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A Comprehensive Review on the Role of Fibre-Reinforced Polymer Composites in Lightweight Automotive Structures

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ABSTRACT: Fibre-reinforced polymer (FRP) composites are advanced composite materials in which fibres are embedded within a polymer matrix to enhance mechanical, thermal, and chemical properties. These composites consist of two primary components: the reinforcement, which carries the applied load and provides strength, and the matrix, which binds the reinforcement and transfers stress between the fibres. The reinforcement contributes significantly to the stiffness and load-bearing capability of the composite structure.

FRP composites have gained significant importance in automotive applications due to their lightweight nature, high strength-to-weight ratio, and cost advantages compared with conventional materials such as steel and aluminium. These materials offer several benefits, including design flexibility, high specific strength, high specific stiffness, corrosion resistance, durability, and reduced structural weight. Among various FRP materials, glass fibre-reinforced polymer composites are the most commonly used because of their low cost, availability, and satisfactory mechanical performance.

KEYWORDS: FRP, GFRP, Composite material, Polymer, Automotive application

INTRODUCTION

In recent years, the application of fibre-reinforced polymer (FRP) composite materials has expanded significantly across various industrial sectors, including aerospace, automotive, marine, and construction industries. A considerable number of industrial components and mechanical systems are now manufactured using FRP composites as alternatives to conventional materials such as aluminium and steel [3]. FRP composites consist of a polymer matrix reinforced with high-strength fibres, including glass, aramid, and carbon fibres, which provide enhanced structural performance [11].

The major advantages of FRP composites include design flexibility, lightweight characteristics, corrosion resistance, high strength, and superior specific mechanical properties. Compared with traditional metallic materials such as steel and aluminium, FRP composites can provide higher strength-to-weight performance and can be manufactured into complex geometrical shapes, including curved, ribbed, and corrugated structures. These combined features make FRP materials highly promising for future engineering applications [13]. However, the manufacturing of FRP composites may involve energy-intensive processes due to the requirement of elevated temperatures and pressures for effective bonding between the constituent materials [15].

Advancements in composite technology have resulted in the development of high-performance fibre-reinforced composites with improved damage tolerance, impact resistance, toughness, sustainability, strength, electromagnetic transparency, biodegradability, production efficiency, and reduced component weight. In comparison with conventional metallic materials, FRP composites also demonstrate excellent stiffness, mechanical damping capacity, chemical resistance, thermal stability, corrosion resistance, and wear resistance [6].

In the automotive sector, FRP composites are utilized in various components such as bumper systems, instrument panels, leaf springs, drive shafts, fuel tanks, cross wheel beams, and intake manifolds [12,13]. Their superior stiffness and strength characteristics are mainly attributed to the reinforcing fibres, which are often stronger, tougher, and stiffer than the polymer matrix. Due to these advantages, FRP composites have found extensive applications in automotive, aerospace, electronic equipment, sporting goods, furniture, medical equipment, and packaging industries [9].

1.1 GFRP (Glass Fibre Reinforced Polymer)

Glass fibre is the most widely used FRP material, because of its low cost and long-established availability on the market.[3] The glass fiber reinforced polyester (FRP) is a composite consisting of a plastic resin matrix, glass fiber reinforcement and other additives. The matrix itself alone does not provide any strength, but it serves as the bond for the reinforcing glass fibers.[13] The Glass fibre (GF) reinforcement and polypropylene (PP) matrix system is a commonly employed material combination, due to its high availability as well as low procurement costs.[4] The glass fiber reinforced composites are composite material system consisting of plastic resin matrix, glass fiber reinforcement and other additives. The glass reinforced composites are strong, lightweight and can be shaped as curved, corrugated, ribbed etc. The glass fiber composites are stronger than steel and aluminum.[13] A new polymer composite suspension spring promises to bring numerous benefits tothe automotive industry, benefits that drivers should ultimately be able to appreciateas well. Audi and Sogefi, an Italian automotive parts manufacturer, collaborated onthe development of a glass fiber-reinforced polymer spring, designed to replace steelsprings used as part of a car's suspension.[12]

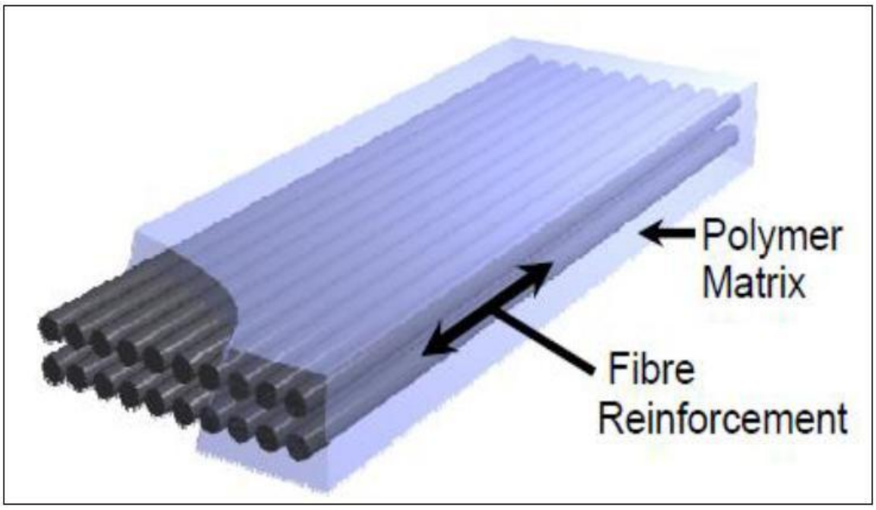

Figure:1Schematic of reinforcement and matrix forming a FRP composite

I. LITERATURE REVIEW

Arvindkumar K. *et al.* (2014) investigated the optimization of an intake manifold design using fibre-reinforced polymer (FRP) composites. The study focused on the design and fabrication of an intake system for a 600 cc Yamaha ZF engine. Since the intake system significantly influences engine performance, noise levels, and emissions, an optimized manifold design is essential for achieving improved volumetric efficiency and overall engine performance. The results demonstrated that replacing conventional aluminium with FRP composites reduced component weight, enhanced charge distribution, and improved torque output over a wide range of engine speeds [1].

Chandramohan D. *et al.* (2013) explored the development of natural fibre-reinforced polymer composites for automotive applications. In this study, natural fibres such as sisal (*Agave sisalana*), banana (*Musa sepientum*), and roselle (*Hibiscus sabdariffa*) were combined individually and in hybrid forms with bio-epoxy resin using a moulding process. The research aimed to promote sustainable materials for automotive components. Mechanical properties, including tensile strength and hardness, were evaluated for different hybrid composite combinations under dry and wet conditions. Brinell hardness testing and scanning electron microscopy (SEM) analysis were performed to investigate the material behaviour and microstructural characteristics. The study also highlighted the fabrication methods and potential applications of these composites in automobile accessories [2].

Marianne Inman *et al.* (2017) conducted a comparative investigation of the mechanical and environmental performance of basalt fibre-reinforced polymer (BFRP) reinforcement and conventional steel reinforcement in concrete beams. The study employed material testing and life cycle assessment (LCA) to evaluate the sustainability and structural performance of both materials. The findings revealed that BFRP reinforcement provides higher strength and lower weight compared with steel reinforcement while also offering improved environmental benefits due to reduced material consumption and lower embodied energy during production [3]. S.Suresh et al. (2014) investigated Experimental determination of the mechanical behavior of glassfiber reinforced polypropylene composites. In this study the influence of the forming pressure and coupler concentration on the mechanical behavior of glass fiber reinforced polypropylene composite laminates were investigated. The experimental results showed that the increase in forming pressure and coupler concentration initially increases both the mechanical properties, and then decreases the properties of the composite laminates. Compared to the coupler concentration, the forming pressure greatly improves both the tensile and flexural properties. Using the Scanning Electron Microscope (SEM), a morphological analysis was carried out to observe the bonding between the matrix and reinforcement.[4] B.V.Kavad et al. (2014) review on effects of Drilling on Glass FiberReinforced Plastic. This paper attempts toreview the influence of machining parameter on the delamination damage of GFRP during drilling. In conventional machiningfeed rate, tool material and cutting speed are the most influential factor on the delamination hence machining at higher speed,harder tool material and lower feed rate have lesser delamination of the GFRP. Vibration assisted drilling and Ultrasonic assisteddrilling have lesser thrust and hence lesser delamination compared to conventional drilling, which indicates that both vibrationassisted drilling and Ultrasonic assisted drilling are more appropriate for drilling of GFRP.[5]

SikiruOluwarotimi Ismail et al. (2016) focused on Comprehensive study on machinability of sustainable and conventionalfibre reinforced polymer composites. This paper presents a comprehensive investigation on the machinability effects of drilling parameters (feed rate, cutting speed and thrust force), drill diameters and chips formation mainly on delamination and surface roughness of hemp fibre reinforced polymer and carbon fibre reinforced polymer composite laminates, using high speed steel (HSS) drills under dry machining condition. The results obtained depict that an increase in feed rate and thrust force caused an increase in delamination and surface roughness of both samples, different from cutting speed. Also, increased drill diameter and types of chips formation caused an increase in both delamination and surface roughness of both samples, as the material removal rate (MRR) increased.[6]

Thermo-mecha et al. (2016) investigated Effect of test temperature on fatigue crack propagation in injection molded plate of short-fiber reinforced plastics. The crack propagation behavior was studied at 298K (RT), 343K, 373K, and 403K with center-notched specimens which were cut from an injection-molded plates of short carbon-fiber reinforced PPS at two fiber angles relative to the loading direction, *i.e.* $\theta = 0°$ (MD) and 90° (TD). Macroscopic crack propagation path was nearly perpendicular to the loading axis for both MD and TD. Microscopically, cracks in MD were blocked by fibers, circumvented fibers, and rarely broke fibers, showed zigzag path. According to SEM observation of fatique fracture surfaces, many fibers were pulled out from the matrix on fatigue fracture surface of the skin layer of MD, and parallel fibers were observed on the fracture surface of TD.[7]

Tushar Sonar et al. reviews on Natural Fiber Reinforced Polymer Composite Material. This paper represents Natural fiber reinforcements have resulted in improved impact toughness and fatigue strength. Many efforts have been made by researchers towards improving mechanical properties, directed at improving the interface between fiber and polymer. This review aims at explaining about the research and development in the improvement in properties of natural fibre reinforced polymer composites along with its application.[8]

Gourav Gupta et al. (2016) reviews on Application and Future of CompositeMaterials. This paper present the current scenario ofapplication composites in industries and go towards the approach of composite material in future direction with itsadvantages, disadvantages and applications in industrial machinery. This paper also showed the Properties,Characteristics, Challenges, Opportunities and Future demand of Composite material towards industrial environment[9].

Ing. Eva Aková (2013) Focused on Developement Of Natural Fiber Reinforced Polymer Composites. The article reviews the recent development of natural fiber reinforced polymer composites, including an experiment on composites reinforced with hop fibers. This paper also present the properties of fibre reinforcement polymer and also its applications in the automotive sector.[10]

II. CONCLUSION

This study presents a comprehensive literature review on the applications of fibre-reinforced polymer (FRP) composites in various areas of the automotive sector. The demand for lightweight components in automobiles has increased significantly to enhance fuel efficiency, reduce emissions, and improve overall vehicle performance. In this context, FRP composites have emerged as promising alternatives to conventional materials such as steel and aluminium due to their high strength-to-weight ratio, corrosion resistance, and design flexibility. Furthermore, the relatively lower manufacturing cost of FRP composites compared with traditional metallic materials provides additional advantages, making them suitable for the development of lightweight and efficient automotive components.

References

[1] K. Arvindkumar, N. Adhithiyan, and V. S. D. Dinesh, "Optimisation of Intake Manifold Design Using Fibre Reinforced Plastic," *International Journal of Scientific & Engineering Research*, vol. 5, pp. 922–925, 2014.

[2] D. Chandramohan and J. Bharanichandar, "Natural Fiber Reinforced Polymer Composites for Automobile Accessories," *American Journal of Environmental Science*, vol. 9, no. 6, pp. 494–504, 2013.

[3] M. Inman, E. R. Thorhallsson, and K. Azrague, "A Mechanical and Environmental Assessment and Comparison of Basalt Fibre Reinforced Polymer (BFRP) Rebar and Steel Rebar in Concrete Beams," *Energy Procedia*, vol. 111, pp. 31–40, 2017.

[4] S. Suresh and V. S. Senthil Kumar, "Experimental Determination of the Mechanical Behaviour of Glass Fiber Reinforced Polypropylene Composites," *Procedia Engineering*, vol. 97, pp. 632–641, 2014.

[5] B. V. Kavad, A. B. Pandey, M. V. Tadavi, and H. C. Jakharia, "A Review Paper on Effects of Drilling on Glass Fiber Reinforced Plastic," *Procedia Technology*, vol. 14, pp. 457–464, 2014.

[6] S. O. Ismail, H. N. Dhakal, I. Popov, and J. Beaugrand, "Comprehensive Study on Machinability of Sustainable and Conventional Fibre Reinforced Polymer Composites," *Engineering Science and Technology, an International Journal*, vol. 19, pp. 2043–2052, 2016.

[7] K. Tanaka, K. Oharada, D. Yamada, and K. Shimizu, "Effect of Test Temperature on Fatigue Crack Propagation in Injection Molded Plate of Short-Fiber Reinforced Plastics," *Procedia Structural Integrity*, vol. 2, pp. 58–65, 2016.

[8] T. Sonar, S. Patil, V. Deshmukh, and R. Acharya, "Natural Fiber Reinforced Polymer Composite Material—A Review," *IOSR Journal of Mechanical and Civil Engineering*, pp. 142–147.

[9] G. Gupta, A. Kumar, R. Tyagi, and S. Kumar, "Application and Future of Composite Materials: A Review," *International Journal of Innovative Research in Science, Engineering and Technology*, vol. 5, pp. 6907–6911, 2016.

[10] E. Aková, "Development of Natural Fiber Reinforced Polymer Composites," *Transfer inovácií*, vol. 25, pp. 3–5, 2013.

[11] H. Ku, H. Wang, N. Pattarachaiyakoop, and M. Trada, "A Review on the Tensile Properties of Natural Fibre Reinforced Polymer Composites," *Centre of Excellence in Engineered Fibre Composites and Faculty of Engineering*.

[12] Polymer Students Association, "Recent Developments in the Field of Polymer Science and Technology," *Polymer Times*, MIT Pune, 2016.

[13] A. John and S. Alex, "A Review on the Composite Materials Used for Automotive Bumper in Passenger Vehicles," *International Journal of Engineering and Management Research*, vol. 4, pp. 98–101, 2014.

[14] K. Alagarraja, A. Dhamodharan, K. Gopinathan, R. Mathan Raj, and K. Ram Kumar, "Fabrication and Testing of Fibre Reinforced Polymer Composite Materials," *IOSR Journal of Mechanical and Civil Engineering*, pp. 27–34.

[15] *Fiber-Reinforced Polymer Composites: Pursuing the Promise*, U.S. Department of Energy, Advanced Manufacturing Office.