Interfacial Behaviour of Composites of Polymer and Orange Peel Particulates

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Abstract : This present work, an attempt has been made to fabricating of a polymer matrix composite (epoxy resin) using orange peel powder and conduct the experimental investigation of mechanical behaviors. Composites having different percentage weight fraction of orange peel for different grain sizes were made using hand layup method. The interfacial behavior of these composites was investigated by tensile test, short beam test, and Rockwell hardness test. According to the ASTM standards, the fabricated composite samples were cut for different experiments and its mechanical properties like density, hardness, tensile strength and short beam strength are performed.

Keywords: Orange Peel Powder; Epoxy resin; hardner: Interfacial compatibilizers;

I. INTRODUCTION:

The use of natural fibers as additives for composite materials presents a great potential for improving their performance and technological application due to their low cost, richness, biodegradability and high specific strength [1]. Additionally, due to their low density of natural fibers, reduce the mass of the composite [2]. This is especially important if such fibers are rests of agro industrial processes and if their raw properties are suitable for composites [3]. However, the major limitation of botanical fibers used as reinforcement is the poor interfacial bond between polar-hydrophilic natural fibers and nonpolar-hydrophobic polymers. Coupling agents such as maleate and silane have been used to increase the compatibility between natural fibers and thermoplastic matrices, thereby enhancing the composite's performance [6,7].

Accordingly extensive studies on preparation and properties of polymer matrix composite (PMC) replacing the synthetic fiber with natural fiber were carried out [8-11]. Recently, car manufacturers have been interested in incorporating natural fiber composites into both interior and exterior parts. Due to These natural composite material parts to lower the overall weight of the vehicle thus increasing fuel efficiency and to increase the sustainability of their manufacturing process. Many companies are already accomplished this and are looking forward to expanding the uses of natural fiber composites [12].

The knowledge gap in the existing literature summarized above has helped to set the objectives of this research work which are outlined as follows:

1) Preparation of raw orange peel powder and sieving it to different grain sizes

2) Fabrication of a new class of epoxy based composite reinforced with orange peel particulate fillers

3) Evaluation of mechanical properties and characteristics of orange peel powder reinforced composite

4) Besides the above all objectives is to develop a new class of composites by incorporating orange peel fiber reinforcing phases into polymeric resin. Also this work is expected to introduce a new class of polymer composite that might find many engineering applications.

II. PREPARATION OF COMPOSITES.

1.1 Processing of Orange Peel Perticulates:

The Oranges were procured from a nearby Market. The Orange Peel were cutted manually to remove peel . The Orange Peel were sun-dried for three days. The cleaned Orange Peel obtained from were cut into pieces of using scissoring.. The collected Orange Peel was then sieved to different mesh sizes. The Orange Peel sizes chosen for the experiment are 100mesh, 170 mesh and 200mesh (shown if figure.2) are collected from mesh sizes of between 70 to 450 due to its highest weight percentage among all sizes. The procedure of making raw orange peel is shown in figure .1.

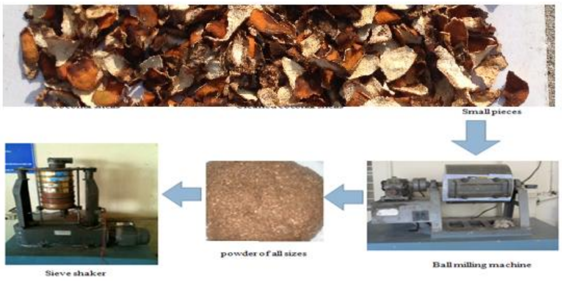

Figure.1 procedure of making raw orange peel powder

Figure.2 Orange Peel powder of three different sizes

1.2 Preparation Of Composites Hand Layup Method:

A wooden mould of 150x60x8 mm Figure.3 was used for casting the composite sheet. For quick and easy removal of the specimen a teflon sheet was attached to the inner and outer surfaces the mould. Mould release spray was also applied at the inner surface of the mould wall. The weight percents of orange peel powder (ie.10, 20 and 30 wt %), were mixed with the matrix material consisting of epoxy resin and hardener in the ratio of 10:1. Care was taken to avoid formation of air bubbles during pouring. Pressure was then applied from the top and the mould was allowed to cure at room temperature for 24 hrs. During the application of pressure some polymer squeezes out from the mould. For this, care has already been taken during pouring. After one day the samples were taken out of the mould, cut into different sizes for further experimentation. Figure .4 (a) and (b) shows the photograph of the samples cut from the slab.

Figure .3 Wooden mould

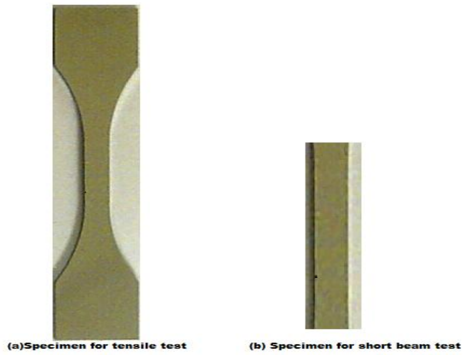

Figure.4 samples for tests

III. MECHANICAL TESTING.

The characterization of the composites reveals that the volume % of fiber is having significant effect on the mechanical properties of composites. Mechanical testing includes testing of micro-hardness, tensile strength and flexural strength respectively.

2.1 Density

Density is one of the most important mechanical properties of the particle board material. The density of orange peel reinforced composite for different mesh sizes for various wt% of particle are calculated. The most commonly used method for calculating the density is to divide its weight by volume of the specimen. Mass of the sample is calculated by using pocket weighing scale.

$$Density = \frac{mass\ of\ sample}{volume\ of\ sample} \qquad (1)$$

2.2 Micro-Hardness

Micro-hardness measurement is done using a Lecco Vickers Hardness (LV 700) tester. A diamond indenter, in the form of a right pyramid with a square base and an angle 136^0 between opposite faces, is forced into the material under a load F. The two diagonals X and Y of the indentation left on the surface of the material after removal of the load are measured and their arithmetic mean L is calculated. In the present study, the load considered F = 10 N and Vickers hardness number is calculated using the following equation:

$$H_v = \frac{0.1889F}{L^2} \text{ and } L = \frac{x+y}{2} \qquad (2)$$

Where,

F is the applied load (N),

L is the diagonal of square impression (mm),

X is the horizontal length (mm) and

Y is the vertical length (mm).

2.3 Tensile Strength

The tensile test is generally performed on flat specimens. The most commonly used specimen geometries are the dog-bone specimen (figure.5). The standard test method as per ASTM D 3039-76 [33] has been used; The value of gauge length (L), width (d) and thickness (t)of the test specimen used in the experimentation as 125 mm, 10 mm and 5 mm. The tensile test is performed in universal testing machine. The tests were performed with a cross head speed of 10mm/min. Figure.6 (a, b) shows the machine used for the test and the sample in loading condition.

Tensile strength was calculated by the formula:

$$S = \frac{F}{A} \tag{3}$$

Where,
F is the maximum load (in newtons);
A is the area of the specimen (in mm^2).
S is the tensile strength (MPa)

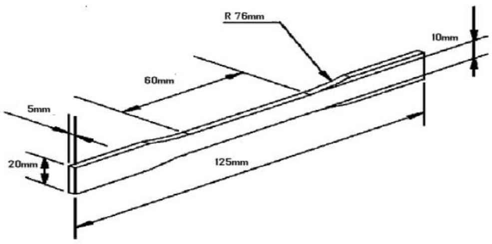

Figure.5 Line diagram of tensile specimen

Figure.6 Universal Testing Machine

2.4 Short Beam Test

This test method determines the short-beam strength of high-modulus fiber reinforced composite materials. The specimen is a short beam machined from a curved or a flat surface up to 6.00 mm thick. Figure.7 describe the specimen configuration and Figure.8 describes loading for the short beam shear test. Based on ASTM standards, the specimen length is 6 times the specimen thickness and the span length is 4 times the specimen thickness. The width of the specimen is 2 times the specimen thickness. [13]

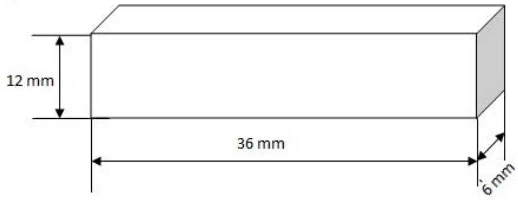

Figure.7 short beam test Specimen configuration (dimensions in mm)

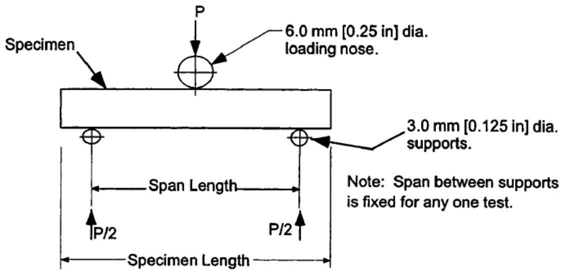

Figure.8 Short beam test loading configuration

As per the loading configuration the fixture for this test should be designed as it won't be available with this particular configuration. Figure.9 shows the fixture for the short beam strength test .

Figure.9 Fixture for short beam test

Test procedure: Test specimens were placed on the two 3.0 mm diameter supports, with care taken to align the center of the specimen in the center of the span. Loading supports were free to rotate, allowing free lateral motion of the specimen. Load was applied in the center of the specimen at the rate described above through the use of a 6.0 mm diameter steel dowel. The beam was loaded until fracture, and the fracture load was taken as a measure of the apparent shear strength of the material. The test set-up can be seen in Figure.10 below.

Figure.10 short beam test setup

Short beam shear strength was calculated for each specimen based on the formula [14]:

$$F_{sbs} = 0.75 \text{ X } Pm / (b \text{ X } h) \quad (4)$$

Where:

Fsbs = short-beam strength, MPa

Pm = maximum load observed during the test, N

b = measured specimen width, mm

h = measured specimen thickness, mm

IV. RESULTS AND DISCUSSIONS

3.1. Density Measurement

From the table.1 it is observed that as the density decreases as the weight percentage of fiber increases and with the increase of mesh size. The decrease in density can be related to the fact that the orange peel particles are light in weight but occupy substantial amount of space.

Figure.11 is the graph drawn between the measured densities of the composites and weight fraction of fiber for different meshes.

Mesh Size	Fiber volume	Density [gm/cm^3]
100	10	1.225
	20	1.164
	30	1.143
170	10	1.15
	20	1.102
	30	1.069
240	10	1.125
	20	1.091
	30	1.012

Table.1 Density of different samples

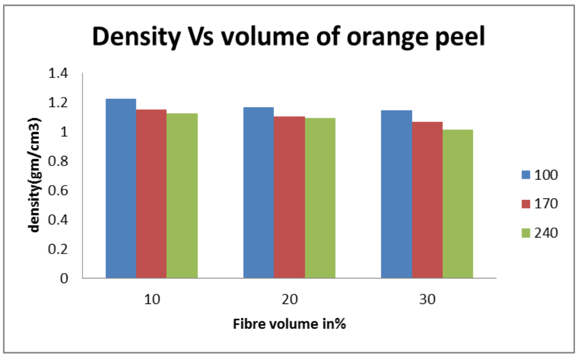

Figure.11 Variation of density with different fiber contents

3.2 Hardness Measurement

Vickers hardness number is measured by Leitz Micro hardness tester. The results are tabulated in the table.2. Figure.12 drawn between the hardness values of composite and the weight percentage of composite for different grain sizes. It is observed that as the reinforcement increases the hardness increases the maximum value is obtained for composite prepared with the 30% composite of 240 mesh.

Mesh Size	Fiber volume	HV
100	10	163
	20	187
	30	180
170	10	185
	20	207
	30	251
240	10	201
	20	214
	30	224

Table .2 hardness of different samples

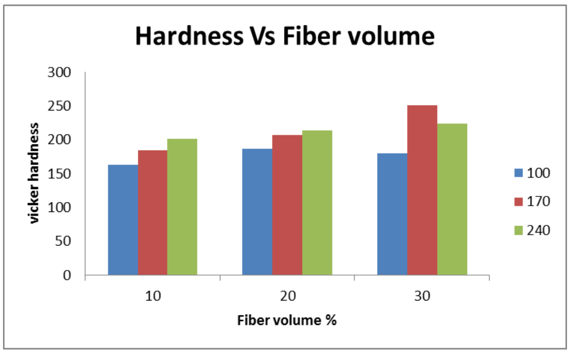

Figure.12 variation of hardness value with different fiber contents

3.3 Tensile Test and Short-beam Test

The results of tensile test and short beam test are conducted on universal testing machine are tabulated below:

Mesh Size	Fiber volume	Tensile strength(MPa)
100	10	18.75
	20	22.51
	30	17.15
170	10	20.12
	20	27.87
	30	24.84
240	10	23.92
	20	22.48
	30	21.89

Table.3 Tensile strength of orange peel powder fibre epoxy composite of 100 mesh, 170mesh, &240 mesh.

Mesh Size	Fiber volume	Short beam strength (MPa)
100	10	4.95
	20	6.15
	30	7.35
170	10	8.25
	20	10.35
	30	10.05
240	10	9.3
	20	8.7
	30	7.9

Table.4 short beam strength of orange peel powder fibre epoxy composite of 100 mesh, 170mesh, &240 mesh.

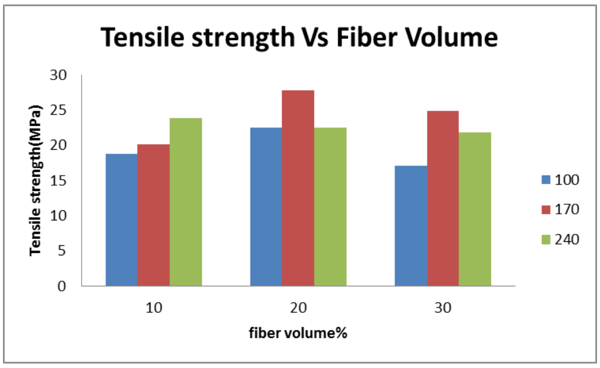

Figure.13 variation of tensile strength values with different fiber contents.

The tensile strength results for various specimens which were prepared with raw orange peel powder particles with different weight fraction for different grains sizes were plotted in Figure.13. The plot shows that, the maximum tensile strength is obtained for the composite prepared with the 20wt % of 170 mesh orange peel particulate filled epoxy composite.

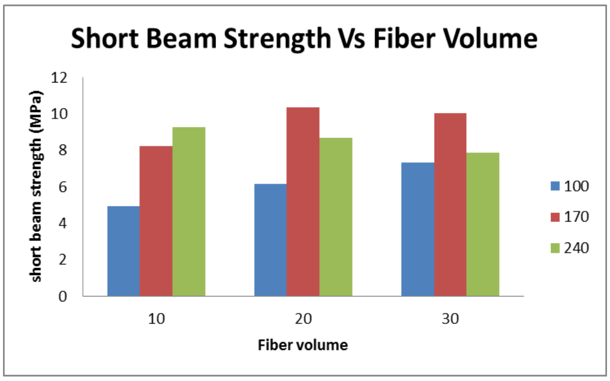

Figure.14 variation of short-beam strength values with different fiber contents.

Figure.14 shows the variation in flexural strength for different volume fraction of particulate composites. The plot shows that, the maximum flexural strength is obtained for the composite prepared with the 20wt % of 170 mesh orange peel particulate filled epoxy composite.

3.4 Comparison of orange peel powder reinforced composite with other natural fiber reinforced composite

A.S. Ferreira et al. conducted the experiments on natural fiber reinforced composites like sisal, ramie, curaua, jute, bamboo and coir and their mechanical properties like tensile strength are obtained as in shown in figure.15 [15].

Fiber	Sisal	Ramie	Curaua	Jute	Bambo	Coir
A(Mpa)	39	21	17	19	54	13

Figure.15 Tensile properties of different natural fiber composite-1

Myrtha Karina et al. conducted experiments on natural composites that are prepared from Kenaf, Acacia, water hyacinth, Banana, polymer and empty fruit bunch (EFB) of oil palm found out the mechanical properties of like tensile strength are shown in the figure.16 [16].

Composites	Tensile strength(Mpa)	
	PP	RPP
Kenaf	16.85	14.87
Acacia	13.03	15.36
Water hyacinth	14.72	13.69
Banana	16.18	16.39
EFB	13.61	14.36
Polymer	30.71	28.86

Figure.16 Tensile properties of different natural fiber composite-2

From the above results it is analysed that the maximum orange peel powder reinforced composite is 27.87 MPa. It is high when compared to other natural fiber composites made up of Kenaf, acacia, water hyacinth banana, EFB, ramie, curaua, coir and jute. It is having strength nearly equal to polymer And it is having less strength compared to sisal and bamboo because of its fiber strength which exhibits naturally. As the orange peel composite exhibits good mechanical properties when compared to other natural composites researchers are showing interest and developing its for future use.

V. CONCLUSIONS

The present work deals with the preparation of characterization of orange peel reinforced epoxy composite. The mechanical behaviour of the composite lead to the following conclusions.

- This work shows that successful fabrication of a orange peel powder reinforced epoxy composites by simple hand lay-up technique.
- The density of the composite gradually decreases with the increase of weight percentage of fiber content.
- The hardness value of the composite increases with increasing of the fiber content. The highest hardness value observed is 251Hv for 170 mesh composite and content of orange peel powder found to be maximum i.e. 30 %
- Maximum tensile strength value is observed for the composite prepared with orange peel powder of 170 mesh and the weight percentage of the fiber is 20%.
- Maximum short-beam strength value is observed for the composite prepared with orange peel powder of 170 mesh and the weight percentage of the fiber is 20%.

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