Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 5 (2023)

Development of Glass Fiber Reinforced Polymer Matrix Composites for Engineering Applications

Suresh.S[1], Raghavendra S[2] and Vijay Kumar[3]

[1]Department of Mechanical Engineering, REVA University, Bangalore
Email: sureshpoojar95@gmail.com
[2]Department of Mechanical Engineering, Sai Vidya Institute of technology, Bangalore
Email: rvs.sdly@gmail.com
[3]Department of Aeronautical Engineering, MVJ college of Engineering, Bangalore
Email: vijaymtechnal@gmail.com

Abstract:
Composite materials are important in engineering applications. Particularly in the aerospace industry. Polymer matrix composites are widely employed in aircraft structural applications. Many components have been developed as a result of the ultization of glass fibre in polymer matrix. In this work, glass fibre is combined with epoxy resin and Polyurethane to achieve mechanical qualities such as tensile, flexural, and hardness strength. Composite laminates of epoxy and polyurethane are tested and the results are compared.

Keywords: Tensile, Aluminium, Epoxy, Glass Fiber, Polymer.

1. Introduction:

Resins, reinforcements, fillers, and additives compose composites. All of these core elements or ingredients contribute a vital part in the final product's manufacturing and function. The “adhesive " that keeps the composite together and impacts the physical qualities of the ultimate result are the resin or polymer. The strength of the material is provided by the reinforcement [1-2]. Fillers and additives are utilised as process or performance aids to provide the finished product particular qualities. FRP composites' mechanical qualities and composition may be customized to their specified use [3]. The mechanical qualities and functionality of a product are affected by the type and quantity of materials used, as well as the manufacturing technique used to create it.

Fibre Reinforced Polymer (FRP) composites are referred to as a thermoset or thermoplastic polymer (plastic) matrix which has been strengthened (combined) with a fibre or other reinforcing material that has a sufficient aspect ratio (length to thickness) to provide a discernible strengthening action in multiple directions. FRP composites are not the same as typical building materials like steel or aluminium.

In simple terms, composite materials typically mixtures of materials with two or more physically separate components that, when taken together, are more effective stiffer, and function well than the individual components.

Composite materials have been used for many years, particularly to reduce weight in the aerospace industry. Natural composites can be found in plants with fibres wrapped by cellulose. Most living organisms have composite structures that make them function efficiently and for a longer life. For example, the microstructure of wood and bone. Tree is a natural composite, which comprises the cellulose, the fibrous material that acts as the reinforcement and lignin, a natural polymer that acts as the matrix. These two constituents together firm the cell walls in the wood and its structure. Bone, the framework of the living beings is another natural composite. The human bone is made of collagen, the organic fibrous material (about 35% by weight), that acts as the reinforcement and the bone tissue is a mineral, containing mostly calcium, phosphate and carbonate, that acts as the matrix (about 65% by weight). We all know that this combination of collagen and mineral is strong and durable [4].

In general polymer composite materials are developed using glass fibers, carbon fibers, and aramid fibers reinforced with thermosetting resins such as epoxy polyester etc., the strong interface between fiber and resin will improve the mechanical strength of the composites. These strength is depends upon the type of reinforcement, its density, specific gravity. Normally wood aluminum, synthetic fibers were reinforced for better strength.

Due to problems with traditional fasteners, epoxy polymer adhesives are increasingly being used in the aircraft industry to manufacture and bond aluminum and polymer composite parts. These composites structures must be stable in high operating temperature environments, but must also resists deformation due to the fluctuating loads. This normally requires adding modifiers to the epoxy-based formulation to increase the material's adhesion, toughness, and peel resistance. From the literature it is proved that epoxy based composites improved fracture toughness and provide better adhesive properties.

Polymer composite materials having many advantages in structural components, required strength and design of materials can be easily tailored. Due to this flexibility in design and manufacturing polymer composites are used widely in aerospace and marine industries. In other words, polymer composites provide the designer with the opportunity to create tailored materials with a range of properties and performances capabilities that those of other known class of materials [6].

Because the simple reason that many materials were more durable and rigid in their fibrous state than in every other form, fibre reinforced composites have gained more popularity than other varieties of composites.

The current inquiry includes the development and testing of a glass fiber reinforced epoxy and polyurethane composites. The matrix materials, glass fibre and foil from aluminium variable reinforcement are layup. The strength of the aluminium foil utilized selectively as a reinforcing element is quite high.

Because mechanical qualities are highly sought in structural materials, they are examined and compared with the matrix. Other characteristics of the material were investigated along with to the mechanical characteristics.

2. Materials and Methods:

Epoxy materials are the most often used composite materials for low-temperature applications [typically less than 200ºF (93ºC)] and provide excellent chemical resistance, great adherence to fibres, superior stability in dimensions, excellent hot/wet performance, and strong dielectric characteristics.

Polyurethanes are among the most flexible polymers. They are made by combining polyester with an isocyanate.

A pair of plates with dimensions of 250mm length 250mm width and a thickness of 8mm. These dimensions are chosen to meet the needs of the development process. Due to its light weight, it has an 8mm thickness.

Acetone is used to clean the plates used in the manufacturing process to eliminate debris. The woven fibre mats (reinforcement) are separated to the requisite dimensions (230230mm) and cleaned on the top and bottom surfaces to avoid affecting the qualities of the laminates. The process of resin preparation is by filling 200ml of epoxy resin in a glass beaker and gently adding the graphite powder into the resin the mixture is stirred well for 10 to 15 minutes and the hardener about 8ml is added to the mixture to produce a chemical response that increases the resin hardness.

Fiber mats are placed in between the plates and resins are applied over the surface of the fiber and allowed for curing (8 hours).the laminates were removed from the plates and specimens were cut as per the ASTM 638D standards.

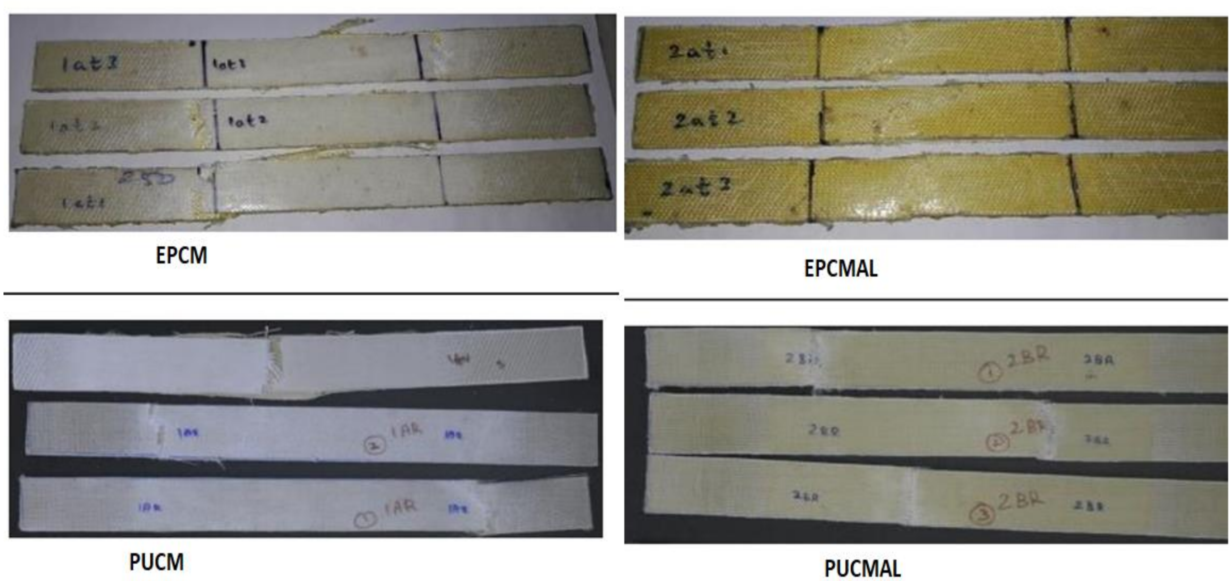

Figure 1: Tensile test specimens

Tensile characteristics of unidirectional and 0/90 degrees cross ply laminates having loads in either direction to reinforcements are determined using this test approach.
The mechanical behavior of composite formed by hand lay-up technique is discussed in this paper. Table 1 show the stress strain, and fracture modulus of the epoxy and polyurethane resin system.

Table1: Tensile test Results

Sl No	Laminate sample Code	Load Fractured in Kgs	Deflection mm	Fracture Modulus N/mm	Stress In N/mm2	Strain X 10-4	Tensile Modulus In N/mm2
1	EPCM Epoxy resin with chopped mat	60	1.7	346	102.4	171.6	5967
2	EPCMAL Epoxy resin with chopped mat aluminium foil	80	5.52	142	150.5	151.3	9947
3	PUCM polyurethane resin with chopped mat	51	2.35	126	31.14	50.11	6214
4	PUCMAL polyurethane resin with chopped mat aluminium foil	42	2.73	305	105.6	446	2367

Epoxy resin based neat composites showed less deflection of 1.7mm with tensile modulus of 5967 N/mm^2, whereas Epoxy resin with chopped mat aluminium foil composites showed larger deflection of 5.52mm and tensile modulus of 9947N/mm^2. This is due to fiber matrix interface.
Again polyurethane resin with chopped mat aluminium foil showed deflection of 2.73mm with tensile modulus of 2367N/mm^2, these differences are attributed due to better fiber matrix interface.
The, polyurethane resin with chopped mat aluminium foil adheres strongly over the matrix, which is the main reason to transfer load from the epoxy matrix to the fiber foil.

3. Conclusion:
From the above results it is observed that laminates prepared using Epoxy resin with chopped mat exhibited minimum defection of 1.7mm with fracture modulus of 346N/m during flexural test. Whereas tensile modulus of 5967N/mm2 which is 59.98 % less compared to laminates made up of Epoxy resin with chopped mat aluminum foil. But aluminum foil laminates showed more deflection of 5.52 mm.
In comparison with epoxy laminates the polyurethane resin with chopped mat laminates showed higher tensile modulus of 6214 N/mm2. Whereas polyurethane resin with chopped mat aluminium foil exhibited better fracture modules of 305 N/m.
From the above results it can be concluded that polyurethane resin with chopped mat adhesion is good, due to the bonding between mat and resin it can able to bear the load.

The earlier tensile results showed that composite materials are stronger and more capable of bearing load when integrated into structures. To preserve structural integrity, the primary needs of any structural component are load carrying and resistance to deflections. Based on the data aforementioned, it is clear that the strength of the materials may be varied based on the needs. Polymer composites are the most promising and appropriate candidate materials for structural development in engineering applications.

References:

[1] Holbery J, Houston D. Natural-fiber-reinforced polymer composites in automotive applications. JOM. 2006 Nov;58(11):80–6.

[2] Maheswari CU, Reddy KO, Muzenda E, Shukla M, Rajulu AV. Mechanical Properties and Chemical Resistance of Short Tamarind Fiber/Unsaturated Polyester Composites: Influence of Fiber Modification and Fiber Content. International Journal of Polymer Analysis and Characterization. 2013 Oct 3;18(7):520–33.

[3] Kim D, Woo H, Ha H, Cao F, Myung HS, Rho JS, et al. Fabrication and properties of thermal insulating glass fiber reinforced composites from low temperature curable polyphosphate inorganic polymers. Composites Science and Technology. 2003 Feb 1;63(3-4):493–9.

[4] Varghese S, Kuriakose B, Thomas S, Joseph K. Effect of Adhesion on the Equilibrium Swelling of Short Sisal Fiber Reinforced Natural Rubber Composites. Rubber Chemistry and Technology. 1995 Mar 1;68(1):37–49.

[5] Seetha Girish av, B. Vijaya, Arjun S, Srinivas Raghavendra. Manufacturing and mechanical characterization of coir fibre composites based on vinyl ester. Advances in Materials and Processing Technologies. 2021 Jan 31;8(2):1997–2006.

[6] Subramanya R, Reddy DNS, Sathyanarayana PS. Tensile, impact and fracture toughness properties of banana fibre-reinforced polymer composites. Advances in Materials and Processing Technologies. 2020 Feb 27;6(4):661–8.