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Tensile and Flexural Strength of rice hull husk with aramid fiber reinforced in vinylester polymer composite

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Abstract- Polymer Matrix Composites (PMC) are gaining more importance compared to the monolithical materials as being more reliable and cheap. Polymer matrix composites finding applications from household to engineering approach. With the advancement of PMC‟s their properties can be increased by the addition of one more fiber made as hybrid composite which boosts the property of PMCs where a single fiber composite lags. In our project we have chosen rice husk as the major reinforcement and aramid as an additional fiber to improve the mechanical property of polymer composite with vinyl ester as the base material prepared by hand lay-up process according to ASTM standards. Test specimens are prepared with different weight fractions of rice-husk at the optimization point of tensile test a small percentage(3%,5%,7%) of aramid are added and tests were conducted and the improvement in mechanical properties (tensile strength and flexural strength) of the hybrid composite material is observed.

Keywords- Aramid, Flexural Strength, Hybrid Polymer Composite, Vinyl ester, Rice Husk

I.INTRODUCTION

Natural polymers are more in concern in the research work as they are naturally and abundantly available and cheap compare to synthetic fiber. Rice husk is used more as a fuel for burning and to some extent its ash is used as admixture in concrete making rather it can be used to prepare a composite to enhance the property of a matrix material which is made available for various applications that may be industrial, constructional, or automotive area. Hardinnawirda [1] studied that with the addition of rice husk filler there is decrease in tensile strength of the composite and its water absorption increases as it absorbs water. D Lingaraju [2] studied on rice husk ash Nano composite using burnishing processes which is increased the hardness of composite material with the increase of depth cut and also smoothen the surface, Treated RHA has good influence on hardness than non-treated RHA.Francis Uchenna OZIOKO [3] studied The effect of carbonization temperatures on wear rate behaviours of different volume fractions of rice husk ash epoxy composite. Wear rate and specific wear rate behaviours of different samples have shown near uniform behaviour. The 950°C carbonized ash showed steady wear rate and specific wear rate behaviour for all ash contents. Dimzoski [4] studied properties of rice-hull-filled polypropylene (PP) composites. Using the concept of linear elastic fracture mechanics, Introduction of rice hulls in the PP matrix resulted in a decreased stress at peak , together with increase of composites tensile modulus and modulus in flexure..Sudhakar Majhi [5] studied that the abrasive wear rate decreases with addition of rice husk fibers as the sliding distance increases for all wt.% of fibers including pure epoxy. It is also observed that 10wt%fiber shows least wear rate. Higher wt.% of fiber also shows lower wear rate but higher than 10wt%, still lower than pure epoxy.

II EXPERIMENTAL WORK

A. Preparation of test samples

Finely milled rice husks were collected from a local rice mill. The milled rice husks contain many impurities like dust, small rice particles, and fine sand particles. Therefore, it needs to be cleaned in order to get pure rice husk. After cleaning with water, the rice husks were dried directly under the sun for 8 hours. Then it were weighted according to the percentage needed (5,10, 15 wt. %). After that, the unsaturated polyester resin and methyl ethyl ketone peroxide (MEPK) catalyst were mixed in a container and stirred well for 3 to 5 minutes. The rice husks were then added gradually and stirred to allow proper dispersion of fibre within the gel like mixture. Before the mixtures were poured inside the mould, the mould was initially polished with a release agent to prevent the composites from sticking to the mould upon removal. Finally, after the mixture had been poured into the mould, it was left at room temperature for 24 hours for fully cured and hardened. The materials used in the present research are tabulated in Table.1 with their properties and suppliers

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Table.1 Specifications of the Materials Used in the Research work

Materials	Specifications	Suppliers
Vinylester	Density: 1.05 g/cm^3 UTS: 60MPa FS:130MPa Heat distortion temperature:125^0	Raja industrial suppliers Bangalore, india
Rice Husk	Bulk density 0.7- 0.8 g/cm^3 length : 3- 6mm	Sri Annapurneshwari Rice mill, Katarki road, Koppal, India
Aramid	Bulk density 1.44 g/cm^3	Jk Epoxie, bangalore
Di-Methylacetamide (promoter).	Density: 0.94 g/cm^3	Raja industrial suppliers Bangalore, india
Cobalt napthalate accelerator	Density: 0.98 g/cm^3	Raja industrial suppliers Bangalore, india
Methyl Ethyl Ketone peroxide (MEKP) catalyst	Density: 1.17 g/cm^3	Raja industrial suppliers Bangalore, india
Mylar Sheet	Thickness - 100(µm) Density – 1.4 (gm/cc)	Kabadi Distributors, Avenue Road, Bangalore

B. Processing of Rice Husk and Aramid/Vinyl ester Composite.

Rice husk Composite is prepared first to know at what percentage of weight fraction the composite gives the Ultimate Tensile Strength from that percentage some percentage of aramid is added to enhance its tensile property. First make some sample preparation calculation before preparing the composite as given below and start the fabrication by preparing the temporary mould using beadings arranged on the granite base representing a rectangular mould of 300x200x5mm. Pour the calculated amount of resin with thoroughly mixed Promoters, Accelerators & Catalyst of 1% to the mould and wait for ten minutes so that it starts pre hardening then put a Mylar sheet on to it and then apply pressure by placing a concrete block over the setup for 24 hours to complete cure the laminate and once the laminate is completely cured then it's ready for machining according to ASTM standard for testing, repeat the procedure by adding 5, 10, 15% wt of rice husk to the resin. At optimum percentage then add 3, 5, and 7% of aramid and repeat then same procedure to get the Hybrid composite and is tested for mechanical properties

Fig. 1 Composite with 0% fiber prepared using Hand layup procedure

C. Sample Preparation

Composite laminate of 300 mm X 200 mm X 5 mm were fabricated according to ASTM standards for mechanical tests.

1) **Density of Vinylester (δ) = 1.05 g/cm^3**

2) **Volume of the mold (V)** = 300x200 x5mm
= 300000mm^3
= **300cm^3**

3) **Mass of resin (m)** = Volume of mould x Density of Vinylester
= 300cm^3 x 1.05g/cm^3
= 315g

Table II Samples Preparation Calculation for Rice husk/Vinyl ester Composite

Samples	% of rice husk	% of Vinylester	Mass of rice husk	Mass of vinyl ester	Total Mass
A	0	100	0	315	315g
B	5	95	11	314	325g
C	10	90	22	298	320g
D	15	85	33	281	314g

Table .III Samples Preparation Calculation for Rice Husk& Aramid / Vinylester Hybrid Composite

Samples	% Resin	% aramid	% rice husk	Mass of resin	Total mass
E	90	3	7	298g	318g
F	90	5	5	298g	316g
G	90	7	3	298g	315g

The above samples are tested for mechanical properties that are tensile and flexural strength according ASTM standards.

III.TESTING

D. Testing parameters

A Universal Testing Machine (UTM) is an instrument used for the measurement of loads and the associated test specimen deflections such as those encountered in tensile, compression or flexural modes. It is used to test the tensile ,Compression, flexural and Inter Laminar Shear Strength (ILSS) properties of materials. Load cells and extensometers measure the key parameters of force and deformation as the sample was tested. The Universal Testing Machine set up is shown in Fig.2

(a) (b)

Fig.2 Universal Testing Machine. (a) Universal testing machine set up. (b) Specimen loaded in tension

a. Ultimate Tensile Strength

Ultimate tensile strength, often referred to tensile strength is the maximum stress that a material can withstand while being stretched or pulled before fracture. The tensile test for the specimens was conducted according to ASTM D3039. The specimens of size 250 mm x 25 mm x 5 mm were tested with a span length of 250 mm in tensile mode at a cross head speed of 1 mm / min. The fixtures used for the tensile testing is shown in Fig. 2(b)

1) Ultimate tensile strength = $\frac{\text{Maximum load in N}}{\text{C/s area in mm}^2}$ in MPa-- (1)

2) Young‟s modulus (E) = $\frac{\text{Stress}}{\text{Strain}}$ in GPa………………… (2)

3) Stress (σ) = $\frac{\text{load (l)}}{\text{area(bxd)}}$ in N/mm^2…….………………………. (3)

4) Strain = $\frac{\text{Change in length}}{\text{Original length}}$…………………………………… (4)

P = maximum load in N
b = width of the specimen in mm ,
d = thickness of the specimen in mm

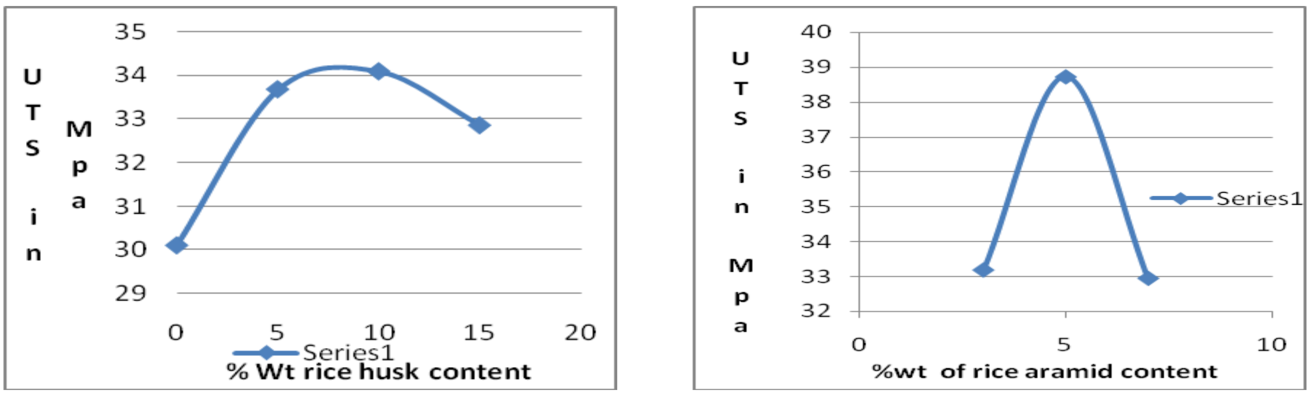
b. Tensile Test Report

Table IV Ultimate Tensile Strength Of Rice husk / Vinylester Composite

Samples	% of Rice husk	Ultimate tensile strength in MPa			Avg UTS in MPa
A	0	27.42	32.66	30.28	30.12
B	5	34.56	33.84	32.64	33.68
C	10	36.54	32.97	32.76	34.09
D	15	33.12	31.98	33.48	32.86

Table V Ultimate Tensile Strength Of Rice Husk & Aramid / Vinyl ester Composite

samples	% wt of Aramid	% Wt of Rice Husk	Ultimate tensile strength in Mpa			Avg UTS in Mpa
E	3	7	32.66	33.66	33	33.18
F	5	5	48.04	34.91	33.25	38.73
G	7	3	33.85	32.64	32.33	32.94



(a) (b)

Fig.3 Graph of Tensile test results. (a) Variation of UTS values with rice husk fibre loading. (b) Variation of UTS values with aramid loading

c. Flexural Strength

The use of flexural tests to determine the mechanical properties of polymeric composites is widely prevalent because of the relative simplicity of the test method, instrumentation and testing equipment required. The flexural strengths of the specimens were determined for specimens using the three-point bending test as per ASTM-D790. The specimens of dimensions 200 mm x 15 mm x 5 mm tested with a span length of 50 mm.

The flexural strength and Modulus of the composites were determined using the equation (1) & (2) respectively

1) Flexural Strength = $\frac{3PL}{2BD^2}$ ….in MPa

2) Flexural Modulus = $\frac{PL^3}{4D^3\,\delta}$ in GPa

P – Peak Load [N],
δ – Deflection at load ‘P’ [mm]

d. Flexural Strength Rice Husk / Vinylester Composite

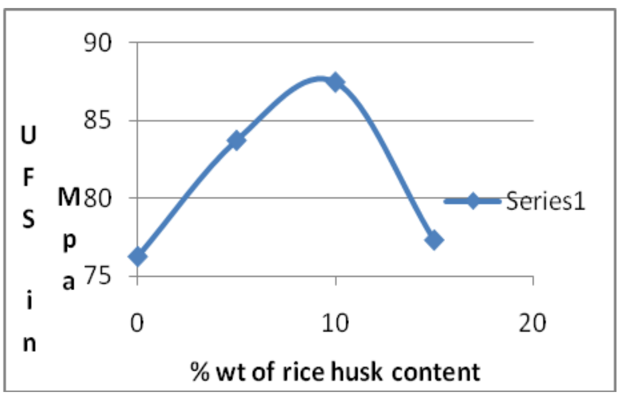
The use of flexural tests to determine the mechanical properties of polymeric composites is widely prevalent because of the relative simplicity of the test method, instrumentation and testing equipment required. Table VI & VII.List the flexural strength of Rice husk / Vinylester composite & Rice Husk Aramid /Vinylester composite

Table VI Ultimate Flexural Strength Of Rice husk / Vinylester Composite

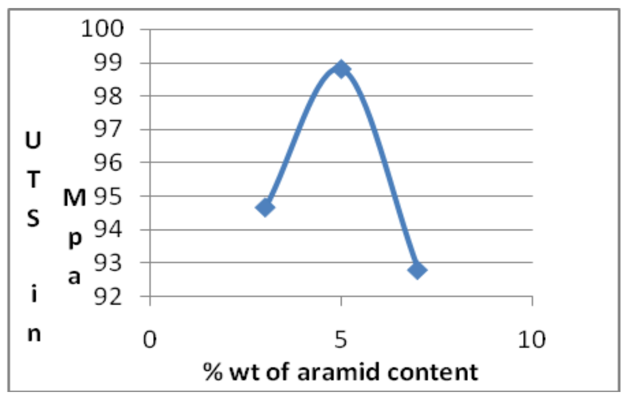
Samples	% of Rice husk	Ultimate flexural strength in MPa			Avg UFS in MPa
A	0	74.00	76.4	78.4	76.27
B	5	84.00	82.4	84.8	83.73
C	10	84.8	87.2	90.4	87.47
D	15	76	78.4	77.6	77.33

Table VII Ultimate Flexural Strength Of Rice Husk & Aramid / Vinylester Composite

Samples	% wt of Aramid	% Wt of Rice Husk	Ultimate Fluxural strength in Mpa			Avg UTS in Mpa
E	3	7	92	95.2	96.8	94.67
F	5	5	99.2	97.6	99.6	98.8
G	7	3	93.6	92	92.8	92.8



(a)



(b)

Fig.4 Graph of Bending test results. (a) Variation of UFS values with rice husk fibre loading. (b) Variation of UFS values with aramid loading.

IV.MORPHOLOGICAL CHARACTERIZATION

Nano level materials cannot be observed through optical microscope due to their aberrations and limit in wavelength of light. Therefore to observe submicron sized particles advanced techniques such as Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), and Atomic Force Microscopy (AFM). In this work, the dispersion of Rice Husk and Aramid in Vinylester resins was studied using SEM. The basic principles of these techniques are presented in the subsequent sections.

4.0 SCANNING ELECTRON MICROSCOPY (SEM)

SEM is basically an electron microscope that images the sample surface by scanning it with a high-energy beam of electrons. The signals produced by SEM result from interactions of the electron beam with atoms at or near the surface of the sample. SEM can produce very high-resolution images of a sample surface, revealing details about less than 1 to 5 nm in size. Due to the very narrow electron beam, SEM micrographs have a large depth of field yielding a characteristic three-dimensional appearance useful for understanding the surface structure of a sample.

For conventional imaging in the SEM, specimens must be electrically conductive, at least at the surface, and electrically grounded to prevent the accumulation of electrostatic charge at the surface. Nonconductive specimens tend to charge when scanned by the electron beam which causes scanning faults and other image artifacts. Therefore, they are coated with an ultrathin coating of electrically conducting material, commonly gold, deposited on the sample either by low vacuum sputter coating or by high vacuum evaporation. The dispersion of Nano fillers in Vinylester was studied using SEM (JEOL JSM 840A, Japan). The samples were examined with gold– sputtering for SEM characterization.

Fig. 5.0 SEM machine

4.1 SEM OF RICE AND ARAMID HUSK/VINYLESTER

Figure 6.1 shows the SEM micrograph of bending fractured specimen of neat vinyl ester smooth surface and the size is higher. With the addition of Rice husk the smooth surfaces sizes are reduced and the reduction was increased with the increase of Rice husk addition. The smooth area represents the voids at higher concentration of Rice husk; the number of voids is more.From the microstructure it is evident that there is inhomogeneous mixture of RHF/Vinyl ester that leading to some voids/pores in the matrix as shown in figure (b). Only in case of 10% filler loading as shown in figure (c) it is found to have good interfacial bonding and no micro cracks which has given the concrete little positive strength to the tensile load,

There are some micro cracks in the matrix material which is responsible for reduction of tensile strength of the composite as seen in figure (d). there is gap surrounding the reinforcement indicating the poor bonding reinforcement and matrix. Poor interfacial bonding results decrease in strength of composite.

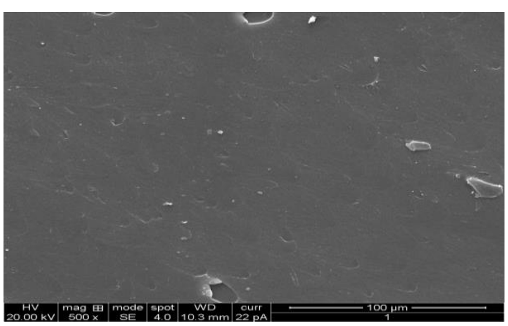


Fig.5.1 SEM of 0% Rice husk/VE composite

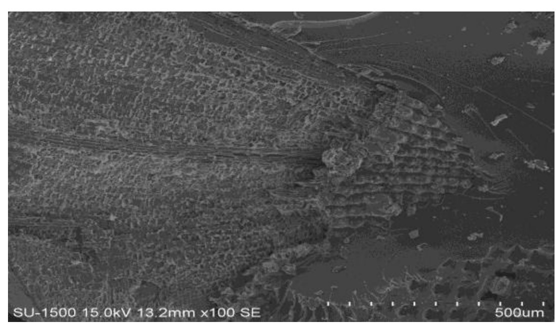


Fig. 5.2 SEM of 5% Rice husk/VE composite

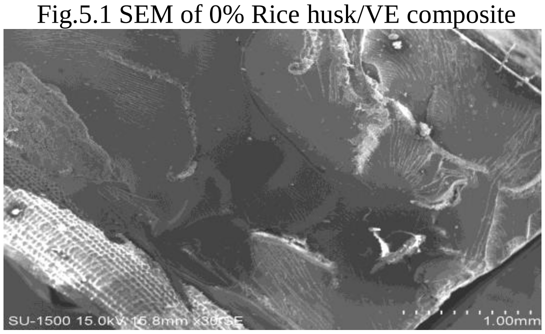


Fig.5.3SEMof10%Rice husk/VE composite

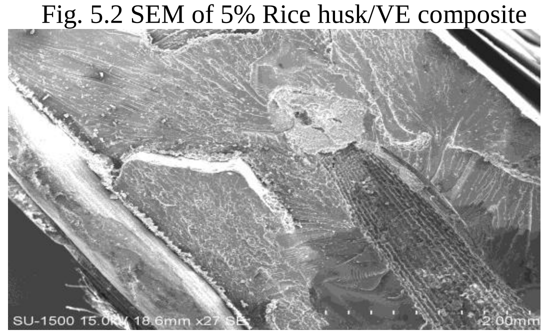


Fig.5.4SEM of 15% Rice husk/VE composite

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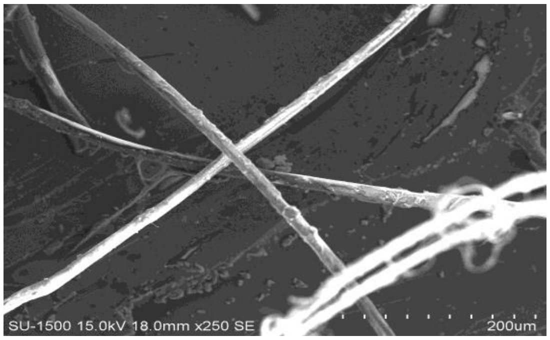

Fig. 5.5 SEM of 3 % Aramid/VE composite

Fig.5.6SEM of 5% Aramid/VE composite

V.RESULTS AND DISCUSSION

MECHANICAL PROPERTIES OF RHF / VINYL ESTER

Experimental Study on : **Rice Husk & Aramid/Vinyl ester composite.**

Mechanical test : **Tensile Test**

Table VIII Results of UTS of composite material

SAMPLES	**ULTIMATE TENSILE STRENGTH**			**RESULTS**
	Rice husk %	Aramid %	Avg.UTS MPa	
A	0	-------	30.12	
B	5	---------	33.68	Tensile strength increases by 10.57%
C	10	--------	34.09	Tensile strength increases by 11.65%
D	15	--------	32.86	Tensile strength increases by 8.34%
F	7	3	35.20	Tensile strength increases by 14.43%, Tensile strength increases by 3.15% from yield point
F	5	5	38.73	Tensile strength increases by 22.23%, Tensile strength increases by 11.98% from yield point
G	3	7	36.40	Tensile strength increases by 17.25%, Tensile strength increases by 6.34% from yield point

Experimental Study on : **Rice Husk & Aramid/Vinylester composite.**
Mechanical tests : T**hree Point Bending Test (Flexural test)**

Table IX. Results of flexural strength of composite material

SAMPLES	**ULTIMATE FLEXURAL STRENGTH**			**RESULTS**
	Rice husk %	Rice Husk %	Avg.FS MPa	
A	0	-----------		
B	5	------------		Flexural strength **increases by 8.90%**
C	10	------------		Flexural strength **increases by 12.80%**
D	15	------------		Flexural strength **increases by 1.37%**
E	7	3		Flexural strength **increases by 19.43 %** flexural strength **increases by 7.2% from yield point**
F	5	5		Flexural strength **increases by 22.80%,** Flexural strength **increases by 11.33% from yield point**
G	3	7		Flexural strength **increases by 17.81%,** Flexural strength **increases by 5.33% from yield point**

VI.CONCLUSION

The conclusion of the study of Rice & Aramid reinforced vinyl ester composite is that there is significant increase in the tensile strength and flexural strength of the composite.

1. With the addition of rice husk to the Vinyl ester the tensile strength increases by 11.65% at 10% fiber loading and decrease at 15% wt of rice husk loading by 8.34% so further addition of rice husk will no longer increases the strength rather it decreases.
2. With the hybridization I.e. by the addition of Aramid at optimum point it increase the tensile strength by further 22.23 % hence hybridization successfully yield more strength compare to single fiber loading
3. The flexural rice husk composite increases by 8.90% at 5% coir loading and 12.80 % at 10% rice husk loading.
4. The flexural strength increase further by 22.80% at 5% aramid.
5. Hybridization results a better improvement in tensile strength but more than 5% of Aramid is not recommended where the flexural property is needed for the application.

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