Review on Synthesis and Characterisation of Jute Reinforced Polymer Composite

Manjul Mishra[1], Piyush Srivastava[2], Love Tyagi[3], Mohd. Amir[4], KLA Khan[5]

[1,2,3,4]Student, Department of Mechanical Engineering, KIET Group of Institutions, Delhi-NCR, Ghaziabad (U.P.), India

[5]Professor, Department of Mechanical Engineering, KIET Group of Institutions, Delhi-NCR, Ghaziabad (U.P.), India

Abstract

Jute fibre Reinforced Composite have significantly substituted various other materials due to their resistance to corrosion, low cost and better mechanical properties. Applications of jute reinforced composite have been widely seen in fields like Aerospace, Automotive, Marine and construction. This paper provides an insight on effect of increase of layers on mechanical properties of jute fibre reinforced composite. Hand Layup method was used for the fabrication of the composite. Certain Mechanical properties such as Tensile Strength and Bending Strength were taken into consideration for the specimen and were evaluated using standard testing methodologies. An increase in strength was observed on increasing the layers of jute fibre binded with Unsaturated Isothelic Polyester resin. The final values of tensile and bending strength of a 5-layer specimen were observed to be comparatively higher with respect to a three-layer specimen.

Keywords: Jute Fibre, Literature Review, Composites, Experimental Methods, Mechanical Characterization.

Introduction

A wide popularity has been seen in case of jute reinforced composites due to its environment friendly nature. In addition to its low density, effective thermal insulation, and biodegradability, it also has a number of other useful properties. In order to present a thorough analysis of the jute reinforced composites, this research study will emphasise the fabrication procedure, mechanical characterization, and matrix materials used. According to ASTM standards, the mechanical tests of composites' tensile, bending properties will be examined. Environmentally friendly natural jute fibre will be used as reinforcement in the current study, with unsaturated isothelic polyester resin serving as the matrix material. Experimentally obtained data was compared with previously obtained results on jute reinforced composites. The volume fraction, mechanical properties of the polymer matrix, manufacturing processes, adhesion or connection between the fibres and the matrix, as well as fibre length, shape, size, composition, orientation, and distribution, all affect the mechanical properties of composite materials.

Literature Review

C. Gnaneval et al (2019) stated that Banana/glass fiber/epoxy hybrid composites were created using the hand layup process and reinforced with treated banana fibers at weight percentages of 30%, 40%, and 50%. The same hand layup procedure was used to create jute/glass fiber/epoxy hybrid composites with jute reinforcement weight percentages of 30%, 40%, and 50%. The computerized tensile tester was used to characterize the tensile behaviors of the synthesized composites.

Sunil Kumar Tiwari et al (2020) conducted his research and concluded that jute-carbon fiber reinforced polypropylene composites were created by combining natural fiber (NF) and carbon fiber (CF). To create the composite, a compression molding procedure with a volume fraction of 0.20 was used. Jute fibers have been placed in a bidirectional fashion to strengthen the composite and give it a nice surface polish. Tensile test, flexural strength test, impact test, and hardness test investigations for characterization were followed by a water absorption test. The highest tensile strength of the CJC reinforced polymer composite was discovered to be 92.336 MPa, the Rockwell hardness number was 103.65, the flexural strength was 44.771 MPa.

Ajith Gopinath et al (2014) discussed in Experimental Investigations on Mechanical Properties of Jute Fiber Reinforced Composites with Polyester and Epoxy Resin Matrices that jute fibers with a length of 5 to 6 mm were used to make fiber reinforced composites. Epoxy and polyester are the resins that were used in this study. The composites were created using a weight ratio of 18:82 fiber to resin. The assembled composites underwent testing to determine their tensile, flexural, impact, and hardness strengths as well as other mechanical characteristics. The findings indicate that jute reinforced epoxy composite outperformed jute-polyester composite in terms of mechanical qualities.

Mazen Alshaaer et al (2021) researched on the characteristics of geopolymer composites reinforced with bidirectional jute fibres and determined that the bidirectional jute-reinforced geopolymer composite (JGC) has a modulus of 66 MPa and is characterized by ductility, high elongation, and strain hardening. By grinding the JGC, a new geopolymer matrix can be created using the geopolymer material and the jute microfibers as reinforcement and filler. When 2.5 wt.% filler was added, the micro-fiber jute-reinforced composite produced impressive mechanical characteristics, with a strength three times more than that of the reference material.

Malvika Sharma et al (2015) discussed about the Development and characterization of fibre reinforced material based on potato starch and jute fibre is that in this, jute fibre is employed as a reinforced fibre and potato starch serves as a matrix in the development of a fibre reinforced polymer material. The findings indicated that larger fibres produced superior results as compared to smaller fibres. Jute fibre that has been treated with a sodium hydroxide solution will outperform untreated fibre in terms of mechanical qualities.

K. Manohar Reddy and B. Chandra Mohana Reddy et al (2021) discussed on Mechanical characterization of chemically treated used jute fibre reinforced epoxy composite with SIC fillers- In the current study, the mechanical characteristics of silicon carbide (Sic) filled used jute epoxy (UJE) composites were examined. These characteristics included tensile strength, flexural strength, Izod impact strength, and hardness. By using the hand lay-up process, silicon carbide filler UJF reinforced polymer composites have been created. Used jute/epoxy laminated composites were reinforced in this situation in varying amounts (3%, 6%, 9%, and 12%). To further understand the impacts of the fill percentage and grain size on mechanical strength, the test results were compared to those of unfilled jute/epoxy composites. Tensile, compression, and impact tests were performed on the generated laminated composites.

Experimental Methods

A. Material Requirements:

- 5 kg Polyester Resin (Unsaturated Isothelic) as a polymer matrix.
- ½ kg Methyl Ether Ketone Peroxide (MEKP) as a Curing Agent.
- 250 gm Cobalt as a Catalyst.
- Jute Fibre as a Reinforcement.
- Paint Brushes of 2 inch each for proper upholding of layers of the Composite and equal distribution of resin over the entire jute fibre.
- Syringes(10ml) were both used for handling the required amounts of MEKP and Cobalt.

B. Fabrication of Composite:

Hand Layup technique was used for Fabrication of woven Fibre mat reinforced unsaturated Isothelic Polyester Resin. The reinforced fibre was woven in a mat form and 500 gm isothelic resin mixed with 6ml hardener (MEKP) and 1 ml Catalyst (Cobalt) is poured over it and spread uniformly with a brush. Another layer of fibre was placed above the first and rolled to remove the excess of matrix. The layers are consolidated, and air bubbles are removed by squeezing using the hand roller. This process is repeated until the required thickness is achieved. A plastic sheet was placed on the top of the mold and pressure was applied. The mould was ready after keeping it for 4-5 h. The specimen was made of 3,4 and 5 layers of jute fiber and was tested for its Strength accordingly to study the variation in Strength. Samples were cut according to ASTM standard of 200mm by 15 mm for tensile and flexural testing.

Fig.1.1 Samples of Composites

Fig.1.2 Universal Testing Machine

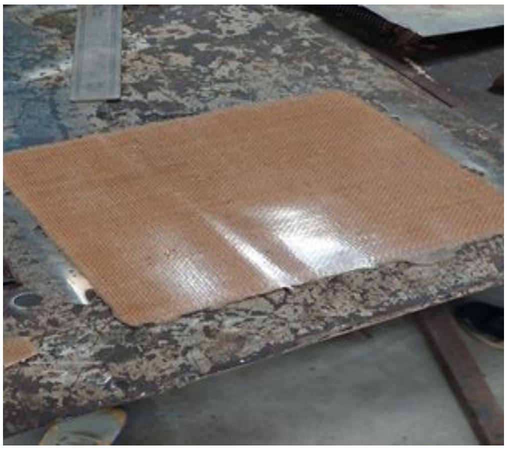

Fig.1.3 Fabricated Composite

C. Mechanical Characterization:

1.Tensile Testing:

A set of tensile tests performed in accordance with ASTM D3039 test standard are used to determine the tensile properties of the composite specimens. To perform a tensile test, the specimen is mounted in a

Universal Testing Machine (UTM), and tension is gradually increased until the specimen fractures. Tensile strength was calculated by dividing the Tensile Load (P) by the area of cross section (A) at Necking Point. All the dimensions were measured with the help of Vernier Calliper.

2.Flexural Testing:

Flexural test was conducted using three-point Bending load. The specimen was mounted on UTM for flexural testing. The Bending Load was obtained, and the Bending Stress was calculated by the help of Bending Equation. According to Bending Equation (M/I = Bending Stress/Y = E/R, where I is the moment of inertia and Y is the distance from neutral axis of the beam), the value of maximum Bending Moment (M) was calculated for a three-point load given by (Load * Span of Specimen)/4. The Moment of Inertia was calculated for a rectangular section by (bt^3)/12, where b and t are width and thickness of the beam. Upon having the respective values of M and I for specimens of three four and five layers, the value of bending strength was calculated. The Point load was held at a distance of 53 mm from the neutral axis.

D. Results and Analysis:

1.Tensile Results:

When the specimens reached their maximum tensile strength, they all failed, indicating that the fibres were unable to support the load. Subsequent failures of the fibres in the fabric caused a dramatic drop in load. The maximum Tensile Load sustained by a 5-layer ,4 layer and a 3-layer specimen were 2400 N, 1800 N and 1100 N. The Tensile Strength obtained for the above specimens were 30 MPa ,24 MPa and 20 MPa respectively. The Strength of the specimen were seen increasing depending on the increase of layers.

2.Flexural Results:

The Bending Loads sustained by a 5-layer ,4 layer and a 3-layer specimen were 1300 N ,700 N and 600 N respectively. The Bending Strength obtained for the above specimens were 38.73 MPa ,32 MPa and 23.3 MPa respectively.

E. Conclusion:

1. To determine the optimal process for fabrication and to compare the three specimens of jute reinforced polymer composite, the synthesis and mechanical characterization have been completed.
2. Maximum Tensile load carrying capacity was obtained for a five-layer specimen (30 MPa) of a jute polyester resin composite.
3. Maximum Bending Load carrying capacity was also obtained for a five-layer specimen (38 MPa).
4. There may be some variation in results due to disorientation in the layers of the specimen during fabrication.

References

[1] R. Saravanan and C. Gnanavel (2019), Synthesis and characterization of treated banana fibers and selected jute fibers-based hybrid composites, Volume 21, Part 1(2020), Pages 988-992.

[2] N. Johri, R. Mishra & H. Thakur (2019), Synthesis and Characterization of Jute- and Chicken-Feather-Fiber-Reinforced Polymer Hybrid Composites, Mechanics of Composite Materials volume 54, pages821–832 (2019).

[3] Sunil Kumar Tiwari, Umamaheswara Rao Akula, Naresh Reddy, Harsh Sharma, Jitendra Kumar Pandey (2020), Synthesis, characterization and finite element analysis of polypropylene composite reinforced by jute and carbon fiber, Volume 46, Part 20, 2021, Pages 10884-10891.

[4] Ajith Gopinath, M. Senthil Kumar, A. Elayaperumal (2014), Experimental Investigations on Mechanical Properties of Jute Fiber Reinforced Composites with Polyester and Epoxy Resin Matrices, Volume 97, Pages 2052-2063.

[5] Hind Abdellaoui, Hala Bensalah, Jamal Echaabi, Rachid Bouhfid, Abouelkacem Qaiss (2015), Fabrication, characterization and modelling of laminated composites based on woven jute fibers reinforced epoxy resin, Volume 68, Pages 104-113.

[6] Mazen Alshaaer (2021), Synthesis, Characterization, and Recyclability of a Functional Jute-Based Geopolymer Composite, Volume 7.

[7] Tara Sena and H. N. Jagannatha Reddy (2013), Pretreatment of Woven Jute FRP Composite and Its Use in Strengthening of Reinforced Concrete Beams in Flexure.

[8] Malvika Sharma (2015), Development and characterization of fiber reinforced material based on potato starch and jute fiber, Volume 10.

[9] B.S. Raju, L.H. Manjunath, Santosh, N. Jagadeeswaran (2020), Fabrication & characterization of ZnS micro particulate filled glass and jute fibre reinforced hybrid polymer composites, Volume 20, Part 2, Pages 125-133.

[10] K. Manohar Reddy, B. Chandra Mohana Reddy (2021), Mechanical characterization of chemically treated used jute fibre reinforced epoxy composite with SIC fillers, Volume 37, Part 2, Pages 917-921.

[11] Abhishek K. Pathak, V. Kumar, Sushant Sharma, T. Yokozeki, S.R. Dhakate (2019), Synthesis and Characterization of Graphene Oxide Reinforced FRP Composites for High-Performance Applications, M. Sharma et al., Journal of Composite Materials, Volume 533, Pages 548-560.

[12] Dhaval Vartak, Yogesh Ghotekar, B. S. Munjal, Pina Bhatt, B. Satyanarayana & A. K. Lal (2021), Fabrication and Characterization of Multi-walled Carbon Nanotube Reinforced FRP Composites, S. Sahoo et al., Materials and Design.

[13] R. Gupta (2016), Mechanical and Thermal Characterization of Hybrid FRP Composites with Carbon and Glass Fibres, Journal of Reinforced Plastics and Composites.

[14] H. Wang (2017), Synthesis and Characterization of Novel FRP Composites Reinforced with Bio-based fibres, Journal of Composite Materials.

[15] Md. Rezaur Rahman, Mahbub Hasan, Md. Monimul Hoque, and Md. Nazrul Islam (2009), Physico-Mechanical Properties of Jute Fiber Reinforced Polypropylene Composites, Volume 29, Issue 3

[16] Sakil Mahmud, K. M. Faridul Hasan, Md. Anwar Jahid, Kazi Mohiuddin, Ruoyu Zhang & Jin Zhu (2021), Comprehensive review on plant fiber-reinforced polymeric biocomposites.

[17] T. Alomayri &I.M. Low (2018), Synthesis and characterization of mechanical properties in cotton fibre-reinforced geopolymer composites, Volume 1, Pages 30-34.

[18] Xuan Liu, Yihua Cui, Senjie Hao, Haiyan Chen (2018), Influence of depositing nano-SiO2 particles on the surface microstructure and properties of jute fibres via in situ synthesis, Volume 109, Pages 368-375.

[19] Md. Sahadat Hossain, Mashrafi Bin Mobarak, Farzana Khan Rony, Sazia Sultana, Monika Mahmud, Samina Ahmed (2020), Fabrication and Characterization of Banana Fiber Reinforced Unsaturated Polyester Resin Based Composite, Volume 29, Pages 84-92.

[20] Malek Ali, Anwar H. Al-Assaf and Mohammad Salah (2022), Date Palm Fiber-Reinforced Recycled Polymer Composites: Synthesis and Characterization.

[21] Shrestha, S., & Shamsuddoha, M., Synthesis and Characterization of Carbon Nanotube Reinforced Polymer Composites for High-Performance Applications.

[22] Jahan, M. S., & Islam, M. S. Synthesis and Characterization of Natural Fiber Reinforced Polymer Composites for Sustainable Applications.

[23] Bandyopadhyay, S., & Mitra, S. Synthesis and Characterization of Ceramic Fiber Reinforced Polymer Composites for High-Temperature Applications.

[24] S. Singha & V. K. Thakur (2008), Synthesis and Characterization of Grewia Optiva Fiber-reinforced PF-based Composites, Volume 57, Pages 1059-1074.

[25] Zhang, Y., Li, C., & Guo, Y., Synthesis and Characterization of Graphene Nanoplatelet Reinforced Polymer Composites for EMI Shielding Applications.

[26] Quazi T. H. Shubhra, A. K. M. M. Alam1, M.A. Gafur2, Sayed M. Shamsuddin, Mubarak A. Khan1, M. Saha*, Dipti Saha, M. A. Quaiyyum, Jahangir A. Khan1, and Md. Ashaduzzaman (2010). Characterization of Plant and Animal Based Natural Fibres Reinforced Polypropylene Composites and Their Comparative Study, Vol.11, No.5, Pages 725-731.

[27] Dmitry Petrenko, Victor Klushin, Alina Zelenskaya, Aleksey Yatsenko, Anton Sotnikov, Anna Ulyankina & Nina Smirnova (2022). Natural fibre reinforced biomass-derived poly(ester-urethane–acrylate) composites for sustainable engineering applications.

[28] Raminder Kaur, Pooja Singh, Surya Tanwar, Gunjan Varshney and Sarla Yadav (2022), Synthesis and Characterization of Glass Fiber Reinforced Polymer Composites for Civil Engineering Applications., Volume 2, Issue 3, Pages 284-314.

[29] Raza, S., & Jamshaid, H, Synthesis and Characterization of Bio-Based Reinforced Polymer Composites for Packaging Applications.

[30] A.S. Singha and Vijay Kumar Thakur (2009), Synthesis, Characterization and Study of Pine Needles Reinforced Polymer Matrix Based Composites, Volume 29, Issue 5.

[31] A. Khalil, Synthesis and characterization of hemp fiber-reinforced epoxy composites for sustainable engineering applications.

[32] Y. Hu, Microstructure and mechanical properties of silica nanoparticle-reinforced carbon fiber/epoxy composites.

[33] S. Ahmed, Effect of fiber orientation on mechanical properties of glass fiber-reinforced polymer composites.