Hygric Strain Estimation for Jute-Pineapple Hybrid Composites through Curved Specimens

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Abstract *-Hybrid composites are prepared through hand layup technique using jute/ pineapple fibers of 40:0, 30:10, 20:20, 10:30 and 0:40 ratios. The overall fiber volume fraction was fixed at 0.4*V_f*. Curved specimens are fabricated and tested in the present investigation. Hygric strain behavior of hybrid natural composites was found out experimentally. A separate test setup has been designed for determination of hygric strain (β) in moisture environment. Changes in radius of curvature for each specimen were measured periodically with respect to time. Moisture concentration (C) was evaluated using weight gain calculation for each specimen. Coefficient of hygric strains are determined from moisture concentration (C) and hygric strains (β). Results indicated that 20P-20J composite has minimum weight gain as compared to all other composites. Pure Jute composite has shown least change in radius of curvature as compared to other composites.*

Key words *-Natural fibers, Polymer composite, Hand layup, Radius of curvature, Hygric strain.*

I. INTRODUCTION

Fiber reinforced composites consists of fibers of high strength and modulus bonded or reinforced in to a matrix with distinct interface between them. A combination of drawn properties that can be achieved because of combined effect of both fibers and the matrix. In general, the role of the matrix is to protect from environmental damages due to moisture and elevated temperature whereas principle load carrying is carried out by fibers. Over the past few years, there has been increasing interest in the usage of natural fibers as reinforcements due to their advantages like biodegradability, renewable, economic, availability, less density, less in weight etc [1]. Consumer goods, housings with low cost and other civil structures are the few potential applications of natural fiber composites worth mentioning [2]. Natural fibers are extracted from seed, leaf, stalk or fruit. The most used natural fibers are cotton, flax and hemp although sisal, kenaf, bamboo, jute and coconut are also widely used. Paramasivam T et.al, Bai.S.Let.al, Kalaprasad GK et.al, Joseph Kuruvilla et.al, conducted experiments on sisal fiber reinforced composites [3-6]. Varadarajulu A et.al, Jindal UC et.al, Yong CAO et.al worked on bamboo reinforced composites [7-9]. N.Venkateswaran et.al, PoyhanaLalyA et.al, Sapuan SM et.al, N.Venkateswaran et.al have done their works on banana reinforced composites [10-13]. Rout J et.al, Varma D.S et.al investigated on coir reinforced composites [14-15]. Natural fiber reinforced composites are proved good stiffness, but strength levels are not on par with glass fiber composites[16].Apart from the advantages mentioned above natural fibers are having certain disadvantages. Low thermal stability, prone to hygric expansions and variations in quality are few to mention. Kulkarni et.al [17] investigated the effect of banana fiber reinforcement on the mechanical properties. Fiber pull out is the main failure mechanism in those composites. Venkateshwaran and ElayaPerumal [18] reviewed various works carried out so far in the field of banana fiber polymer composite. In order to achieve enhanced properties composites are hybridized. Cost effective composites can be manufactured using hybridization approach. Kasama and Nitina [19] conducted studies on the effect of glass fiber hybridization in sisal fiber composites. Improvement in mechanical, thermal and water resistance properties are obtained due to incorporation of glass fibers. N.Venkateswaran et.al [20] investigated on the moisture absorption behaviour of banana/sisal hybrid natural composites. Results revealed that upon the addition of sisal fiber (50% by weight) to banana/ epoxy composites, there is a decrease in moisture absorption behaviour.

With this background, in the present work an attempt has been made to fabricate pineapple, jute natural fiber hybrid composites and studying their hygric expansion behaviour when exposed to moisture environment. For comparison purpose, pure pineapple and pure jute composites are also fabricated and tested.

II. FABRICATION OF COMPOSITE

A rubber material (1500mm×1500mm×13mm) sheet is used for the preparation of mould. Cavity of circular asymmetric shape of inner diameter 100mm, outer diameter 120mm, depth 13mm and an angle 120° is created on the sheet. The specimens are prepared using hand layup technique. Polymer coating was applied on the sheets. Measured amount of chopped fibers, resin and hardeners were used for the production of various types of composites. Then resin was again applied, next to it fiber of another kind. Care has been taken to avoid bubble formation by applying proper rolling force at the top. This procedure was repeated until four alternating fibers have been laid. On the top a polymer coating is applied to ensure a good surface finish. Finally a releasing sheet was kept on the top. The specimens were collected after sufficientamount of curingperiod.Fig. 1 shows the obtained specimens after fabrication.

Fig1:Obtained specimens after fabrication

III. TESTING

A. Moisture concentration estimation

Specimens are exposed to the moisture environment as shown in Fig. 2 The specimens are then removed periodically from the water bath and weighed on an analytical balance to determine the weight gain.

Fig2: Specimens immersed in water

B. Radius measurement

A separate test set up was designed with 1 meter scale fixed at a measured distance from the center point of the clamp to measure linear deformation of the specimen. A protractor is attached to the vertical plate in order to measure angular deformation. The protractor of range (1^0-180^0) is prepared. For the convenience of measurement both the scale and protractor measuring faces are in the same direction. The specimens were then accommodated into the set-up, Fig. 3 [21]. The test was conducted for four months duration and readings are noted at an interval of one month. The deflection changes i.e change in specimen radius of curvature is measured to estimate hygric strain behavior.

Fig 3:Set up for hygirc strain measurement

IV.RESULTS AND DISCUSSIONS

TABLE I. SUMMARY GAIN RESULTS OF WEIGHT FOR DIFFERENT COMPOSITES.

Composite type	Weight gain (gms)			
	Month 1	*Month 2*	*Month 3*	*Month 4*
40 (P)/0 (J)	0	2.475	5.475	6.75
30(P)/10(J)	0	2.1125	5.825	8.875
20(P)/20(J)	0	1.775	3.125	4.625
10(P)/30(J)	0	1.1	4.825	6.875
0(P)/40(J)	0	2.075	4.25	7.375

Table 1 shows summary of weight gains for all the fractions of composites. Fig. 4 shows the weight gain trends of all five composite specimens after four months. In the first month there is no change in the weights of specimen for all the composites. It can be seen that with increasing time the weight gain also increases for all the composites. This is true because more is the immersion time and higher is the weight gain. From pure case of pineapple to 30(P)/10(J) composite the gain is noticeable. But for 20(P)/20(J) case the weight gain is less. For other two cases the increase in weight gain has been observed. The weight gain is highest for 30(P)/10(J) and lowest for 20(P)/20(J).

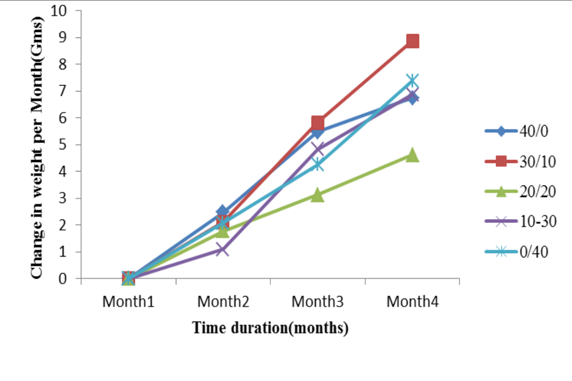

Fig 4: Weight gain Vs Time duration for all composites

Table 2 shows summary of change in radius of curvature for all the fractions of composites. Fig. 5 shows the change in the radius of curvature of the all the composite specimens for four months. In the first month there is no change in the radius of curvature. In the second month there is a change in the radius of curvature. As explained earlier, the more is the time spent more is chance of absorbing water which results in bulging, hence increase in radius. In the third month there is a reasonable incremental change. In the fourth month the change of radius of curvature is maximum. Higher moisture absorbing capability of the fiber and higher time of immersion are the two reasons which results change of radius of curvature. However, the change in radius of curvature is high for the pure pineapple case and low for pure jute case.

TABLE II.SUMMARY RESULTS OF CHANGE IN RADIUS OF CURVATURE FOR DIFFERENT COMPOSITES.

Composite type	Change in radius of curvature(cms)			
	Month 1	*Month 2*	*Month 3*	*Month 4*
40(P)/0(J)	0	0.3625	0.7375	1.35
30(P)/10(J)	0	0.25	0.5	0.8625
20(P)/20(J)	0	0.3	0.6125	0.985
10(P)/30(J)	0	0.25	0.5375	1.075
0(P)/40(J)	0	0.2125	0.6	0.95

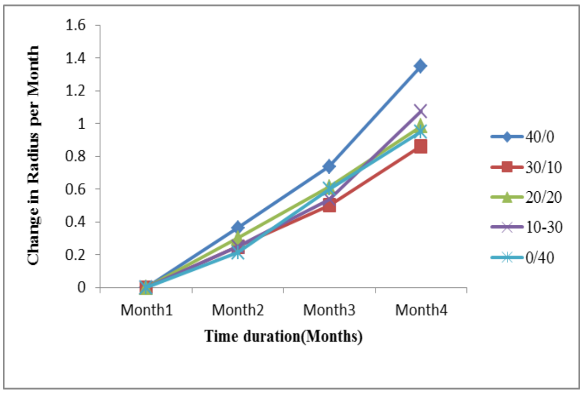

Fig 5:Change in radiusVs Time duration for all composites

Fig. 6 shows plot between measured average weight gain versus average change in radius of curvature for pure pineapple case (40/0) fiber composite. The slopes of these curves yield the coefficient of moisture expansion (β = 0.999). The changes in radius of curvature and weight gain are the two parameters which influences the coefficient of higric expansion. The reason for the result can be speculated in two ways. The absorbing capability of moisture in to the specimen through weight gain is high. Secondly the obtained change in radius of curvature is also reasonably high for pineapple fiber composite. It can be understood that what ever the moisture that has gone in to the specimen caused the weight gain might have not reflected in change in radius proportinately. It can be concluded that radius of curvature has dominent role for the result as compared to weight gain. However, the obtained coefficient of higric expansion is a maximum value.

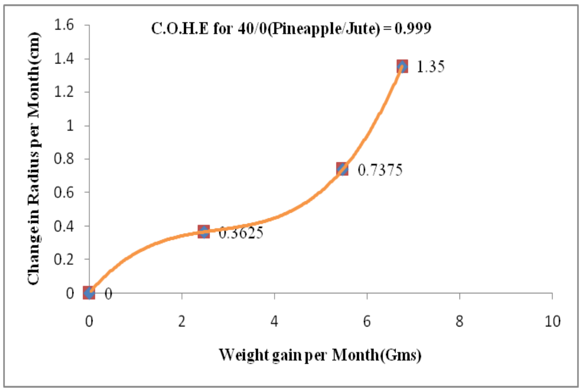

Fig 6:Change in radius Vs Weight gain for pure pineapple composite

Fig. 7 shows plot between measured average weight gain versus average change in radius of curvature for pineapple/jute case(30/10)fiber composite. The slopes of these curves yield the coefficient of moisture expansion (β = 0.994). The hygric expansion coefficient value of 30/10 pineapple/jute is low when compared to pure pineapple. As some portion of pineapple fiber has been replaced with jute fibers, which might have resulted in lower coefficient of hygric expansion.

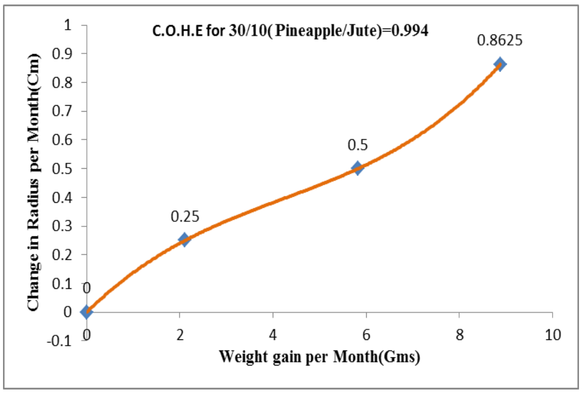

Fig7:Change in radius VsWeight gain for 30P-10J composite

As discussed earlier, both radius of curvature and weight gain factor play a vital role for obtaining coefficient of hygric expansion. Whatever the weight gain that has resulted might not have contributed to enlarge or increase in radius of curvature and hence the coefficient of hygric expansion is less as compared to previous. As compared to pure pineapple composite case, the present hybrid composite has lower change in radius of curvature but higher weight gain. Hence, it can be concluded that weight gain factor has a negligeble effect on coefficient of hygric expansion.

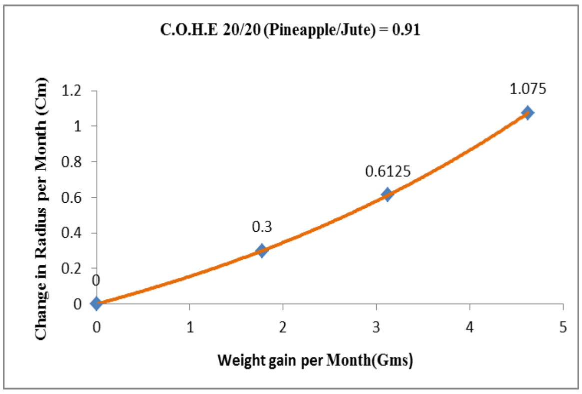

Fig 8: Change in radius Vs Weight gain for 20P-20J composite

Fig. 8 shows plot between measured average weight gain versus average change in radius of curvature for (20/20) pineapple/jute case fiber composite. The slopes of these curves yield the coefficient of moisture expansion (β = 0.910). The hygric expansion coefficient value of 20/20 jute/pineapple is low when compared to pure pineapple and also 30/10 hybrid composite. It can be observed that the resulted weight gain is much lower as compared to earlier cases. But the obtained radius of curvature is little bit higher as compared to previous cases. Hence, the obtained result. Low coefficient hygric expansion is an encouraging sign for all practical purposes. It is interesting to see this sign for hybrid composite with equal proportions. This can also be attributed to correct hybridization effect.

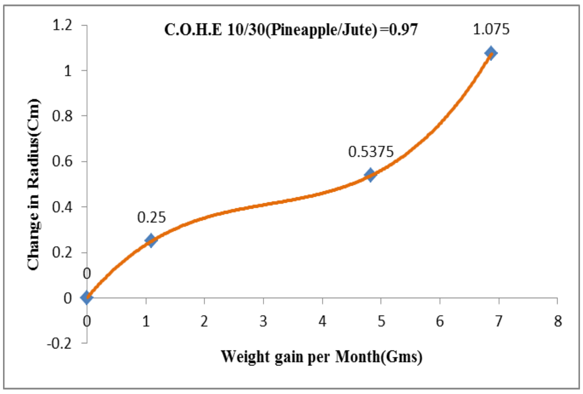

Fig 9:Change in radiusVsWeight gain for 10P-30J composite

Fig. 9 shows plot between measured average weight gain versus average change in radius of curvature for pineapple/jute case(10/30)fiber composite. The slopes of these curves yield the coefficient of moisture expansion (β = 0.97). The hygric expansion coefficient value of 10/30 jute/pineapple is high compared to 20/20 hybrid case. As the jute fiber content is more as compared to pineapple this composite should result in lower coefficient of hygric expansion. The result is not in tune with the earlier trend. It is interesting to observe that both weight gains as well as change in radius of curvature are higher than earlier composite. Apart from the two factors (weight gain and radius of curvature) manufacturing factors also affect the hygric behavior of the composite. It can be speculated that formation of manufacturing defects like voids, cracks which will make the composite to absorb more water resulting in high weight gain as well as increased radius of curvature. The deviation of the trend may be because of the above reason.

Fig. 10 shows plot between measured average weight gain versus average change in radius of curvature for pure jute case (0/40) fiber composite. The slopes of these curves yield the coefficient of moisture expansion (β = 0.9775). As discussed earlier, due to the less moisture absorbing capability this composite should have been resulted in lower hygric expansion. But the result is not in tune with the trend. This may be due to the reasons explained in the above para.

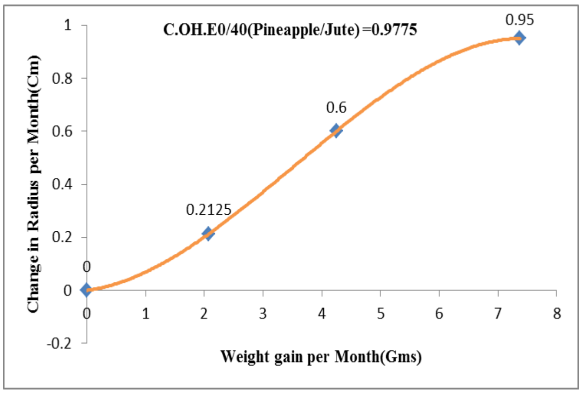

Fig 10:Change in radiusVsWeight gain for pure jute composite

V.CONCLUSIONS

1. The natural fiber reinforced epoxy hybrid composites are successfully fabricated using hand lay-up technique.

2. Due to high moisture absorbing capability of the pineapple fiber, Pure pineapple showed high hygric strain behavior compared to all the composites.

3. As jute fiber has lowest moisture absorbing capacity, it resulted in lower weight gain as well as minimum change in radius of curvature. Hence, 0P/40J resulted with lower hygric strain coefficient.

4. Manufacturing defects like voids, cracks which will accentuate the process of absorbing the moisture and results in higher hygric behavior.

5. Due to the low density of proposed natural fibers compared to the synthetic fibers, the composites can be regarded as a useful material in light weight applications.

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