

INTRODUCTION OF NEW COMPOSITE MATERIAL IN MECHANICAL APPLICATIONS

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Abstract

Increasing the needs of different engineering applications invite the development of new materials. This work deals with fabrication and investigation of mechanical properties of fiber such as Glass fiber and Chopped strand mat with Epoxy resin. The Glass fiber and Chopped strand mat were prepared with various weight ratios (50:50 and 75:25) and then incorporated into the Epoxy matrix by hand lay-up technique. Synthetic Fiber composite are a class of materials which are currently replacing the natural fiber composite for practical applications. The glass fiber and Chopped strand as reinforcements used separately. Fiber is used to laminate the composite on top and bottom, which improves the surface finish and adds strength. Advantages of Chopped strand mat are light weight, low cost, simple maintenance and superior corrosion resistance have been recognized although the design of fiber reinforced materials are typically not well understood as those for metallic counterpart. Glass fibers alone have very less Young's modulus, shear modulus and Poisson's ratio and because of this disadvantage this material is not recommended for many works in aircrafts. The mechanical properties such as tensile strength, flexural strength and impact values were evaluated. This study shows that addition of glass fiber and chopped strand mat composites of 50-50% and 50%-75% of weight results in increasing the mechanical properties. The results indicated that this composite used as alternate material for natural fiber polymer composites.

Key words: Glass Fiber, Chopped strand mat, Epoxy resin , Mechanical properties, Hybrid.

1.Introduction

Composites

Today construction industry is revolutionizing in two major ways. One way is the development of construction techniques, such as using automated tools in construction. The other is the

advancement in high-performance construction materials, such as the introduction of high strength composite. We are introducing the new systems for carrying out the tensile test in the universal testing machine to get the accurate results. Due to the poor mechanical properties of the glass fiber reinforced plastic material; there is a need to go for alternatives like

aluminium foil and other natural fibers. But the aluminium foil are too costly therefore a combination of glass fiber with chopped strand mat can get the assured mechanical properties. These materials could then be a very good, easy-to-manufacture alternative for cellular metals in most of their applications (e.g. in the core of car bonnet, shock absorbers) because of the interesting properties associated with their low weight. The main advantage of crumpled materials compared to foam would be the ease, and hence the cost, of the manufacturing process. But the mechanical properties of natural fiber composites are less than that of synthetic composite like glass fiber reinforced polymer (GFRP). The present study tells us the results of chemical treatments on flexural and tensile properties of chemical compound composites made-up by reinforcing treated chopped strand mat into 50-50 and 50-75 mixture of contemporary and recycled epoxy matrix. The advancement of FRP composites in car bonnet has resulted in the combination of two or more different fibers such as chopped strand mat and glass into a structure to improve its mechanical performance at little cost.

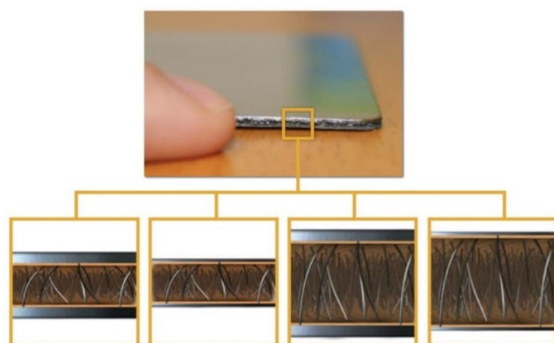


FIG.1.1.1 COMPOSITES

Types of Composites:

Composites can be grouped into categories based on the nature of the matrix each type possesses.

They are

- a) Metal Matrix Composites (MMC)
- b) Ceramic Matrix Composites (CMC)
- c) Polymer Matrix Composites (PMC)
- a) Metal Matrix Composites (MMCs)

Examples of matrices in such composites include aluminum, magnesium and titanium. The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large coefficient of thermal expansion, thermal and electrical conductivities of metals can be reduced by the addition of fibers such as silicon carbide.

b) Ceramic Matrix Composites (CMCs)

Examples of matrices such as alumina, calcium, aluminosilicate reinforced by silicon carbide. The advantages of CMC include high strength, hardness, high service temperature limits for ceramics, chemical inertness and low density. Naturally resistant to high temperature, ceramic materials have a tendency to become brittle and to fracture. Composites successfully made with ceramic matrices are reinforced with Silicon carbide fibers. These composites offer the same high temperature tolerance of super alloys but without such a high density. The brittle nature of ceramics makes composite fabrication difficult. Usually most CMC production procedures involve starting materials in powder form. There are four classes of ceramics matrices: glass (easy to fabricate because of low softening temperatures, include borosilicate and aluminosilicates), conventional ceramics (silicon carbide, silicon nitride, aluminum oxide and zirconium oxide are fully crystalline), cement and concrete carbon components.

c) Polymer Matrix Composites

Most commonly used matrix materials are polymeric. The reason for this is twofold. In general the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. These difficulties are overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites need not involve high pressure and doesn't require high temperature. Also equipment required for manufacturing polymer matrix composites are simpler. For this reason polymer matrix composites developed rapidly and soon became popular for structural applications. Composites are used because overall properties of the composites are superior to those of the individual components for example polymer/ceramic. Composites have a greater modulus than the polymer component but aren't as brittle as ceramics. Two types of polymer composites are:

- Fiber reinforced polymer (FRP)
- Particle reinforced polymer (PRP)

Fiber Reinforced Polymer

Common fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcement and the main source of strength while matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. The fibers carry the loads along their longitudinal directions. Sometimes, filler might be added to smooth the manufacturing process, impart special properties to the composites, and / or reduce the product cost. Common fiber reinforcing agents include asbestos, carbon / graphite fibers, beryllium, beryllium carbide, beryllium oxide, molybdenum, aluminum oxide, glass fibers, polyamide, natural fibers etc. Similarly common matrix materials

include epoxy, phenolic, polyester, polyurethane, polyetherethyketone (PEEK), vinyl ester etc. Among these resin materials, PEEK is most widely used. Epoxy, which has higher adhesion and less shrinkage than PEEK, stands second for its high cost.

Particle Reinforced Polymer

Particles used for reinforcing include ceramics and glasses such as small mineral particles, metal particles such as aluminum and amorphous materials, including polymers and carbon black. Particles are used to increase the modulus of the matrix and to decrease the ductility of the matrix. Particles are also used to reduce the cost of the composites. Reinforcements and matrices can be common, inexpensive materials and are easily processed. Some of the useful properties of ceramics and glasses include high melting temp., low density, high strength, stiffness; wear resistance, and corrosion resistance. Many ceramics are good electrical and thermal insulators. Some have special properties; some are magnetic materials; some are piezoelectric materials; and a few special ceramics are even superconductors at very low temperatures. Ceramics and glasses have one major drawback: they are brittle. An example of particle reinforced composites is an automobile tire, which has carbon black particles in a matrix of poly-isobutylene elastomeric polymer. Polymer composite materials have generated wide interest in various engineering fields, particularly in aerospace applications. Research is underway worldwide to develop newer Composites with varied combinations of fibers and fillers, so as to make them useable under different operational conditions. Against this backdrop, the present work has been taken up to develop a series of PEEK based composites with glass fiber reinforcement and with ceramic

fillers and to study their response to solid particle erosion done either after the fruits have just developed or when they have ripened ready for food purposes.

Polymer fibre glass

The glass fibers are divided into three classes, E-glass, S-glass and C-glass. The E-glass is designated for electrical use and the S-glass for high strength. The C-glass is for high corrosion resistance, and it is uncommon for civil engineering application. Of the three fibers, the E-glass is the most common reinforcement material used in civil structures. It is produced from lime-alumina-borosilicate which can be easily obtained from abundance of raw materials like sand. The fibers are drawn into very fine filaments with diameters ranging from 2 to 13×10^{-6} m. The glass fiber strength and modulus can degrade with increasing temperature. Although the glass material creeps under a sustained load, it can be designed to perform satisfactorily. The fiber itself is regarded as an isotropic material and has a lower thermal expansion coefficient than that of steel. Among these synthetic fibers, the fiberglass is the least expensive and carbon being the most expensive. So the glass fiber uses in most of the applications due its economic factor and its enhanced properties.



Chopped strand mat

Chopped Strand Mat (CSM) is a non-woven mat made from 3B E-CR glass filaments, consisting of chopped fibres randomly and yet evenly orientated. The 50 mm length chopped fibres are coated with silane coupling agent and are held together using an emulsion binder. CSM is particularly suitable for hand lay-up process using thermoset resin systems to manufacture wide range of products for automobile, re-creation, chemical, electrical industries.



Resins

They are viscous liquids that are capable of hardening permanently. The resins that are used in fiber-reinforced composites are sometimes referred to as 'polymers'. Polymers can be classified under two types, according to the effect of heat on their properties.

- Thermoplastic Resins.
- Thermosetting Resins (Polyester and epoxy-High elastic model).

Thermoplastics soften with heating and eventually melt, hardening again with cooling. Typical thermoplastics include nylon, polypropylene, and ABS, and these can be reinforcement, although usually only with short, chopped fibers such as glass.

Thermosetting materials, or 'thermosets', formed from a chemical reaction, where the resin and hardener or resin and catalyst are mixed and then undergo a non-

reversible chemical reaction to form a hard, infusible product.

The determination of whether to use a thermoplastic or thermosetting resin depends largely on the application. Thermosetting resins are preferred because of their increased ability to withstand elevated temperatures. It is expected that the composite spring will be at a working temperature of 100°F to 1000°F and hence thermosetting resins are chosen as thermoplastic works well only for cold and ambient working conditions.

Epoxy resin

The resin is another important constituents in composites. The two classes of resins are the thermoplastics and thermosets. A thermoplastic resin remains a solid at room temperature. It melts when heated and solidifies when cooled. The long-chain polymers do not chemically cross link. Because they do not cure permanently, they are undesirable for structural application. Conversely, a thermosetting resin will cure permanently by irreversible cross linking at elevated temperatures. This characteristic makes the thermoset resin composites very desirable for structural applications. The most common resins used in composites are the unsaturated polyesters, epoxies, and vinyl esters; the least common ones are the polyurethanes and phenolics.

The epoxies used in composites are mainly the glycidyl ethers and amines. The material properties and cure rates can be formulated to meet the required performance. Epoxies are generally found in marine, automotive, electrical and appliance applications. The high viscosity in epoxy resins limits its use to certain processes such as molding, filament winding, and hand lay-up. The right curing agent should be carefully selected because it will affect the type of chemical reaction, pot life and final material

properties. Although epoxies can be expensive, it may be worth the cost when high performance is required.

The epoxy AY-105 was used as reinforcement and matrix respectively. The hardener HY-951 was used as curing agent. In this work the aluminium foil, glass fiber, epoxy and hardener were purchased from local supplier. Epoxy has the viscosity and lap shear at 25 °C, 11345 MPa and 12.63 MPa respectively.



Curing of epoxy resin with hardener

Epoxy resins are cured by means of a curing agent, often referred to as catalysts, hardeners or activators. Often amines are used as curing agents. In amine curing agents, each hydrogen on an amine nitrogen is reactive and can open one epoxide ring to form a covalent bond.

2. Mechanical Testing

Compressive Test

Compressive test is performed on the universal testing machine (UTM) and compression testing machine (CTM). COMPRESSIVE TESTS are performed for several reasons. The results of compressive tests are used in selecting materials for engineering applications. compressive properties frequently are included in material specifications to ensure quality. Compressive properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, compressive properties often are used to predict the behavior of a material under forms of loading other than compression.

TABLE .2.1 LOAD TEST

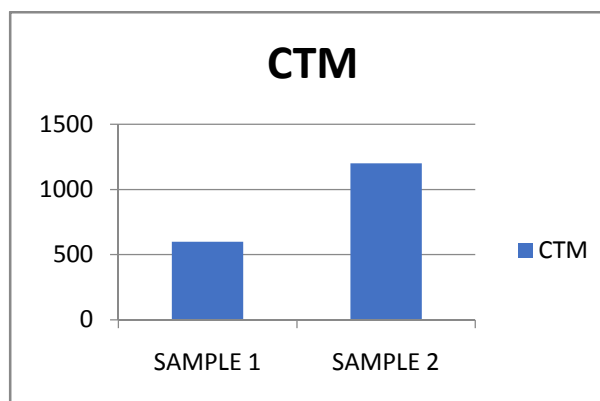


CHART 2.1 CTM TEST

Impact Test

Impact testing is of enormous importance. A collision between two objects can often result in damage to one or both of them. The damage might be a scratch, crack, fracture or break. Scientists need to know about how materials and products behave under impact and the magnitude of forces they can resist. When two objects collide, damage is often done to one or other of them. How well something resists damage is called its impact resistance. An impact test measures how much energy is

absorbed when an object fractures or breaks under a high speed collision. It's an important property. The safety of many consumer products depends on their resistance to breaking. But impact resistance is difficult to quantify. An impact testing machine with charpy arrangement is employed to perform the test. It is done as per the ASTM: D256 standards.

S.no	Composite specimen	Composite ratio	Machines	Impact
1	Sample 1	1:1	Izod impact machine	36.2KJ/m ²
2	Sample 2	2:3		44.7KJ/m ²

TABLE .2.2IMPACT TEST

s.no	Composite specimen	Composite ratio	Machine	Load KN
1	Sample 1	1:1	CTM	900
2	Sample 2	2:3	CTM	1200

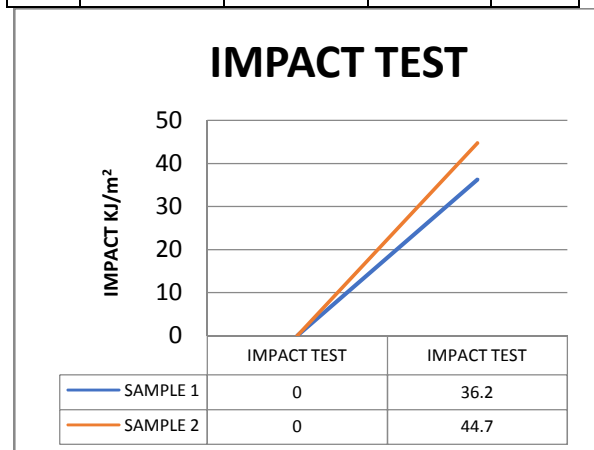


CHART 2.2 IMPACT TEST

Hardness Test

The Rockwell test is generally easier to perform, and more accurate than other types of hardness testing methods. The Rockwell test method is used on all metals, except in condition where the test metal structure or

surface conditions would be too large for the application, or where the sample size or sample shape prohibits its use. The Rockwell method measures the permanent depth of indentation produced by a force/load on an indenter. First, a preliminary test force (commonly referred to as preload or minor load) is applied to a sample using a diamond or ball indenter. This preload breaks through the surface to reduce the effects of surface finish. After holding the preliminary test force for a specified dwell time, the baseline depth of indentation is measured.

INDENTOR: DIAMOND				
s.no	Composite Specimen	Composite Ratio	Machine	Hardness Number
1	sample 1	1:1	RHN	C50
2	sample 2	2:3	BHN	Dia-0.8mm

TABLE .2.3 HARDNESS TEST

Weight Test(Tested Component)

S.No	Dimension Of The Tested Component	Weight
1	(250x25x3)mm	110g
2	(250x25x4)mm	130g

TABLE .2.4 WEIGHT TEST

4.Conclusion

Present study and experiment work show that successful fabrication of glass fiber and Chopped strand mat reinforced epoxy hybrid composite. Chemical treatment of glass fiber is good obtain interfacial bonding but due to higher amount of glass fiber proportional to the epoxy property decrease after a certain proportion. Proper homogeneous mixing of glass fiber and

chopped strand mat with epoxy composite also very important in fabrication of hybrid composite otherwise some non-uniformity is occur like air trapped between it or porosity. Epoxy resins are flexible, tough and posses very good heat resisting property. Because of polar nature of molecule they posses excellent adhesion quality.

5.Application

- Used for car bonnet application.
- Water resistant application.
- Helicopter rotor blades and drive shafts.
- Ailerons and floor panels of aircrafts.
- In automobile sector they are used in transmission units, chassis members, Suspensions, and structural body parts of cars and lorries.
- In medical world they are used for making orthoses.
- Car doors panels are made of fibers reinforcement.

6.Advantages

- They offer better flexibility in the selection of fiber and matrix materials, which helps in better tailoring of the mechanical properties. For example the modulus, strength, fatigue performance etc of glass reinforced composites can be enhanced by inclusion of carbon fibers.
- Better wear resistance
- Low thermal expansion coefficient.
- Combination of high tensile strength and high failure strain.
- Better impact and flexural properties.
- Reduced overall cost of the composite.
- Low notch sensitivity.
- Non catastrophic.

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