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A Study on Cotton-Ramie Fabric Reinforced Composites

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Abstract

Cotton-Ramie fabric/UP resin composites were formed by using hand lay up method and cured at room temperature for 24 hours. The primary mechanical properties such as; tensile strength, flexural strength, flexural modulus and impact strength with three different content of the ramie fibers on the composites were studied. The result shows that, with the increase the content of ramie fibre on cotton – ramie fabric reinforced composites; all those primary mechanical properties are improved.

Keywords: cotton-ramie fabric, UP resin composite, mechanical properties.

1 INTRODUCTION

Composite materials (or composites for short) are engineered material made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct on a macroscopic level within the finished structure [8].

There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination. Engineered composite materials must be formed to shape. The matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mold cavity or onto the mold surface. The matrix material experiences a melding event, after which the part shape is essentially set. Depending upon the

nature of the matrix material, this melding event can occur in various ways such as chemical polymerization or solidification from the melted state [5].

Matrix

The variety of matrices like polymer, metal, alloy, inter-metallic, ceramic, carbon and cement have been used for making composites [3].

The role of the matrix in a fibre – reinforced composites are (1) to transfer stresses between the fibers, (2) to provide a barrier against an adverse environment, and (3) to protect the surface of the fibers from mechanical abrasion [5]. Another role of the matrix is to support the fibres and bond them together in the composite material [4]

The starting material for thermo set polyester matrix is an unsaturated polyester resin, and the curing time for polyester depend on the decomposition rate catalyst, which can be increased by increasing the curing temperature. As in the case of epoxy resins, the properties of polyester resin depend strongly on the cross-link density. The modulus, glass transition temperature, and thermal stability of cured polyester resin are improved by increasing the cross-link density, but the strain to failure and impact energy is reduced [3].

Reinforcement

The reinforcement for composites may be in the form of particles, whisker, fibers, lamellae or a mesh. They may increase the strength, stiffness or modify the failure advantageously [3].

Ramie is one of the strongest natural fibres. It exhibits even greater strength when wet. Ramie fibre is known especially for its ability to hold shape, reduce wrinkling, and introduce a silky luster to the fabric appearance. It is not as durable as other fibre, and so is usually used as a blend with other fibres such as cotton or wool. It is similar to flax in absorbency, density and microscopic appearance. However it will not dye as well as cotton. Because of its high molecular crystallinity, ramie is stiff and brittle and will break if folded repeatedly in the same place; it lacks resiliency and is low in elasticity and elongation potential [7]. The important mechanical properties of ramie fibre are the tenacity of the fibre, strength of the fibre, breaking extension of fibre in dry, breaking extension of fibre in wet and tensile strength of the fibre [6].

One of the production methods of composites is hand lay-up method. Hand lay-up is the traditional technique used in producing composite. In hand lay-up, the fibre reinforcement is manually inserted into a single sided mould, and resin is then forced into the fibers using hand rollers and squeegees [1].

2 EXPERIMENTAL

The polymer, catalyst and promoter used in this study were an Unsaturated Polyester resin, MEKP and cobalt octane respectively purchased from Sakti Fibre Glass, Chennai.

The reinforcement used were cotton-ramie fabric with three different weight fraction of ramie fibre as weft produced by inserting one thread per pick, two thread per pick and three thread per pick for three different samples respectively, woven along with the cotton yarn as warp at weaving laboratory Textile Department Anna University Chennai

The three composite samples were produced by using hand lay up method, to achieving the desire thickness, five layer of fabric for each samples are used. Unsaturated Polyester resin along with promoter and catalyst were forced into the fabrics using hand rollers and squeegees and it were cured at room temperature for 24 hours and then removed from the mould. The mechanical properties such as; tensile strength, flexural strength, flexural modulus and impact strength were performed following standards of ASTM.

To investigate the effect of content of the ramie fibre on cotton-ramie fabric reinforced composite, the tensile strength of the ramie yarn and fabric prepared for each sample were measured. Scanning Electron Microscope also performed to analyze the surface of composites material at the point of break.

3. RESULTS AND DISCUSSION

3.1 Effect of content of ramie fibers on tensile strength of cotton-ramie fabric reinforced composites material

The figure 3.1 shows the effect of content of ramie fibre on tensile strength of cotton-ramie fabric reinforced composites. It can be conclude that the tensile strength increases by increase the content of ramie fibre on cotton-ramie fabric reinforced composites material.

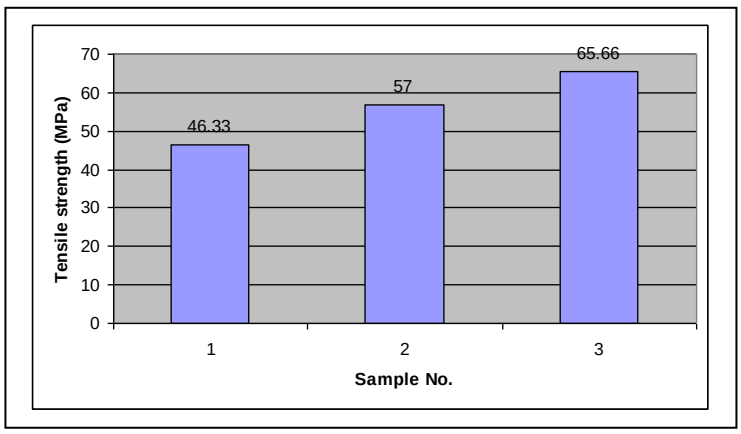
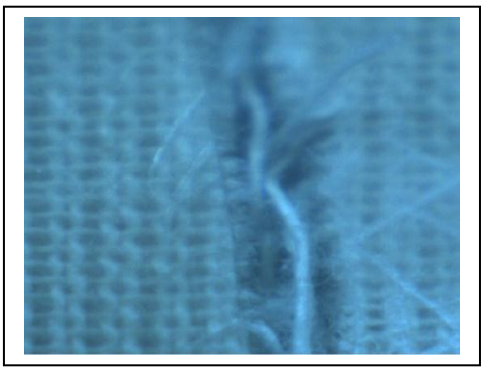


Fig. 3.1 Tensile strength of cotton-ramie fabric reinforced composite

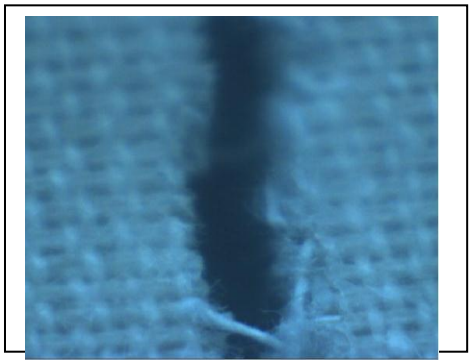
F-test shows that the F actual is greater than F critical, it can be inferred that the increases the content of ramie fibre on cotton-ramie fabric reinforced composite material is significantly affected to the tensile strength properties of composites material. Y = 1.1X + 33.67 is the regression model used to analysis the correlation between the tensile strength and content of ramie fibre with the value of correlation is 0.9945.

The tensile strength of cotton-ramie fabric reinforced composite materials is increased by 28.88% and 46.66% compared with the 10% content of ramie fibers on cotton-ramie fabric reinforced composites when 20% and 30% of content of ramie fibre respectively is added. This attributed to the presence of more fibre bundles or in other words due to the increase in weight fraction of the reinforcement in composite. By increasing the content of ramie fibre, the weight per square meter of the fabric is increased by 21.9% and 46.2% on 20% and 30% content of ramie fibre as compared with the 10% content of ramie fibre, resulting in superior properties in case of the latter.

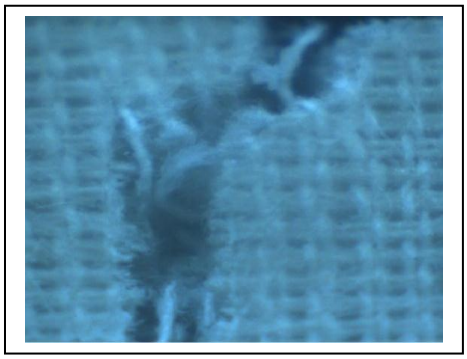
From the Fig. 3.2 below it can be seen the breakage point after tensile test.



Perpendicular breakage (a)



Perpendicular breakage (b)



Curvilinear breakage(c)

Fig. 3.2 Breakage Point after Tensile Test

In the first and second samples (a) and (b) which contain the 10% and 20% of ramie fibre respectively, shows that the breakage point is perpendicular to the axis whereas in the third sample (c) which contain 30% of ramie fibre shows that the breakage point is curvilinear. It is indicating better interaction between the fibre and the matrix. Generally the breakage occurs by delaminating of the matrix cracking followed by fibre breakage. Due to better interaction between fibre and matrix, the load required to break the sample which contain more number of ramie fiber is higher. Fig. 3.3 below shows how the interaction between the fibre and matrix.

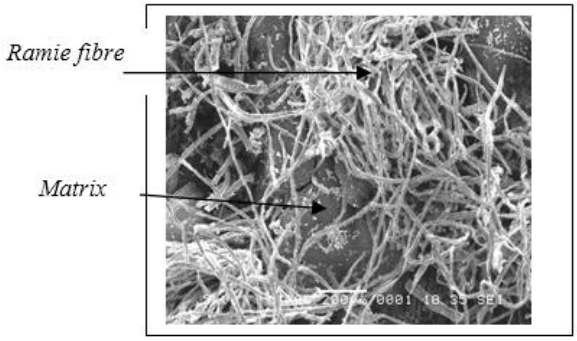


Fig. 3.3 Surface Image after breakage on Tensile Test

From the fig 3.3 above it is very clear that the fibre is fully covered by the matrix resulting better interaction between fibre and the matrix.

3.2 Effect of content of ramie fibers on flexural properties of cotton-ramie fabric reinforced composites material

As shown in Fig. 3.4 and Fig 3.5, the flexural strength and flexural modulus of cotton-ramie fabric reinforced composite material is increases with increase the content of

ramie fibre on cotton-ramie fabric reinforced composites which means that the stiffness of UP resin is improved.

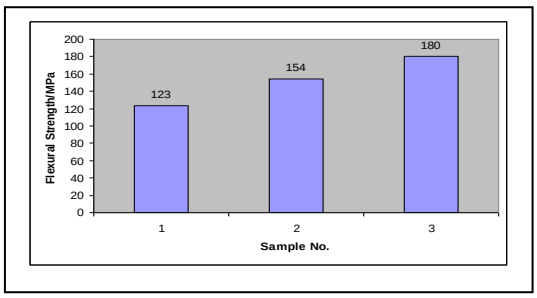


Fig. 3.4 Flexural strength of cotton-ramie fabric reinforced composites

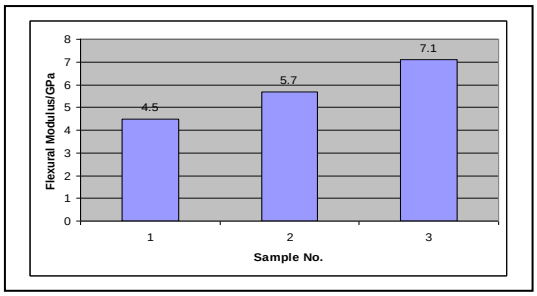


Fig. 3.5 Flexural modulus of cotton-ramie fabric reinforced composite

An increase of content of ramie fibre on cotton-ramie fabric is significantly affected to the flexural strength properties of composites material; it was confirmed by F-test. $Y = 2.65X + 99.56$ is the regression model for flexural strength and the content of ramie fibre. The correlation between the flexural strength actual and flexural strength calculated is 0.9976

From the fig.3.4 also, we can conclude that the flexural strength of cotton ramie-ramie fabric reinforced composites is increased by 25.20% and 46.34% on 20% and 30% content of ramie fibers respectively compared with the 10% content of ramie fibers.

Similarly for flexural modulus, F-test was confirmed that the increase of content of ramie fibre is significantly affected to the flexural modulus properties. The regression model for flexural modulus and the content of ramie is $Y = 0.157X + 2.77$ with the correlation is 0.9893. From the graph also we can seen that the flexural modulus is increases by 26.66% and 57.77% when 20% and 30% of content of ramie fibre is added respectively compared the 10% content of ramie fibers.

When the composite laminates are subjected to different kinds of forces, the behavior of laminates is bound to be different. When laminate is subjected to flexural load, it is subjected to both compression at the top and tension at the bottom. This results in competition between tensile, comprehensive and shear failure mechanism when the

laminates are subjected to a bending load. In other words, the flexural behavior of the laminates depends on the number of the fibre bundles bridging the fracture plane.

The flexural strength and flexural modulus of the laminate for different content of ramie fibre can be seen that flexural value also follows a similar trend to that of the tensile properties. With increase the content of ramie fibre, there is an increase in flexural strength and flexural modulus due to the more number of fibre bundles presence as a bridging there fore the resistant to load is more when the content of ramie is increased.

3.4 Effect of content of ramie fibers on impact strength of cotton-ramie fabric reinforced composites material

The impact strength properties of cotton-ramie fabric reinforced composite material are shown in fig.3.6 below. Generally the impact strength properties of cotton-ramie fabric reinforced composites material is increases by increase the content of ramie fibers. From the graph below, compared with the 10% of ramie content, the impact strength properties are increased by 10.22% and 30.79% when the content of ramie fibers increased 20% and 30% respectively

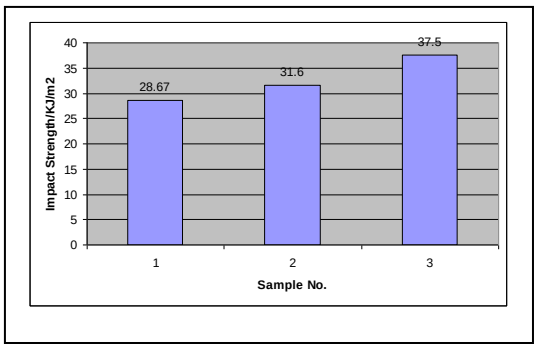


Fig. 3.6 Impact strength of cotton-ramie fabric reinforced composite

We can say that the increases the content of ramie fibers on cotton-ramie fabric reinforced composite material is significantly affect the impact strength. It was confirmed by F-test. $Y = 0.498X + 22.789$ is the regression model to predict the correlation between the impact strength and the content of ramie fibre and the correlation value is 0.9999.

When the composite is subjected to the sudden load in weft direction, the composite strength is depend only to the ramie fibre and interaction between that ramie fibre and matrix. That is the reason when we increases the content of ramie fibre, the impact strength is also increase.

4. REALIZATION OF STRENGTH GAIN

The realization of strength gain is the ratio of strength of cotton-ramie fabric reinforced composite with respect to the blank composite strength and fabric strength. The strength of blank composite is 23 MPa [2]. Table below shows the realization of strength gain for those ratios,

Table 4.1 Strength gain in composite with respect to blank Composite and fabric strength

Sample No	Blank Composite		Fabric	
	SG (%)	CV (%)	SG (%)	CV (%)
1	201.4493	3.3	446.5	7.79
2	247.8261	1.75	537.2	3.7
3	285.5072	1.76	669.4	4.71

It can be seen from the table 4.1 above, with respect to the strength of blank composite; by increasing the content of ramie fiber in cotton-ramie fabric reinforced composite the realization of strength is gained. The strength is gained by, 2 times, 2.4 times and 2.8 times by increasing 10%, 20% and 30% content of ramie fiber respectively. Similarly, with respect to fabric strength, the realization of strength gain in cotton-ramie fabric reinforced composite is gained by 4.4 times, 5.3 times and 6.7 times by increasing at the same respectively. Realization of strength gain, sample No. 2 which contains 20% of ramie fibre shows better than others. It is confirmed by coefficient variation value.

Table 4.2 Realization of fiber strength in Composite

	Content of Ramie Fibre		
	10%	20%	30%
EFSC in comp. (MPa)	75.9	128.8	181.7
Actual comp. TS (MPa)	46.3	57.0	65.7
RFS in Composite (%)	61.04	44.24	36.13

It can be seen also from table 4.2 above, the gap between actual composite tensile strength and expected fibre tensile strength contribution (EFSC) in composite is increase, therefore the composite which contain the 10% of ramie fiber shows highest percentage of realization fiber strength (RFS).

5. CONCLUSION

The mechanical properties of cotton-ramie fabric reinforced composite such as, tensile strength, flexural strength, flexural modulus and impact strength are improved significantly where the content of ramie fibers is increased. This means that the cotton-ramie fabric is good reinforcement material to improve the UP matrix. The application of cotton-ramie fabric reinforcing UP matrix is used for low performance as part without over-loads. With respect to realization of expected fiber strength contribution in composite, sample No. 1 which contains 10% ramie fiber shows higher value compared other.

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