



ICRAMC_2017

Fabrication of Glass/Jute/Epoxy Composite Based Industrial Safety Helmet

Pramendra Kumar Bajpai^a, Khushi Ram^{b*}, Lokesh Kumar Gahlot^c, Vivek Kumar Jha^d

^{a, b, c, d} *Netaji Subhas Institute of Technology, Dwarka, Delhi-110078*

**Contact: ramkhushi51@gmail.com, phone +91-9868351665*

Abstract

This work focused on the development and characterization of hybrid glass/jute reinforced epoxy composite for industrial safety helmet. The total numbers of fiber layers are fixed and by varying the weight percentage of matrix and different fiber layers. Five different composites were manufactured using hand lay-up technique. One layer of glass and three layers of jute reinforce epoxy hybrid composite achieved maximum flexural strength of 100.78 MPa. Three layer of glass and one layer of jute reinforce epoxy hybrid composite achieved maximum impact strength of 72.24 J/m. The study results shows that 3-Glass 1-Jute fiber reinforced epoxy composite which has maximum impact strength can be used to replace the existing industrial safety helmet material.

© 2017 Elsevier Ltd. All rights reserved.

Selection and/or Peer-review under responsibility of International Conference On Recent Advances In Material Chemistry.

Keywords: Glass fiber; jute fiber; hybrid composite; industrial safety helmet.

1. Introduction

Uses of natural fiber based polymer composite is expanding due to various environmental and health issues related to synthetic based plastics [1-2]. Hybrid polymer composites combines the properties of different constituents (different fibers) and result in a more versatile product. Sanjay and Yogesha [3] analyzed the mechanical properties of jute/E-glass fiber reinforced epoxy hybrid composite fabricated by using hand layup technique. The authors concluded that jute/E-glass fiber reinforced epoxy hybrid composite has achieved better properties than the jute fiber reinforced epoxy composite. Sanjay et al. [4] fabricated the jute/glass fibers reinforced polyester composite by varying the weight fraction of jute/glass. The tensile and flexural properties of the developed composite were

2214-7853© 2017 Elsevier Ltd. All rights reserved.

Selection and/or Peer-review under responsibility of International Conference On Recent Advances In Material Chemistry.

examined and the authors concluded that tensile strength was maximum when weight percentage of jute and glass fiber in equal percentage then the other developed composites. Ram et al. [5] reviewed the properties of natural fiber composites to replace the existing safety helmet material. The authors showed that natural fiber hybrid composites can replace the existing industrial safety helmet materials which are eco-friendly and light in weight. Kumar et al. [6] fabricated the carbon/PCB powder (E-WASTE) epoxy composite for industrial safety helmet using compression moulding method. The authors concluded that 52/48 weight percentage of carbon/PCB (E-WASTE) powder has maximum tensile strength, flexural strength and impact strength which can replace the existing industrial safety helmet. sanjay et al.[7] studied the natural fiber composites application for engineering and commercial purpose. The authors compared the mechanical properties of natural fibers with synthetic fibers and showed the various applications of natural fiber based composites and their hybrid composites. Arthanarieswaram et al. [8] analyzed the effect of glass fiber hybridization with randomly oriented natural fibers. The authors concluded that glass fiber improved the tensile strength and impact strength of natural fiber composite. Gopinath et al. [9] analyzed the mechanical properties of jute/epoxy reinforced epoxy composites and jute/polyester reinforced epoxy composites. The composite were synthesized at 18:82 fibers resin weight percentages. The authors concluded that jute reinforced epoxy composites shown superior mechanical properties than jute-polyester reinforced epoxy composites. Khan et al. [10] analyzed the mechanical properties of woven jute fabric reinforced polylactic acid composites. The authors concluded that woven structure exhibited better properties under tensile, flexural and impact loading as compared to non-woven reinforced polylactic acid composites. Surendra et al. [11] fabricated the sisal fiber reinforced polymer composite and sisal/jute/okra fiber reinforced polymer hybrid composite. The authors concluded that the mechanical properties of sisal/jute/okra fiber reinforced polymer hybrid composites were better than the sisal fiber reinforced polymer composite. Ramesh et al. [12] fabricated the banana fiber reinforced polymer composite using hand layup technique by varying the weight percentage of fiber as 40, 50 and 60. The authors concluded that the composite having 50 weight percentage of fiber content can be used as an alternative material for synthetic fiber reinforced polymer composites. Murali et al. [13] fabricated the sisal/banana/jute particle reinforced epoxy composite for industrial safety helmet using hand lay-up technique. The authors concluded that sisal/banana/jute particle fiber reinforced epoxy composite can be used as an alternate material of ABS plastics for industrial helmet.

The purpose of the present investigation is development and mechanical characterization of hybrid glass/jute fiber reinforced epoxy composites for industrial safety helmet. In this study, the consequences of hybridization of jute fiber with glass fiber reinforced epoxy composite are examined.

2. Methods and materials

Two types of fibers, Jute and glass are used in this study for the fabrication of fiber reinforced polymer composite. Jute fibers are supplied by Jute N fabrics, New Delhi (India) in woven mat form and S-glass are supplied by Hindustan Tech fibers pvt. Ltd., New Delhi (India) in woven mat form. Epoxy polymer used as the matrix material, is supplied by Shankar Dyes and Chemicals, New Delhi-06 (India).

3. Processing

Hand lay-up technique has been used for the fabrication of composites specimen and industrial safety helmet. Open mould plastic board was used for the fabrication of composite. The epoxy was thoroughly mixed with hardener (curing agent) in a suitable proportion. First plastic board was covered by non-reactive thin plastic sheet to give fine surface finish. After that, silica gel was applied on the plastic sheet to avoid sticking of polymer to surface. A layer of polymer was applied by using brush and then woven fiber mat was placed over it and then a roller was used to remove the air bubbles trapped in it. The same process was repeated for the four layers of fiber and covered by applying silica gel on thin plastic sheet and placed on last layer of polymer. On the plastic sheet plastic board was placed and the dead load of 15-20 kg was applied. After curing at room temperature for 40-48 hours, developed composite were taken out. The helmet mould has been prepared by plaster of Paris (POP) as shown in figure 1. Table 1 shows the detailed composition of fibers used for the manufacturing of the composites.



Fig. 1 Industrial Helmet Mould

Table 1. Designation and details of compositions

Designation	Composition
4-Glass	Epoxy (55%) + Glass (45%)
3-Glass 1-Jute	Epoxy (62%) + Glass (32 %) + Jute (6 %)
2-Glass 2-Jute	Epoxy (70 %) + Glass (20 %) + Jute (10 %)
1-Glass 3-Jute	Epoxy (68 %) + Glass (12 %) + Jute (20 %)
4-Jute	Epoxy (77 %) + Jute (23 %)

4. Mechanical Characterization

4.1 Flexural Test

Flexural testing of the composites was carried out as per ASTM D790 [14] standard. The three bend point test was performed on universal testing machine (Instron 1195) and load was applied at the rate of 5 mm per minute. In three points bend test, two points supported the specimen sample and at third point gradual load is applied up to the fracture of the sample. The test is repeated for each composition for three times and their average value is taken.

4.2 Impact test

Notched Izod testing of composites was carried out as per ASTM D256 [14] standard. The pendulum impact testing machine ascertains the notch impact strength of the material by shattering the notched specimen with a pendulum hammer. The energy consumed is measured on dial-indicator which is used to calculate impact strength of

specimen. The impact testing machine has maximum impact energy 50J with weight of pendulum 5 Kg and striking velocity 5.35m/s. The test is repeated for each composition for three times and their value is taken.

4.3 Morphology test

Scanning electron microscope (SEM) was used to study the surface details of composites. SEM images are used to study the fiber-matrix interaction and how breaking and de-bonding of fibers take place. Scanning electron microscope (SEM) was done using S-3700N HITACHI model.

5. Result and Discussion

5.1 Flexural strength and modulus

The values of flexural strength and the flexural modulus of the developed composites are shown in figure 2 and figure 3. The maximum value of flexural strength is 100.78 MPa for the 1-glass3-jute composite and the minimum value of the flexural strength is 55.56 MPa for the 4-glass composite. It is observed that the value of flexural strength increase with decrease in weight percentage of glass fiber and increases with increase in weight percentage of jute fiber. The maximum flexural strength when the weight fraction of glass/jute is 12/20. After that increase in weight percentage of jute fiber decreases the strength. This may happen because of the improper impregnation of jute fiber into the matrix which leads the debonding of fibers.

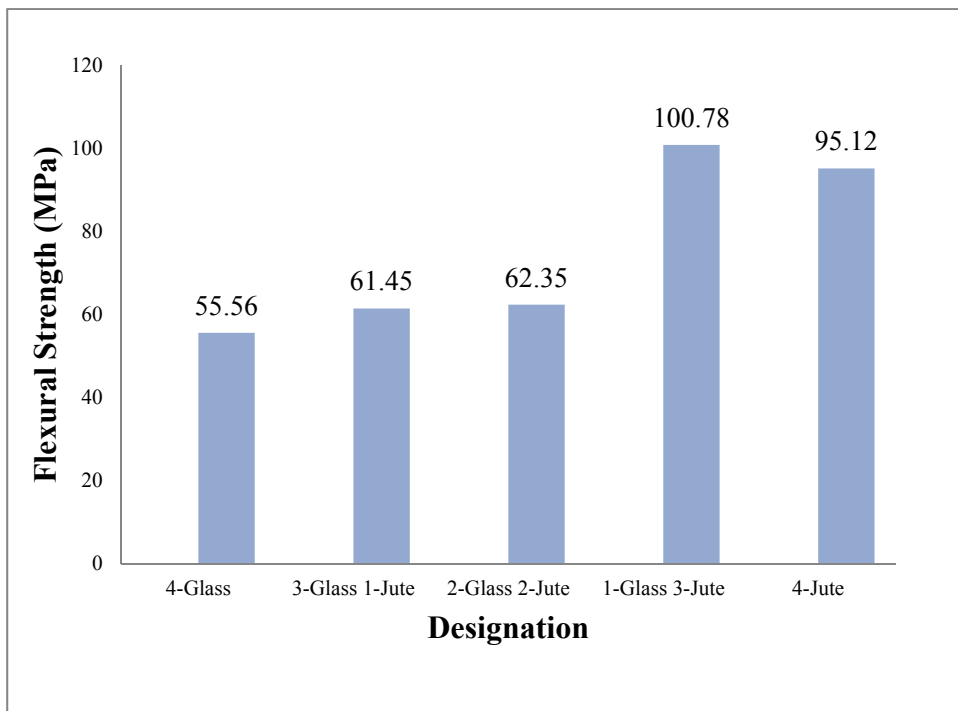


Fig. 2 Flexural Strength of Developed Composite Samples

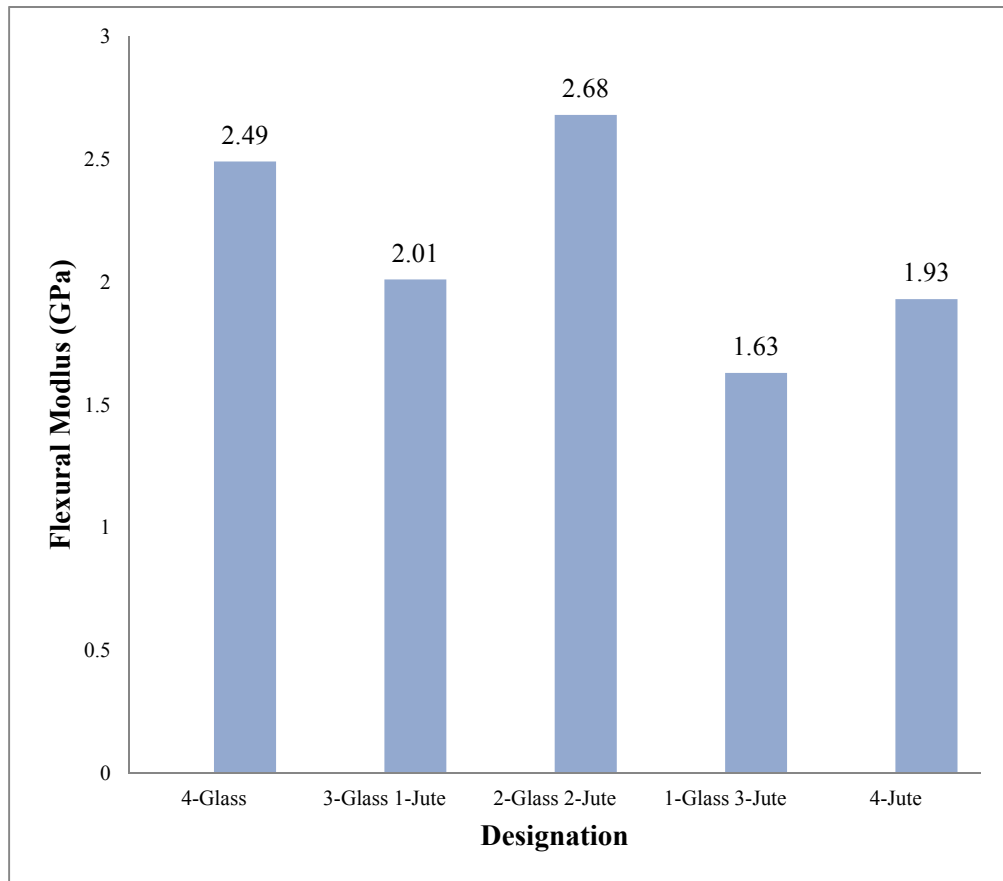


Fig. 3 Flexural Modulus of Developed Composite Samples

5.2 Impact strength

The impact strength of the developed composites is shown in the figure 4. The maximum value of impact strength is 72.24 J/m for the 3-glass1-jute epoxy composite sample and the minimum value is 27.46 J/m for the 4-jute epoxy composite. The result shows that the impact strength of glass/epoxy composite (62.43 J/m) is better than the jute/epoxy composite (27.46 J/m). By the incorporation of jute fibers with glass fibers first increases the impact strength of glass/epoxy composite by 16.32%. Further increase in weight percentage of jute fibers results in decrease of impact strength of glass/jute/epoxy hybrid composite as shown in figure 4. Initial, increase in impact strength of glass/epoxy composite may be because of the ductile nature of jute fibers than the glass fibers. Increasing weight percentage of jute fibers in glass/epoxy composite may involve improper wetting of jute fibers with epoxy matrix which weakens the interface and hence reduction in impact strength of hybrid composite.

The final helmet was fabricated by 3-Glass 1-Jute sample because it has shown maximum impact strength of 72.24 J/m. The flexural strength for the same sample was 61.45 MPa. The final fabricated industrial safety helmet was shown in figure 5.

SEM studies have been performed to study the failure analysis of the tested specimen. The SEM images are shown in figure 6 and 7. Figures show different constituents (different fibers, matrix), their breaking pattern and fracture region.

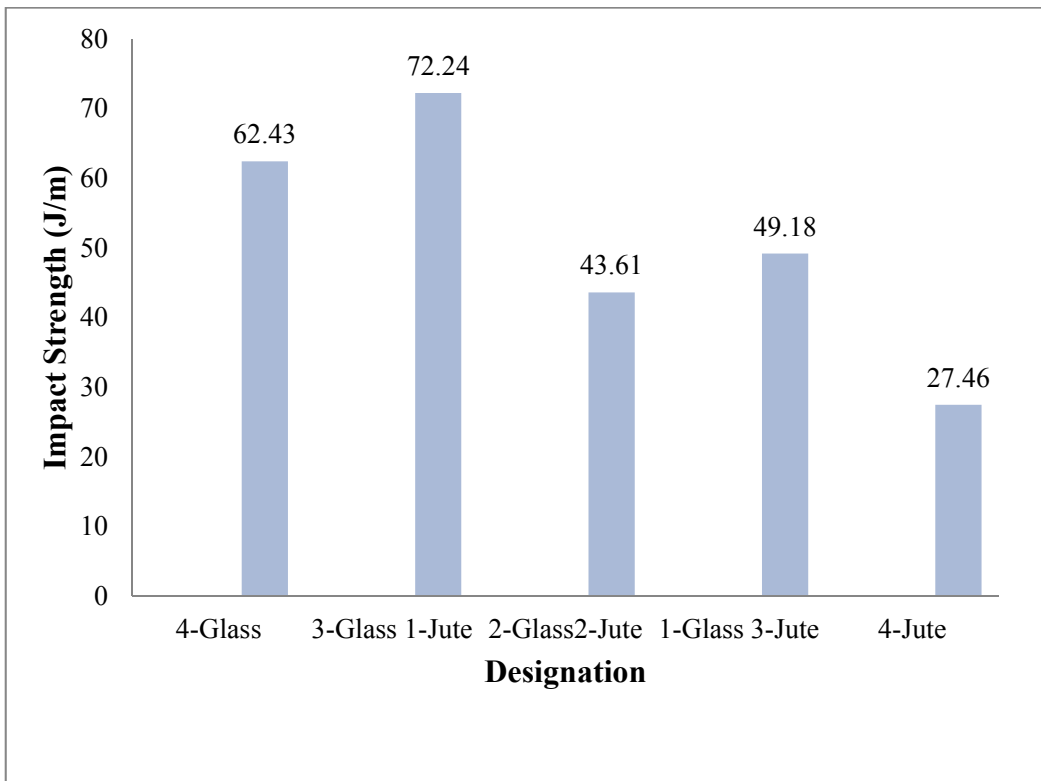


Fig. 4 Impact Strength of Developed Composite Sample



Fig. 5 The final Industrial Safety Helmet

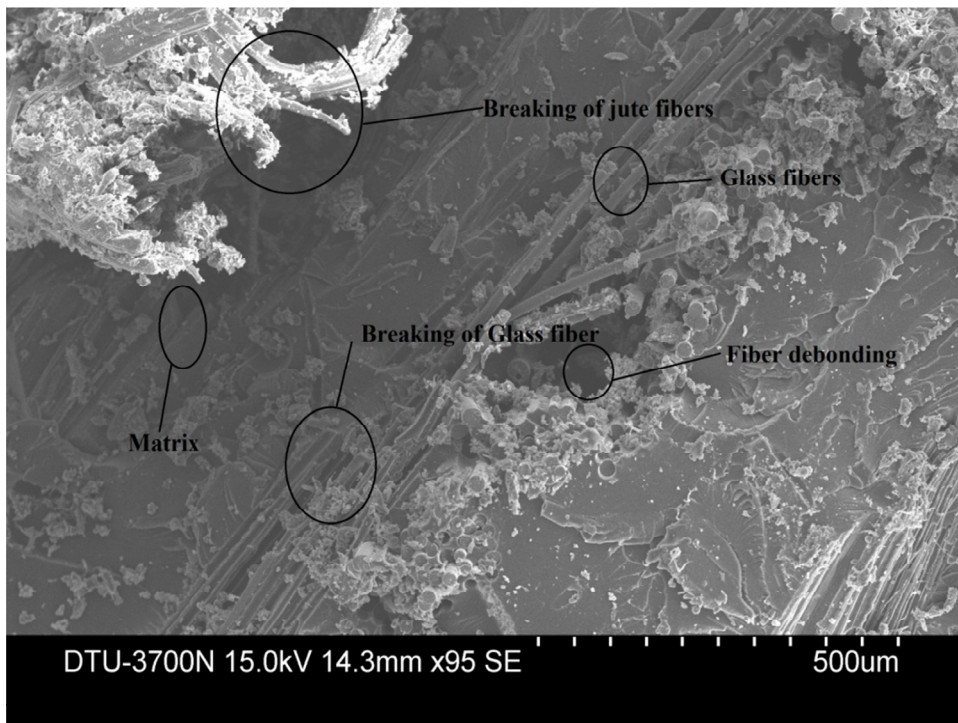
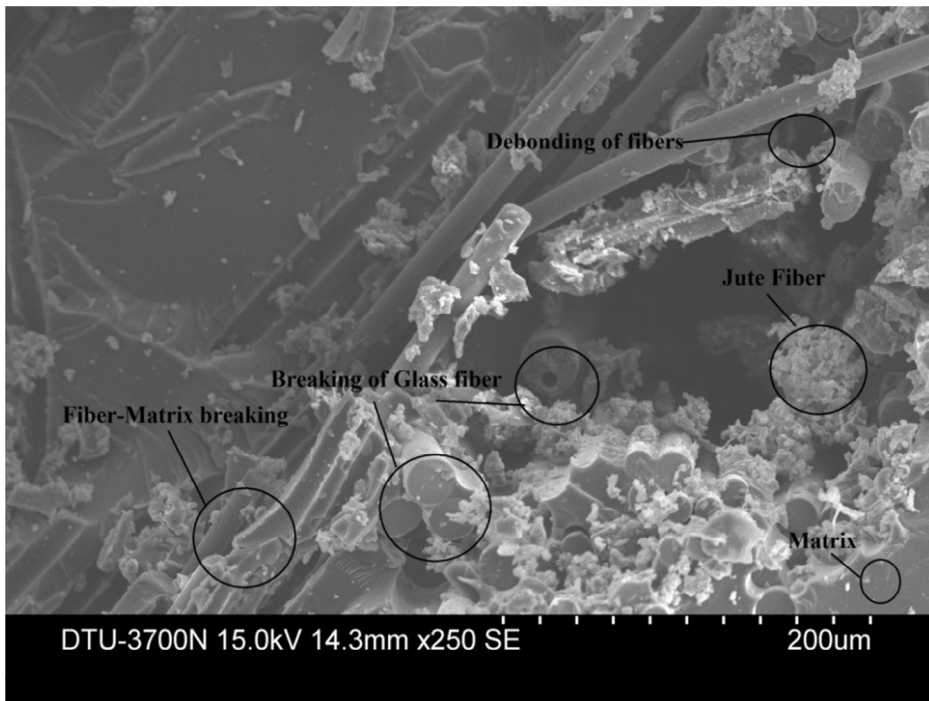


Fig. 6 and 7 SEM image of Glass/Jute/Epoxy Hybrid Composite

Table 2 Comparison of Glass/Jute/Epoxy Hybrid composite with Existed Helmet

Material of helmet	Impact Strength (J/m)	Flexural Strength	References
Glass/Jute/Epoxy Hybrid Composite	72.24	61.45 (MPa)	Present work
Acrylonitrile butadiene styrene	50	0.1 (KN)	[13]

6. Conclusion

In the present study, the fabrication and mechanical characterization of glass and jute reinforced epoxy composites for industrial safety helmet has been carried out with varying weight percentage of glass and jute fibers. The following observations can be drawn:

1. The glass/jute hybrid epoxy composite has more impact strength than the acrylonitrile butadiene styrene (ABS).
2. The result shows that glass/jute epoxy composite can be replace the existing industrial safety helmet because of its better mechanical properties and light in weight.
3. The incorporation of jute fiber makes it eco-friendly.

References

- [1] P.K. Bajpai, I. Singh, J. Madaan, J. Thermoplast. Compos. Mater. (2012) 1-30.
- [2] E. Elbadry, H. Hamada1, J. Mech. Eng. Autom. 2 (2012), 381-388.
- [3] M.R. Sanjay, B. Yogesha, J. Miner. Mater. Charact. Eng.4(2015) 15-25.
- [4] M.R. Sanjay, G.R. Arpitha, B. Yogesha, J. Mech. Civ. Eng. 11 (2014) 50-57.
- [5] K. Ram, V. Chaudhary, F. Ahmad, P. K. Bajpai, Int. J. Adv. Prod. Ind. Eng. (2017) 34-38.
- [6] G.G. Kumar, G. Ranganath, M. Sakthivel, Asian J. Res. Social Sci. Humanities 6 (2016) 1964-1973.
- [7] M.R. Sanjay, G.R. Arpitha, L. LaxmanaNaik, K. Gopalakrishna, B. Yogesha, Nat. res. 7 (2016) 108-114
- [8] V.P. Arthanarieswaran, A. Kumaravel, M. Kathirselvam, Mater. Des. (2014) 194-202.
- [9] A. Gopinatha, M. SenthilKumar, A. Elayaperumal, Procedia Eng. 97 (2014) 2052-2063.
- [10] G.M.A. Khan, M. Terano, M.A. Gafur, M. ShamsuAlam, J. King Saud Univ. – Eng. Sci. (2016) 69-74.
- [11] I.V. Surendra, K.V. Rao, K.V.P.P. Chandu, J. Eng. Trends Technol. 19 (2015).
- [12] M. Ramesh, T.S. AnandaAtreya, U.S. Aswin, H. Eashwar, C. Deepa, Procedia Eng. 97, (2014) 563-572.
- [13] B. Murali, D. Chandramohan, S.K. NagoorVali, B. Mohan, J. Middle East Appl. Sci. Techno. (2014) 584-587.
- [14] C. Babu, K.K. Kalesh, Int. J. Stud. Tech. Approach 1 (2015) 7-14.