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# Recent Developments of Hybrid Fiber Reinforced Composites in the Field of Mechanical Engineering: A Review

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**Abstract—***Fiber reinforced polymer composites are used in various engineering fields due to their good properties like corrosion resistance, high durability, and high strength to weight ratio. Hybrid composites are made by blending the natural fibers and synthetic fiber with each other as reinforcement material in an appropriate matrix material such epoxy to obtain the desired properties which cannot be obtained alone by a natural fiber composite or synthetic composite fiber. Hybridization of the fiber composite materials is required to obtain a combination of properties such as tensile modulus, compressive modulus, etc. which cannot meet from single FRP composite. This paper reviews the recent research and developments of fiber reinforced composites and their applications in the field of mechanical engineering. FRP composites have a wide range of application areas in mechanical engineering such as aerospace sector, marine sector, and automobile sector and in field of wind turbine etc.*

**Keywords:** *Hybrid composites, strain rate, tensile strength, natural fiber.*

## Introduction

Hybrid FRPcomposites are made of two or more composite fibers which are used as reinforcements in a suitable matrix material such as epoxy. These reinforced materials (fibers) could be of two types either synthetic fibers or natural fibers. While synthetic fibers have higher strength and stiffness they lacks in ductility and have brittleness in nature and on the other side natural fibers have superior ductility and toughness and dampening characteristics.

The other reason of using hybrid composites is due to their less density and thus they contribute to reduce the weight and hence the system become less bulky. In the field of aerospace industry where we cannot accommodate more weight in space these materials shows great application. In the field of automobile also weight reduction leads to greater fuel economy and less emissions[1].

Some of the synthetic fibers which are worldwide used are: 1. Glass fiber 2. Carbon fiber 3.basalt fibers etc.

In today's world where sustainability and recyclability is major concern the use of natural fibers is getting more attention. Some of the commonly used natural fibers in the industry are:

**Table1. Natural fibers used across the globe and their production[2]**

| Natural Fiber | Production in ($10^3$tons) |
|---|---|
| Sugar cane | 75,000 |
| Bamboo | 30,000 |
| Jute fiber | 2300 |
| Kenaf | 970 |
| Flax | 830 |
| Sisal | 375 |
| Coir | 100 |
| Ramie | 100 |

The performance of composite materials is affected by various characteristics such as 1. Orientation of fibers [3] 2. Strength of fibers [4] 3.physical properties of fibers [5] 4. Interfacial adhesion property of fibers [6].

## Mechanical properties of Hybrid FRP Composites

Wenjie Wang and Xuejie zhang discussed about Strain rate effect on the dynamic tensile behaviour of flax fibre reinforced polymer while working on flax fibre reinforced polymer (FFRP) composite under static and dynamic loadings using a high-speed servo-hydraulic testing machine with a strain rate ranging from 0.764 $s^{-1}$ to 135.68 $s^{-1}$ .The results show that the tensile strength, failure strain, DIF and energy absorption of FFRP increased with the strain rate when it was higher than 79.12 $s^{-1}$[7].

Hande Sezgin and Omer B Berkalp studied a four plied jute, carbon, E-glass fabric-reinforced hybrid composite with different stacking sequences, manufactured by vacuum infusion technique, to understand the structure of the composites, fiber weight and fiber volume ratios in the

laminate system. The mechanical properties of samples are obtained by tensile test and v- notched charpy test. It is seen that jute fabric-reinforced polyester composite has the lowest tensile strength while carbon fiber-reinforced composite has maximum tensile strength [8].

Qasim S. Khan, M. Neaz Sheikh, et al. in their studies on Fibre Reinforced polymer bars found that when compression test is performed on GFRP and CFRP bars according to ASTM D695-10 it has been found that the failure was due to the separation of longitudinal fibers. The modulus of elasticity of CFRP bars was 1.6 times of GFRP bars in compression [9].

Sutanu Samantha, M. Muralidhar et al. used bamboo, Jute and Glass fiber to fabricate the four-layer composite samples in different stacking order by hand layup technique and compressive and tensile modulus were evaluated and it was found that tensile modulus was greater than the compressive modulus [10].

Hasan Ikbal et al. in his research found that low elongation fibers breaks first followed by higher failure strain under compressive loading. Also as low elongation fiber content increases in sample ultimate compressive strain decreases [11].

Rami A. Hawileh, Adi Abu-Obeidah et al. studied the temperature effect on the mechanical properties of carbon glass and carbon-glass laminate hybrid composite and found that due to the exposure to temperature the strength decrease in the Carbon and Glass composites is more as compared to composites made of carbon- glass hybridization[12].

J.V. Muruga lal Jayan et al. investigated the mechanical strength of double strap FRP joint with different stacking sequence such as

$0^0$, angle ply $[+45^0/-45^0]$, cross ply $[0^0/90^0]$and found that maximum ultimate loads and displacement are found in $0^0$ laminates[13].

G. Seshanandan et al. investigated the effect on the mechanical properties of Nano titanium oxide particles in hybrid jute-glass composites. In his research he mixed $TiO_2$ particles in hybrid FRP composite in 2%, 4% and 6% weight fractions. It was seen that by mixing of 6 % $TiO_2$, there was an increment of 24% in tensile strength, 50% in flexural strength and 43.7% increment in shear strength[14].

K. Naresh et al. in his research paper investigated the effects of varying strain rate on FRP hybrid composite. The testing material was Glass, Carbon, and epoxy based composite and it was seen that tensile modulus increases for Glass-Epoxy composite by 2.8 times[15].

**Application Areas of Hybrid Composites in Mechanical Engineering**

**a) Automobile sector**

Due to increased demand of weight reduction and to enhance the fuel efficiency, hybrid composite are more demanded in automobile industry.

**Table 2: Application of polymer composite in automobile**

| Component | Polymer composite (in percentage) |
|---|---|
| Exterior component | 40% |
| Interior component | 25% |
| Structural component | 20% |
| Powertrain component | 15% |

Automobile parts such as seat back, pillar cover, car windshield, spoilers, front and rear bumper, door panel, hood, roof panel are made of hybrid fibers like epoxy/glass/carbon and natural fibers.

**a) Aeronautical sector**

Aero planes needs materials with high specific properties. Glass and Carbon hybrid composites are mainly used in aeronautical applications due to their superior strength. Natural fibers are used in the parts where the elastic modulus value has less importance, because of less cost of material.

Fiber epoxy composites are used in aircraft engine parts.

Pilot's cabin doors of aircraft are made up of composite materials mainly hybrid composites.

Boron graphite hybrid composite is used in fighter jets.

**b) Wind power generation**

Wind turbine blades requires good dampening properties and good stiffness thus to impart both of these qualities with low cost blades of wind turbines are made of glass/carbon/ jute (any natural fiber) hybrid composite. Here glass and carbon fibers provide stiffness to matrix and jute fiber provides dampening characters.

**c) Marine application**

Earlier ships have many parts made of metals which under water are susceptible to corrosion and also metal have low strength to weight ratio thus to make a large part such as hull of ship welding at various places is required which creates many heat affected zones which are areas of stress concentration and exposure to corrosion and thus reduced fatigue life to avoid these problems the hulls of ships are now made of hybrid composites because they have high strength to weight ratio and less corrosive nature.

## Conclusion

From the adobe paper following conclusion can be drawn:

- Hybrid composites have high strength to weight ratio as compared to metals and they can be mixed as the desired properties are required.
- Natural fibers in hybridization with synthetic fibers have various applications in field of mechanical engineering such as Automobile, Aeronautical, wind turbine and marine areas.

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