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A Review on Mechanical and Physical Properties of Hybrid Polymer Composites

Srinivasa C S ¹, Sanket S Shetty ², Sudarshan B ², Yashas B Shetty ², Shashank V Poojary ²

Assistant Professor, Department of Mechanical Engineering, Alva's Institute of Engineering and Technology,

Moodbidri, (Affiliated to Vishvesvaraya Technological University, Belgaum) Karnataka, India ¹

U.G. Student, Department of Mechanical Engineering, Alva's Institute of Engineering and Technology, Moodbidri,

(Affiliated to Vishvesvaraya Technological University, Belgaum) Karnataka, India ²

ABSTRACT: For researchers, polymer composites have recently become one of the important aspects in so many different fields. This is because the strength-to-weight ratio of polymer composites is higher than that of most traditional alloys and composites that are used for different fields today. In addition, to reach the maximum mechanical properties and physical properties, researchers are also coming up with different kinds of hybrid polymer composites. Therefore, the focus of this analysis of hybrid polymer composites is on the different Mechanical features and physical characteristics. This thorough analysis is an effort to achieve the key elements of this area as research holes that are not done to date. The bond of the materials would result in epoxy resin in the hybrid composite. By applying the filler to the composite material, the performance of composites can be further improved. Production of natural fiber and filler composites for certain engineering applications as a sustainable alternative material, especially in the field of aerospace and automotive applications.

KEYWORDS: Hybrid Composites, Impact, Flexural, Tensile Strengths, Mechanical strength, Thermal stability, Morphology, Flame retardancy, Crystallinity.

I. INTRODUCTION

Scientists and researchers have been in the midst of earlier research and development to find better energy sources such as gas, steam, crude oil, etc. But researchers have been looking constantly for structural materials in today's world that can transcend the limitations of current traditional materials. Composite materials which are made out of fibers that are naturally available will have the better benefit of lightweight, very good biodegradability character and also available at low cost compared to other materials[1]. The use of polymer composites in structural components will also help to reduce major problems such as corrosion and fatigue, resulting in material loss and therefore resource loss. Although it has very good reasonable properties, composite materials are still evolving with the technologies. Lots of innovations are ongoing for better yield [2]. This also finds its use in aircraft, tanks, and bulletproof jackets for military combat. Polymer matrix composite products are used by the electrical and electronic industries in laptops, computers, cell phones, printers, fans, coolers, air conditioners, watches, etc. Although synthetic fibers have very good exhibiting properties than the natural fibers it has some disadvantages [3]. Many of the corrosion problems are resolved by polymer matrix composite in consideration of many engineering applications. Among all the composite materials seashell has a very good biodegradability feature [4]. Because of the environment-friendly nature and the problem-free disposal and nontoxic in nature fibers which are naturally available play a major role[6].

II. HYBRID POLYMER COMPOSITES

If a component has a mixture of two or more different reinforcement fibers or other materials is called hybrid polymer composites. Either it is polymer-based, metal-based, or ceramic-based irrespective of the base which came from these reinforcements gives strength and very good bonding with the matrix as well as the composite material. Different fibers have different densities, a structural diameter that is extracted, and different mechanical strength values.

Fiber	Diameter (μm)	Density (g/cc)	Young's modulus (GPa)	Tensile strength (MPa)
Abaca	10 to 30	1.5	31.1 to 33.6	430 to 813
Jute	25 to 250	1.3 to 1.49	13 to 26.5	393 to 800
Pineapple	20 to 80	1.44	34.5 to 82.5	413 to 1627
Sisal	100 to 300	1.44	9 to 20	227 to 400
Flax	12 to 16	1.5	27.6 to 80	345 to 1500
Coir	100 to 460	1.15	4 to 6	108 to 252
Bamboo	10 to 30	0.91	35.91	503
Banana	160 to 200	1.35	3.5	56

Table 1: Physical and mechanical properties of natural and artificial fibers

In a hybrid composite material, using synthetic fibers as reinforcement material in the mixture can expect better mechanical and physical properties, and also if we think about the overall cost of the component with synthetic fibers is a bit costly but still, it yields good strength [10]. By the hybrid polymer composites we can expect better surface properties in composite material and it is mentioned in the recent work too [11]. In hybrid composite material better properties we get by very good compatibility and bonding between the reinforcement and the matrix [12]. In the case of hybrid composite material, the collaborative stress transfer will be there and which helps in both ductility and the brittleness in the component. A lot of interiors and exterior structural and non-structural design and decorative work can be done using these composites [13].

III. MECHANICAL PROPERTIES OF HYBRID POLYMER COMPOSITES

Impact properties

The impact strength of a hybrid polymer composite is nothing but the failure that occurs due to the load which is impacted on the material. There are different kinds of testing methods researchers follow to get the exact impact result on the material.

In a study [1] it's far said that the hybrid palm and Bagasse fiber composite samples of percentage 60:40 with alkaline remedy will display the effect power price of 2KJ/m². And the alternative untreated composite of the equal percentage will display the effect power price of 1.5KJ/m². By those comparisons, it's been concluded in the paper that alkaline handled samples give 33% boom withinside the effect power as compared untreated one.

[3] In this look at they've performed the test with 25% weight of glass fiber and 5% weight of Rice husk, 30% top of the glass fiber and 20% weight of glass fiber & 10% weight of RH and that they were given the outcomes as 447.195J/m, 370. seventy-seven J/m land 357.73J/m respectively. From those outcomes, they've concluded that lowering the glass fiber and growing the RH changed into now no longer truly affect the polymer composite.

In one of the research on [6] hybrid Palm-epoxy composite, it's been observed that there's a development withinside the case of a boom withinside the filler material. It has been concluded that this development in effect power cost is handiest due to the deposition of palm leaf stem stalk withinside the configuration regions. And additionally due to the reduced bond power among the epoxy matrix and palm fiber.

In one of the take a look at [7], it's been perceived that there may be a boom of 11.39% ineffective electricity fee among the comparative take-a-look at the specimen without graphene and with graphene.

In this study [9] they achieved a higher impact strength value of 831.74 KJ / m² in the hybrid composite. They achieved an impact strength value of 461.21 KJ / m² in jute and an impact strength value of 350.39 KJ / m² in the glass fiber composite that the hybrid compound has very good impact strength.

Flexural properties

The main intention in doing a flexural test is to get or measure the result from the composite material of how much bending force it can sustain.

In this study [1] the results indicated that the hybrid palm and Bagasse fiber composite samples of proportion 60:40 with alkaline treatment exhibit the maximum flexural strength value of 28.79MPa and another untreated composite of the same proportion exhibit the flexural strength value of 20.01MPa. So it is stated in the study that the flexural strength value of the untreated composites is 43.90% lower as compared to treated composites. From these results, they concluded that the bond between the fiber and matrix was made by the alkaline treatment will always increase the flexural strength of the composite.

In one of the studies [3], it is showed that the hybrid polymer composite material with 25% weight of glass fiber and 5% weight of rice husk in entire sum exhibits the flexural strength value of 275.51MPa. On the other side, it is observed that the flexural strength value is decreased by 8.8% by changing the weight percent ratio as 20% weight of glass fiber and 15% weight of rice husk. By these results, they have also quoted that the main load-carrying member in the sandwich composite is the skin of the composite. It is only because of the outer layers and the number of layers the bending strength and the stiffness properties were controlled.

In this study [6] it has been related that the flexural strength value is gradually increasing with decreasing filler material contained in the composition. It is also noted that the main cause for the sub-stranded flexural strength is formed stress concentration zones that lead to cracks in the material.

In a study on [7] hybrid MWCNT and graphene composite material, it has been noticed that there is a 35.4% increase in flexural strength value in the case of the composition made without the graphene filler material. It was also observed that it is best suitable for all kinds as it is showing better properties.

After experimenting [9] on three different composite materials they got the result as 32.35MPa, 3080MPa, and 32.55MPa of hybrid composites, Jute fiber composite, and glass fiber composite respectively. By these results, it has been concluded that because of the orientation, volume fraction, and dimension difference it is showing poor results as compared to the tensile strength.

Tensile properties

To get the effectiveness and quality of the material when it is stretched towards a certain load that is going to be used in different sectors plays an important role in the modern era. Irrespective of the application every composite material will undergo a tensile test and a few more to sustain the marketplace in its way.

In this study [1] the results indicated that the hybrid Palm and bagasse fiber composites samples of proportion 60:40 with alkaline treatment exhibit the maximum tensile strength value of 19.80MPa and another untreated composite of the same proportion exhibit the tensile strength value of 13.79MPa, so that it is clearly stated in the study that the untreated composites tensile strength value on comparing with percentage is 43.58% lower than the treated composites.

In one of the studies [2], it is determined that the tensile strength property of composite laminate is drastically increasing with the increase in the strain rate, and on the other side, it is also quoted that the tensile strength of the composite laminate is eventually decreasing with the increase in the temperature in all the strain rates.

In a recent study [3] it is illustrated that the hybrid composite material with 25% weight of rice husk showed the highest tensile value of 215.42MPa. But on the other hand, it is observed that the tensile strength value is decreased by 25% by varying the weight percentage ratio as 15% weight of glass fiber and 15% weight of rice husk and lastly it has been concluded in the study that if the percent of glass fiber decreases the high tensile strength value will also decrease.

In one of the recent studies [4] on hybrid Seashell with a composite material with three different compositions as 35% Seashell with 25% glass fiber, 40% Seashell with 20% glass fiber, and 45% Seashell with 15% glass fiber and keeping the 40% epoxy resin constant throughout. By these composition testing results, they have concluded that the composition one and three are exhibiting the better tensile strength because of the better interfacial distribution of Seashell and glass fiber in the resin. Composition two is imposed as decreased in tensile strength because of the high resin void content in the mixture of the composite.

In [5] one of the comparison studies on carbon nanotubes and graphene sheet it had resulted that instead of using carbon nano-tube as reinforcement as a replacement if we use graphene sheet as a reinforcement there is recorded increased Young's modulus. Tensile strength and surface crack energy as 18%, 8.7%, and 5% respectively. The importance of nano-reinforcement and polymer matrices in a composite material is also noted.

Work is also explored in biomaterial as a reinforcing. In one of the studies [6] on hybrid palm-epoxy composite with bio-material as a filler material. It has been observed that as the filler material quantity is increased in the composition will eventually decrease the tensile strength of the composite material. This result is taken into consideration as it is only because of the poor bonding between the filler material and the epoxy matrix. It also causes micro-cracks during the time of loading. It is also recited that the other motive for the poor tensile strength was the irregular stress distribution among matrix and fiber.

In a study [7] on hybrid multiwall carbon nanotubes and graphene material, the experiment was conducted with and without filler materials. It has been observed that there is an increase of 19.44% in modulus of elasticity in a hybrid polymer composite specimen which was made with MWCNT and graphene. And the specimen which was made only with graphene filler material has shown a 28% increase in Young's modulus as compared with the filler material MWCNT.

An experiment study [9] on the Jute, cotton, and glass fiber reinforced hybrid composites. IT has been noticed that the glass fiber composite has a very good Young's modulus value of 1.33GPa, which is close to the glass fiber composite material. They had also concluded that comparing all the three composite jute is showing poor tensile strength.

IV. PHYSICAL PROPERTIES OF HYBRID POLYMER COMPOSITE

Mechanical strength

Improvement of mechanical properties is an essential objective to achieve technical applications of polymer composite [8]. The results of the tensile strength of the fiber-reinforced composites E, E/SF, E/BF, E/CF, and E/SBCF are shown in Fig. 3. The tensile strength of pure composite E is noted to be much lower than that of composite E/SF, composite E/BF, composite E/CF, and composite hybrid E/SBCF. Compared to the hybrid E/SBCF composite, the overall tensile strength obtained in the E/SF composite is greater. The composites exhibited higher impact strength than the plain resin, and for all glass-ramie fractions. Impact strength greatly improved when glass fiber was applied to the composite [16].

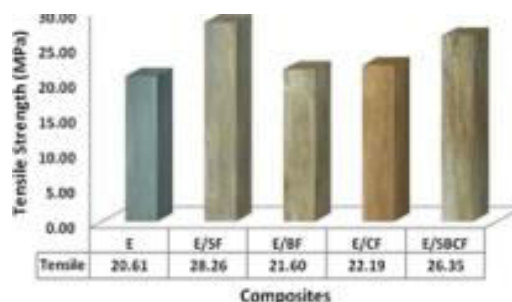


Fig. Variations of Tensile strength with different fiber composites

Thermal conductivity

It is also important for the thermal conductivity of composites to determine conditions for heat flow. Conductivity to thermal Properties are independent of direction and can be calculated under conditions of both steady-state and transient heat flow. Transient methods are determinations of the thermal Diffusivity, which may be the thermal conductivity Derived.

Polymers are applied to antistatic agents to decrease their tendency to attract electrical power. Controlling static control in some plastic production and processing, electricity is necessary. Handling operations, as well as finished goods. The Static Plastics charges can generate shocks, present fire hazards Dust and attract it [08].

Corrosion resistance

Polymer composites can be designed for excellent corrosion (somewhat of a misnomer) resistance to specific hostile environments. Much emphasis must be placed upon the selection of a suitable resin system when designing against a hostile chemical environment. However, attention to the details of design is needed to ensure that optimum performance is achieved [15].

Good corrosion resistance is not just achieved by selecting an optimum resin. The whole manufacturing process, installation, and service life needs to be optimized. Composite materials are highly anisotropic and this results in more basic mechanical properties being required for a basic characterization. In addition, their high anisotropy complicates the test methods and gives different properties in tension, compression, and shear [18].

Morphology

The fractured surface morphology of the samples was analyzed using an EM-30AX scanning electron microscope. The morphology analysis of polymer intercalated clay nanocomposite is very much important to understand the texture, nature, fracture mechanism, and toughening properties of polymer composite. Aliphatic diamine has been used as a curing agent in epoxy/intercalated clay nanocomposite[8].

The scanning electron and tapping-mode atomic force microscopy are used to study the fracture surface topology. The morphological properties like fiber breakage, fractured edge of fiber, fiber pull out, dislocation of fiber, and orientation of the fiber of each tested specimen and matrix due to mechanical loading were studied [26].

Water Absorption Test

Water absorption tests were carried out for each specimen, with dimensions of 20 mm × 20 mm × 5 mm, as per ASTM D 570-98. In the water absorption test fibers, reinforced epoxy matrix composites were studied by immersion in normal water at room temperature for 120 hours. The test samples were prepared as per ASTM D 570. The Samples were taken out of the water after a fixed duration of time and cleaned with the help of a dry cloth to remove water from the surface. The moisture absorption quantity in the composites is calculated by weighing the samples in a periodic interval of time. The percentage of water absorptive is expressed as the ratio of increase in mass of the samples to the initial mass [17].

S.No	Flax: Bamboo(%)	Immersion time(hrs)	Weight ofsamplebeforeimmer sion(g)	Weight ofsampleafterimmers ion(g)	%ofWeightgain (%)
1	0: 40	120	41.50	46.63	11
2	10:30	120	44.72	49.74	10.09
3	20:20	120	40.17	45.32	11.36
4	30:10	120	38.24	42.18	9.3

Table 2. Water absorption test values

Flame retardancy

Flame retardancy can be accomplished by inhibiting or disrupting the combustion cycle of composite materials. For composite materials, the combustion cycle can be disrupted in three different ways. Firstly, introducing the chemicals that decompose endothermically when subjected to heat prevents the temperature of composite materials from exceeding the pyrolysis temperature. Secondly, adding those chemicals that during pyrolysis reaction create more non-flammable by-products and more char. This char layer serves as a physical barrier that hinders the transfer of heat and mass between the gas and condensed phase [14].

This mechanism is called the mechanism of condensed phases. The third method is known as the mechanism of the gas phase. In this scenario, FR-chemicals release more non-flammable gases during combustion, leading to a decrease in the effective oxygen concentration in the flame zone and thereby acting as an FR agent [14].

Polymer	Ignition temperature (°C)	Thermal degradation temperature (°C)
Polyethylene	370	399
Polypropylene	330	354
Poly(styrene)	319	356
Epoxy resin	427	427
Nylon-6	430	424

Table.3 Flammability of some composite-making polymer matrix.

Crystallinity

It is well known that the crystallization process plays a crucial role in the properties of semi-crystalline polymers and that the presence of carbon fibers as reinforcement can also affect this process. However, the images obtained by polarized light optical microscopy in this work do not show any evidence of nucleation under the cooling rates performed, when analyzed in the range of 0.5 to 20 °C/min. Also for the slowest cooling, as it can be seen, the crystal growth seemed to take place homogeneously. While the formation of PPS crystallites was highly homogeneous, a different behavior was observed for the cooling performed at 5 °C/min [12].

The very low thickness of the produced polymer film allowed the depiction of crystallite nucleation on the microfilament surface due to the creation of a bubble on the surface of a carbon fiber microfilament. It is assumed that nucleation detection was only possible due to the film thickness, as there was no overlapping of crystallites. In addition, the development of crystals tends to evolve in a very homogeneous way, as before. A trans crystalline coating can also be seen on the carbon fiber base, due to nucleation. Such a phenomenon was not visualized far from the fiber on the bubble boundary, which eliminates the probability that the layer generated was the result of the existence of the bubble.

V. CONCLUSIONS AND FUTURE SCOPE

We have implemented an automatic text detection technique from an image for Inpainting. Our algorithm successfully detects the text region from the image which consists of mixed text-picture-graphic regions. We have applied our algorithm on many images and found that it successfully detects the text region.

The physical, mechanical, and dynamic mechanical characteristics of fiber-reinforced polyester composites are defined in this article. With the addition of glass fibers, the flexural and impact properties of glass-reinforced polyester composites have been found to increase. In comparison, the slight difference in fiber length did not show a clear impact on the composites' flexural properties. It was clear that the hybrid fiber had a high degree of intensity and compactness relative to the solitary fiber structure. The manufacture of the polymer composite with the rough-surfaced fiber tightly bound with the matrix was specifically revealed.

For hybrid composite with the maximum percentage of jute fibers, a storage module, loss module, and glass transition temperature were found to be high due to strong adhesion between fibers and matrix that causes effective transfer of stress. The composite of the hybrid indicated better thermal stability at temperatures greater than epoxy, and everything additional composites. The literature shows that jute and banana fibers are the two natural fibers that are mostly used reinforcements in hybrid polymer composites.

Kevlar hybrid composites also have outstanding mechanical properties, especially under conditions of impact loading, which makes them ideal for military applications. Composite materials have good mechanical, electrical, chemical properties, due to which we can use composite material in many various industries. Various automotive and aerospace parts are made by composite content due to their positive characteristics. Composite items such as chairs, walls, doors, mating, civil building, etc are used for domestic purposes. We may use composite material for improved production of the components in the maritime, chemical industry, and athletics.

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