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Characterization of Jute and carbon fiber Hybrid FRP composite

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Abstract

In the present work pultrusion process was used to develop hybrid composite of jute and carbon fiber. Carbon fiber (CF) was chosen for hybridization so as to increase the bending & impact strength of pultruded Jute fiber reinforced composite(FRP) and yet to obtain optimal composition to achieve maximum strength with the above said reinforcements. Epoxy resin was used as the matrix in this study and the fiber to resin ratio was kept constant while the fraction of carbon fiber was varied to analyze the effect of the carbon fiber on impact & bending strength of the Jute-Carbon fiber hybrid composite. Pultrusion process parameters were kept constant, the pultrusion speed was kept at 100mm/min and temperature of die was 250˚C. The fraction of Carbon fiber was varied from 0% to 70% in this hybrid FRP composite. The bending and Impact strength of pultruded hybrid FRP composite was tested and found increment in 40 to 45% and 200 to 250% in bending and impact strength respectively, when Carbon Fiber weight percentage increases from 0 to 70% with respect to Jute Fiber.

Key word: Pultrusion, Hybrid Composite, Carbon fiber, Jute Fiber

Introduction:

Gupta and Srivastava (2016) discussed in his review paper that hybridization can improve the mechanical properties of single fiber-reinforced polymer composite. Carbon fiber reinforced polymer composite (CFRP) products are the most commonly used FRP composite where strength is the prime requirement. But Carbon fiber is very costly as compared to naturally available fiber such as jute, coir, cotton etc. Moreover, Carbon fiber possesses highest strength among all available Fibers. On the other hand the jute fiber composites are having very low strength fiber material but on the same time they are very economical. So an attempt is made to enhance the strength of Pultruded jute fiber composite. Ramesh et al. (2013) found hybridization of sisal, jute and glass fiber exhibited better tensile strength and modulus when compared with jute and glass hybrid FRP or sisal and glass hybrid FRP. Boopalan et al. (2013) developed and tested 50/50 jute and banana hybrid FRP and found that higher tensile strength, flexural strength and impact strength over the single natural fiber composites. Ahmed et al. [8] investigated various combinations of jute-glass laminates evaluating tensile, flexural, and interlaminar shear properties as measures of performance. Gupta et al.(2014) investigated the effect of CaCO3 on hand layup GFRP composite tensile strength. Gupta et al.(2015) used bagasse fiber, carbon black and CaCO3as filler in pultruded glass reinforced polymer composite and optimize the tensile strength. Gupta et.al. (2016) develop hybrid filler for optimizing the flexural strength of pultruded jute fiber reinforced composite. Glass fiber reinforced plastics(GFRP) are most commonly used type of FRP composite . Alam et al.(2015) shows in their study that jute and carbon fiber hybrid composite plate with 10% carbon content had shown 170% higher tensile strength as compared to that of plate without carbon fibre. The carbon content also had enhanced the modulus of elasticity of plates. Higher percentage of carbon had shown higher tensile strength and modulus of elasticity of hybrid composite plates.

Material and Methods of Manufacturing:

Material used for manufacturing of GFRP by hand layup process is as follows:

Fiber Used For Reinforcement:	Jute Fiber roving 2200 mesh and Carbon Fiber roving of 2200 mesh
RESIN USED:	Epoxy resin
HARDENER USED:	Phenalkamine Epoxy hardener 10% of resin
Fiber to resin ratio:	70:30

Method of manufacturing hybrid FRP composite:

An indigenously developed lab scale pultrusion set up was used for manufacturing the Pultruded hybrid FRP composite, the setup is shown in figure 1. To manufacture the hybrid composite in the lab fiber bundles were prepared as shown in figure 2; the carbon fiber roving was mixed with jute roving as per the carbon fiber % required in the hybrids composite. The composition of hybridization scheme is given in table 1. The pultrusion setup was adjusted for Die heater temperature and the pulling speed to 250^{o}C and 100mm/min respectively.

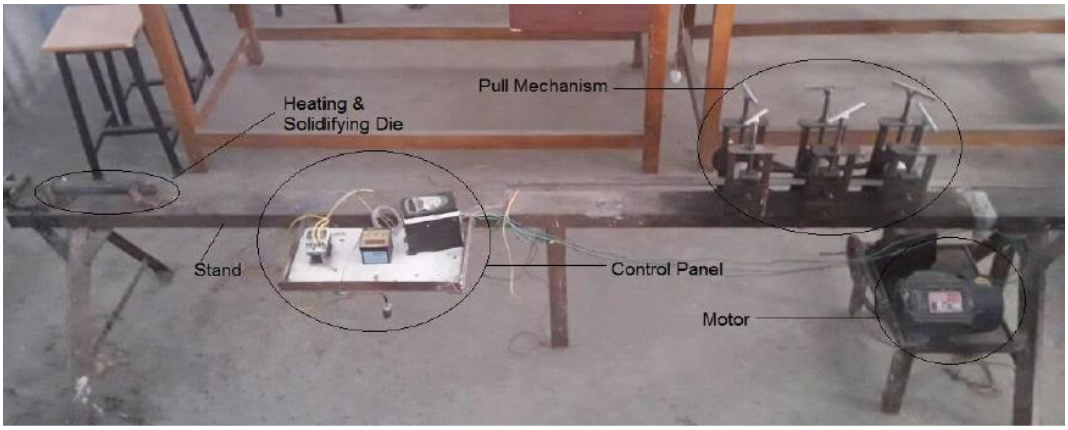


Figure1: Lab Scale Pultrusion setup

Figure 2: Preformed jute and carbon fiber bundle for pultrusion of hybrid FRP composite

Table1: % of jute and carbon fiber in total fiber contain of hybrid FRP composite

Specimen No.	Jute Fiber %	Carbon fiber %	Total fiber to resin ratio
1	100%	0	70:30
2	70%	30%	
3	60%	40%	
4	50%	50%	
5	40%	60%	
6	30%	70%	

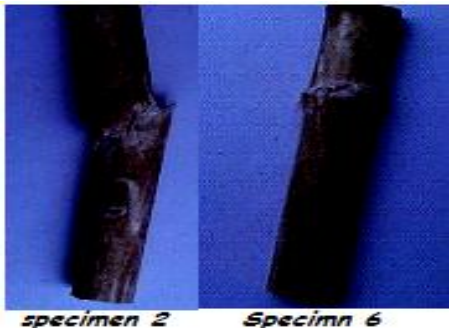
After prepare fiber bundles and adjusting the pultrusion setup, the epoxy resin was poured in the bath tub and hardener was mixed in the resin. The fiber bundles were impregnated in resin bath and pulled against the hot die. As the impregnated jute and carbon fiber passes through hot die cured hybrid composite comes out at the die exit. The hybrid FRP composite rod are shown in figure 3.

Figure3 : Pultruded jute Carbon fiber hybrid FRP composite rod

After pultrusion of all six pultruded rod the specimen for bending and impact testing were cut according to ASTM D 790 and ASTM D296 respectively.

Result and Analysis:

The bending and impact testing of hybrid FRP composite specimen were conducted as per ASTM D 790 and ASTM D296 respectively. The test result of bending and impact testing are given in table 2. The figure 4 (a) shows the bending fracture of specimen 2 and specimen 6 and figure 4(b) shows impact failure of specimen 2 and specimen 6.



(a) bending Fracture of Hybrid FRP composite **(b) Impact fracture of Hybrid FRP composite**

Figure 4: Fracture of Hybrid FRP composite

Table2: Bending and impact testing result of Hybrid FRP composite

Specimen no	Composition		Bending Test		Impact Test		Average bending strength (MPa)	Average Impact strength (Joule)
	Jute fiber %	Carbon fiber %	Sample 1	Sample 2	Sample 1	Sample 2		
1	100	0	366.26	385.89	10	12	376.08	11
2	70	30	457.83	412.05	18	16	434.94	17
3	60	40	483.99	464.37	20	19	474.18	19.5
4	50	50	503.61	470.91	20	23	487.26	21.5
5	40	60	519.96	497.07	30	30	487.26	30
6	30	70	549.40	525.23	36	32	508.52	34

The bending strength and impact strength variation can be seen in the figure 5 and figure 6 respectively

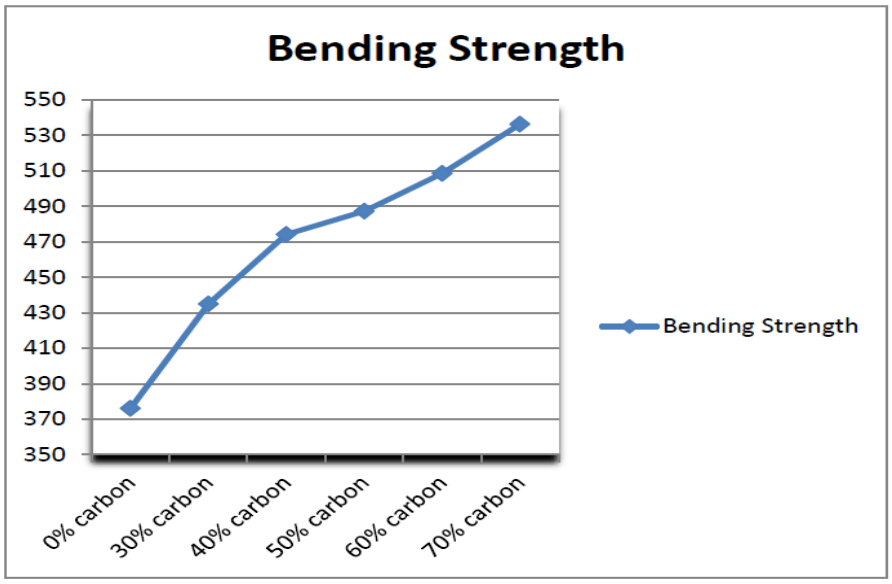


Figure 5- Plot of Bending Strength (MPa) v/s the variation in weight percentage of carbon fiber

In bend testing we see that when we increase the percentage of carbon fiber in jute fiber then the bending strength of jute fiber at 70% CF and 30% JF increases to almost 1.5 times of strength of pure jute fiber. Pure jute fiber has lowest bending strength as compared to when CF is added to it. The Pultruded jute fiber composite bending strength increases in between 40 to 45% when CF weight percentage increases from 0 to 70% with respect to JF.

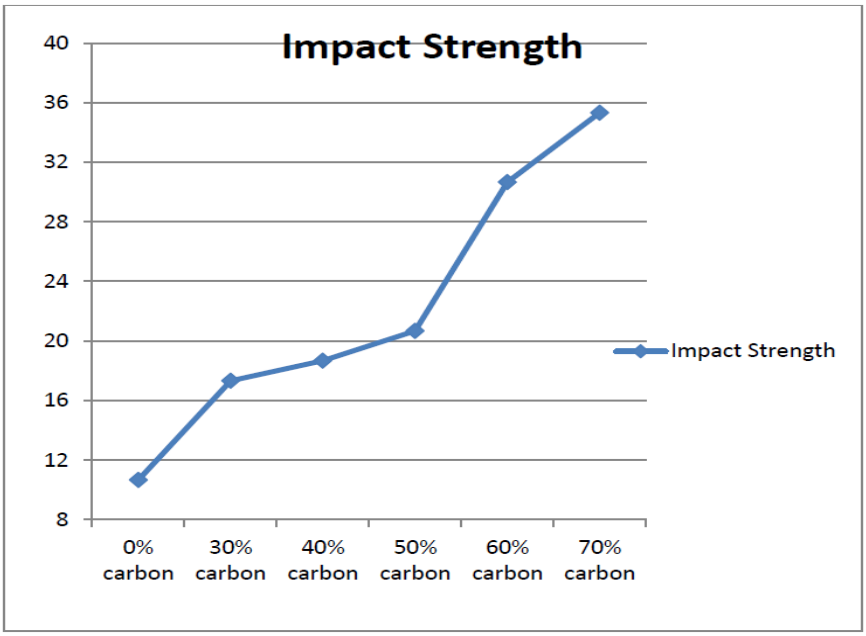


Figure 6- Plot of Impact Strength (joule) v/s the variation in weight percentage of Carbon fiber

In impact testing we see that when carbon fiber is mixed in jute fiber then impact strength of fiber increases. Pure jute fiber has least strength as it has absorbed the least energy i.e. 10 J. The best proportion by our analysis is 70:30 (C:J) i.e as carbon fiber % increases impact strength increases. We can use any proportion according to our requirement.When we require low amount of energy but higher than pure jute then we can use these compositions then it will also become economical.

CONCLUSION

It can conclude from present work that increasing the carbon fiber weight percentage in hybrid FRP composite, the characteristics of the pultruded jute fiber composite changes as follows-

• The Pultruded jute fiber composite bending strength increases in between 40 to 45% when CF weight percentage increases from 0 to 70% with respect to JF.

• The Pultruded jute fiber composite impact strength increases in between 200 to 250% when CF weight percentage increases from 0 to 70% with respect to JF.

• From the present study it can also concluded that the addition of CF in Pultruded jute fiber composite improve impact strength more than the bending strength.

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