Fabrication and Testing of Hybrid Polymer Composite Material by Using Carbon, Glass, Kevlar Fibers

P.Madhu Raghava[1], P.V.Subhanjaneyulu[2], B.V.Amarnath Reddy[3], S.N.Pradeep Kumar Reddy[4]

[1]Department of Mechanical Engineering, SVR Engineering College Nandyal, Andrapradesh, India.

[2]Department of Mechanical Engineering, SVR Engineering College Nandyal, Andrapradesh, India.

[3]Department of Mechanical Engineering, SVR Engineering College Nandyal, Andrapradesh, India.

[4]Department of Mechanical Engineering, SVR Engineering College Nandyal, Andrapradesh, India.

ABSTRACT

Composites which made up of fiber reinforcements are universally endorsed option for the automobiles with a lightweight. Due to the unique properties of fiber-reinforced composites, it became a perfect alternative for traditionally used materials. Most of the automobile industries prefer polymer matrix fiber-reinforced composites for the reason that its light weight helps in carbon emission reduction and Additive manufacturing (AM) produces a complex shaped product from its data, layer by layer, with high precision and much less material wastage. As compared to the conventional manufacturing process, there are many positive environmental advantages of additive manufacturing technologies. Most importantly, there is less waste of raw material and the use of new and smart materials.

In this work, we first focused on creating the composite material utilizing the Hand Lay-Up method with materials such as Carbon Fiber/Epoxy Composite with Copper Oxide (CuO) Nanoparticles and Banana Glass Fiber. Following that, we readied ASTMD638 specimens for both compressive and tensile testing. We created an ASTMD638 model for the investigation's tensile and compressive tests using Solid Works design program, and we then saved the design model in STL format. This STL format was uploaded into the CURA software for slicing. The slicing model was then saved into G-code format, and it was printed in a fused deposition modeling machine. Lastly, we tested both specimens using a compressive test setup in a Universal Testing Machine model (INSTRON-3369) UTM, and the results showed 3D printed files.

Keywords: Glass Fiber, Banana Fiber, Carbon Fiber, Copper Oxide Nano filler, 3D printing Machine,Corbon Fiber Filament.

1. INTRODUCTION

The development of composite materials and their related design and manufacturing technologies is one of the most important advances in the history of materials. Composites are the material used in various fields having exclusive mechanical and physical properties and are developed for particular application. Composite materials having a range of advantages over other conventional materials such as tensile strength, impact strength, flexural strengths, stiffness and fatigue characteristics. Because of their numerous advantages they are widely used in the aerospace industry, commercial mechanical engineering applications, like machine components, automobiles, combustion engines, mechanical components like drive shafts, tanks, brakes, pressure vessels and flywheels, thermal control and electronic packaging, railway coaches and aircraft structures etc. When two or more materials with different properties are combined together, they form a composite material. Composite material comprise of strong load carrying material (known as reinforcement) imbedded with weaker materials (known as matrix).The primary functions of the matrix are to transfer stresses between the reinforcing fibers/particles and to protect them from mechanical and/or environmental damage whereas the presence of fibers/particles in a composite improves its mechanical properties like tensile strength, flexural strength, impact strength, stiffness etc. Composites can be classified according to different criteria. Depending on the type of matrix materials, composite materials can be classified into three categories such as metal matrix composites, ceramic matrix composites and polymer matrix composites. Each type of composite material is suitable for specific applications. When the matrix material is taken as metal like aluminum, copper, it is called as metal matrix composite. These are having high ductility and strength, good fracture toughness, inter-laminar shear strength and transverse tensile strength and also having superior electrical and thermal conductivity. These materials are high dimensional stable due to low thermal expansion coefficient of matrix and withstand to a high temperature.

1.1 POLYMER MATRIX COMPOSITES

Polymer matrix composites consist of a polymer resin as the matrix material which filled with a variety of reinforcements. This kind of composite is used in the greatest diversity of composite applications due to its advantages such as low density, good thermal and electrical insulator, ease of fabrication, and low cost. The properties of polymer matrix composites are mainly determined by three constitutive elements such as the types of reinforcements (particles and fibers), the type of polymer, and the interface between them. Polymers are divided into two categories such as thermoplastics and thermosets. Thermoplastic are in general, ductile and tougher than thermoset materials. They are reversible and can be reshaped by application of heat and pressure. Thermoplastic molecules do not cross-link and therefore they are flexible and reform able. Generally, thermoplastics show poor creep resistance, especially at elevated temperatures, as compared to thermosets. Their lower stiffness and strength values require the use of fillers and reinforcements for structural applications. The most common materials used in thermoplastic composites are nylon, polyetheretherketone, Acetal, polyphenylene sulfide, polycarbonate, Teflon, polyethylene etc. Thermoset are materials that undergo a curing process through part fabrication and once cured cannot be re-melted or reformed. Thermoset materials are brittle in nature and offer greater dimensional stability, better rigidity, and higher chemical, electrical, and solvent resistance. The most common resin materials used in thermoset composites are epoxy, polyester, phenolics, vinyl ester, and polyamides. Based on the types of reinforcement, polymer composites can be classified as particulate reinforced polymer composite and fiber reinforced polymer composit**es.**

1.2 COMPOSITE MATERIALS: A composite material is a combined material created from two or more components, selected filler or reinforcing agent and a compatible matrix, binder (i.e. resin) in order to obtain specific characteristics or a property that was not there before. The matrix is the continuous phase, and the reinforcement constitutes the dispersed phase. It is the behavior and properties of the interface that generally control the properties of the composite.

1.3 HYBRID COMPOSITES: Hybrid composites contain more than one type of fiber in a single matrix material. In principle, several different fiber types may be incorporated into a hybrid, but it is more likely that a combination of only two types of fibers would be most beneficial . They have been developed as a logical sequel to conventional composites containing one fiber. Hybrid composites have unique features that can be used to meet various design requirements in a more economical way than conventional composites. This is because expensive fibers like graphite and boron can be partially replaced by less expensive fibres such as glass and Kevlar . Some of the specific advantages of hybrid composites over conventional composites include balanced strength and stiffness, balanced bending and membrane mechanical properties, balanced thermal distortion stability, reduced weight and/or cost, improved fatigue resistance, reduced notch.

2. LITERATURE SURVEY AND SCOPE OF THE PROJECT: The evolution of composite material has replaced most of the conventional material of construction in automobile, aviation industry etc. Fibre reinforced composites have been widely successful in hundreds of applications where there was a need for high strength materials. There are thousands of custom formulations which offer FRPs a wide variety of tensile and flexural strengths. When compared with traditional materials such as metals, the combination of high strength and lower weight has made FRP an extremely popular choice for improving a product’s design and performance.

2.1 Literature Survey Related to Present Work: Polymer matrix composites are predominantly used for the aerospace industry, but the decreasing price of carbon Fibres is widening the applications of these composites to include the automobile, marine, sports, biomedical, construction, and other industries. Carbon Fiber polymer-matrix composites have started to be used in automobiles mainly for saving weight for fuel economy. The so-called graphite car employs carbon Fibre epoxy-matrix composites for body panels, structural members, bumpers, wheels, drive shaft, engine components, and suspension systems. This car is 570 kg lighter than an equivalent vehicle made of steel. It weighs only 1250 kg instead of the conventional 1800 kg for the average American car. Thermoplastic composites with PEEK and polycarbonate (PC) matrices are finding use as spring elements for car suspension systems. An investigation was conducted by Isaac M Daniel et.al on failure modes and criteria for their occurrence in composite columns and beams. They found that the initiation of the various failure modes depends on the material properties, geometric dimensions and type of loading. They 18 reported that the loading type or condition determines the state of stress throughout the composite structure, which controls the location and mode of failure. The appropriate failure criteria at any point of the structure account for the biaxiality or triaxiality of the state of stress. Jeam Marc et.al investigates the modeling of the flexural behavior of all-thermoplastic composite structures with improved aesthetic properties, manufactured by isothermal compression molding. A four noded plate element based on a refined higher order shear deformation theory is developed by Topdar et.al for the analysis of composite plates. This plate theory satisfies the conditions of inter-laminar shear stress continuity and stress free top and bottom surfaces of the plate. Moreover, the number of independent unknowns is the same as that in the first order shear deformation theory. Banerji and Nirmal reported an increase in flexural strength of unidirectional carbon Fibre/ Poly(methyl methacrylate), composite laminates having polyethylene Fibres plies at the lower face Li and Xian showed that the incorporation of a moderate amount of carbon Fibres into ultra-high-modulus polyethylene (UHMPE) Fibres reinforced composites greatly improved the compressive strength, flexural modulus while the addition of a small amount of UHMPE Fibres into a carbon Fibre reinforced composite remarkably enhanced the ductility with only a small decrease in compressive strength. Rohchoon and Jang studied the effect of stacking sequence on the flexural properties and flexural failure modes of aramid-UHMPE hybrid composites. The flexural strength depends upon the type of Fibres at the compressive face and dispersion extent of the Fibres. Matteson and Crane reported increase in flexural strength by using unidirectional steel wire tapes in glass Fibre composites and carbon Fibres composites. They showed that the increase in flexural strength was due to a change in failure mode from compressive buckling to nearly ductile tensile failure. Bradley and 19 Harris used unidirectional high carbon steel wires to improve the impact properties of epoxy resin reinforced with unidirectional carbon Fibre reinforced. Unfortunately, flexural design methodologies rely on their experimental boundary conditions and the particular laminate setup, since a scaling of the results is very difficult. The occurrence of usual failure modes under flexural loading conditions, like delamination, matrix tensile fracture, localized compressive failure and Fibre shear failure is strongly dependent of the material configuration (Fibre type, resin type, lay-up, and thickness), the loading type. In this respect, three point bend test equipment along with specimen indicated in figure 1 was used as a fast and cost efficient comparison tool.**Jawad Kadhim Uleiwi [11]:** Studies Investigated the effect of fibre volume fraction on the flexural properties of the laminated composite constructed of different layers, one of them having reinforced glass fibre and the other layer reinforced with Kevlar fibre has been investigated experimentally and the results illustrate that tension stress decreases with the increase in fibre volume fraction of glass fibre of the lower layer while it increases with the increase of Kevlar volume fraction of the upper layer.**Wen-Pin Lin et.al [12]:** Studies analysed the Failure of Fibre-Reinforced Composite Laminates under Biaxial Tensile Loading. With the onset of failure for individual lamina is determined by a mixed failure criterion composed of the maximum stress criteria. It was observed that after the initial damage takes place, the response of the lamina was described and observed to be brittle or degrading modes with the collapse of the entire laminate. **Amjad J. Aref et.al [13**]: Examined the structural behaviour of the fibre reinforced polymer-concrete hybrid bridge superstructure system subjected to negative moment flexural loads through experimental procedures. The experimental results showed that 20 the design of the hybrid FRP-concrete bridge superstructure under a negative flexural moment is found to be stiffness- driven instead of strength-driven.**Slimane Metiche and Radhouane Masmoudi [14]:**Studied the flexural behaviour of light weight fibre reinforced polymer (FRP) poles. Experimental results show that the use of low linear density glass-Fibres could provide an increase of the ultimate load carrying capacity up to 38 % for some fibre reinforced polymer poles. It is also observed that , the positioning of the hole in the compression side compared to the tension side leads to an increase of the ultimate load carrying capacity up to 22 % for the 5.4m (18 feet) fibre reinforced polymer poles and it was learnt that there was no significant effect (3,5%) for the 12m (40 feet) fibre reinforced polymer poles. This is mainly due to the stacking sequence and the stress states generated around the hole. **H. A. Rijsdijk et.al [15]:** Investigated the influence of maleic-anhydride-modified polypropylene (m-PP) on monotonic mechanical properties of continuous-glass-fibrereinforced polypropylene (PP) composites. This study showed an increase in composite strength as a result of the addition of maleic-anhydride- modified PP to continuous-glass-fibre-reinforced PP composites. An optimum in both longitudinal and transverse flexural strength was reached for composites based on a PP matrix with 10wt% m-PP.**P.N.B. Reis et.al [16]:** Studied the flexural behaviour of hand manufactured hybrid laminated composites with a hemp natural fibre/polypropylene core and two glass fibres/polypropylene surface layers at each side of the specimen. Laminate composites (LC) present an ultimate strength about 4% higher than the hybrid laminated composites (HLC) associated to changes in failure mechanisms, while the stiffness modulus was also about 3.8% higher. Fatigue strength of hybrid laminated composites 21 is also about 20% lower than the laminated composites as consequence of the change of the failure mechanisms and of the different static strengths.**M. Davallo et.al [17]:** Investigated the Mechanical behaviour of unidirectional glasspolyester composites to identify performance differences of composites with different glass lay-ups and laminate thicknesses during flexure and tensile testing formed by hand lay-up moulding (HLU). es. The damage generated in the composites exhibited matrix cracking on the lower face followed by the coalescence of delaminations formed within the reinforcing plies. **Michel Espinosa Klymus et.al [18]:** Evaluated the fracture pattern of four composites for indirect dental restoration relating to three-point flexural strength. Further the compressive strength and modulus of elasticity were also addressed. Composites polymerized under high temperatures (belle Glass and Targis) had higher flexural strength and elastic modulus values than composites polymerized by light temperatures (Artglass and Solidex). It was found that they failed earlier under compression because they were more rigid and showed partial fracture in the material bulk. **S. Benjamin Lazarus et.al [19]:** Investigated the mechanical properties of natural Fibre developed using a plant fibre which is used for green manuring called Sunhemp. Polyester is used as the matrix to prepare the composite. From the results the applications of the composite for some specific purposes can be decided upon since the maximum value of strength is achieved for a particular Fibre length and Fibre weight ratio.**M. Wesolowski et.al [20]**

2.2. Scope of the project: Keeping in view of the current status of research the following objectives are set in the scope of the present research work.Fabrication and testing of hybrid polymer composite material (carbon, glass, Kevlar fibres).To study the tensile, compression and flexural tests on hybrid composite material. **Materials and methods**

3.MATERIALS :The raw materials used in this works are **,**Epoxy Resin LY556**,**Hardener HY951**,** Glass Fiber**,** carbon fibre**,** Kevlar fibre

4.Methodology

4.1. EPOXY RESIN: Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxidase group. A wide range of epoxy resins are produced industrially. The raw materials for epoxy resin production are today largely petroleum derived , although some plant derived sources are now becoming commercially available (e.g. plant derived glycerol used to make epichlorohydrin)Epoxy resins are polymeric or semi-polymeric materials or an Oligomer, and as such rarely exist as pure substances, since variable chain length results from the Polymerization reaction used to produce them. High purity grades can be produced for certain applications, e.g. using a distillation purification process. **Hardener:** A hardener is a component of certain types of mixtures. In other mixtures hardener is used as a curing component. A hardener can be either a reactant or acatalyst in the chemical reaction that occurs during the mixing process. Hardeners are almost always necessary to make an epoxy resin useful for its intended purpose. Without a hardener, epoxies do not achieve anywhere near the impressive mechanical and chemical properties that they would with the hardener The correct type of hardener must be selected to ensure the epoxy mixture will meet the requirements of the application**GLASS Fiberg**lass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as"fiberglass".This material contains little or no air or gas, is more dense, and is a much poorer thermal insulator than is glass wool. Glass-reinforced plastic (GRP) is a composite material or fiber-reinforced plastic made of a plastic reinforced by fine glass fibers. Like graphite-reinforced plastic, the composite material is commonly referred to as fiberglass. The glass can be in the form of a chopped strand mat (CSM) or a woven fabric. **CARBON FIBER:** Carbon fibers are usually combined with other materials to form a composite. When impregnated with a plastic resin and baked it forms carbon-fiber-reinforced polymer (often referred to as carbon fiber) which has a very high strength-to-weight ratio, and is extremely rigid although somewhat brittle. Carbon fibers are also composited with other materials, such as graphite, to form reinforced carbon-carbon composites, which have a very high heat tolerance. To produce a carbon fiber, the carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber as the crystal alignment gives the fiber high strength-to-volume ratio (in other words, it is strong for its size). Several thousand carbon fibers are bundled together to form a tow, which may be used by itself or woven into a fabrication **KEVLAR FIBER:** Kevlar has many applications, ranging from bicycle tires and racing sails to bulletproof vests, because of its high tensile strength-to-weight ratio; by this measure it is five times stronger than steel.[2] It also is used to make modern marching drumheads that withstand high impact. When used as a woven material, it is suitable for mooring lines and other underwater applications. Kevlar maintains its strength and resilience down to cryogenic temperatures (−196 °C); in fact, it is slightly stronger at low temperatures. At higher temperatures the tensile strength is immediately reduced by about 10–20%, and after some hours the strength progressively reduces further. For example: enduring 160 °C (320 °F) for 500 hours, reduces strength by about 10%; and enduring 260 °C (500 °F) for 70 hours, reduces strength by about 50%. **RELEASING AGENT:**A release agent is a chemical used to prevent other materials from bonding to surfaces. It can provide a solution in processes involving mold release, die-cast release, plastic release, adhesive release, and tire and web release. Release agents are coated onto some plastic films to prevent adhesives from bonding to the plastic surface. Some release agents, also known as de-molding agent, form oil, parting agent or form releaser, are substances used in molding and casting that aid in the separation of a mould from the material being molded and reduce imperfections in the molded surface.

4.2 FABRICATION OF COMPOSITES

Pre-Fabrication: Before the fabrication, the fabrics and matrix (appropriate quantity of resin with its hardener based on calculations done for the required thickness and reinforcement-matrix ratio to be taken) has to be kept in oven setting the temperature at 60c so that the moisture from resin and fabric (if present) will be removed, then the resin and hardener is mixed together and gently stirred. **Fabrication:** For the fabrication of polymer matrix composite the required fibers (Reinforcement media)and Epoxy resin (Matrix material) are to be collected then by applying releasing agent on the work table mount the releasing layer then again apply the releasing agent and place the first layer of fabric and wet it then apply the next layer and again wet that follow the same procedure for all remaining layers, the wetting should be done in such a way that the resin should be distributed equally on the lamina, care should be taken that there should be no starvation or excess of resin on the lamina. After the last layer again the resin is applied and covered with Teflon sheet and then the dead weight is applied over the mold. As the mold is ready it is left to reach the gel time of the resin, as it reaches the gel time, vacuum is applied by covering the mold by vacuum bag, and is left for some time to get set so as the resin should be spread equally on mold and excess of resin can be drawn outside. After the vacuum time it is left as it is at room temperature for 24hrs to cure. Therefore it is also called as Room Temperature Vacuum Bag Molding. **Post Curing:** As the laminate is ready, it has to be subjected to post curing so that all the layers of the lamina bond together. This can be achieved by keeping the lamina in oven and set the oven to increase the temperature gradually to 500C in 15 minutes from room temperature and hold the30 minutes again ramping up to 800C in next 15 minutes and hold the temperature for 30 minutes again ramp up to 900C in 15 minutes and hold for 30 minutes then ramp up to 1200C in 30 minutes and hold for 60 minutes then let the oven cool down slowly to room temperature.

4.3. HAND LAY-UP METHOD

Hand lay-up is a simple method for composite production. A mold must be used for hand lay-up parts unless the composite is to be joined directly to another structure. The mold can be as simple as a flat sheet or have infinite curves and edges. For some shapes, molds must be joined in sections so they can be taken apart for part removal after curing. Before lay-up, the mold is prepared with a release agent to insure that the part will not adhere to the mold. Reinforcement fibers can be cut and laid in the mold. It is up to the designer to organize the type, amount and direction of the fibers24being used. Resin must then be catalyzed and added to the fibers. A brush, roller or can be used to impregnate the fibers with the resin. The lay-up technicians responsible for controlling the amount of resin and the quality of saturation.

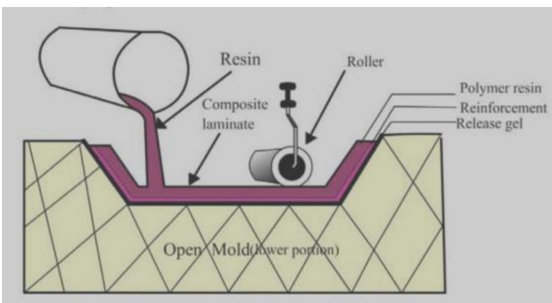

fig:3.6: Hand Layup Techniques

4.4. PROCEDURE FOR HAND LAYUP TECHNIQUE

The Glass mould is placed on the table, to make sure that mould is free from dirt; The fibers are cutting the required size of 150x150x3mm, to make different thickness of layers. Place the mould on table and apply wax on glass mold, to avoid sticking of fiber to glass mould,Resin and hardener are mix the ratio o 1:10 using measuring jar., To apply the epoxy resin on the mould and placed the first glass fiber On the mould, And then the epoxy resin is uniformly applied on the fiber. Then the second fiber is placed on the first fiber, and then is applied on second fiber and placed third fiber on it, Repeat this process with different type of layers, Mould is closed with the glass plate.

Fig: Hand Lay Experimental Set up

4.5. EXTRACTION PROCES

After fabricated the fiber composite, the fiber should be extracted using hot air oven

Fig: Extracting the Fiber

4.6. MECHANICAL TESTING

TENSILE TEST: Uniaxial tensile test is known as a basic and universal engineering test to achieve material parameters such as ultimate standard tensile specimen with known dimensions (gauge length and cross sectional area perpendicular to the load direction) till failure. The applied tensile load and extension are recorded during the test for the calculation of stress and strain. A range of universal standards provided by Professional societies such as American Society of Testing and Materials (ASTM), British standard, JIS standard and DIN standard provides testing are selected based on preferential uses. Each standard may contain a variety of test standards suitable for different materials, dimensions and fabrication history. For instance, ASTM E8: is a standard test method for tension testing of metallic materials and ASTM B557 is standard test methods of tension testing and cast aluminum and magnesium alloy products A standard specimen is prepared in a round or a square section along the gauge length as shown below, depending on the standard used. Both ends of the specimens should have sufficient length and a surface condition such that they are firmly gripped during testing. The initial gauge length Lo is standardized (in several countries) and varies with the diameter (Do) or the cross-sectional area of the specimen as listed in table 1. This is because if the gauge length is too long, the % elongation might be underestimated in this case. Any heat treatments should be applied on to the specimen prior to machining to produce the final specimen readily for testing. This has been done to prevent surface oxide scales that might act as stress concentration which might subsequently affect the final tensile properties due to premature failure. There might be some strength, yield strength, %elongation, area of reduction and Young's modulus. These important parameters obtained from the standard tensile testing are useful for the selection of engineering materials for any applications required. The tensile testing is carried out by applying longitudinal or axial load at a specific extension rate to exceptions, for examples, surface hardening or surface coating on the materials. These processes should be employed after specimen machining in order to obtain the tensile properties results which include the actual specimen surface conditions the equipment used for tensile testing ranges from simple devices to complicated controlled systems. The so-called universal testing machines are commonly used, which are driven by mechanical screw or hydraulic systems. The below figure illustrates a relatively simple screw-driven machine using large two screws to apply the load whereas next figure shows a hydraulic testing machine Using the pressure of oil in a piston for load supply. These types of machines can be used not only for tension, but also for compression, bending and torsion tests. A more modernized closed-loop servo-hydraulic machine provides variations of load, strain, or testing machine motion (stroke) using a combination of actuator rod and piston. Most of the machines used now days are linked to a computer-controlled system in which the load and extension data can be graphically displayed together with the calculations of stress and strain. General techniques utilized for measuring loads and displacements employs sensors providing electrical signals. Load cells are used for measuring the load applied while strain gauges are used for strain measurement. A Change in a linear dimension is proportional to the change in electrical voltage of the strain gauge attached on to the specimen.

Fig: 3.9: Tensile Specimens and testing (150x15x3mm)

Flexural test: Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress, The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact 'fibers'. However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile stress. Therefore, it is common for flexural strengths to be higher than tensile strengths for the same material. Conversely, a homogeneous material with defects only on its surfaces (e.g., due to scratches) might have a higher tensile strength than flexural strength. If we don't take into account defects of any kind, it is clear that the material will fail under a bending force which is smaller than the corresponding tensile force. Both of these forces will induce the same failure stress, whose value depends on the strength of the material.

Fig: flexural test specimen and testing

(150x15x3mm specimen)

Compression test: A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, "squashed", crushed, or flattened. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten. A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tension test.Compression Test machines are universal testing machines specially configured to evaluate static compressive strength characteristics of materials, products, and components. Our compression test machines measure characteristics such as ultimate compression strength, yield strength, deflection and modulus. Compression test machines are typically configured by adding compression platens to a universal test machine but we also have compression only machines available.

Fig: compression test specimen and testing

(15x3mm thickness specimen)

Several variations the most common purpose of a flexure test is to measure flexural strength and Flexural modulus. Flexural strength is defined as the maximum stress at the outermost fiber on either the compression or tension side of the specimen. Flexural modulus is calculated from the slope of the stress vs. strain deflection curve. These two values can be used to evaluate the sample materials ability to withstand flexure or bending forces.

RESULTS AND DISCUSSION

TENSILE STRENGTH OF COMPOSITES: The composite specimens are tested for tensile properties in universal testing machine and obtained tensile strength are shown in the below figure. The value of tensile strength obtained is

Specimen layers	Composition Of specimen	Max load (N)	Tensile stress(mpa)	Young`s modulus(mpa)
3 layers	1C+1K+1G	2634.32	58.54	4063.27
4 layers	2K+1C+1G	6623.45	147.41	6763.38
5 layers	2K+2C+1G	7366.24	163.63	8060.47

Table Tensile Strength Test Results

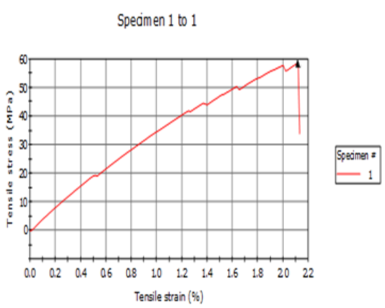

Figure :Curve shows relationship with stress strain of **3 layers(1C+1K+1G)**

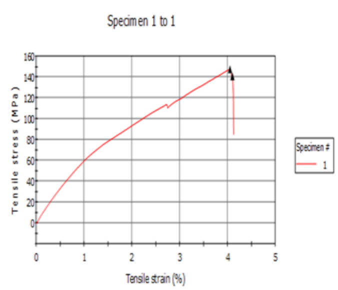

Figure :Curve shows relationship with stress strain of **4 layers(2K+1C+1G)**

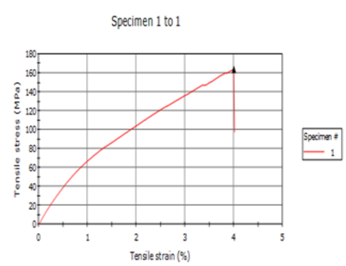

Figure :Curve shows relationship with stress strain of **5 layers(2K+2C+1G)**

4.2 FLEXURAL STRENGTH OF COMPOSITES

The flexural strength is one of the important factors in NFRPCs and the following figure shows the variations in the flexural strength of composites. The value of flextural strength obtained is

Specimen layer	Composition of specimen	Max load (kn)	Max stress (mpa)	Flex modulus (mpa)
3 layers	1C+1K+1G	0.31	174.45	7211.19
4 layers	2K+1C+1G	0.73	404.81	17381.40
5 layers	2G+2K+1C	0.86	475.88	23900.36

Table: Flexural test results

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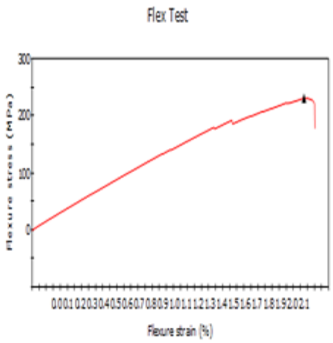

Figure :Curve shows relationship with stress strain of **3 layers(1C+1K+1G)**

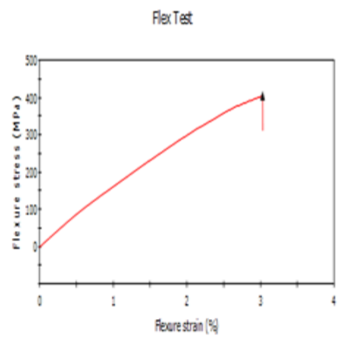

Figure :Curve shows relationship with stress strain of **3 layers(2K+1C+1G)**

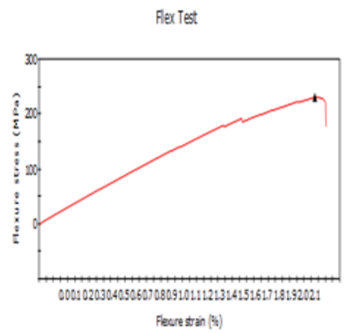

Figure :Curve shows relationship with stress strain of **3 layers(2G+2K+1C)**

4.3 COMPRESSION STRENGTH OF COMPOSITES

The composite specimens are tested for compressive properties in universal testing machine and obtained compressive strength are shown in the below figure. The value of compressive strength obtained is,

Specimen layers	Composition of specimen	Max load (KN)	Compressive stress (mpa)	Young`s modulus(mpa)
3 layers	**1C+1G+1K**	**1.61**	**100.87**	**15792.54**
4 layers	**2K+1C+1G**	**1.74**	**105.40**	**8319.71815**
5 layers	**2K+2C+1G**	**5.68**	**126.12**	**13240.19759**

Table 4.3 compressive test results

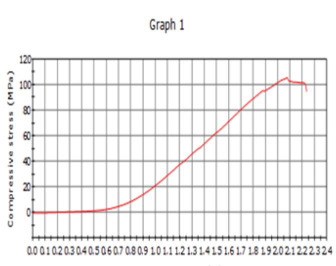

Figure :Curve shows relationship with stress strain of **3 layers(1C+1G+1K)**

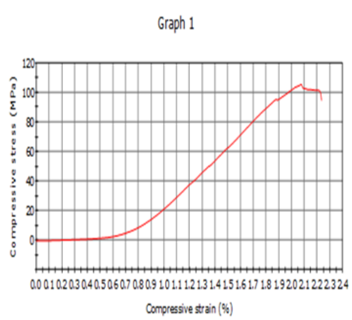

Figure :Curve shows relationship with stress strain of **3 layers(2K+1C+1G)**

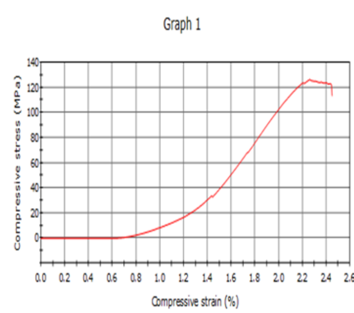

Figure :Curve shows relationship with stress strain of **3 layers(2K+2C+1G)**

DISCUSSION

In the above test results we were compared and discussed that, the tensile test by increasing the layers of fiber the tensile strength should be increase and the young`s modulus also increase. In the flexural test the sample of 3, 4, 5 layers the high bending flexural modulus should be the 5 layer specimen compared to other 2 layer samples. In the compression test we compared the three layers of composite they are 3,4,5 layers specimen. By increasing the layers of fiber the young`s modulus should be decrease. By 3 layer specimen the young`s modulus should be increase**.**

CONCLUSION

This work shows that successful fabrication of hybrid polymer composite material Used as glass carbon kevlar fiber and epoxy resin with weight percentage fabricated by simple hand lay-up technique. The mechanical properties epoxy / glass / carbon / kevlar fiber were studied. Various mechanical properties investigations were carried out based on the mechanical properties of composite material 5 layer specimen of tensile test specimen have good mechanical properties. And the 3 layer specimen compression test which gives high young`s modulus strength. In the flexural test 5 layer specimen gives good mechanical properties. Overall results when we compared the mechanical properties of composite material. We conclude addition of fiber layers has given good mechanical strength. Tensile flexural test were improved by adding of fiber layers gives good mechanical strength. In compression test normal 3 layer specimen improves the high mechanical strength. Future Work of This study leaves wide scope for future investigations. It can be extended to newer composite material by increasing of fiber layers. There is a very wide scope for future scholars to explore this area of research. Many other aspects of this problem like effect of fiber orientation layer thickness of fiber material of such composites require further investigation.

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