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A REVIEW ON MECHANICAL PROPERTIES OF GFRP WITH DIFFERENT FILLER MATERIALS

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Abstract - *The trends in the mechanical characterization of composite materials with different fillers materials to make it a hybrid composite. In the present study an effort is made to understand the behavior of different combination of filler material to the Glass Fiber Reinforced Polymer (GFRP) and test results are compared. The Mechanical properties of the materials are discussed here, for the hybrid composite the epoxy resin is used as a binder, by adding the filler to the composite material we can further improve the mechanical properties and performance of composites.*

Key Words: **Composite materials, Hybrid composites, Mechanical Properties**.

1. INTRODUCTION

Two or more chemically distinct materials combined to have improved properties is known as a composite material these two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. A composite material consists of two phases namely Primary and secondary phase, primary phase forms the matrix within which the secondary phase is imbedded Primary phase has any of three basic material types: polymers, metals, or ceramics. Secondary phase is referred to as the imbedded phase or called the reinforcing agent it serves to strengthen the composite (fibers, particles, etc.). There are five basic types of composite materials namely fiber, particle, flake, laminar or layered and filled composites. Composite materials are classified as, (a) Metal Matrix Composites (MMCs): Mixtures of ceramics and metals, such as cemented carbides and other cermets, e.g., Aluminum or magnesium reinforced by strong, high stiffness fibers (b) Ceramic Matrix Composites (CMCs): Least common composite matrix, e.g., Aluminum oxide and silicon carbide are materials that can be imbedded with fibers for improved properties, especially in high temperature applications. (c) Polymer Matrix Composites (PMCs): Thermosetting resins are the most widely used polymers in PMCs. e.g., Epoxy and polyester are commonly mixed with fiber reinforcement. Matrix material serves several functions in the composite, provides the bulk form of the part or product, Holds the imbedded phase in place, and Shares the load with the secondary phase. Composites can be very strong and stiff, yet very light in weight, so ratios of strength-to-weight and stiffness-to-weight are several times greater than steel or aluminum, Fatigue properties are generally better than for common engineering metals, Toughness is often greater than most of the metals, Composites can be designed that do not corrode like steel, Possible to achieve combinations of properties not attainable with metals, ceramics, or polymers alone. The glass is the most commonly fiber used in polymer matrix composites because of its high strength, low cost, high chemical resistance and easy available fiber. The addition of natural fiber to the glass fiber can make the composite hybrid and glass fiber has high strength/weight ratio. Fillers are introduced to reduce the cost of composite without affecting its basic properties. The mechanical properties of filled hybrid composites depend mainly on size, shape, distribution and volume fraction of filler in the hybrid composite. At present, polyester resins are widely used in various engineering and structural applications. In order to reduce cost of materials used, with improve in their processing and product performances, various fillers are added into the resins during processing. Though hybrid composites are susceptible to mechanical damage, when subjected to tension, compression, and flexural loads resulting in interlayer delamination/debonding. Use of low cost easily available fillers may be useful to bring the cost of component down. Over the past several decades an enormous efforts have been made to study the mechanical characteristics of composites.

2. LITERATURE REVIEW

Manjunath Shettar et al [1] made the experiment on An Experimental Study of Mechanical Properties of GFRP Hybrid Composite with Different Fillers. In this the investigations on the composite specimens were carried out to determine the tensile strength and flexural strength. Hematite ore filled composite shows better tensile strength and chicken feather filled composite shows the better flexural strength, than the unfilled composite. Hence, it proves that depend up on the requirement of properties of composite, the different fillers can be used. Last, the use of filler materials reduced the production cost of composite.

Manjunath Shettar et al [2] made an experiment on Fabrication and Experimental Study of Mechanical Properties of GFRP with Cement as Filler Material for Fishing Boat Application, In this research work, glass fiber reinforced polyester composites filled with cement filler

have been successful fabricated by simple hand lay-up technique. It has been noticed that the mechanical properties of the composites such as tensile strength, flexural strength, impact strength and hardness of the composites are also greatly influenced by the filler content, ie., as the percentage of cement increases the property of the material.

R.Balaji et al [3] conducted experiment on Experimental Study of Mechanical Properties and Drilling Properties of Glass Fiber Composite. This paper presents an investigation on aspects of various mechanical properties and drilling of Glass fiber Mat Composite. Drilling experiments was conducted to study the delamination factor and hole quality on GFRP composites. Also the study carried out for Tensile Strength, Hardness and Flexural Strength of Glass Fiber Composite. Glass fiber is used as a fiber, SIC and ZNO as filler material. Results indicated that the Composite have the Tensile Strength of 272.43 N/mm2 and an ultimate tensile load of 34 KN. feed rate and cutting speed are seen to contribute the most to the delamination effect.

T. Madhusudhan et al [4] did experiment on mechanical characteristics and tribological behavior study on natural - glass fiber reinforced polymer hybrid composites: a review, the author shows that the combination of Glass/Jute, Glass/Sisal increases the tensile strength, Flexural and Impact strengths. Incorporation of Natural Rubber to the Glass Fiber composites increases Tensile and Fracture toughness as well as flexibility. Bi-directional Glass fiber reinforced epoxy composite showed better wear resistance than unidirectional reinforced composites. Incorporation of natural fiber with GFRP can improve properties and used as an alternative material for other synthetic composites.

Pavan Hiremath et al [5] studied Investigation on Mechanical and Physical Properties of GFRP-Egg Shell Powder Hybrid Composites. The work was focused on to analyses the influence of egg shell powder as filler materials on the mechanical behavior of glass fiber, reinforced resin matrix. All composite with filler material exhibited better tensile strength than unfilled composites. Adding filler material might have resulted in restriction of propagation of crack and delamination. The shape and size of egg shell powder was the fine-tuning factor. By using egg shell filler material the composite doors can be made stiffer and less economical for domestic applications. Also where the reduced flame propagation property is required egg shell powder filled hybrid composites could be the best option. But where the water absorption is key factor then this type of hybrid composites could not be the right choice.

N.S. Mohan et al [6] has done experiment on Fabrication and Investigation of Epoxy resin based Glass Fiber-Coconut Fiber Hybrid Composite Material, this research work shows the result of Tensile testing of 6% treated coir fiber specimens show the best tensile characteristics. The tensile strength and Young's Modulus were found to be decreased with incorporation of coir fibers. The Impact test results shows that the impact strength is highest for the 4% treated coir fiber specimens, it is observed in this case that as the percentage of alkali treatment of fibers increases, the impact strength decreases. From the results of the flexural test it is evident that 6% treated fibers yield the best results. this could be due to the fibers bonding better with the resin. A higher percentage treatment could cause degradation to the fibers. Therefore, natural fiber composites can also be very cost effective material for application in building and construction areas, storage devices, electronic devices, automobile and railway coach interior parts, toys and other miscellaneous applications.

T. Madhusudhan et al [7] made experiment on Investigation on wear resistance behavior of sic filled hybrid composites, the author shows that the study wear test was conducted on polymer matrix composites with ceramic filler with a view of investigating variation of the wear resistance. Unfilled polymer composites shows higher wear loss when compared to composites filled with SIC filler. The wear resistance of the material increases with increase in the filler content of SIC in all the material combination subjected to test. Wear loss of the material increases with increase in the abrading distance irrespective of the combination used. The material combination with Sisal and Glass fiber shows maximum wear loss when compared all other combination for same testing condition.

TP Sathishkumar et al [8] made experiments on Glass fiber-reinforced polymer composites - a review. This research work shows that the mechanical, dynamics, tribological, thermal and water absorption properties of GFRP composites have been discussed. Ultimate tensile strength and flexural strength of the fiber glass polyester composite increased with increase in the fiber glass V_f of fiber weight fractions. The elastic strain of the composite increased with the fiber glass V_f up to 0.25, and then subsequently decreased with further increase in fiber glass V_f. The Young's modulus of elasticity of the composite increased with the fiber glass V_f. The damping properties of GRP were improved by increasing the GF content in composite and the natural frequency was measured for all conditions lower wear was found for more fiber incorporated in the polymers. Compressive and impact strengths decrease.

Syed Altaf Hussain et al [9] conducted experiment on Machinability of glass fiber reinforced plastic (GFRP) composite materials. the author studied machinability of GFRP composite tubes of different fiber orientation angle vary from 30 to90 degrees. In machining of GFRP composites the surface roughness is highly influenced by feed followed by cutting speed and fiber orientation angle. Depth of cut has very little effect in machining GFRP composites. While machining GFRP composites moderate cutting speed, low feed rate, moderate depth of cut and low fiber orientation angle are preferred.

T. Madhusudhan et al [10] conducted experiment on the experimental study on wear behavior of sic filled hybrid composites using taguchi method. The author concludes that the material was predominantly influencing the wear character, followed by load on the material, later abrading distance and then by speed of rotation of disc. Taguchi material analysis is best suited to minimize the number experiments.

Moneeb Genedy et al [11] made experiment on Improving Fatigue Performance of GFRP Composite Using Carbon Nanotubes. The research in this paper is to demonstrate that the fatigue life of GFRP can be significantly improved by an order of magnitude by incorporating Multi-Wall Carbon Nanotubes (MWCNTs) during GFRP fabrication. GFRP coupons were fabricated and tested under static tension and cyclic tension with mean fatigue stress equal to 40% of the GFRP tensile strength. Microstructural investigations using scanning electron microscopy (SEM) and Fourier Transform Infrared (FTIR) spectroscopy were used for further investigation of the effect of MWCNTs on the GFRP composite. The experimental results show the 0.5 wt.% and the 1.0 wt.% MWCNTs were able to improve the fatigue life of GFRP by 1143% and 986%, respectively, compared with neat GFRP.

Prof T. Madhusudhan et al [12] made experiment on a review on mechanical properties of natural fiber reinforced hybrid composites, the author states that the mixing of natural fiber with Glass-Fiber reinforced polymers are finding increased applications. The hybrid composite has better strength as compared to the composite fabricated separately.

Madhusudhan T et al [13] the experiment shows that Comparison of Hybrid Composites with Different Filler Material. In this paper material with two fiber and tungsten carbide filler shows higher strength when compared with polymer composites with 3 fiber and SIC carbide as the filler material. The cold treatment has degraded material strength in all the mechanical characteristics except the hardness. The bonding between the materials may be the reason for decrease in the strength. Cold treatment has increased only the hardness of the material. This may due to increased brittleness. The hybrid material with aramid-glass-carbon fibers filled with SIC has showed higher strength than hybrid material with aramid and glass fiber filled with WC. This may be due to the resistance of the fibers or may be due to incorporation of SIC filler material

3. CONCLUSIONS

The above review shows the physical and mechanical properties and GFRP composites with different filler materials, a lot of research is going on in GFRP due to its wide range of use in various applications. The following may be concluded based on this review.

- Use of filler material reduces the cost of the composites.
- Hematite ore filled composites shows better tensile strength.
- Chicken feather filled composites shows better flexural strength.
- As the percentage of cement increases in composite, the mechanical property of that material increases.
- The feed rate and cutting speed are seen to contribute the most to the Delamination effect.
- Adding filler material might have resulted in restriction on propagation of crack and delamination.
- By using egg shell filler material the composite doors can be made stiffer and less economical for the domestic applications.
- Observation on composite proves that as the percentage of alkali treatment of fiber increases the impact strength of the material decreases.
- Natural fiber composites can be cost effective for building and construction.
- Ultimate tensile strength and flexural strength of the fiber glass polyester composite increased with increase in the fiber glass V_f of fiber weight fractions.
- While machining GFRP composites moderate cutting speed, low feed rate, moderate depth of cut and low fiber orientation angle are preferred.
- Fatigue life of the material can be increased by incorporating multiwall carbon nanotubes.
- The wear resistance of the material increases with increase in the filler content of SIC.
- The combination of Glass/Jute, Glass/Sisal increases the tensile strength, Flexural and Impact strengths.

Incorporation of natural fiber with GFRP can improve properties and used as an alternative material for other synthetic composites.

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