests were carried out. The impact strength was evaluated based on the norm CSN 64 0611. The representation of the fracture surface and adhesive layers was carried out using a stereoscopic microscope (owing to the chips shape irregularity expressed in 2D flat surface). Results were found that Inclusion of wood flour decreased the impact resistance of the composites compared to the resin without fillers up to 51 %, tensile strength of lap adherend by 27 %, tensile strength representing cohesive characteristics up to 57 %. In the area of hardness and abrasive wear in the interval 5-20 % filler in the matrix significant changes have not occurred compared to resin without filler. The benefits can include reduced cost of composites. The assumed price per kilogram epoxy resin is 10 EUR. Based on the experiment these composite systems can be used in agrocomplex for sealing and bonding larger units that do not require high quality connections, i.e., where the reached mechanical properties of the composite systems are sufficient.

Vinay Mishra, Anshuman Srivastava: They have done experiments to know the mechanical properties of composite.They take different composition of epoxy and some weight of apple as raw materials. They carried tensile test, flexural strength test, hardness test. In the present work 10, 20 and 30 wt % wood apple shell powder dispersed in Epoxy matrix (E- WA) composites have been prepared using Hand layup technique.Tensile test had a cross sectional dimension of (2.25 X 3) mm2, the length of the gauge section was kept 15 mm. Tensile tests were performed at room temperature.

METHODOLOGY:

- **Material collection:** First we collected the materials that are required for the synthesis. We collected the coconut shell , peanut husk , wood powder (nilgeri) , and epoxy (L12 K6)
- **Mold Preparation:** After collection of materials the mold was prepared with ASTM standard dimensions to various tests such as tensile test, compression test,

bending test, impact test and hardness test. The mold was prepared using acrylic sheet of 4mm thickness.

- **Synthesis of materials:** As we know the materials collected contain various impurities and they have to be removed. Hence first they were finely powdered and sieved using the mesh size of 30 ASM .After that the powdered material was treated with NaOH to remove the impurities and dried under the sunlight. Now the materials were ready for preparation of the composite.
- **Preparation of Composite:** Now all the materials were mixed with different composition in a beaker and stirred well to remove gas bubbles. Then thestandardmold box was filled completely with this mixture. This mold box was kept undisturbed for about 24 hrs for curing. After curing the materials were removed from the mold box to carry out the testing.

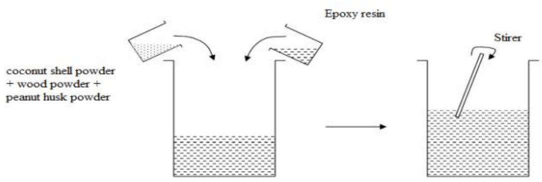

Fig 1: Hand layup technique

- **Sample Characterisation:** The composite materials prepared were tested .Various tests such as tensile test, compression test etc. were conducted and the readings were noted down.

Impact Test Specimens: Impact is defined as the resistance of a material to rapidly applied loads. An impact test is a dynamic test in which a selected specimen which is usually notched is struck and broken by a single blow in a specially designed machine. According to ASTM D256 the composites were prepared. The purpose of impact testing is to measure an object's ability to resist high rate loading. It is usually thought of in terms of two objects striking each other at high relativespeeds. A part or materials ability to resist impact often is one of the determining factors in the service life of a part, or in the suitability of a designated material for a particular application. The specimens were prepared for charpy impact test. In this test the specimen is clamped vertically with the notch facing the striker.
The dimensions of rectangular specimen are 63.5mm × 12.7mm ×12.7mm.

Fig 2: Impact Test Specimens

TENSILE TEST SPECIMENS

The Tensile Test is performed for several reasons. The results of tensile tests are used in Tensile properties frequently are included in material specifications to ensure quality. Tensile properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a material under forms of loading other than uniaxial tension.

The strength of a material often is the primary concern. The strength of interest may be measured in terms of either the stress necessary to cause appreciable plastic deformation or the maximum stress that the material can withstand. These measures of strength are used, with appropriate caution (in the form of safety factors), in engineering design. Also of interest is the material's ductility, which is a measure of how much it can be deformed before it fractures. Rarely is ductility incorporated directly in design; rather, it is included in material specifications to ensure quality and toughness. Low ductility in a tensile test often is accompanied by low resistance to fracture under other forms of loading. Elastic properties also may be of interest, but special techniques must be used to measure these properties during tensile testing, and more accurate measurements can be made by ultrasonic techniques specimen is used rectangular bar of 220 mm x 25 mm x 10mm.

Fig 3: Tensile test specimen

Bending test specimens:

Bending test was used to determine the modulus of elasticity. This test was carried out according to (ASTM – D790). Rectangular specimens with dimensions of (130×25×10) mm were used in this test. Specimens were fixed between two points; certain load (weight) was applied in the middle of the specimens.

Fig 4: Bending test specimen

Hardness Test Specimens

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting. There are different hardness test methods they are, Rockwell Hardness test, Brinell hardness test, Vickers Hardness test, Micro hardness Test. In this work Rockwell Hardness test method is used. The specimen used is a rectangular bar of 10mm × 10mm × 10mm.

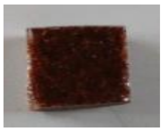

Fig 5: Hardness test specimen

Compression Test Specimens:

As there is a chance of buckling of long specimen, for compression test short specimen are used. Hence, this test involves measurement of smaller changes in length. It results into lesser accuracy. As per ASTM standards the dimension used is 25.4mmx12.7mmx12.7mm

RESULTS AND DISCUSSION:

Composition	Epoxy in Wt %	Coconut Shell Powder in Wt %	Wood Powder in Wt %	Peanut Husk Powder in Wt %
Composition 1	85	5	5	5
Composition 2	77.5	7.5	7.5	7.5
Composition 2	70	10	10	10

TENSILE TEST:

Length of the Specimen=220mm

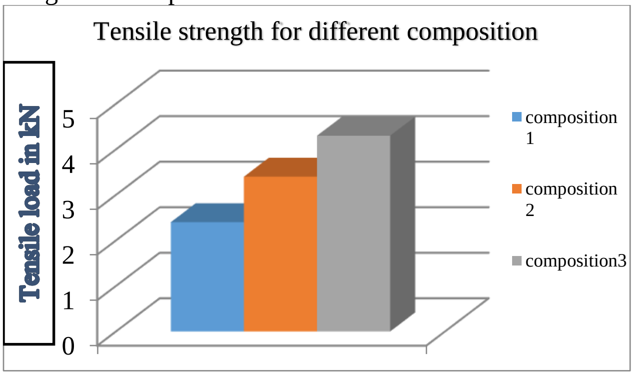

Fig 6 (a): Tensile strength for various compositions

Fig 6 (b): Specimen after tensile test

COMPRESSION TEST

Length of the Specimen=25mm

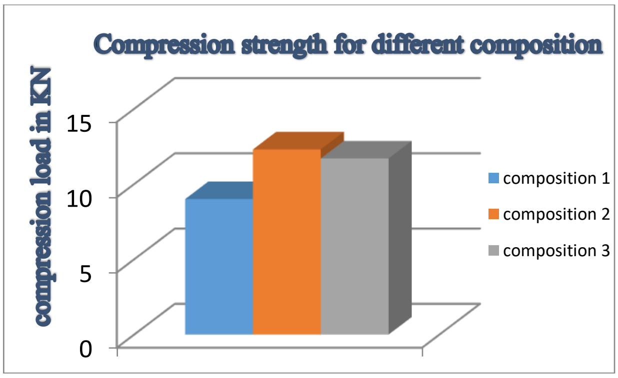

Fig 7 (a): Compression strength for different composition

Fig 6 (b): Specimen after compression test

IMPACT TEST (CHARPY TEST):

Cross Sectional Area=15mm*12mm

Length of the Specimen=65mm

Table 1: Load for different compositions

COMPOSITIONS	LOAD IN JOULES
Composition 1	20
Composition 2	30
Composition 3	30

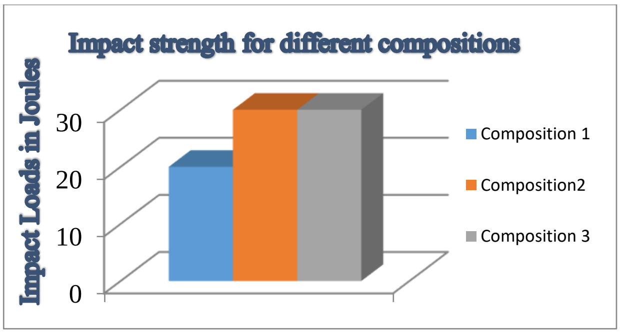

Fig 7 (a): Impact strength for different composition

Fig 7 (b): Specimen after impact test

ROCKWELL HARDNESS TEST:

Indenter = (1/16) ball

Cross sectional area = 10*10 mm

Scale=E

Load in Kgf =60

Fig 8: Specimen mounted on Rockwell hardness test machine

Sl no	Composition	Hardness no. Trials	Hardness no. Avg.
1	Composition 1	62	54
		46	
		55	
2	Composition 2	52	51
		50	
		52	
3	Composition 3	47	45
		41	
		48	

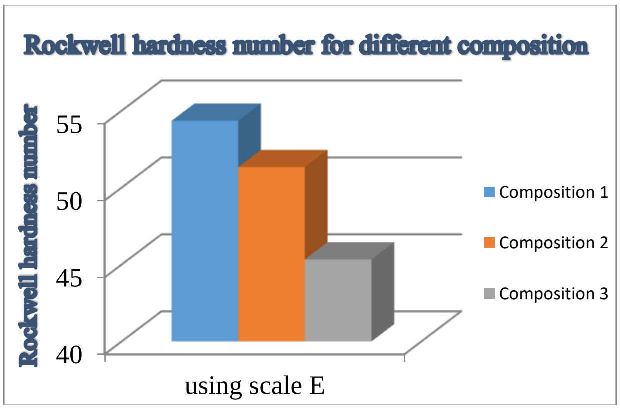

Fig 9 (a): Rockwell hardness number for different compositions

BENDING TEST:

Table 2: composition for bending test specimen

Composition 1		Composition 2		Composition 3	
Load	Deflection	Load	Deflection	Load	Deflection
1	41	1	10	1	20
2	85	2	32	2	43
3	140	3	64	3	70
4	182	4	92	4	92
		5	125	5	110

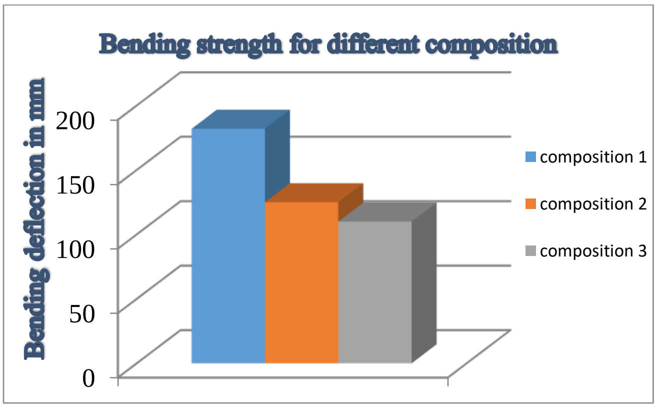

Fig 10 (a): Bending strength for different composition

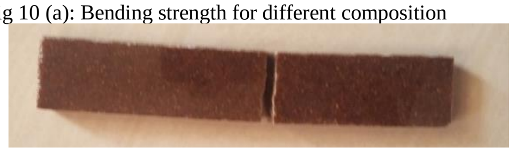

Fig 10 (b): Specimen after bending test

CONCLUSION:

Hybrid composite with epoxy as a resin and reinforcing both wood powder, peanut husk powder and coconut shell powder random oriented composites were used by keeping the compositions of epoxy L12 K6 70%, 77.5% and 85% and specimens were prepared by hand layup technique for different volume fractions and were prepared according to ASTM standards

- As the percentage of epoxy resin increases then decreasing the tensile strength
- As the percentage of epoxy resin increases up to 77.5% the compression strength increases later increase in epoxy resin percentage decreases the compression strength.
- As the epoxy resin percentage increases up to 85% the bending strength decreases.
- As the epoxy percentage increases up to 85% the impact strength decreases.

From the overall test results we conclude that at 77.5% of epoxy resin composition 2 the compression strength shows better results.

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