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NYLON/GLASS FABRICS SYNTHETIC REINFORCED POLYMER HYBRID COMPOSITES

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ABSTRACT

Composite materials are being widely used in many light weight & high strength applications because of their excellent directional oriented properties. Their use becomes imperative in many corrosive environments. Commercially available synthetic fibers are used widely in many applications for composites fabrication owing to their high strengths and modulus. They also have good strength comparable with synthetic fiber reinforced composites. To take advantages of both natural and synthetic fibers, they can be combined in the same matrix to produce hybrid composites that take full advantages of best properties of the constituents. In this work, an attempt has been made to check the effort of fibers when it has been evaluated its mechanical and chemical properties to see the behavior of the composite material on nylon/glass fabrics synthetic reinforced polymer hybrid composites

1. INTRODUCTION

Fiber reinforced polymer materials are composites consisting of high strength fibers (reinforcement) embedded in polymeric matrices. Fibers in these materials are the load-carrying

Elements and provide strength and rigidity, while the polymer matrices maintain the fibers alignment (position and orientation) and protect them against the environment and possible damage. A pure polymer does not usually have requisite mechanical strength for application in various fields. The reinforcement by high strength fibers provides the polymer substantially enhanced mechanical properties and makes the fiber reinforced polymer composites (FRPCs) suitable for a large number of diverse applications ranging from aerospace to sports equipment.

The FRPCs are developed primarily using synthetic fibers such as glass, carbon, aramid, Kevlar etc. Synthetic FRPCs have unique advantages over monolithic polymer materials. Besides high strength and high stiffness, these composites have long fatigue life and adaptability to the intended function of the structure. Additional improvements can also be realized in the synthetic FRPCs with regarding corrosion resistance, wear resistance, appearance, temperature-dependent behavior, environmental stability, thermal insulation and conductivity1. Specific properties of these materials (such as high-stiffness, high-strength, and low-density as compared to metals) make the material highly desirable in primary and secondary structures of both military and civilian aircraft. These FRPCs are also used in various forms in the transportation industry. Ship structures incorporate composites in various forms. Kevlar or equivalent aramids have many applications in aerospace such as landing gear doors, aircraft cabin and jet engines. Although the SFRPCs possess exclusive mechanical strength, they have got some serious drawbacks such as high cost, high density (as compared to polymers), and poor recycling and nonbiodegradable

Properties. The biodegradability of the natural plant fibers may present a healthy ecosystem while the low costs and good performance of these fibers are able to fulfill the economic interest of industry. But still the mechanical strength of a natural fibers reinforced polymer composite (NFRPC) could not match that of a SFRPC and the natural fibers would not replace synthetic fibers in all applications. Composite materials have been increasingly used in automotive engineering, aerospace development, marine technology, electronic devices, and construction industries.

2. FUNDAMENTALS OF COMPOSITES

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Modern composite materials are usually optimized to achieve a particular balance of properties for a given range of applications. Given the vast range of materials that may be considered as composites and the broad range of uses for which composite materials may be designed, it is difficult to agree upon a single, simple and useful definition. However, as a common practical definition, composite materials may be restricted to emphasize those materials that contain a continuous matrix constituent that binds together and provides form to an array of a stronger, stiffer reinforcement constituent. The resulting composite material has a balance of structural properties that is superior to either constituent material alone. The improved structural properties generally result from a load-sharing mechanism. Although composites optimized for other functional properties (besides high structural efficiency) could be produced from completely different constituent combinations than fit this structural definition, it has been found that composites developed for structural applications also provide attractive performance in these other functional areas as well. As a result, this simple definition for structural composites provides a useful definition for most current functional composites. Thus, composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase. Many types of reinforcements also often have good thermal and electrical conductivity, a coefficient of thermal expansion (CTE) that is less than the matrix, and/ or good wear resistance. There are, however, exceptions that may still be considered composites, such as rubber-modified polymers, where the discontinuous phase is more compliant and more ductile than the polymer, resulting in improved toughness. Similarly, steel wires have been used to reinforce gray cast iron in truck and trailer brake drums.

3. POLYMER MATRIX COMPOSITE

Polymers make ideal materials as they can be processed easily, possess lightweight, and desirable mechanical properties. It follows, therefore, that high temperature resins are extensively used in aeronautical applications. Two main kinds of polymers are thermosets and thermoplastics. Thermosets have qualities such as a well-bonded three-dimensional molecular structure after curing. They decompose instead of melting on hardening. Merely changing the basic composition of the resin is enough to alter the conditions suitably for curing and determine its other characteristics. They can be retained in a partially cured condition too over prolonged periods of time, rendering Thermosets very flexible. Thus, they are most suited as matrix bases for advanced conditions fiber reinforced composites. Thermosets find wide ranging applications in the chopped fiber composites form particularly when a premixed or molding compound with fibers of specific quality and aspect ratio happens to be starting material as in epoxy, polymer and phenolic polyamide resins. Thermoplastics have one- or two-dimensional molecular structure and they tend to at an elevated temperature and show exaggerated melting point. Another advantage is that the process of softening at elevated temperatures can reversed to regain its properties during cooling, facilitating applications of conventional compress techniques to mould the compounds. Resins reinforced with thermoplastics now comprised an emerging group of composites. The theme of most experiments in this area to improve the base properties of the resins and extract the greatest functional advantages from them in new avenues, including attempts to replace metals in die-casting processes. In crystalline thermoplastics, the reinforcement affects the morphologyto a considerable extent, prompting the reinforcement to empower nucleation. Whenever crystalline or amorphous, these resins possess the facility to alter their **c**reep over an extensive range of temperature. But this range includes the point at which the usage of resins is constrained, and the reinforcement in such systems can increase the failure load as well as creep resistance.

3.1 GLASS FIBRES

Glass fibers are manufactured by drawing molten glass into very fine threads and then immediately protecting them from contact with the atmosphere or with hard surfaces in order to preserve the defect free structure that is created by the drawing process. Glass fibers are as strong as any of the newer inorganic fibers but they lack rigidity on account of their molecular structure. The properties of glasses can be modified to a limited extent by changing the chemical composition of the glass, but the only glass used to any great extent in composite materials is ordinary borosilicate glass, known as E-glass. The largest volume usage of composite materials involves E-glass as the reinforcement. S-glass (called Rglass in France) has somewhat better properties than E-glass, including higher thermal stability, but its higher cost has limited the extent of its use. Wallenberger and Brown (1994) have recently described the properties of experimental calcium aluminate glass fibers with stiffness as high as 180GPa. Over 95% of the fibers used in reinforced plastics are glass fibers, as they are inexpensive, easy to manufacture and possess high strength and stiffness with respect to the plastics with which they are reinforced. Their low density, resistance to chemicals, insulation capacity are other bonus characteristics, although the one major disadvantage in glass is that it is prone to break when subjected to high tensile stress for a long time.. However, it remains break-resistant at higher stress-levels in shorter time frames. This property mitigates the effective strength of glass especially when glass is expected to sustain such loads for many months or years continuously.

Period of loading, temperature, moisture and other factors also dictate the tolerance levels of glass fibers and the disadvantage is further compounded by the fact that the brittleness of glass does not make room for prior warning before the catastrophic failure. But all this can be easily overlooked in view of the fact that the wide range of glass fiber variety lend themselves amicably to fabrication processes like matched die moulding, filament winding lay-up and so on. Glass fibers are available in the form of mats, tapes, cloth, continuous and chopped filaments, and yarns. Addition of chemicals to silica sand while making glass yields different types of glasses.

3.2 NYLON

Nylon is a generic designation for a family of synthetic polymers, more specifically aliphatic or semi-aromatic polyamides. They can be melt processed into fibers, films or shapes. The first example of nylon (nylon 66) was produced on February 28, 1935, by Wallace Carothers at DuPont's research facility at the DuPont Experimental Station Nylon polymers have found significant commercial applications in fibres (apparel, flooring and rubber reinforcement), in shapes (moulded parts for cars, electrical equipment, etc.), and in films (mostly for food packaging. Nylon is one of the most widely used plastics in the world, especially as a bearing and wear material. Nylons are frequently used as replacements for bronze, brass, aluminum, steel and other metals, as well as other plastics, wood, and rubber. Nylons offer extremely good wear resistance, coupled with high tensile strength and modulus of elasticity. They also have high impact resistance, a high heat distortion temperature, and resist wear, abrasion, and vibration. In addition, nylons can withstand sustained contact with a wide variety of chemicals, alkalies, dilute acids or oxidizing agents. Another important factor, both economically and mechanically, is the relative light weight of nylon -- approximately 1/8 the weight of bronze, 1/7 the weight of cast iron, and 1/2 the weight of aluminum -- which reduces both the inertial and static loads and eases the handling of large components during maintenance or replacement procedures

Nylon is a thermoplastic silky material, first used commercially in a nylon-bristled toothbrush (1938), followed more famously by women's stockings ("nylons"; 1940) after being introduced as a fabric at the 1939 New York World's Fair. Nylon is made of repeating units linked by amide bonds and is a type of polyamide and is frequently referred to as such Nylon was the first commercially successful synthetic thermoplastic polymer. Commercially, nylon polymer is made by reacting monomers which are either lactams, acid/amines or stoichiometric mixtures of diamines (-NH_2) anddiacids (-COOH). Mixtures of these can be polymerized together to make copolymers. Nylon polymers can be mixed with a wide variety of additives to achieve many different property variations. Nylon was intended to be a synthetic replacement for silk and substituted for it in many different products after silk became scarce during World War II. It replaced silk in military applications such as parachutes and flak vests, and was used in many types of vehicle tires After initial commercialization of nylon as a fiber, applications in the form of shapes and films were also developed. The main market for nylon shapes now is in auto components, but there are many others.

4. MATRIX MATERIALS

Although it is undoubtedly true that the high strength of composites is largely due to the fiber reinforcement, the importance of matrix material cannot be underestimated as it provides support for the fibers and assists the fibers in carrying the loads. It also provides stability to the composite material. Resin matrix system acts as a binding agent in a structural component in which the fibers are embedded. When too much resin is used, the part is classified as resin rich. On the other hand if there is too little resin, the part is called resin starved. A resin rich part is more susceptible to cracking due to lack of fiber support, whereas a resin starved part is weaker because of void areas and the fact that fibers are not held together and they are not well supported.

4. EXPERIMENTATION

4.1 SPECIMEN PREPARATION & EXPERIMENTAL SETUP

In this work experimental analysis was carried out to study the tensile behavior of nylon/glass hybrid natural composite. Three different types of nylon & glass composites were fabricated by varying the fiber volume.

4.2 Specimen preparation

The composite specimens were fabricated using commercially available nylon & glass fabric. The laminates were fabricated using hand lay-up technique with a stacking sequence of [0/90]. A commercially available unsaturated polyester resin (epoxy) was mixed with hardener in suitable proportions. For nylon reinforced composite the number of layers varied from 5 layers to 25 layers. The curing time was around 24hrs at normal room temperature.

4.3 SPECIMEN CONFIGURATION FOR TENSILE TEST

For Tensile testing of all the composites, ASTM-3039D standard was adopted. Figure shows the specimen configuration.

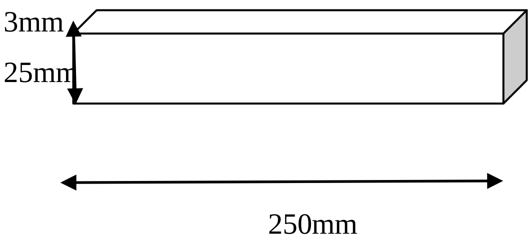
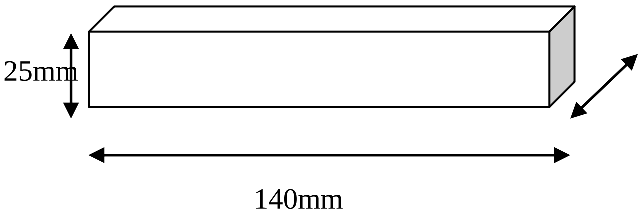


Fig1. Specimen configuration for tensile test

The specimens were tested without tabs in a standard UTM (universal testing machine). The cross head rate was 10mm/min. Load displacement curves were obtained for all the specimens. For each type of composite three tests were performed & their tensile property was evaluated.

4.4 SPECIMEN CONFIGURATION FOR COMPRESSION TEST

For compression testing of all the composites, ASTM D6641 standard was adopted. Figure shows the specimen configuration.



Fig;2. Specimen configuration for compression test

The specimens were tested without tabs in a standard UTM (universal testing machine). The cross head rate was 10mm/min. Load displacement curves were obtained for all the specimens. For each type of composite three tests were performed & their compressive property was evaluated.

5. METHODOLOGY

Hand lay-up is the simplest and oldest open molding method of the composite fabrication processes. It is a low volume, labor intensive method suited especially for large components, such as boat hulls. Glass or other reinforcing mat or woven fabric or roving is positioned manually in the open mold, and resin is poured, brushed, or sprayed over and into the glass plies. Entrapped air is removed manually with squeegees or rollers to complete the laminates structure. Room temperature curing polyesters and epoxies are the most commonly used matrix resins. Curing is initiated by a catalyst in the resin system, which hardens the fiber reinforced resin composite without external heat. For a high quality part surface, a pigmented gel coat is first applied to the mold surface.

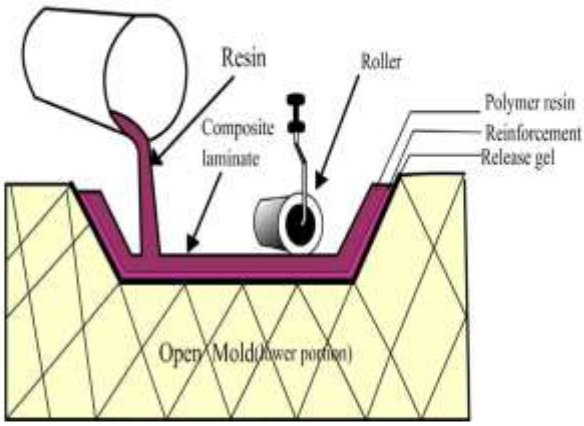


Fig 4 Hand Lay-Up Method

The most basic fabrication method for thermoset composites is hand layup, which typically consists of laying dry fabric layers, or "plies," or prepare plies, by hand onto a tool to form a laminate stack. Resin is applied to the dry plies after layup is complete (e.g., by means of resin infusion). In a variation known as wet layup, each ply is coated with resin and "debulked" or compacted after it is placed.

Hand lay-up molding is used for the production of parts of any dimensions such as technical parts with a surface area of a few square feet, as well as swimming pools as large as 1600 square feet (approx. 150 m^2). But this method is generally limited to the manufacture of parts with relatively simple shapes that require only one face to have a smooth appearance (the other face being rough from the molding operation). It is recommended for small and medium volumes requiring minimal investment in molds and equipment.

6. RESULTS & DISCUSSIONS

6.1 Behaviour of composites under tensile loads for different volume fractions

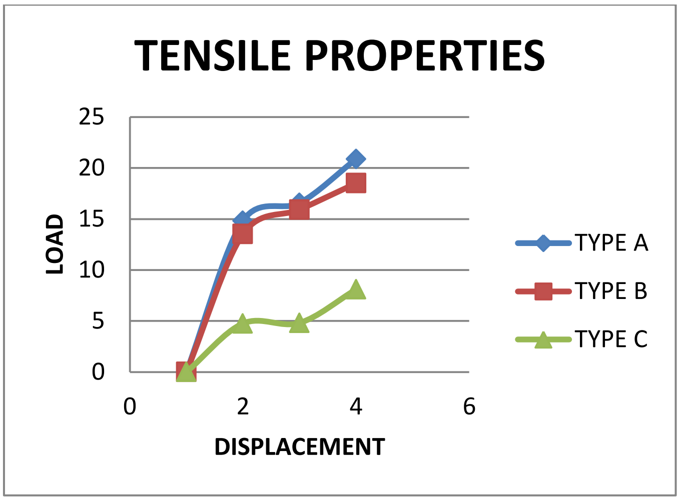


Figure shows the variation of ultimate strength with fiber volume for nylon/glass reinforced composite .It can be seen that TYPE-A withstands more tensile loads than the other two types of composites. In type-A the percentage of glass fabrics is more than the nylon. It consists of 75% of the glass and remaining 25% nylon. From the above graph it can be concluded that the composite with more glass fibers can withstand more tensile loads than the other two models.

6.2 Behavior of hybrid composites under tensile loads for different volume fractions :

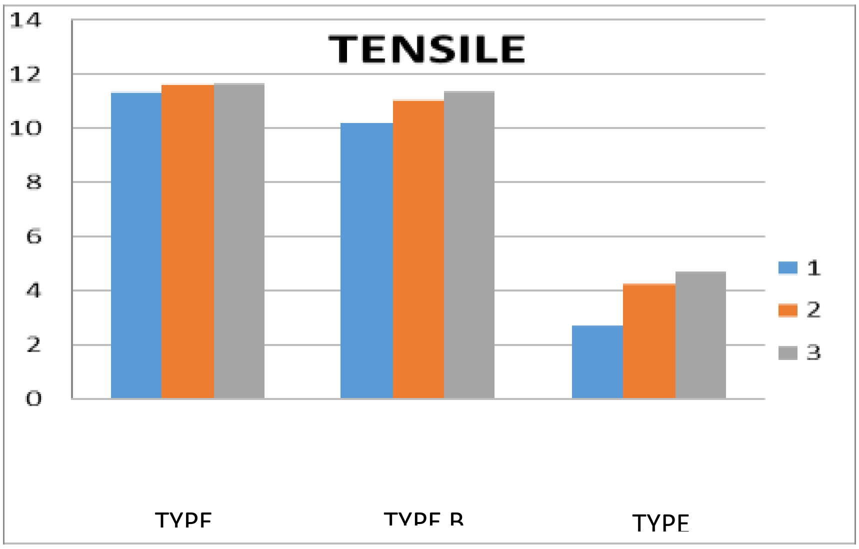
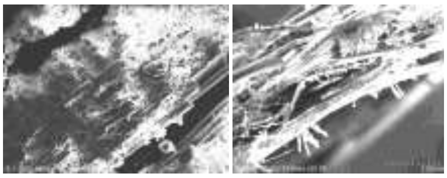


Figure shows the variation of ultimate strength with fiber volume for nylon/glass reinforced composite .It can be seen that TYPE-A withstands more tensile loads than the other two types of composites. In type-A the percentage of glass fabrics is more than the nylon. It consists of 75% of the glass and remaining 25% nylon. From the above graph it can be concluded that the composite with more glass fibers can withstand more tensile loads than the other two models. The above graph shows the variation of various types of models of type-A, B & C.



Fig; SEM testing

7. CONCLUSION

In this work an attempt was made to determine the tensile, compressive properties of nylon/glass reinforced synthetic polymer hybrid composite. Tensile & compressive tests were conducted on four specimens of each type of composite & the average was considered for the value. The following observations were made:

- The strength of the composites increased as the glass fiber volume increased for all types of composite specimens irrespective of fiber and matrix materials.
- The ultimate strength of the hybrid composites increased with fiber volume up to certain fiber volume fraction and decreased thereafter.
- Polyester composites have higher strength than the epoxy composites for the same fiber volume.
- Finally it can be concluded that by comparing among the three types of hybrid composites TYPE-A has the better mechanical properties

8. SCOPE FOR FUTURE WORK

There is a big scope for carrying out further study on the composites some of them which are listed below.

- The composites can be mixed with different materials like graphite powder, fly ash, etc., to improve the strength.
- The same resin can be reinforced with other available new natural fibers to fabricate different composite.
- Other tests like impact test, flexural test, impact test etc., can be done to determine other mechanical properties.
- Effect of environment on the mechanical properties of the same composite can be evaluated.

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