International Journal Of Advance Research, Ideas And Innovations In Technology

IJARIIT

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 6 - V7I6-1246)
Available online at: https://www.ijariit.com

Mechanical characterization of E-Glass/Epoxy composite with a filler material as Ceramic Powder

Mrunalini Uttam Patil
mrunalinip972@gmail.com
Rajarambapu Institute of Technology, Uran Islampur, Maharashtra

Mukund Kavade
mukund.kavade@ritindia.edu
Rajarambapu Institute of Technology, Uran Islampur, Maharashtra

ABSTRACT

Glass Fiber Reinforced Epoxy (GFRE) composites play a huge part in practically every aspect of daily life, and the subject of glass composites has become one of the most important study topics in the last decade. To improve mechanical qualities, polymers are usually reinforced with fibers or fillers. The mechanical properties of E-glass/Epoxy composites filled with ceramic materials as filler material were investigated in this study. Composites containing varying percentages of ceramic powder, such as 5%, 10%, and 15%. The ASTM-compliant testing specimen was created using the hand layup method. The mechanical parameters of the produced composites, such as ultimate tensile strength, flexural strength, and Rockwell hardness, were investigated. The test findings show that composites with a 5% volume fraction of Al2O3 filler material had the lowest hardness and therefore highest ultimate tensile strength.

Keywords: *GFRE composite, Hand- layup, Filler material, ceramic Powder, Mechanical Properties*

1. INTRODUCTION

The phrase composite material refers to two or more materials that have been mixed on a macroscopic scale to generate a useful third material. The benefit of composite materials is that, if correctly constructed, they usually introduce the best attributes of their constituents or components, as well as some traits that neither ingredient has. Strength, fatigue life, stiffness, corrosion resistance, thermal insulation, and weight are some of the attributes that can be improved by constructing a composite material.

There are two types of elements in composite materials: matrix and reinforcement. Matrix refers to the parts that are continuous and present in greater quantities. The matrix's primary roles are to keep or bind fibers together, equally distribute load across fibers, protect fibers from mechanical and environmental degradation, and carry inter-laminar shear. The other component is reinforcement, which has the primary goal of improving mechanical qualities such as stiffness and strength. Natural fiber-reinforced polymer composite materials are attracting a lot of attention, both in terms of industrial applications and basic research. They are renewable, inexpensive, recyclable (to some extent), and biodegradable. Plants including flax, cotton, hemp, jute, sisal, pineapple, ramie, bamboo, and banana have good mechanical qualities, making them an appealing ecological alternative to glass, carbon, and man-made fibers used in composites.

Due to several desirable properties such as high specific strength, high specific stiffness, and controlled anisotropy, fibrous composites, particularly glass fiber–reinforced epoxy composites in which glass fiber is the primary load-carrying element, are increasingly used in military and aerospace applications. The mechanical properties of composites are the most significant since they are governed by factors such as filler type, matrix

type, filler concentration, filler dispersion, fiber alignment, length, aspect ratio, fiber-matrix interphase properties, and fiber-resin matrix adhesion. Glass fiber reinforcement comes in a variety of forms, including roving's, mats, woven fabric, hybrid fibers, multiaxial fabrics, and short glass fibers, which are the most common and commonly utilized.

2. LITERATURE REVIEW

Sudeep Deshpande et al [1] A research of E-glass fiber/jute fiber reinforced epoxy composites filled with different amounts of bone and coconut shell powder was carried out in this paper. The mechanical parameters of the manufactured composites, such as ultimate tensile strength, flexural strength, interlaminar shear strength (ILSS), tensile modulus, impact strength, and hardness, were examined using a hand lay-up technique. These were compared to unfilled HFRP composites in terms of test outcomes. According to the findings, the mechanical characteristics of the composites improved as the filler quantity rose. The flexural strength, interlaminar shear strength (ILSS), tensile modulus, and hardness of composites loaded with 15% volume coconut shell powder were the highest. The use of filler (15 percent vol.) of bone powder provided maximum impact strength.

K.Devendra et al [2] The mechanical properties of E-glass fiber reinforced epoxy composites filled with various filler materials were investigated in this study. Composites containing varying concentrations of fly ash, aluminum oxide (Al2O3), magnesium hydroxide (Mg(OH)2), and hematite powder were fabricated using a standard method, and the mechanical properties of the fabricated composites, such as ultimate tensile strength, impact strength, and hardness, were investigated. The composites loaded with 10% volume (Mg(OH)2) had the highest ultimate tensile strength and hardness, according to the data. The impact strength of composites containing fly ash was the highest. K.A.Rameshkumar [3] In this research, three different types of composite specimens were made by combining 10mm glass fiber, fly ash, and epoxy matrix in 50:50, 65:35, and 70:30 ratios. The specimens were prepared under ASTM guidelines. The mechanical properties of the three mixtures mentioned above were examined using various mechanical equipment. The inclusion of fly ash considerably enhances ultimate tensile strength as well as compressive enhanced hardness qualities, according to research.

G. Mallesh et al [4] Composites are made up of two or more materials with different physical and chemical properties. These are gradually gaining in importance as structural materials in today's engineering design and development activity, owing to their appealing qualities such as a high strength-to-weight ratio, as well as higher thermal, corrosive, and wear resistance. As a result, these materials have the potential to take the place of traditional materials. Natural fiber-reinforced polymer composites have gained traction in a variety of applications due to their environmental benefits over synthetic fiber-based polymer composites. The mechanical characteristics of glass-epoxy composites filled with variable volume fractions of industrial blast furnace slag and coconut shell powder were tested on glass-epoxy composites filled with varying volume fractions of industrial blast furnace slag and coconut shell powder in this study. From the results, it was found that the mechanical properties of the composites fabricated were increased with the increase in filler content.

Venkatesha B.K et al [5] Biomedical prosthetic devices are artificial substitutes that operate as original elements in the human body. Non-toxic, physiologically and chemically stable materials must be utilized in prosthetic devices, as well as having sufficient mechanical integrity and strength to bear physiological demands. Due to their excellent mechanical properties, the role of natural and artificial fibers reinforced hybrid composite materials is developing at a quicker rate in engineering and biomedical science. Bamboo is one of the most important renewables, fast-growing natural resources, and it can be found almost anywhere on the planet. Despite their attractiveness as low-cost materials, bamboo fibers have lesser strength, lower modulus, and poor moisture resistance when compared to glass fiber. The most common reinforcing ingredient is glass fiber. One method for overcoming these constraints is to effectively hybridise Bamboo fiber with the stronger E-Glass fiber. The mechanical properties of fiber-reinforced polymer composites will be improved by adding CaCO3, TiO2, Sic, and Al2O3 micro fillers to the hybrid composites. In the field of biomedical prosthetic devices, this work gives a review of mechanical characteristics and fatigue life evaluation of E-Glass/Bamboo fiber-reinforced polymer composites. Jush kumar Siddani et al [6] This study looks at how to make epoxy composites with a high number of micro-fillers, up to 10% by weight. Each specimen's experimental thermal conductivity tests are analyzed and compared to FEM Analysis. The main focus of this research was on using spherical silicon carbide (SiC) and titanium oxide (TiO2) micro-fillers individually to improve both heat conductivity and mechanical endurance. The heat transfer process within an epoxy matrix filled with micro silicon carbide particles and titanium oxide separately will be explained using a numerical solution using the finite element package ANSYS, and its effective thermal conductivity values will be validated using experimental results and theoretical model correlations.

G.Devendhar Rao et al [7] Machining composite materials can be difficult because of the anisotropic and non-homogeneous structures found in composites, as well as the helter-skelter abrasiveness of their reinforcing elements. This research focuses on the mechanical properties of glass/ epoxy composite materials for fillers (SiO2 and PTFE), as well as the materials utilized in the grid to help move those mechanically functioning features of a composite forward. The mechanical properties of freshly created composites are described using elasticity tests, tensile strength tests, and flexural tests.

3. FABRICATION OF COMPOSITE MATERIAL

As a reinforcing agent, bidirectional (woven) glass fiber orientated at 0° and 90° is used in this study. Filler materials include epoxy resin (LY556), hardener (HY- 951), and ceramic powder with particle sizes ranging from 80 to 100 pm. In a 100:50 ratio, woven E-glass fiber is blended with epoxy resin and hardener. After that, the combined material is mechanically agitated and put into various moulds using the hand lay-up process. For the simple removal of composites from the mould, a mould release sheet is used. The cast is left to cure for 24 hours under a load of 20 kg at room temperature (27 °C). By varying the volume fraction of ceramic powder in the GFRE composite, for example, 45:50:5%. where woven glass fiber consists 45 percent, matrix material makes up 50 percent, and ceramic powder makes up 5% Similarly, the second sample has a ratio of 40:50:10 percent while the third sample has a ratio of 35:50:15 percent. After curing, samples were cut to the desired dimensions according to ASTM Standard for various mechanical tests.

Mechanical Property Testing: Tensile, flexural, and Rockwell hardness measurements were used to assess the mechanical properties of composites. Universal testing machine and Rockwell hardness testing machine were used to conduct tensile, flexural, and Rockwell hardness tests, respectively. Tensile strength, flexural strength, and Rockwell hardness were measured on four similar samples. Tensile tests were performed at room temperature using a universal testing machine following ASTM D638-14. Test specimens with dimensions of 165 mm in length, 20 mm in width, and 3 mm in thickness. A 250 KN computerized universal testing machine was used to load the specimen between two manually adjustable grips (Servo UTM). The test was repeated four times, with the average value used to calculate the composites' tensile strength. Universal Testing Machine Specifications Micro Control Systems' TUF-C-600 universal testing machine is a Micro Control Systems device (Servo).

The flexural characteristics of the composite samples are tested on the UTM utilizing a 3-point bending test. The flexural strength of composites was tested using universal testing equipment in accordance with ASTM D7264. The specimens have dimensions of 250 mm x 40 mm x 3 mm. The test was done twice, with the average data used to determine the flexural strength.

4.RESULTS AND DISCUSSION

The outcomes of this research are discussed. The constituent materials' qualities influence the mechanical properties of fiber-reinforced epoxy composites (type, quantity, fiber distribution, and orientation, void content). Aside from such characteristics, the nature of interfacial connections and load transfer processes in the interphase is also essential.

4.1 Tensile Properties

The tensile strength of the E-glass fiber reinforced epoxy composites depends upon the strength and modulus of the fibers, strength and chemical stability of the matrix, fiber-matrix interaction, and fiber length from the obtained results it was observed that composite filled by 5% Volume fraction of ceramic powder (Al2O3) exhibited a maximum ultimate tensile strength of 299.5 MPa when compared with other concentration of the filler material such as 10% and 15%. This may be due to good particle dispersion and strong polymer/filler interface adhesion for effective stress transfer. 10% volume fraction of filler material in GFRE composite shows higher percentage elongation as compared with other concentrations of the filler material. Ultimate tensile strength increases with decreasing volume fraction of filler material.

4.2 Flexural Properties

The three-point bending test determines the material's modulus of elasticity in bending, flexural stress, flexural strain, and flexural stress-strain response. The key benefit of a bending flexural test is how simple it is to prepare and test the specimen.10% volume fraction of filler material shows higher flexural strength as compared with the other concentration of filler material because the strong bond between filler material with matrix material and 15 % volume fraction of filler material shows higher elongation at peak and 10 % volume fraction shows lower elongation at peak in case of the flexural test.

4.3 Rockwell Hardness Properties

The Rockwell hardness tester is utilized to determine the hardness of GFRE composite with filler material as ceramic powder. The Rockwell scale is a hardness rating system based on a material's indentation hardness. In the Rockwell test, the depth of penetration of a preloaded is compared to the depth of penetration of an indenter under a severe load. Various loads of indenters are used on different scales, each of which is denoted by a single letter. The L scale is utilized to determine the hardness of the GFRE composite in this study. The hardness test is carried out with a ball indenter 1/4" and a load of 60 kg. All of the specimens were tested for Rockwell hardness at a temperature of 25 °C. All measurements were taken after the indenter established firm contact with the specimen for 10 seconds. 15 % volume fraction of the filler material indicate a higher hardness value in comparison with other concentration of filler material such as 5% and 10%. As the volume fraction of the filler material is increased the hardness value is increased.

5. CONCLUSIONS

The following findings were obtained based on the test results received from the various tests carried out:

- The 5% volume fraction of the filler material as ceramic powder shows higher ultimate tensile strength as compared to the other volume fraction of filler material such as 10% and 15%.
- The 10% volume fraction of the filler material shows a higher percentage of strain in comparison with the other volume fraction.
- In the case of the flexural test, 10 % of the filler material shows higher flexural strength as compared with other concentrations at 5% and 15%.
- The 15% volume fraction of filler material GFRE composite shows a high Rockwell hardness value as compared with other volume fractions of filler material such as 5% and 10%.
- As the percentage of the filler material is increased the hardness of the material is also increasing resulting in lower ultimate tensile strength therefore the 5% volume fraction of the filler material is recommended because it gives low hardness and hence high ultimate tensile strength.

6. REFERENCES

[1] Sudeep Deshpande, T Rangaswamy (2014) Effect of Fillers on E-Glass/Jute Fiber Reinforced Epoxy Composites *Int. Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 4, Issue 8(Version 5).*

[2] K. Devendra, T. Rangaswamy (2013) Strength Characterization of E-Glass Fiber Reinforced Epoxy Composites with Filler Materials Journal of Minerals and Materials Characterization and Engineering, 353-35.

[3] Dr. K. A. Rameshkumar (2015) Investigation of Mechanical Properties on Epoxy, Fly Ash and E - Glass Fiber Reinforcement Composite Material International Journal of Machine and Construction Engineering ISSN (Online): 2394 – 3025.

[4] Dr. G. Mallesh & Mr. Pradeep Kumar V G (2017) Mechanical Characterization of Csp And Ggbs Filled Glass - Epoxy Composites Global Journal of Engineering Science And Researches ISSN 2348– 8034.

[5] Venkatesha B. K., Dr. R. Saravanan and Dr. D. Saravana Bavasn (2017) Review on Mechanical Properties and Fatigue Life of E-Glass/Bamboo Fiber Reinforced Polymer Composites International Journal of Engineering Sciences & Management ISSN 2277 – 5528.

[6] Jush Kumar Siddani, Dr. C. Srinivas, G. Moses Dayan (2018) Comparitive Study on Mechanical and Thermal Behaviour of Glass Fiber Reinforced Epoxy Based Composites wWith Sic & Tio International Journal Of Engineering Sciences & Research Technology.
[7] G. Devendhar Rao, K. Srinivasa Reddy, P. Raghavendra Rao, P. Madusudana Rao (2017).
[8] Mechanical Properties of E-Glass Fiber Reinforced Epoxy Composites with SnO2 And Ptfe International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 (Volume-6, Issue-7).
[9] Vithal Rao Chauhan, Dr. K R Dinesh, Dr. K Veeresh, VeerabhadrappaAlgur,Manjunath Shettar (2016) Influence Of Ceria Oxide As Filler Material On E-Glass Fiber/Epoxy Reinforced Hybrid Composites International Journal of Advances in Scientific Research and Engineering ISSN: 2454-8006 [Vol. 02, Issue 06].
[10] Suresh J.S, Dr. M. Pramila Devi, Dr. .M Sasidhar (2017) Effect On Mechanical Properties Of Epoxy Hybrid Composites Modified With Titanium Oxide (Tio2) And Silicon Carbide (SIC) IJESC Volume 7 Issue No.10.
[11] Hemant kumar sahu, Akshay kumar sahu (2017) Mechanical Behaviour Of E-Glass Fiber Reinforced With Epoxycomposites IJARIIE-ISSN(O)-2395-4396 Vol-3.

