Development and Performance analysis of Hybrid Based Polymer Composite

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Abstract: Fiber Supported Polymer Network composites are generally utilized as primary materials. These materials trade ordinary materials for severe reasons. What's more, these materials are liked for their lightweight and strength. They additionally find widespread application in fuel pipelines and slurry conveying medium in the mechanical application. This exploration tends to the assembling of glass fiber and standard fiber mix composites. Impact of stacking arrangement on malleable, flexural, and sway estimations of untreated woven jute and Glass texture supported polyester half breed composites have been examined tentatively. Overlays were created by hand lay-up method and followed by restoring at room temperature for 48 h. Separate Jute and Glass fiber overlays were manufactured for correlation reasons. Likewise, these materials are tried for tribological properties like disintegration. Shifting the surface speed, a grouping of slurry and openness time disintegration done. Corrosion-tested examples were oppressed for SEM assessment. SEM micrographs on the FRP showed the misshapen that happened was fundamental because of cutting wear, and the method of disappointment was because of a fragile break. A general examination of the multitude of overlays' properties uncovered that the incorporation of glass in jute covers bring about an equilibrium in ecological effect and cost.

1. Introduction

1.1 General Background
It is an axiom that innovative improvement relies upon propels in the field of materials. Whatever the area might be, the last limit on headway depends upon materials. Composite materials address only a monster step in the always consistent undertaking of streamlining in materials. It is characterized as a multiphase framework that comprises at any rate two unique gatherings of materials that are artificially and particular and isolated by interfaces.

1.2 Fiber Reinforced polymeric (FRP) materials
FRPs comprise either thermosetting or thermoplastic polymers that structure the lattice stage in which filaments are inserted to shape composites. The part of the polymer framework is to move pressure to filaments adequately. It ties the filaments together and shields them from mechanical and substance harm by scraping the area of their surfaces or by the synthetic assault of some unessential ecological matter.

1.3 Classification of FRPs
FRPs are comprehensively named single layer or multi-facet composites. Single-layer composites comprise a few transparent layers, with each layer having a similar direction and properties. The whole cover hence shows up as a single composite. At the point when the constituent materials in each layer are identical, they are called covers. Diverse or mixture composites comprise layers of various constituent materials.

1.4 Hybrid Composite
Natural mindfulness everywhere in the world concentrated on utilizing cellulose fiber as support in the polymer network. The standard fiber-supported composites are sensibly solid, lightweight, and liberated from wellbeing dangers, biodegradable, and subsequently, they can be utilized as building.
materials and underground pipelines. Despite the benefits, they experience the ill effects of certain constraints, such as lower modulus, helpless dampness protection from assimilation, and quiet strength when contrasted and engineered filaments like glass and carbon.

1.5 Jute-Glass fiber-reinforced composites (Hybrid)

We have utilized jute fiber for such a long time in low-worth items, for example, gunny sacks, twine, and floor covering backing, that we will, in general, think about jute as a lousy quality asset. We have not acknowledged the immense potential for the utilization of jute in fiber-based composites.

2. Literature Review

K. Sabeel Ahmed, 2008 Crossovers have been found to have fantastic potential for more extensive applications. It is a subject of examination, and endeavors have been made to improve regular filaments’ properties and make them savvy and arduous. The impact of stacking grouping on tensile, flexural, and interlinear shear properties has yielded significant outcomes. The fuse of glass in jute improves the properties of the coming about the mixture [1]. N. Sgriccia, M. C. Hawley, and M. Mishra, 2008 Examinations were directed to portray the surfaces of treated and untreated strands and to research water assimilation in standard fiber composites. Common fiber composites ingest more water than glass fiber composites. The soluble base treatment eliminates lignin and hemicelluloses from the outside of traditional strands. ESEM showed that the saline treatment covered the strands [2]. K. Sabeel Ahmed and S. Vijayarangan, 2008 Impact of stacking grouping on tensile, flexural, and interlaminar shear properties of woven jute-glass texture built-up isophthalic polyester composites have been tentatively assessed. The joining of glass in jute fiber composites improves the properties of coming about half-breed composites [3]. Ha Na Yu, Seong Su Kim, In Uk Hwang and Dae Gil Le, 2008 Porousness and primary strength of composite fortifications made from internal jute tangle and external glass fiber was contrasted and glass texture support for re-home of underground lines [4]. J. Stabik, Mackeson, and H. Tomanek, 2007 Disintegration opposition testing of Plastic lines made of PVC and polypropylene loaded up with calcium carbonate were contrasted and consequences of standard scraped spot test and hardness test [5]. G. Srinivasa Rao, Syed Waheedullah Ghori, 2021 have studied the fiber tensile, impact and morphological properties of date palm and kenaf reinforced epoxy composite [13]. Z. Leman, E. S. Zainudin, 2021 has performed the experimental investigation and development and performance analysis of hybrid composite side door impact beam [14].

3. Experimental details

3.1 Description of panels fabricated.

The composites manufactured were as a rectangular board of uniform thickness. Cutting of examples for different tests is simple from this shape. Glass and jute utilized for various boards have the measurements demonstrated in Table 1. The thickness of the boards changed from each because of the thickness of the strands used in them. Notwithstanding, thickness above half inches was kept up, taking all things together commissions to investigate the disintegration wear rate adequately.

| Panels   | Length(inches) | Width(inches) | Thickness(mm) |
|----------|----------------|---------------|---------------|
|          | L              | W             | Jute          | Glass         |
| Jute     | 12             | 10            | ------        | 0.5           |
| Glass    | 12             | 10            | 1.6           | 0.5           |
| Hybrid 1 | 12             | 10            | 1.6           | 0.5           |
3.2 Material and sample preparation
From our overlays of 10" x 10" size, tests of different sizes were cut for various tests. Long pieces of 30" x 2.5" were cut as rectangular segments. For Flexural and Effect tests, the measures of the examples were 6.4" x 1.25". A hardness test was performed on the 10" x 10" overlay itself. The samples were cut utilizing hacksaw and were additionally machined to accomplish the ideal measurements as in fig 1. The examples for disintegration tests were machined to the element of 6.25" x 2.5". Thickness (x) being equivalent to that of instance yet not surpassing 17.5 mm. Openings were penetrated on it utilizing the boring machine.

| Hybrid 2 | 12 | 12 | 0.9 | 0.5 |
|----------|----|----|-----|-----|
| Hybrid 3 | 12 | 12 | 0.9 | 0.2 |

3.3 Test Exposer
The examination incorporates different sorts of tribological tests, mechanical tests, and portrayal. The other boundaries were thought of, which were fluctuated as needs be to have a comprehensive examination on GFRPs and Half and halves. The accompanying test openings were considered for execution examination. They are as per the following: Radiography Testing (NDT), Tensile Testing, Hardness Testing, Impact Testing, Flexural Testing and Erosion Wear Studies.

3.4 Tensile test and hardness test
A malleable test was done to notice the strength of the delivered material. The example of required measurement was disfigured with an expanding pliable burden applied along with the long hub of material at a consistent rate, as demonstrated in Fig 2. The Universal Testing Machine of KALPAK utilizing 40-ton load was used thinking about the appropriateness for different applications. The hardness test was performed utilizing Bar Coal Impressed. The gadget's indenter was squeezed against the cover surface, and the hardness esteems got from the dial present on the top in BAI units. Fig 3 shows the device with a testing strategy.

Figure 1. Samples for Mechanical & NDT Testing

3.5 Radiography Testing (NDT)
This procedure includes the utilization of infiltrating X-beam radiation (electromagnetic radiation of high recurrence and less frequency) to look at parts and items for defects. An X-beam machine appeared in fig 4 is utilized as a wellspring of radiation, and appropriate boundaries like Focus to Film Distance, X-beam tube Voltage, current, and openness time are to be set for the X-beam machine. At that point, X-beam
Radiation is coordinated along with the hand lay-up onto the X-beam film. After uncovering the film, it must be created and deciphered, as demonstrated in Fig 5.

![Fig 4. X-Ray Machine](image1)

![Fig 5. Sample over Photographic Film](image2)

### 3.6 Impact Test and Flexural test

Flexural or curve tests are not difficult to do and can be utilized to determine the composite's fiber/framework interfacial strength. It was performed to decide the energy consumed by the material during the crack. Effect strength (IZOD) was estimated in an effect analyzer (Zed wick, Germany), as demonstrated in Fig 6.

![Figure 6. Three-point bending set-up](image3)

![Figure 7. Specimen fitted in the apparatus.](image4)

### 4. Result and Discussion

#### 4.1 Fiber Volume Fraction and Tensile test

| Panel Type | Fiber vol. fraction (Vf in %) | Type of laminate | Panel Type | Max Force | Tensile Strength | Young’s modulus |
|------------|------------------------------|------------------|------------|------------|-----------------|-----------------|
| Glass      | 49.63                        | Thin             | Glass      | 80.4       | 228             | 18.312          |
| Jute       | 59.71                        | Thin             | Hybrid 1   | 20.14      | 47              | 6.47            |
| Hybrid 1   | 58.05                        | Thin             | Hybrid 2   | 20.04      | 89              | 5.67            |
| Hybrid 2   | 51.6                         | Thin             | Hybrid 3   | 9.72       | 78              | 7.377           |
| Hybrid 3   | 35.3                         | Thick            |            |            |                 |                 |
Tensile test on various examples is impacted by the strength and modulus of the filaments. The rigidity of jute composite shifts between 23.56 – 29.49 MPa and modulus between 1.5 – 6.4 GPa. Sharp expansion in the rigidity of jute fiber happens with the consolidation of glass. They ascribed to the explanation that glass filaments are more grounded than jute strands. Around 42% expansion in elasticity occurred by changing the stacking grouping in half breed 2 from crossover 1. However, in half and half, I 53.8% increment while in crossover II 76% expansion in elasticity is accomplished when contrasted with jute boards. Epoxy mixture showed transitional conduct; thus, the order of tensile strength is: Glass > hybrid-II > Hybrid- I > Hybrid- III > jute

4.2 Hardness Test

Table 4. Result of Hardness test

| Panels               | Hardness Value (BAIU) |
|----------------------|-----------------------|
|                      | Glass top | Jute top |
| Glass                | 37.625     | -------- |
| Jute                 | --------   | 9.25     |
| Hybrid 1             | 40.124     | 5.875    |
| Hybrid 2             | 35.8       | 9.25     |
| Hybrid 3             | 37.1       | 10.5     |

The results show that the hardness esteem relies on the interfacial holding between the limit filaments and the grid. However, with jute, an increment of 12% in hardness by utilizing epoxy rather than polyester. Stacking succession doesn't acquire a significant change hardness as the limit strands administer it.

4.3 Radiography Test (utilizing X-Beam)

Saw few spots on the uncovered photographic film on every one of the examples. They happened in patches locally and were not generally seen. These are known as Flaws which, for the most part, go with the hand lay-up fabricating measure. Delamination’s, assuming any, are viewed as faint lines contrasted with great locales in the film. The accompanying tests were done on acceptable examples to get precise outcomes.

4.4 Impact Test

Table 5. Impact test values

| Panel’s type | Energy | Impact strength |
|--------------|--------|-----------------|
| Glass        | 24     | 141.3           |
| Hybrid 1     | 10.6   | 47.3            |
| Hybrid 2     | 7.1    | 63.43           |
Figure 10. Impact strength of various panels

Impact test on various examples is reliant on the strength of the fiber. The glass fiber had the option to retain more energy than the half and halves. However, an expansion of the jute board sway test was seen by a fuse of glass filaments. An increment of 39% and 54% is seen in half and a half I and cross breed II individually compared to jute boards.

Table 6. Flexural values

| Panels Types   | Peak load(N) | σ_max (N/mm²) | E(N/mm²) |
|----------------|--------------|---------------|----------|
| Glass          | 4616.56      | 368.624       | 355.7    |
| Hybrid 1       | 855.5        | 42.008        | 225.8    |
| Hybrid 2       | 297.15       | 46.41         | 513.12   |
| Hybrid 3       | 446.15       | 267.695       | 8100     |

The fiber could retain more energy in light of solid interfacial holding between the glass fiber and the grid. Hybrid-II is 34% better than Mixture I in supporting effect, subsequently demonstrating that the stacking succession is one of the overseeing elements of effect disappointment. Stacking succession is one of the overseeing elements of effect disappointment.

Figure 11. Load vs. dis. of glass and hybrid 1 panels  Figure 12: Load vs. dis. of hybrid 2 & hybrid 3

The conversations on the flexural test perception are as per the following: Flexural strength and modulus are constrained by the power of the limit layers of support. The mark deviation from the linearity is the sign of disappointment because of the improvement break on the strain side. The heap uprooting chart is no direct under the flexural load. It is in this way hard to find the specific start of fiber disappointment. The breaking strands and fractional draw out of fiber and so forth are associated with disappointment due to flexural. Hybrid-III shows the greatest flexural strength among the distinctive half-breed boards. They show that the kind of pitch impacts flexural strength. It is more for epoxy than polyester.
Flexural isn't tremendously influenced by stacking arrangement. Thus, it exclusively relies on fiber and network strength and their interfacial holding.

5. Conclusion
Considering the different examinations on mechanical and tribological properties Sharp expansion in jute fiber's rigidity happens with glass consideration in the jute/glass fiber crossover composites. I 53.8% increment in half breed while in crossover II 76% increment in rigidity is accomplished contrasted with jute boards. Epoxy crossover showed a middle-of-the-road behavior. Around 42% expansion in rigidity occurred by changing the stacking succession in half and half 2 from mixture 1. The hardness esteem relies on the interfacial holding between the limit strands and the lattice. In the above study shows that the jute epoxy exhibited higher tensile and flexural properties. Impact test yields that an increment of 39% and 54% happens in half and a half I and crossover II individually when contrasted with jute boards. Half and half II is 34% better than crossover I in supporting effect in this manner, demonstrating that the stacking arrangement is one of the overseeing components of effect disappointment. Flexural strength and modulus are constrained by the strength of the limit layers of support and aren't tremendously influenced by stacking succession. They rely upon the interfacial holding between the fiber and network. Factors like time length, sway speed, speed, and slurry fixation are critical control factors influencing the mass misfortune and disintegration wear rate. The morphologies of dissolved surfaces saw by SEM recommend that general disintegration harm of composites comprises of framework evacuation and openness of fiber, fiber breaking, and expulsion of broken filaments. It is shown that hybridization with engineered fiber is a reasonable methodology for improving mechanical properties and characteristic strands' solidness. An outcome, equilibrium in climate effect, execution, and cost could be accomplished. The above results of this research indicate better mechanical properties for jute-epoxy, which makes it better suited for the automotive applications rather than jute-polyester composites. Though the composites have some merits and demerits, the combination of the useful properties of two different materials, quicker processing time, lower manufacturing cost, etc., make them as a versatile material in the field of engineering and technology. Hence with this conclusion, it is sure that the technology shows composite is the most wanted material in the recent trend.

5.1 Scope of future work
In future this study can be extended to new hybrid composites using filler fiber combinations like Al2O3 and Sic, etc. The fiber, matrix interface in natural fiber composites can be enhanced by using advanced treatment methods of natural fibers. New technologies for decreasing the absorption property of jute can greatly expand its possibilities in new exciting and creative designs possible never before. In order to expand the use of jute fiber-based composites in adverse environments, it is necessary to interfere with natures recycling chemistry. High performance adhesives along with fiber modification can be used to manufacture structural jute-fiber based composite materials with uniform densities, durable in adverse environments, and high strength.

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