

FABRICATION OF NEW NATURAL COMPOSITE USED FOR AVIATION INDUSTRY

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in

Aeronautical Engineering

By

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INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade “A” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **V. Aldin Revan Paul (Reg. No. 37260003)** and **J. Arvind Siddharth (Reg. No. 37260003)** who carried out the project entitled **"FABRICATION OF A NEW NATURAL COMPOSITE USED FOR AVIATION INDUSTRY"** under our supervision from December 10 to March 2021.

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DECLARATION

We **V. Aldin Revan Paul (Reg.No. 37260003)** and **J. Arvind Siddharth (Reg No. 37260005)** hereby declare that the Project Report entitled **“FABRICATION OF NEW NATURAL COMPOSITE MATERIAL USED FOR AVIATION INDUSTRY”** done by us under the guidance of **Dr. BOMMADEVI, M.E., Ph.D.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Aeronautical Engineering.

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SIGNATURE OF THE CANDIDATE

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ABSTRACT

A novel hybrid combination of flax fibers and zirconia nanoparticles has been introduced first time as the reinforcement in composite preparation for the eco-friendly high strength mechanical properties. The natural fiber flax is combined with zirconia nanoparticle to create a new natural composite material. The flax fiber used was extracted from the plant *linum usitatissimum* as flax fibers. The zirconia nanoparticle was synthesized using sol gel method. The fabrication process is done by combining flax fiber with zirconia and epoxy bio resin and the hardener. A positive improvement was observed for the composites. When the carbon glass fiber which is currently used in the aviation industry is compared with the new natural composite material which is fabricated it is clearly shown that new composite material has a drastic improvement in the tensile strength, flexural and bending strength and in impact strength, also scanning electron microscopy of the new composite was carried out to understand the interface of the fiber nature. Thermal stability of the new natural composite material is also found higher than the carbon glass fiber. A comparative study between the carbon and new natural composite material made using natural flax fiber and zirconia nanoparticle is done. It has been proved that the new natural composite material has a potential to replace carbon glass fibers used in aviation industry.

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CHAPTER 1

INTRODUCTION

1.1 COMPOSITES

Humans are aware of composite materials since several years ago and applied made many different combinations and innovations to the development of the human life. They found that mud brick if aligned in the study will make the house and many buildings stronger. The wisdom of the ancient civilization is still a mystery for many scientists because of the structural integrity of their buildings.

Currently the need of the better and strong composite fiber is increasing day by day, many researches and innovations have been progressed in natural fibers for automobile and aerospace industries, Natural fibers like flax, ramie, timber and organic materials will have more impact in the automobile and aerospace and aviation industries, these fibers will also be ecofriendly.

The heterogeneous structures forming composites meeting the essential designs are formed by composites and these are often imbued with the characteristics desired and the classification scope is limited by them. On the other hand, new types of composites are being innovated all the times is a new fact and specific purpose is served by every type of composite such as fake, filled, laminar or particulate composite.

In the matrix of another material the fibers or particle which are embedded would be the modern-day composite material examples which in general are seen to be structural. For primary structures such as recreational structures, aero-space industry, marine and commercial scale the composite materials are more frequently used. Material, the main processing, the manufacture of some important specifications, allowable materials are some of the parts of composite which are used in the applications of aircrafts. In aircraft structures the most effective and efficient use of highly advanced composites is the highly loaded parts and their applications which include high fatigue loads, thicker gages, a winged structure named fuselage, corrosive areas or any area which are likely to undergo corrosion, reduction in critical weight such as the use of wings, fuselage etc. By weighing the benefits against costs, the use must be justified.

.1.2 DEFINITION

There are often two highly distinct phases which include matrix and dispersed phase in the composite material which is often used. They do exhibit the bulk like characteristics which are often different from the constituents.

1.2.1 Matrix phase

The matrix is a term which is used for primary phase which also have an endless character. There are few harder phases in the matrix and is typically more ductile. The dispersed particles are there to be held by the matrix and also some of the load is shared as well.

1.2.2 Dispersed (reinforcing) phase

Inside the matrix the second phase or phases are embedded in the form of something discontinuous. The dispersed phase is also known as secondary phase. As compared to matrix this is typically the stronger phase, reinforcing phase is another name given to it. Alloys, ceramics doped, some metallic alloys, additives mixed with polymers etc. are the common material which does exhibit structural dispersed phases. On the other hand, these kinds of materials are often not regarded as composite materials because the features of some of the materials used are almost similar to the basic ingredients or constituents including steel and its physical properties which are similar to iron in its pure form.

1.3 CLASSIFICATION OF COMPOSITES

Composite materials are classified into following types

- Based in matrix material
- Based on fiber reinforcement

1.3.1 Based on matrix material

The composites have classified into two based on the matrix materials

- Metal matrix composites (MMC)
- Polymer matrix composites (PMC)

1.3.1.1 Metal Matrix Composites (MMC)

MMC which is abbreviated as Metal Matrix Composites are generally made of some important metallic matrix which include some essential elements such as Iron, Cobalt, magnesium, aluminum, copper etc. The oxides and carbides are considered to be dispersed ceramics, the metallic phase of the composite include some elements such as lead, tungsten, molybdenum etc. CMC stands for Ceramic Matrix Composites and they are generally made from the ceramic matrix, the ceramic material and other embedded fibers are included in it which is considered as dispersed phase.

1.3.1.2 Polymer Matrix Composites (PMC)

Polymer Matrix Composites (PMC) are composed of a matrix from thermo set (Unsaturated Polyester (UP), Epoxy (EP) or thermoplastic (Polycarbonate (PC), Polyvinylchloride, Nylon, Polystyrene) and embedded glass, carbon, steel or fibers (dispersed phase).

1.3.2 Based on reinforcing material structure

Particulate Composites contains a matrix reinforced by a dispersed particle in sort of particles.

1.3.2.1 Fibrous Composites

Short-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of discontinuous fibers (length $< 100 \times \text{diameter}$). Long-fiber reinforced composites consist of a matrix reinforced by a dispersed phase in form of continuous fibers. They can be either unidirectional orientated fibers or bidirectional orientated fibers (woven).

1.3.2.2 Laminate Composites

When a fiber reinforced composite consists of several layers with different fiber orientations, it's called multilayer (angle-ply) composite.

1.4 MATRIX AND THEIR FUNCTIONS:

The holding of fibers together is the main function which is performed by the matrix material inside a composite material. The main function is to protect the matrix from environment and supply or distribution of load between the fibers in the even

pattern in such a way that strain level is equal on all the fibers, this can also increase the laminate's transverse properties and can enhance the fracture resistant nature of the component and its impact. This matrix can also be helpful for the avoiding of propagation in the crack growth by offering the path of alternate failure along fibers and interface along with inter laminar shear of the matrix they carry.

1.5 PROPERTIES OF A MATRIX

For the matrix the characteristics needed are those which are particularly important for the structures made of composite and are used to reduce the absorption of moisture, lesser shrinking, thermal expansion coefficient reduction, characteristics regarding good flow in such a way that in the fiber bundles the penetration is possible and voids are eliminated during the process of compacting and process of curing, strength of reasonable form, elongation and modulus. It has to be kept in mind that as compared to the existing fiber, the elasticity is must so that load can be passed on to the fibers, elevated temperature strength on the basis of applications, potential of coldness on the basis of the used application, resistance to chemical in the excellent form are some of the processes which are easily conducted for the shape of composite in ultimate form, shape maintaining stability in dimensions of the composite.

1.6 FACTORS INFLUENCING PROPERTIES OF COMPOSITE

A selected lay up or ply arrangement is the key for the structural laminate and imposed on thereon it is supported by the varied criterion. The fiber orientation for the success of pies is the laminate lay-up definition which helps in the lamination in reference to the frame over the long haul.

1.6.1 Influence of Fiber Orientation

Orientation is the key on which the strength and stiffness of a composite laminate depends especially in regard to the direction of load to the orientation of plies. To supply structurally efficient design the proper selection of ply orientation is very significant.

1.6.2 Laminate Lay-Up Code

The layup code for the lamination process and the orientation is supposed to be specified by it for the plies of every kind according to the axis of reference, orientation-based plies number, plies with their appropriate geometric sequence, at

angles the plies adjacent to the angles of orientation which in terms of magnitude are equal but their signs are opposite. There should be proper assigned positive and negative signs.

1.7 ADVANTAGES OF NATURAL COMPOSITE MATERIAL

- Resistive to corrosion and also higher resistance to fatigue
- Stiffness to weight ratio is high in terms of strength. Weight savings are starting most significantly from 25 to 45 percent of the load of conventional metallic designs as enumerated above.
- The reliability is also greater and structure repairs are lesser in number and are fewer inspections.
- To fulfill the requirements of designs the directional tailoring potential is there. The proper pattern is given to the fiber so that the structure is tailored to sustain the load applied in an efficient manner. Redundancy is found in the fiber to fiber load path.
- There is a good achievement of enhanced resistance to dent. The damage is not sustained by the composite since these composites are very thin in the form of gage sheet metals.
- To realize the profiles of smooth aerodynamics it is easy for the process of reduction of drag. With smooth surface finish the complex double curvature parts are supposed to be created during the operations of manufacture.
- Improved and enhanced torsion stiffness is offered by the composite it also reduces the intermediate bearing numbers, higher speed of whirling and structural element support. There is a reduction in the cost of assembly and common manufacturing of part count.
- To impact the damage there is higher resistance as well.
- Like metals, thermoplastics make some uncertain memories period. Thermoplastics have fast interaction cycles, making them alluring for prime volume business applications that customarily are the space of sheet metals. Also, thermoplastics can even be changed.
- Composites are dimensionally steady for example they have low warm conductivity and low coefficient of warm development. Composite materials will

be custom fitted to fits a wide scope of warm development plan prerequisites and to diminish warm anxieties

- Manufacture and get together are improved because of part mix (joint/latch decrease) in this manner diminishing expense.
- The improved climate capacity of composites during a marine climate also to their consumption obstruction and toughness lessen the personal time for support.

1.8 DISADVANTAGE OF NATURAL COMPOSITE MATERIAL

- The cost of raw material
- Clear cut designing rules are lacking
- The methods lack higher manufacturing productivity
- Raw materials and fabrication re costly
- Lesser productivity is there in the methods for manufacturing.
- Brittleness is found in composites as compared to the metallic wrought and hence they are more likely to undergo damage.

CHAPTER 2

AIM AND SCOPE

2.1 AIM

A new natural composite material is going to be prepared using one of the fabricating processes called hand lay-up process. The composite is fabricated by the combination of flax fiber and zirconia in two different ratios 5% and 10% of the zirconia mixture and epoxy resin with hardener according to the fiber's weight ratio . A set of specimens for the tensile, flexural or impact testing systems such as bending are suggested according to the testing and Materials society of America which is also known as ASTM. With the help of water jet cutting machine the standard specimen is cut according to the conditions of the ASTM standards. SEM (Scanning Electron microcopy) is preferred to view the natural behavior of the flax with zirconia nanoparticle. In this work, comparison of the tensile, flexural and impact strength properties of the new natural composite with carbon glass fiber will be shown.

2.2 SCOPE

For the composites there is a wide scope in neutral composite materials also in the industries such as automobiles, aerospace industry, wind driven energy sources, electrical industry, construction of civil structures, domesticated uses, medicinal or pharmaceutical industries, electrical industries etc. are all included in the group of industries which can make use of composite in ideally useful ways in day-to-day life. Here we will look come scope and useful areas where new composite material made up of flax and zirconia is used

2.2.1 Aerospace and Aviation industry

Today mainly the man-made materials such as carbon and glass fiber are widely used to make composite parts in aviation industries. Natural and ecofriendly materials or naturally obtained resin systems have not widely used in aviation industry and aerospace field. Many military aircrafts and civil aircrafts now contain very low quantities of lightweight and carbon glass fibers as fabricated panels and moldings. they are also used in airframes, wing spars, fuel tanks, pressured gas containers. many modern-day aircrafts are being increasingly designed to contain as much lightweight

composite materials, so natural fibers are an abundant and renewable resources, so their cost is relatively low compared to other conventional fibers. The uses of lightweight are more in need at aerospace industries, materials of high tensile strength for structural purposes, these requirements are also fitting for aeronautical structures. Since the materials should be transparent to radio frequency waves and stable towards both UV and radiation and moisture.

2.2.2 Automobile engineering

Automobile industries have increasing their interest in weight reduction in order to permit the conservation of both energy and fuel and performance of motor. By reducing the weight of an automobile structures have many benefits in fuel economy. The natural fibers have not played an important role in automobile industries till now. But they need the eco-friendly composite which can be strong and lightweight. Many sports hybrid cars need lightweight body and high rigid material to increase their performance of engine.

2.3 LITERATURE SURVEY

We investigated the behavior of different natural fibers with different nanoparticles and finally found the combination of the flax fiber and zirconia nanoparticle with bio epoxy resin will be the considerable replacement for the carbon glass fiber. The fabrication process done by using hand layup process and tensile test, flexural test and Charpy impact test was performed. Fractures surfaces were examined by scanning electron microscopy. The review of the initial work is done for the clear and better understanding.

Lina Boulos, M Reza foruzanmehr, Azezki Tagnit, Hamou, Matheiu Robert (2017). In this article the authors have carried out an experiment on the outer surface and coating techniques on the flax fibers modified with zirconia with sol gel method. In this experiment they have done some modified coating techniques to the flax materials coated with zirconia using sol gel method to improve their performance as composite reinforcement. This research is mainly based on the flax fiber and their chemical modification of the surface. The results show that nature of the differently combined fibers has a significant effect of ZrO_2 treatment on the decrease flax fiber's property of hydrophilicity.

Vishnu Prasad, K Sekar, Soney Varghese, MA Joseph (2020). In this study, the process of coating of nano titanium dioxide (TiO_2) in the natural fiber called flax fiber this is a modification technique. The process of silane coating with nanoparticles on flax fibers at the weight percentage 0.2, 0.4, 0.6 and 0.8 to develop the matrix interface and chemical properties of flax fiber. The improved interface is tested by performing many modes I, II & III interlaminar fractures toughness (ILFT) and dynamic mechanical analysis (DMA). the results indicate that the fiber modified composites with coating shows 24% improvement in toughness respectively. The storage modulus which is obtained from the DMA also shows improved fiber modified composites. SEM analysis also shows the drastic change in the ratio mechanism. FTIR analysis gives the details on the coating by nanoparticles.

The study performed by some of the investigative workers names **Anu Ajith, Gujiun Xian, Hui Li, Zajna Sherief, Sabu Thomas (2016)** indicated the process of grafting of hydrous Zirconia nano particles and that the modification of flax fiber is possible and a simple process of hydrolysis is needed for the solution of Zirconia oxychloride and the properties of binding fibers in the process and how the process is likely to impact on it are discussed and analyzed. The process of grafting is simply used in this experimental as a key process. The nano particles are taken, and the process is performed on these nano particles and the spectroscopy analysis and microscopy confirm this analysis. To an epoxy resin the test was conducted to determine the tensile and bonding strength which means the (diglycidyl ether bisphenol -f) for the flax fibers in the modified pattern. These fibers were checked with a tensile test of single fiber and other pull out tests for micro bonding in the respective manner. In the flax fiber the process of grafting is performed with the help of outcomes of nano particles and it demonstrated some remarkable and visible betterment in the shear strength as well as other mechanical characteristics. Reinforced with epoxy model composites the unidirectional flax fibers were made by the manual way and demonstrations were given to clarify the eco-friendly properties along with other important micro thermal properties. With outcomes of nano particles, the outcomes of the surface grafting for the flax can tremendously improve the transition temperature of glass and also it can enhance the storage modulus.

In the end, flax fiber can be graded by a simple process with the help of zirconia at hydrous state and to increase the mechanical properties of these flax fibers the process is found to be highly effective.

Lina Boulos, M Reza foruzanmehr, Azezki Tagnit, Hamou, Matheiu Robert (2018). In this research study compares the durability of different states of the flax fibers (untreated and treated with zirconium). They have involved a process of surface grafting of the flax fibers with zirconia and they have compared the specimens which is treated with zirconia and untreated with zirconia. The results show that the treated specimens of the flax fibers treated with zirconia exhibited improved mechanical performance due to the improved durability of the ZrO_2 treated fibers and the stronger reaction of the flax fabrics to cement and the specimens untreated with zirconia has a very low mechanical properties when compared to the specimens compared to the flax fiber treated with zirconia .

Maria Carolina Seghini, Fabienne Touchard, Laurence chocinski-Arnault, Vincent Placket (2020). This work researches the impacts of a harmless to the ecosystem treatment dependent on supercritical carbon dioxide on the interfacial response of the flax filaments with polymer lattices. The trial incorporates numerous cycles of creating a characteristic composite material which is made by normal strands, the outcomes have presumed that the common filaments have more improved mechanical properties when analyzed the composite as of now utilizing in car enterprises.

J Harding, L .MO Welsh (1983). in this diary a top to bottom examination is given of techniques utilized in endeavors taken to improve the mechanical properties of the composite material with extreme elastic burden and the issues looked in the plan of an ideal tractable effect testing machine. Hopkinson's pressing factor bar (SHPB), is portrayed powerful pressure strain bends for the unidirectional - supported carbon/epoxy composites, in which the disappointment happens in under $30\mu\text{sec}$ at a nonpartisan strain pace of around 400 sec^{-1} , are set and their necessities are appeared. An augmentation of the strategies to affirm the testing of woven overing supported glass, In the outcome the pliable modulus, and the strength consumed in cracking is resolved. the restrictions of the strategy are talked about.

Yingji Wu, Changlei Xia, Liping cai, Andres c Garcia, Sheldon Q Shi (2018). In this investigation they have a primary target to supplant the glass fiber sheet forming compound (GM-SMC) utilizing characteristic fiber support composites (NFRCs) in the vehicle business. This work has a primary goal to hoist the mechanical properties and water confirmation capacity of NFRCs by impregnating magnesium hydroxide (MH) to kenaf filaments and manufacturing composites were radically improved by 73% and 53% contrasted and ordinary NFRCs, separately. They have likewise taken SEM test, as per SEM results it presumed that the MH impregnation is observably improved the adaptability of kenaf filaments and polymer grid, which is valuable for the mechanical property improvement of the composites. The examples are contrasted with the normal NFRCs, the 24-h water absorbs ion and the protruding thickness of MH impregnated NFRC(MH-NFRC) were observably diminished by 83.9% and 84.2% separately. At the point when the composite thickness was exposed to correlation if MH-NFRC and GF-SMC the particular modulus of break and elasticity of MH-NFRC were 116% and 109.2% of the GF-SMC. They have done examination utilizing Semipro programming. The outcomes show that the natural dangers of the composites were diminished by 22.8% when contrasted with different filaments. Also, they have arrived at a resolution that the recently improved NFRC had an incredible capacity for supplanting the GF-SMC in vehicle businesses, with decreased energy use and can be ecofriendly.

Yonqiu Liu (2020). In this examination conventional detachment of the oil and water advancements have been supplanted by the improvement of the practical strands of flax. The utilization of the oil obstructions with uncommon liquidity is a promising option for isolating oil from water. The mix of flax strands by plasma-initiated poly (acrylic corrosive) (PAA) polymerization joined by nano TiO₂ fixation were discovered to have the option to have the option to improve the hydrophilicity by synchrotron. The altered fiber was described by synchrotron-based Fourier change infrared spectroscopy. The outcomes presume that the created flax fiber with this switchable conduct has promising application including the detachment of immiscible oil water combination and oil in water emulsion situations.

Famil Tak Lau, Pui – yan Hung, Min-Hao Zhu, David Hui (2018). In this examination they have done an exploration dependent on the utilization of regular filaments for underlying use of structural designing in present day days. Right now, since the characteristic fiber supported polymers (NFRP) composites have been generally usable in car and building businesses, it is as yet a space to affirm them to higher stage underlying executes like essential primary parts of aeronautics and marine designs, it is bizarre task to test the nature of regular strands and polymers. In this paper investigation on various states in identified with the utilization of common filaments for human existence designing is given. Fundamental logical constructions utilized on the pressure development in composites are additionally referenced to the give a thought for investigates and specialists to comprehend the plan and necessity of utilizing normal strands for primary use in the advanced days.

MReza Foruzanmehr, Pascal Y Vuillaume, Matheiu Robert, Said Elkoun (2015). This investigation has a primary goal in working flax filaments made on the advanced strands by the sol gel strategy. The filaments were first and foremost treated to accomplish a base acquirable unpleasantness and afterward a covering was applied utilizing the plunge coat technique. The translucent designs and the construction of the TiO₂ ground film were resolved utilizing X-beam diffraction, and Transmission Electron Microscopy. Compound and specialized properties of the TiO₂ ground flax strands were researched by a ductile test. Utilizing Dynamic contact point tensiometer was done to test the contrast between wettability of the TiO₂ united and non-joined flax strands. The outcomes in these investigation shows that the particles gained from the Sol-Gel strategy made a 100nm-thick film of TiO₂ in the mineral structure. The testing cycle of the pliable tests shows an outstanding improvement in mechanical properties of the TiO₂ joined flax strands.

MReza Foruzanmehr, Pascal Y Villaume, Matheiu Robert, Said Elkoun (2018). In this experiment, flax fibers were treated with oxide in order to increase the interfacial forcing reaction of cellulosic fibrils to a TiO₂ coating. The reaction of cellulose oxidation and the grafting of TiO₂ was observed on cellulose crystalline structures using x ray diffraction. X-ray photo electron spectroscopy is used to compare the adhesion of TiO₂ sol with non-oxidized cellulosic fibers. In addition, transmission electron microscopy and atomic force microscopy were taken to show the quality of the interface between the fibers and TiO₂ coating. The results concluded that the effect

of cellulose oxidation increased drastically the reaction time of the cellulosic surface with TiO_2 coating, the thermal resistance of the fibers is also improved. Similarly, the fiber's oxidation along with the TiO_2 grafting to increase the properties of tensile strength and ductility and rigidity

Marie Bayart, Florent Gauvin, M Reza Foruzanmehr, Said Elkoun, Mathieu Robert. PLA composites Reinforced with nano-coated flax fibers were made to treat with an SiO_2 nanoparticle coating. Flax fibers were treated by heat press by stacking four PLA films and flax fibers of three plates. Structure and scattering of the flax fibers were seen in small angle X ray scattering (SAXS), SEM (Scanning electron microscopy) and (TEM) Transmission electron microscopy. Accelerated aging of the fibers was done on the 3 materials by placing them in a 50-degree Celsius water bath until saturation to investigate the coating on the water diffusion. mechanical properties of the different composites were investigated by tensile. It was observed that fibers which is coated were also permitted the decrease in uptake of the by 10% and their protection during preserving the condition the mechanical properties.

Limbo Yan, Nawawi chow, Krishnan Jayaraman. As support in composite in this review the flax fiber usage has gained much popularity and the main reason behind it is the increased requirements of the materials which are emerging and are supportable as well. The cost of flax fibers is less, and precise mechanical properties are performed by them especially when the properties are contrasted with the properties of glass fibers. With thermo plastic and thermosets along with some biodegradable matrices the composites are made from flax. All these materials exhibit good mechanical features and also the composites and the flax fiber growth are estimated in this evaluation. In the beginning the structure of fiber is considered along with some key mechanical features, the cost and a lot of parameters running along with it are considered. Along with this, the fiber configuration outcomes in the processes used for manufacturing, and the use of fibers are analyzed and reviewed. The toughness, training and strength of the composites made of flax fibers is studied to determine their exact nature.

Yue-feng Zhu, Lei shi, Ji liang, David Hui, Kin -tak lau (2008). The nano particles and their sizes which range from few to twenty nanometers are determined. The Zirconia manufactured as noticed was influencing the c phase and 3D structure of the composite. From the crystals of zirconia at higher temperatures it existed quite normally. It has been displayed in the investigational outcomes that alumina ceramix have some mechanical properties especially when they are mixed well inside the nano particles manufactured in the carbon nano tubes used externally in an improved manner in such a way that single zirconia nano particles and nano tubes are left behind. For CNT/ZrO₂ the fracture durability was made better by the simple process whereby the effects are combined.

Dipen Kumar rajak, Durgesh d pagar, Pradeep L Menezes, Emanoillinul (2019) in this century as we have seen that the composites arise from the potentially obtainable material are tested. The diverse range of fibers are used and investigated in this experiment. The composite materials significance and applications are studied here. In several fields the applications have reinforced the composite material and their features and other important aspects. In several fields of applications the excellent performance was seen and composite materials have been made of fiber reinforced materials which have a potential to be used as substitute over some metallic solitary alloys.

Jens Bachmann, Xiaosu Yi, Hugh Gong, Xavier Martinez, Gabriel Buggedu, Sergio oller (2017) to evaluate the probable applications is the main aim of this project along with applications usage which are ecofriendly to modify and enhance the composite material in the sector of airspace. This process is complicated and some partners are there from China and other parts of Europe. Flax and Ramie like natural fibers are there which for reinforcement of various kinds are used inside the cores of sandwiches. In this paper we have also used a bio-based epoxy resins in the improved materials for the selection grades out looking the interior and other important infrastructures.

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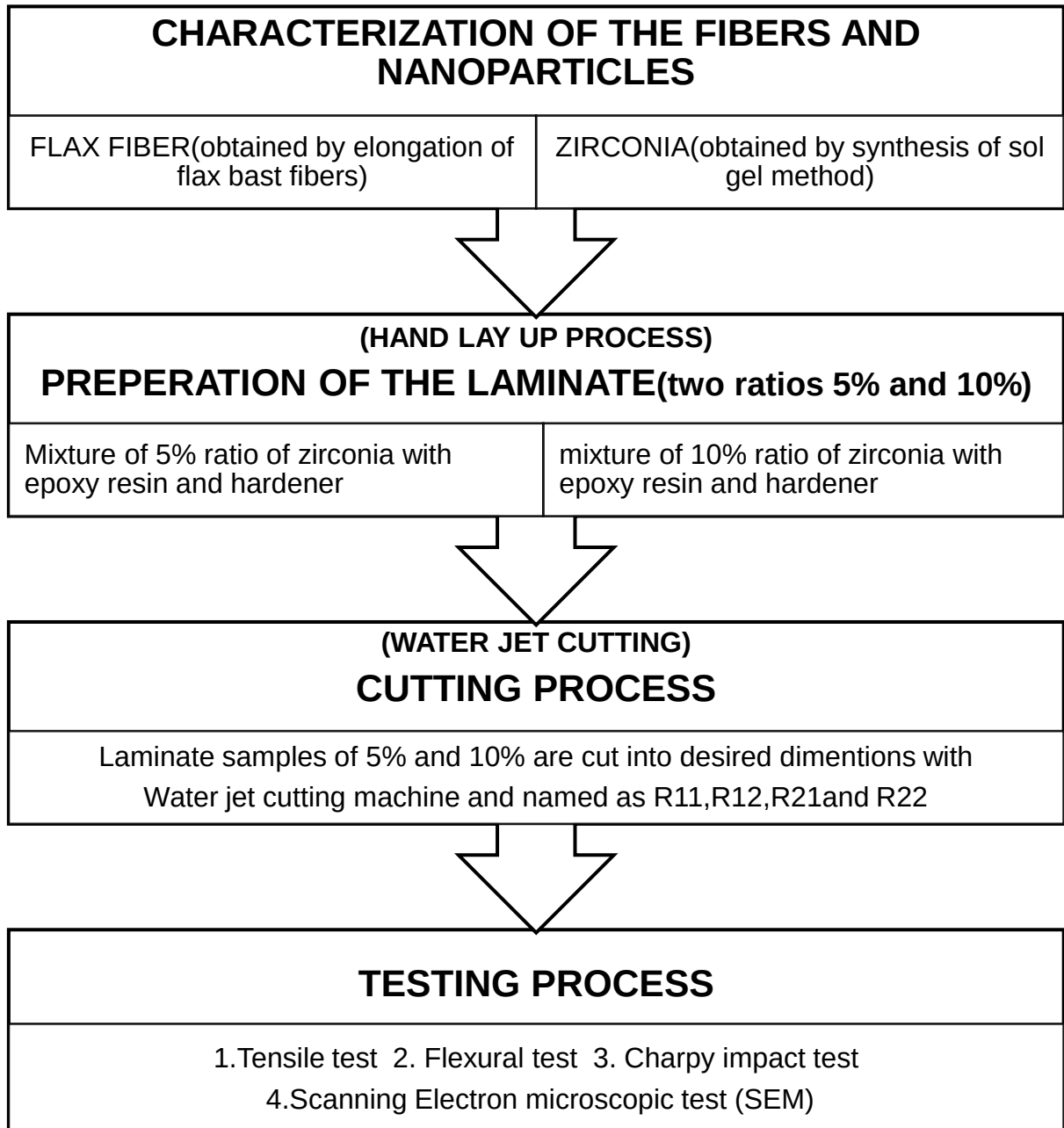
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CHAPTER 3

EXPERIMENTAL METHODS, MATERIALS USED AND PROCESSES INVOLVED

3.1 METHODOLOGY CHART



3.2 FLAX FIBERS

The common flax or linseed is a name given to flax. The flax is a flowering plant such belongs to the family Linaceae and is known as *Linum usitatissimum*. It is generally cultivated as fiber crop and food as well in the temperate climate containing crop regions. Linen is a kind of fabric which is obtained from flax and is much common in western countries. The material is commonly used in undergarments, tablecloths and bed sheets. It is widely used natural fiber and it is easily gettable.

3.2.1 Manufacture of the flax fiber

Flax fibers are generally removed from the bast or skin of the stem of the flax plants. Flax fibers are organized in the form of slim filament, grouped in the longitudinal slim bundles dispersed circularly everywhere a vital wooden cylinder. the extraction of the fiber will be done in three stages, the decoration process is done by removing the bark, then the cortex is then scraped to remove most of the outer bark, and the last stage is the residual cortex materials is dried out and degummed to remove the spinnable fibers.



Fig 3.1 Sheets of flax fibers

Fibers are then drawn into strands and wound on a foaming tube. strands are groups of more than 204 filaments. The flax fibers strands can be converted into several forms.

3.2.2 Applications of flax fibers

In recent years, the use of flax fibers as strengthening in composites has gained popularity due to an increasing requirement for developing sustainable materials. Composites made of flax fibers with thermoplastic, thermoset, and decomposable matrices have showed decent mechanical properties. Other than composites the best grade of flax are used for linen cloths such as damasks, lace and sheeting, rougher grades are used for the purpose of production of twine and rope, flax fiber is also a raw material for high quality paper industries and widely used in rolling paper for cigarettes.

3.3 ZIRCONIA

Zirconia, otherwise called zirconium dioxide (ZrO_2), is found in its most regular structure in the mineral baddeleyite. In any case, it can likewise be artificially gotten from zircon. It is the most economically significant oxide framed by zirconia. It will normally happen with monoclinic glasslike structure, is the mineral baddeleyite. It has a molar mass of 123.218g/mol. Zirconia is white tone in appearance. It has thickness of 5.68 g/cm

3.3.1 Synthesis of zirconia

Zirconia or zirconium oxide nanoparticle is synthesized using sol-gel method technique. Commonly zirconia has been prepared by precipitation method to synthesize nanocrystalline zirconia.



Fig 3.2 Zirconia

Figure 3.2 is the zirconia nanoparticles which is used in this process in different ratios.

3.3.2 Engineering properties

Zirconia dioxide is one of the widely studied and used materials in ceramics. ZrO_2 approves a monoclinic rock crystal structure at normal temperature and changes to tetragonal and three-dimensional structures or forms at higher temperatures, the changes of volume of caused by the structure's changes from tetragonal to monoclinic to three-dimensional encourages large stresses, producing it to crack upon freezing from high temperatures.

3.3.3 Chemical reactions

Zirconia is unactive in chemical reactions. It is gradually confronted by intense hydrofluoric acid and sulfuric acid when heated with carbon, it changes to zirconium carbide. When the zirconia animated with carbon in the company of chlorine, it adapts to zirconium tetrachloride.

3.3.4 Applications of zirconia

Zirconia plays a very important role in production and manufacturing of the hard ceramics; it is useful in making dentistry. It also acts as a protective coating on titanium particles. It is used as a intractable material in insulation, abrasives and enamels. It has very low thermal conduction thus used as a thermal wall covering in jet and diesel engines to permit process at high temperatures. Change reinforced zirconia is used to make ceramics knives. Since of the solidity ceramics-edged flatware stays sharp elongated than other steel knives. Due to its infusibility and brilliant luminosity when incandescent, it is used in stick lights for limelight. zirconia has very low dielectric property so it can used as insulator in transistors.

3.4 RESIN AND HARDENER

Bio epoxy resin L4.555 and hardener HY.951106 is used for fabrication process. The use of bio epoxy resin is to improve the matrix interface of the flax fiber and zirconia nanoparticle.



Fig 3.3 Epoxy resin and hardener

Figure 3.3 represents the epoxy resin and hardener used in this fabrication process.

3.5 FABRICATION PROCESS

All in all, the supporting and network materials are consolidated, compacted and prepared to go through a merging occasion. Following the merging occasion, the part shape is fundamentally set, despite the fact that it can distort under certain interaction conditions. For a thermo set polymeric grid material, the merging occurrence is a relieving response that is begun by the utilization of additional warmth or substance responsiveness like natural peroxide. For a thermoplastic polymeric network material, the merging occasion is solidifying from the liquid state. For a metal lattice material, for example, titanium foil, the merging occasion is a joining at high pressing factor and a temperature close to the soften point is higher than ordinary temperature

For a few embellishment methodologies, it is appropriate to allude to single form piece as a "lower" shape and elective form piece as an "upper" form. Lower and upper allude to the various articulations of the molded board, not the examples development in space. The formed item is regularly referenced as a board. For specific calculations and material combinations, it very well may be referenced as an embellishment. For certain unremitting cycles, it very well may be referenced as a profile. Applied with a pressing factor roller, a splash gadget or physically. This interaction is for the most part done at encompassing temperature and barometrical pressing factor.

3.6 CLASSIFICATION OF FABRICATION PROCESS

There are 4 types of Fabrication process.

- ❖ Vacuum bag molding
- ❖ Resin transfer molding (RTM) Open molding process
- ❖ Spray Lay –up
- ❖ Hand Lay –up

3.6.1 Vacuum Bag Molding

An interaction utilizing a reciprocal form set that shapes the two outsides of the sheet. On the minor side is a solid form and on the unrivaled side is a flexible film or vacuum sack. The versatile layer can be a recyclable silicone material or an expelled polymer film. After vacuum is applied to the shape opening. This cycle can be made at either encompassing or high temperature with surrounding air pressure following up on the vacuum sack. Most modest way is utilizing an endeavor vacuum and air blower or a vacuum siphon. A vacuum pack is a sack made of tough elastic covered texture or a polymer film used to bond or cover materials. In certain applications the pack envelops the entire material, or in different applications a shape is utilized to frame one face of the overlay with the sack being single sided to cover the outside essence of the overlay to the form. The open end is fixed, and the air is drawn out of the sack through an areola utilizing a vacuum siphon. Subsequently, uniform pressing factor impending one air is valuable to the surfaces of the item inside the pack, holding parts created while the glue fixes. The entire sack might be set in a temperature-controlled broiler, oil shower, or water shower and somewhat warmed to animate restoring.

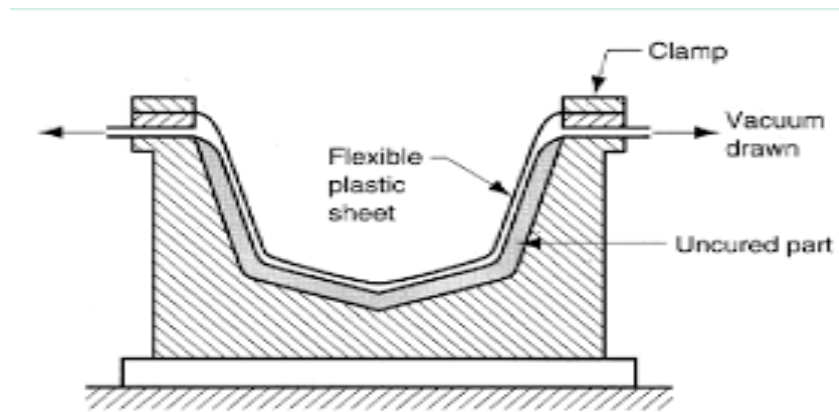


Fig 3.4 Vacuum bag molding process

Figure 3.4 shows the vacuum bag molding process and the equipment used for that process

3.6.2 Resin Transfer Molding (RTM)

A cycle utilizing a respective shape set those structures the two outsides of the board. A minor side is a rigid form. The unrivaled side can be a rigid or adaptable form. Versatile molds can be produced using composite materials, silicone or press out polymer movies like nylon. The different sides fit made to deliver a shaped opening. The remarkable element of pitch move shaping is that the fortifying materials are situated into this hole and the form set is shut before the blueprint of framework material. Tar move forming incorporates a few changes which fluctuate in the system of how the sap is introduced to help in the shape cavity. These distinctions incorporate everything from vacuum imbue ment to vacuum helped pitch move forming (VARTM). This technique can be made at either encompassing or high temperature.

The benefits of RTM are that it is more affordable than hand lay-up, can be computerized, and doesn't require refrigerated capacity for pre-prigs. Significant downsides incorporate the capital cost needed for having two shapes rather than one.

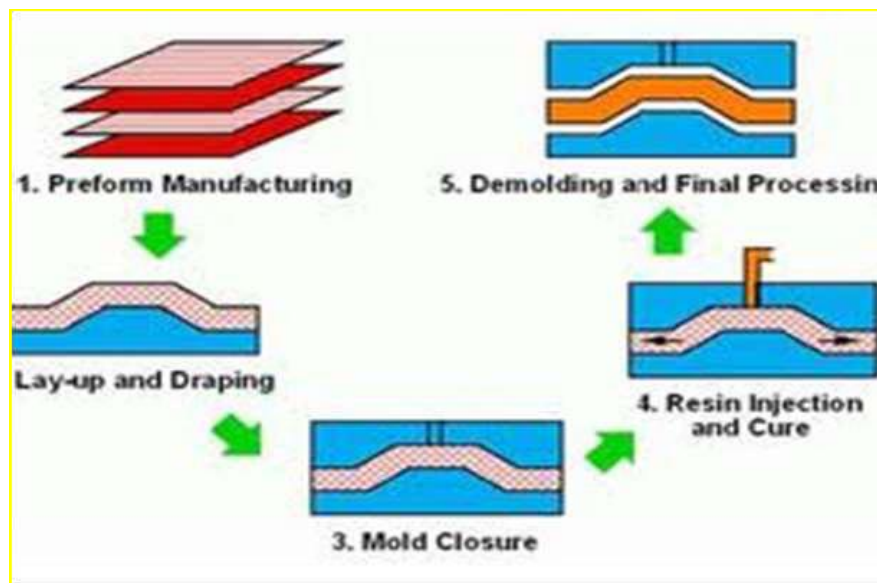


Fig 3.5 Resin transfer molding process(RTM)

Figure 3.5 represents the resin transfer molding process and the procedure is clearly explained in that figure

3.6.3 Spray Lay –up

Fiber is sliced in a hand-held gun and nourished into a spray of catalyzed resin fixed at the mold. The dumped materials are left to cure below normal atmospheric environments.

Materials Options

Resins: Primarily polyester.

Fibers: Glass roving only.

Cores: None. These have to be combined distinctly.

3.6.3.1 Advantages

- Commonly used for several years.
- Cheap way of rapidly leaving Fiber and resin.
- Cost efficient tooling.

3.6.3.2 Disadvantages

- Laminates have a habit to be very resin-rich and hence extremely heavyweight.
- Only short Fibers are combined which strictly bounds the mechanical properties of the laminate.
- Resins want to be low in viscosity to be spray able. This usually concessions their mechanical/thermal properties.

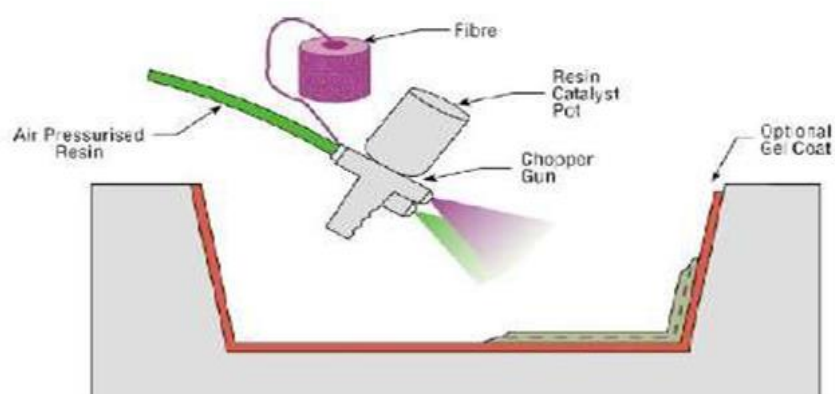


Fig3.6 Spray lay up process

Figure 3.6 represents the spray lay up process and clearly explains how the process is done.

3.6.3.3 Typical Applications:

Simple inclusions, casually packed structural panels, e.g. caravan frames, truck fairings, bathtubs, shower trays, some minor dinghies.

3.6.4 Hand lay up (open molding) process

An open molding technique which is used to produce the wide variety of composites is known as hand lay up technique. This is the method whereby some important products such as bath tubs, house ware, automobile parts and machineries are made along with boats, tanks, aero space and other architectural products. In this process with the help of composites some other products are made as well which range in size and other aspects and the size normally range from small to very giant sized. Per mold manufacturing volume is smaller though it is easier to produce the products with significant construction with the help of molds of huge variations.

The molds are given treatment with the process of description gel coat and kept in a spray gun for the surfaces of higher quality. In this way when the materials are preserved suitably with the help of gel coat the molds are topped up with the roll stock fiber glass for some additional physical support. The painting rollers are used and resins are laminated in the useful manner for the purpose of brushing, spraying and making use of other important products. The trapped air is eradicated as the laminating resins are used to pour, brush and spray this also helps in the reinforcement of the methodological wetting. The fiber glass layer which succeeds are further included in it and this helps to make the width of lamination. End grain balsa, foam and honey comb are some of the low density materials which can widen the lamination and a sandwich like structure is obtained in this process.

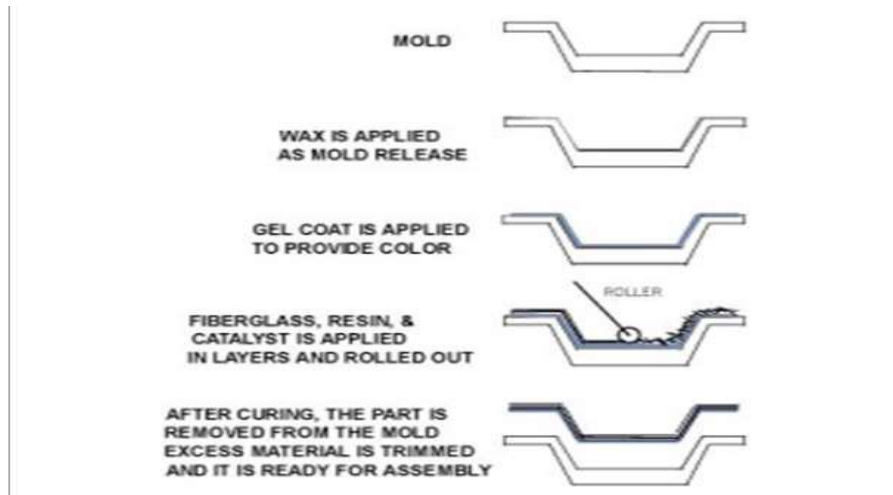


Fig: 3.7 Steps Involved In Hand Lay-Up

Figure 3.7 explains the steps involved in the hand lay up method, hand lay up method is the easiest and cheap methods, for this fabrication we have chosen hand lay up process.

3.6.4.1 Advantages

- Extensively used for several years.
- Modest ideologies to teach.
- Low price tooling, if room-temperature treatment resins are used.
- Extensive choice of providers and material types.
- Higher Fiber fillings, and extended Fibers than with spray lay-up.

3.6.4.1 Disadvantages

- The mixing of the Resin, the fillings of the laminate resin, the quality of laminate all these features are dependent very much on the laminators services. The laminates carrying lower content of resins cannot be completed frequently without the extreme voids amount combination.
- The resins' safety attentions and health aspects are also concerning. The molecular weights of the resins hand up are lower which means that as compared to the products of higher molecular weights these products are likely to be injurious to health. The resins with lower viscosity indicate that the infiltrate clothing tendency is also enlarged in these resins.

3.7 PREPERATION OF THE LAMINATE

The laminate is organized for directing numerous investigational tests. The fabrication process and testing process were done in Micro lab, A material testing lab, Ambattur, Chennai. Laminates were prepared by hand lay up method. All the fiber sheets are cut according to the dimensions. In these laminates we are going to use natural fiber flax and zirconia nanoparticles. The bio epoxy resin LY556 and the hardener HS951. The materials are bought from Light Mach Composites, Chennai.

3.7.1 Hand layup method on epoxy resin and mixture of zirconia

We have done hand layup process for this laminate, the preparations of new laminate are done by several steps, firstly the flax sheets are cut into the dimensions of 30x30 cm of 7 layers and the weighed, the mass of the flax sheets of 7 layers is 192 gm. Secondly the epoxy resin is taken according to the mass of the flax fibers, and the hardener is taken in the ratio of 10:1 ratio, the zirconia is taken in 2 ratios 5% and 10% to compare the final results with the CRGF, then the mixture of the zirconia epoxy resin and hardener is applied on the sheets of the flax one by one, the mixture is applied using a painting brush, mylooon sheet is placed on the aluminum plate to avoid sticking of the mixture. This process is repeated until the desired thickness is achieved. Excess Resins are removes using roller, lastly weight is applied on the laminate to avoid voids. Laminate are left to cure under the normal room temperature for 24 hours.

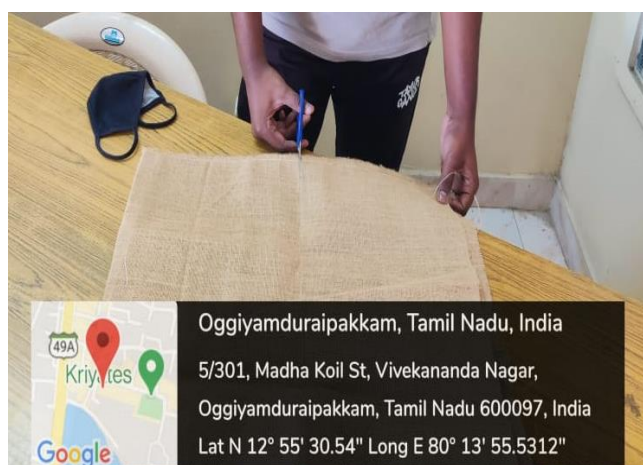


Fig 3.8 cutting of flax sheets

In the fig 3.8 the flax sheets which is obtained is cut in 30x30cm into 14 sheets. 7 sheets for one laminate preparation and another 7 for other laminate preparation.



Fig3.9 Weight of the flax sheets

In fig 3.9 the flax sheets which was cut into 30x30cm ,is taken 7sheets and weighed and found 0.192 gms.



Fig3.10 weight of the zirconia

In the above figure 3.10 the weight of the zirconia nanoparticle is taken 5%ratio of the flax sheets weight, and same zirconia nanoparticles is taken in the ratio of 10% of flax sheets weight.



Fig3.11 Applying of the mixture for 5% ratio laminate

In the above figure 3.11 the mixture of zirconia which is taken in 5% ratio ,epoxy resin and the hardener is applied ,the ratio of the hardner is 10:1 of the weight of the flax fiber,then myloor sheets is placed under the alumnium plate to avoid sticking.



Fig 3.12 Applying of the mixture for 10%ratio laminate

In the above figure 3.12 the mixture of zirconia which is taken in 10% ratio ,epoxy resin and the hardener is applied ,the ratio of the hardner is 10:1 of the weight of the flax fiber,then myloor sheets is placed under the alumnium plate to avoid sticking.



Fig 3.13 New fabricated laminate made by 5% ratio

Fig 3.13 shows the newly fabriacated composite made by 5% ratio of zirconia,this is obatianed after apllying the mixture and let it dry until 24 hrs in room temperature.

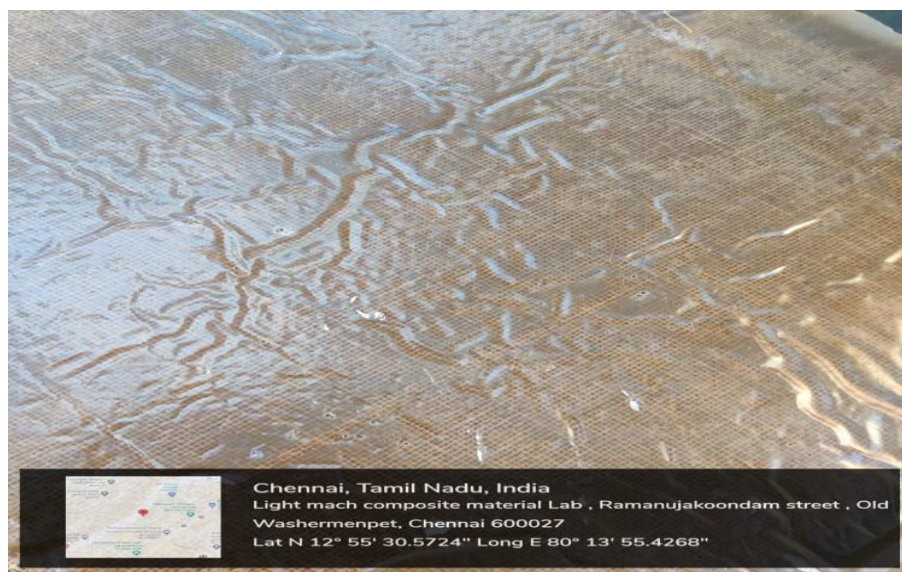


Fig 3.14 New fabricated laminate made by 10 %ratio

Fig 3.14 shows the newly fabriacated composite made by 10% ratio of zirconia,this is obatianed after apllying the mixture and let it dry until 24 hrs in room temperature.

3.8 WATER JET CUTTING

A water jet or water based jet is a shaper water jet. The design of this water jet is made in such a way that include wide constancy of materials which makes use of water jet under higher pressure. Sometimes the unpleasant materials are used in combination with water. The utilization of combination of water and harsh materials to cut the rock like materials and metals is the unpleasant jet term which alludes to the process explicitly. The unadultrated or mixed water jet are used for the water jet cutting and in such a way that added abrasives are not used in the process for more fragile materials such as elastic and wood the water jets are used.

Sometimes in the creation of some parts of machines the water stream cutting is used as well. The most admired way is the water stream cutting whereby at higher temperature with different techniques the materisl are being sliced and are touchy as well. There are a lot of ventures whereby the water jet cutting can be used and some of the major fields include the mining and aviation for the process of forming and cutting.

3.8.1 Operations

The cutter is generally associated with a high-pressure water pump where the water is then expelled from the nozzle, cutting over the material by spraying it with the jet of high- speed water. Extracts in the form of postponed grit or other abrasives, such as garnet and aluminum oxide, can support in this development.



3.15 Water jet cutting machine

Figure 3.15 refers to the Water jet cutting machine used to cut the laminates into desired dimensions

3.8.2 Benefits

To cut the materials without any significant influence on the structural trademark is one of the biggest benefit of the water jet. HAZ kind of zones are not included in this process. The HAZ stands for heat influenced zone. The temperature and likewise properties are minimised and in this way metals are allowed to be cut down in such a way that their central properties are unharmed and unchanged. For the assembling of convoluted cuts in the material the water jet cutters are cultivated additionally. Complex shapes can be framed with the 3D machine heads, master programming etc.

By trading parts in the spout the kerf or width can be cut and this can be highly recognizable process. In this way the grafting extent and changing of the sort can be done. in the assortment of 0.04" to 0.05" (1.016 to 1.27 mm) the run of mill rough kets have the kerfs. These can be 0.02" (0.508 mm) or more thin in structure. Non-grating trims are typically 0.007" to 0.013" (0.178 to 0.33 mm), yet can be just about as minor as 0.003" (0.076 mm), this is actually the average thickness of a human hair. The minor subtitles can be there in these little planes especially when their uses are checked in the selection criteria.

The exactness of lower degree in the water jets is as much as to 0.005" (0.13 mm) and 0.001" (0.025 mm) are decencies. The water stream cut can diminish the measure of the fight material shaped because of its moderatly fine kerf. This alwso allows the customary custting systems to be settled altogether in the similar pattern with the help of water stream cutting. One to more gallons which make up 2-4 liters of water are used in the water jets and the contingent upon opening size of the head is cut. With the help of shut circle framework the water can be resued. To channels and orchestrate of the down channels the squander water can be commonly spotless enough. The non poisonous garnet grating material is used for the redundancy and it can be disasterous in the imminent form and also it can be arranged in the landfill for most of its parts. Lesser drifting residual particles are produced additonally by the water streams along with some other residual materials such as smoke, impurities, vapor and reduce the management to prologue the use of materials which are unsafe.

3.5.3 Cutting of Laminates into Samples of Desired dimensions.

Water jet Technology was used to cut each laminate into smaller pieces, for various experiments

Tensile test - sample was cut into dog bone shape (165x19) mm

Flexural test - sample was cut into flat shape (100x12.7)mm.

Impact test - sample was cut into flat shape (65.5x12.7) mm.



Fig 3.16 5% and 10% laminates cut into plates (R11, R12,R21& R22)

In this figure 3.16 the laminate made up of 5% and 10 % ratio is cut into desired dimensions and shapes for the testing process. here in the above image the markings R11 refers to one plate of ratio 5% and R12 refers to the second plate of the ratio 5% R21 refers to one plate of ratio 10% and R22 refers to second plate of ratio 10.

CHAPTER 4

RESULTS, DISCUSSION AND COMPARISON

4.1 TENSILE TEST

The major materials are included in the pliable resting which is also known as strain testing. The model which is presented to pressure up until the disappointing pressure is made is known as a science test. The testing outcomes are sometimes used in the ordinary cases to select the materials which have been used for the esteem control applications. This also helps to predict and anticipate the reactivity of material when different powers are used. The straight forwardly explained and estimated properties in the special pliable testing procedure are higher rigidity, extensive and extreme lengthening, territory on the other hand is decreased. The young's modulus, poisson's proportion, the yielding strength along with the highlights of strain solidification are some of the amounts which accompany the properties which can be resolved. By the most and largely used track down the uniaxial ductile testing is used and this helps to track down the isotropic material's mechanical highlights. For some of the materials which are anisotropic such as simpler and composite materials, the process of biaxial elastic testing is considered the key.

4.1.1 Equipment

In the ductile testing the machine which is most extensively used and is recognised as well is generally inclusive of the machines used for testing. Two cross heads are there in these kinds of machines. One of the machine is generally adjusted for the length of the example while to apply strain the other one is resolved into the samples to be tested. The pressure driven as well as force driven forces are there for the power driven machines under the influence of electromagnetic. For testing examples which have been tried ever there are machines with appropriate potentials to be used. Power limit, speed, precision and accuracy, exactness are four major constraints driving it. The machines essentially create adequate way to power the limit alluding the ways to breakdown the example. To put on the power quickly the machines are supposed to have the option as well. This can power the machines quickly and are slower enough to suitably copy the transparent applications. The check length and power applied

should be measured absolutely and precisely and it has to be taken into consideration before designing of any such machine. The main example of it is the machines in enormous amount which can be used to quantify the prolongations in the longer period of time and with harder material these machines fail to work and even before breaking these machines often encounter shorter lengths.

In the testing machine the course of action is a little bit risky as we all know that in such cases the example is skewed at the balancing aside or at any particular point. The machine is given the example of the twisting power. For the weak materials this is particularly terrible as the outcomes are slanted drastically. We can reduce the current condition simply by making use of the seats of molded circles and between the holds by applying the U joints and testing machines etc. In any case where the pressure strain bend is applied on the first segment, the adjustment is made for the direct example and in the testing machines the examples are shown as well. With an extensometer the strain measurements are most routinely estimated on the other hand, the frequently used strain checks are used on the testing machines with the examples of estimated poisson's proportion. Th machines of modern times have highly advanced features and more powers, framework extension and estimation which include the electric sensors linked to the gadgets of assorted information such as computers. These are designed especially for the work programming and getting the exact and precise data. The machines should outperorm ASTM, NIST, ASM metal tractable testing in any case for the precision based prerequisites so that they can be used any time.



Fig: 4.1: UTM Machine for tensile and flexural test

The above figure 4.1 represents UTM machine ,ultimate testing machine ,we have used this machine for tensile test and flexural or bending test of the new laminated composite .

Table 4.1 Result of the tensile test

Test parameters	Observed values			
Sample ID	R11 is 5%	R12	R21 is 10%	R22
Gauge Width (mm)	13.14	13.44	13.54	13.56
Gauge thickness(mm)	6.59	6.15	6.43	6.38
Original cross-sectional area (mm ²)	86.59	87.49	87.06	86.51
Ultimate Tensile load (kN)	2.80	2.81	2.28	2.21
Ultimate tensile Strength (N/mm ² or Mpa)	32.00	32.00	26.00	26.0

The table 4.1 show the result of the tensile test for the fabricated laminates R11 represents the plate no 1 of ratio 5% and R12 represents the plate no 02 of ratio 5%..R12 represents the plate no 01 of ratio 10% and finally the r22 represents the plate no 02 of the ratio 10%. The above table shows the gauge width,gauge thickness,original cross-sectional area,ultimate tensile load and ultimate tensile strength of R11,R12,R21&R22.

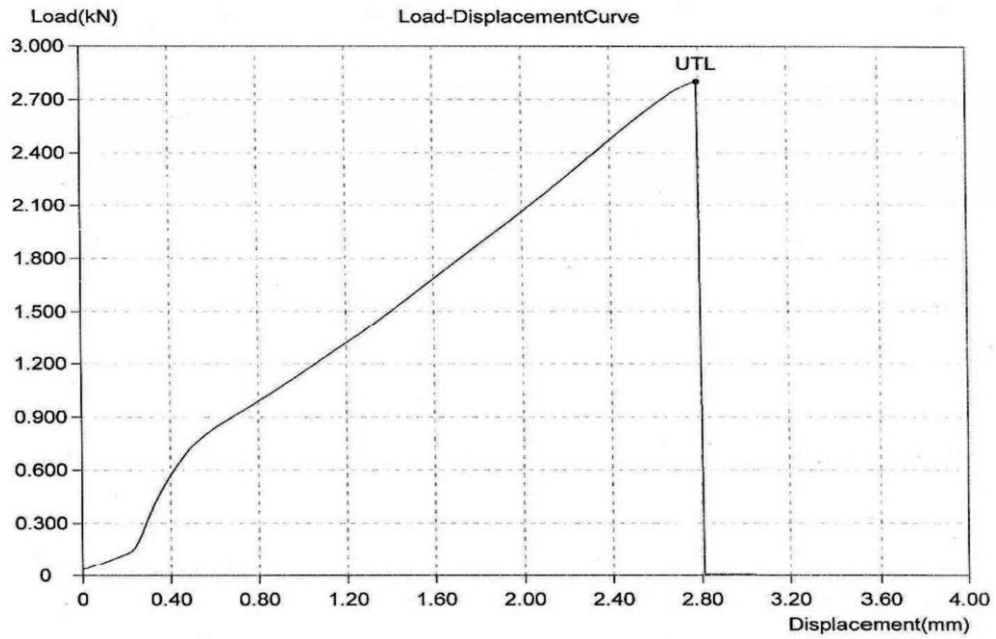


Fig 4.2 Load vs displacement graph of tensile strength for R11

Here in figure 4.2 the applied load is 2.8 kN which is ultimate testing load ,for the testing load of 2.8 kN the displacement is 1.61 mm

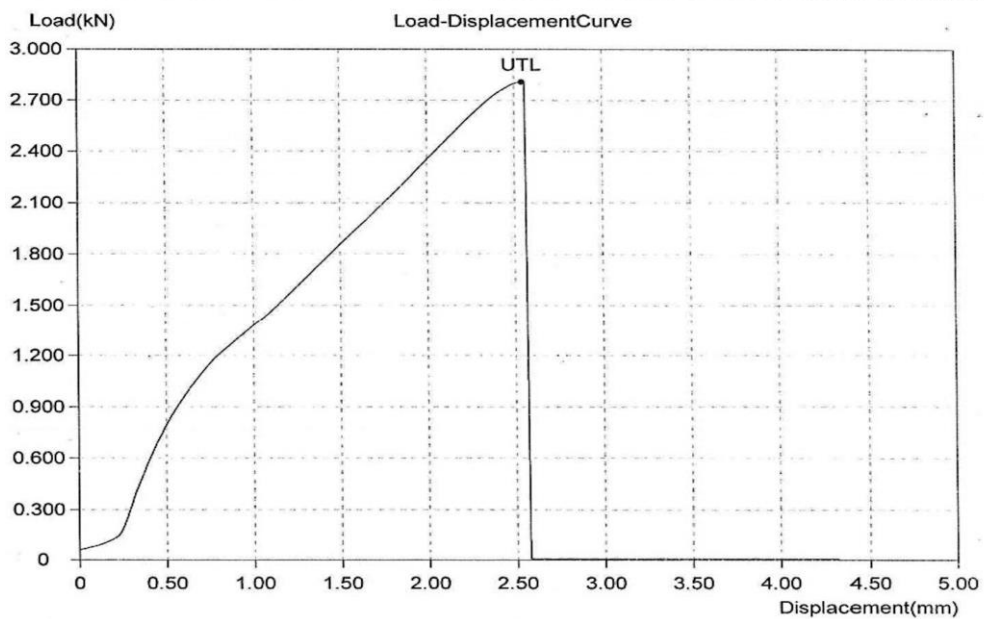


Fig 4.3 Load vs displacement graph of tensile strength for R12

Here in figure 4.3 the applied load is 2.43 kN which is ultimate testing load ,for the testing load of 2.43 kN the displacement is 2.79 mm

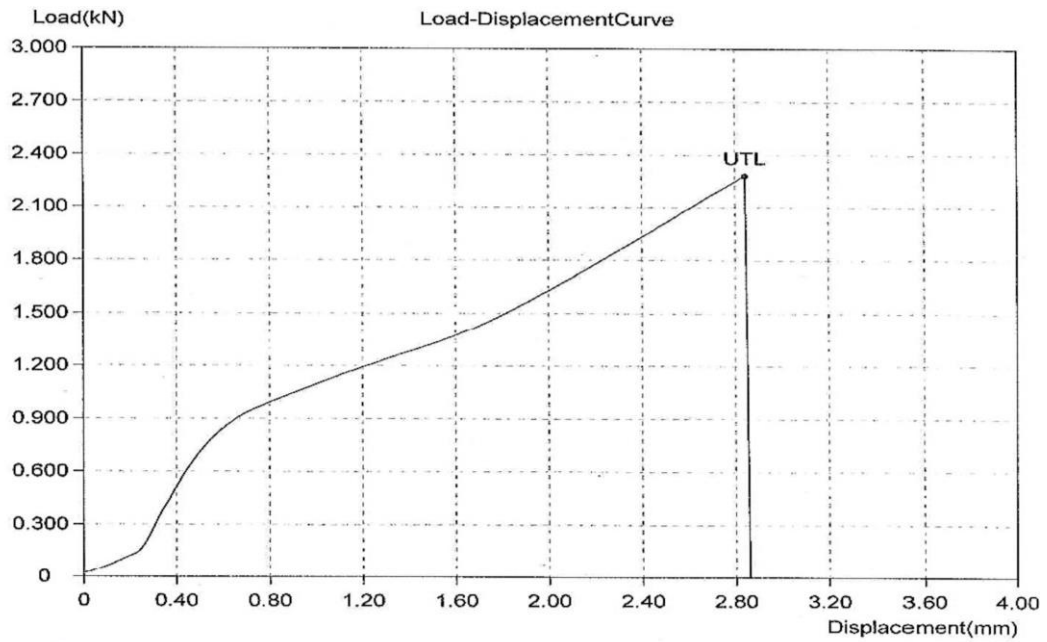


Fig 4.4 Load vs displacement graph of tensile strength for R21

Here in figure 4.4 the applied load is 3.234 kN which is ultimate testing load ,for the testing load of 3.234 kN the displacement is 3.49mm,and the Ultimate tensile strength is 29

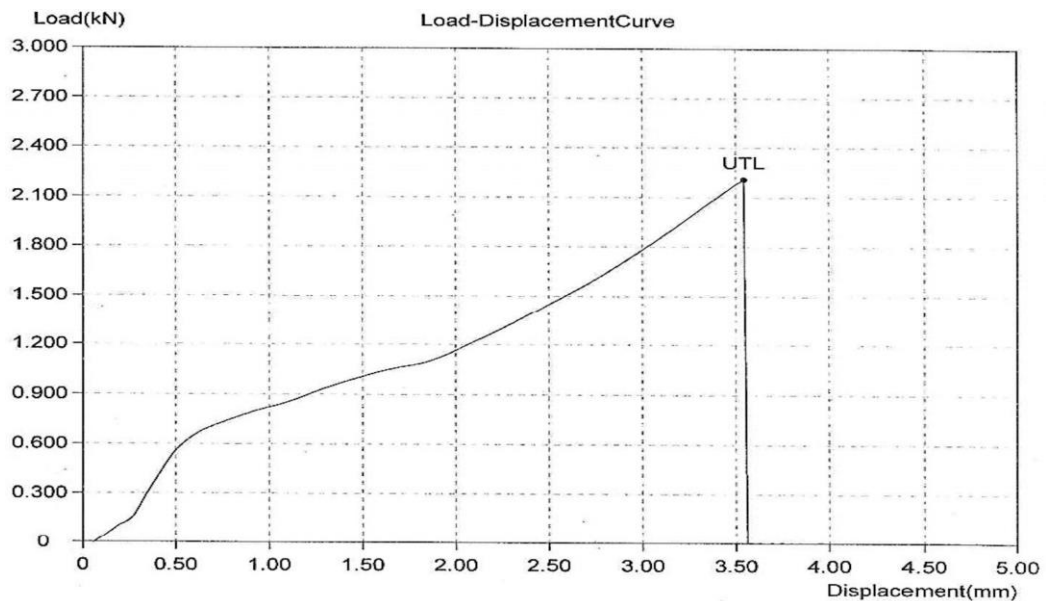


Fig 4.5 Load vs displacement graph of tensile strength for R22

Here in fig 4.5 the applied load is 2.763kN which is ultimate testing load ,for the testing load of 2.763 kN the displacement is 2.243 mm,and the Ultimate tensile strength is 24.

4.2 FLEXURAL TEST

According to the standards of ASTM the specimen were cut for the purpose of bending test. Under 2 point setup the specimen was reserved at the upper edge of it and to complete the act of comprehensive load was applied from the top to the central point. To the system the values are moved via serial ports and are plotted together in the graph. The outcomes of the graph are recorded and printed.

The modulus of elasticity is obtained by the three point bending flexural testing in the flexural strain with the bending resulting in the flexural stress in the material which has the potential of bearing flexural stress and strain. The three point flexural test offers some benefits as well which is regardless of the preparaton of speciment and testing. Some drawbacks are there as well in this system which include the delciacy of the relaiable testing methods and strain rates with known loaded geometry.

4.2.1 Testing Method

The detailed fixture on the universal testing machine is the general testing method for the direction of the test. For the preparation of test the details are needed to conduct the tests and obtain outcomes. Two auxiliary pins are there where the samples are located at an appropriate distance from the loading pin at third point which is dropped at the constant rate from the top until the specimen breaks down.

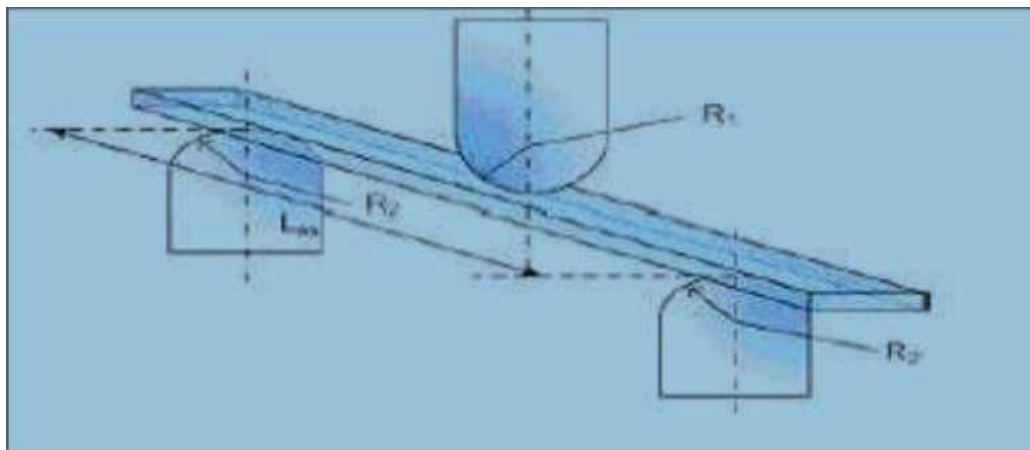


Fig 4.6 Three-point bending test setup

Figure 4.6 shows the setup we used for bending test .In a three point bending test set up, the convex side of the sheet or plate is positioned in a tension and the external fibers will be subected to maximum stress and strain or elongation surpasses the material's limits, fracture toughness can be calculated using three point flexural test

Table 4.2 Results of flexural test

Test parameters	Observed Values			
Sample ID	R11 is 5%	R12	R21 is 10%	R22
Flexural Strength (N/mm ² or Mpa)	55.00	53.00	33.00	32.00

The table 4.2 gives a results of flexural test taken in ultimate testing machine the results are noted the a load vs displacment graphs were plot in the system and printed out which is attached below

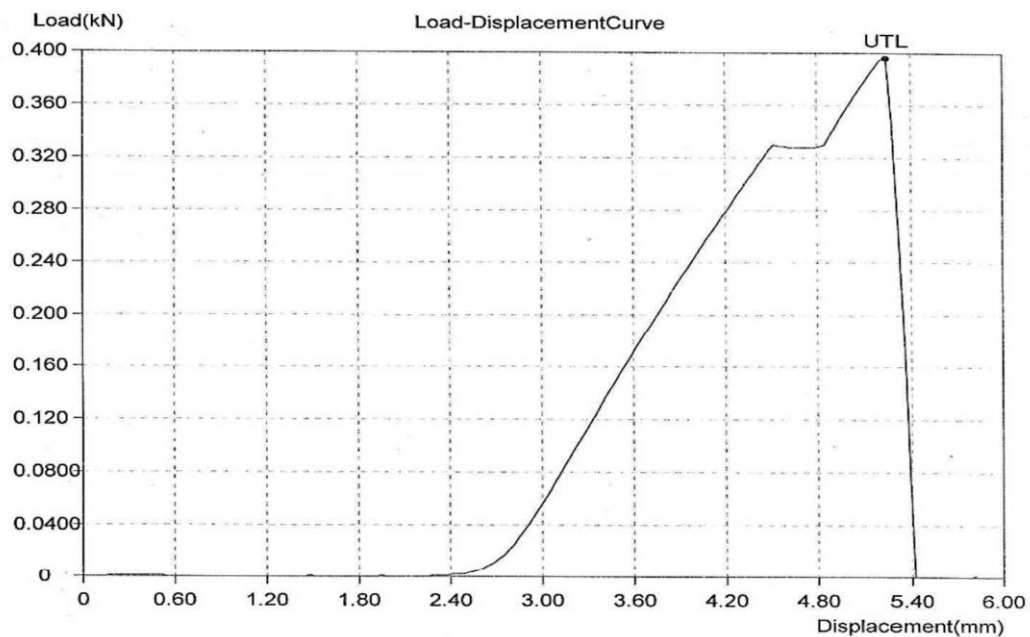
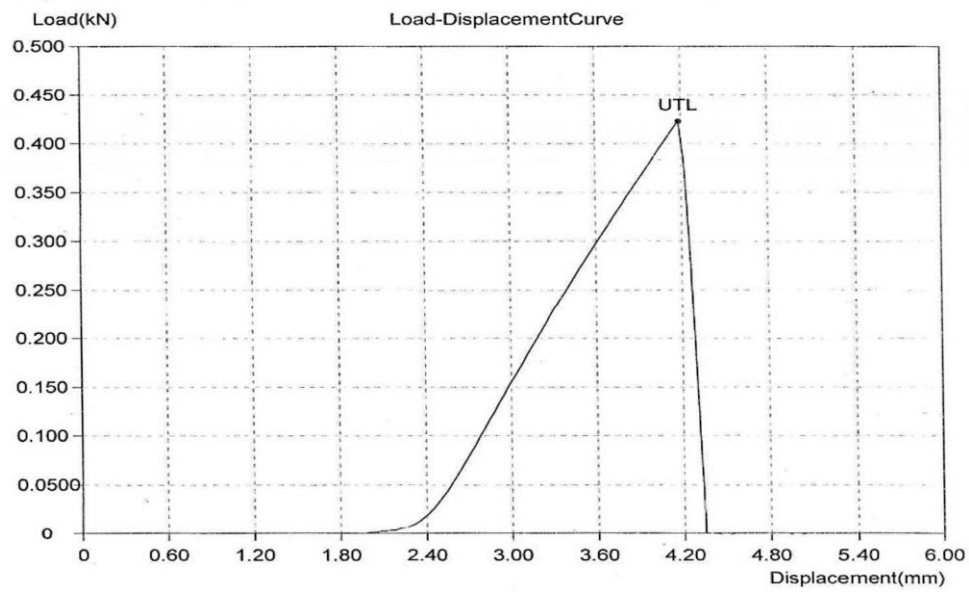


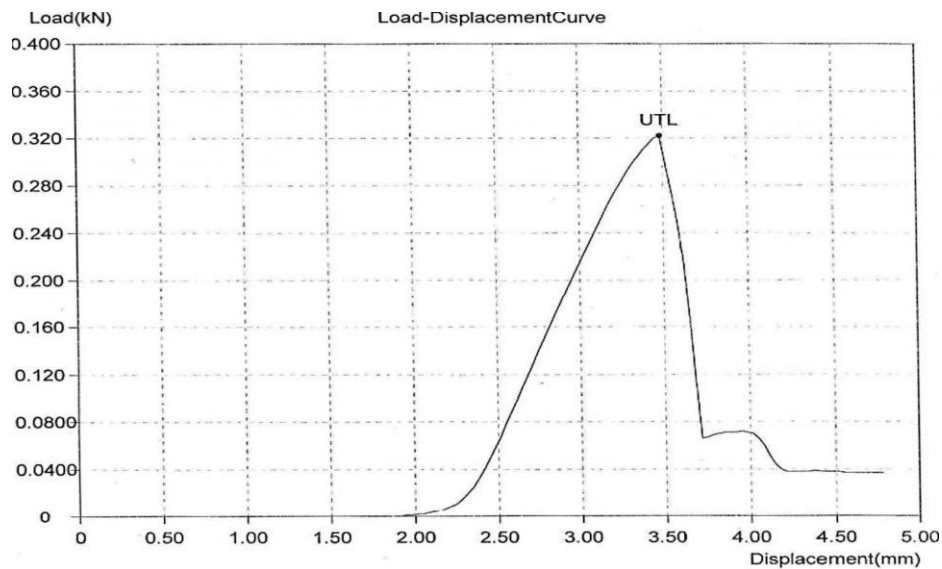
Fig 4.7 load vs displacement curve of flexural strength of R11

Here in figure 4.7 flexural test for the R11 the ultimate testing load applied is 0.232 kN and the load displacement is found to be 2.4 mm and the flexural strength obtained is 55 Mpa



4.8 load vs displacement curve of flexural strength for R12

Here in figure 4.8 flexural test for the R11 the ultimate testing load applied is 0.236 kN and the load displacement is found to be 5.5 mm and the flexural strength obtained is 53 Mpa



4.9 load vs displacement curve for flexural strength for R21

Here in figure 4.9 flexural test for the R11 the ultimate testing load applied is 0.238 kN and the load displacement is found to be 5.9 mm and the flexural strength obtained is 33 Mpa

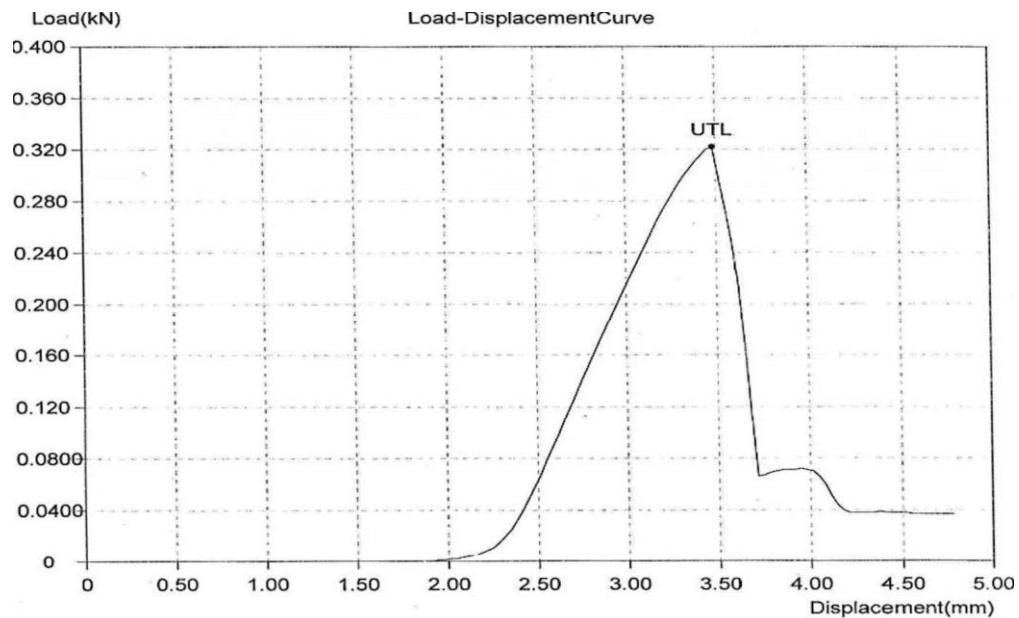


Fig 4.10 Load vs displacement curve of flexural strength for R22

Here in figure 4.10 flexural test for the R11 the ultimate testing load applied is 0.153 kN and the load displacement is found to be 3.7 mm and the flexural strength obtained is 32 Mpa

4.3 IMPACT TEST

The specimens were cut for impact test according to the ASTM standards .The specimen was locked in the machine and the knob is dragged down and the readings dial are noted.



Fig: 4.11 Impact machine for impact test

Figure 4.11 is the impact test machine used for this testing process

Values range: 0J to 14J.

Dead weight in the oscillator: 8Kg

Model& Make: K-1.4 & KrystalEquipments, India.

I-ZOD Impact machine is superior choice for aluminum and other metal and fiber composites since its values are lesser and is a deadly process to measure in a charpy impact test which has dead mass of more than 20Kg and least values will start from 6J. An impact test was used to control the quantity of energy that was essential to breakdown the specimen. An UN-notched I-zod Impact test was directed to study the impression energy conferring to ASTM. The UN-notched specimens were reserved in a girder position, and a pendulum has oscillated around to breakdown the specimen. The impact energy (J) was noted using a dial gauge that was tailored on the machine. Five samples were occupied for each test, and the results were average

Table 4.3 Results of Charpy impact test

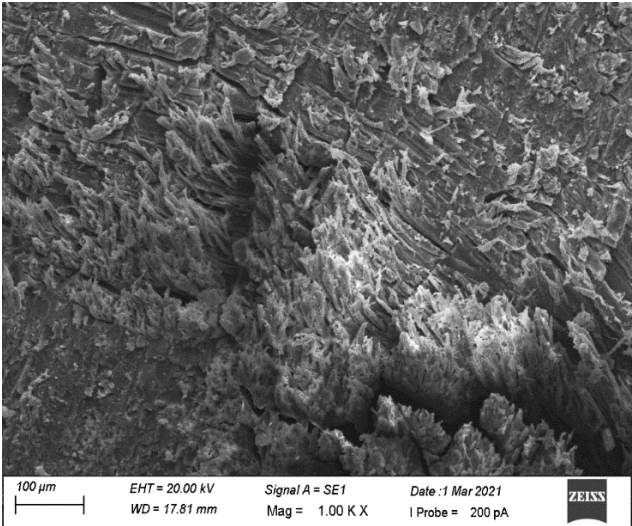
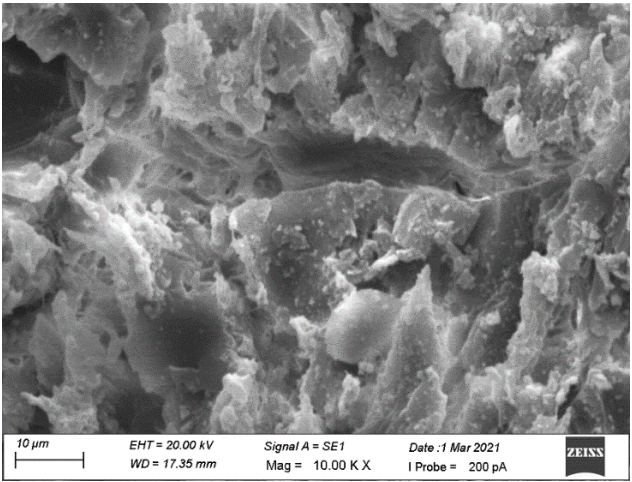
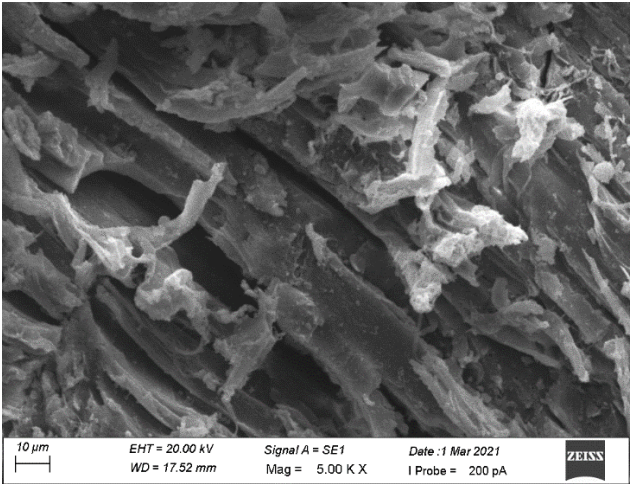
Specimen Size(mm)	Notch type	Test Temperature (degree Celcius)	Sample ID	Absorbed Energy- Joules	
				ID-1	ID-2
8x13x65	Un Notched	24	R11 is 5%	02	02
8x13x65	Un Notched	24	R21is 10%	02	02

The table 4.3 is the results obtained from the impact testing machine for the tested laminates.

4.4 SEM TEST

The two laminates (5% ratio and 10% ratio) were enclosed with Pd-Au and were seen using scanning electron microscopy (SEM) (Hitachi S-3000N) with

Secondary Electron (SE) to examine the effect of each treatment on the structure of fibers surface.



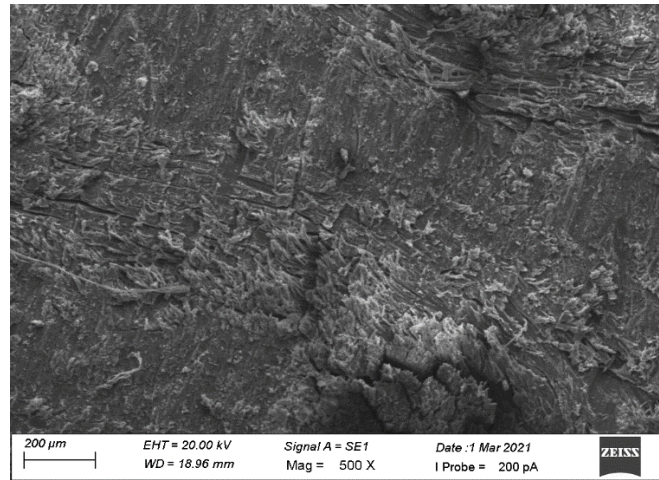


Fig 4.12 Sem images of the flax fibers reacting with zirconia

Figure 4.12 shows the results of the SEM (Scanning Electron Microscopy), the results have clearly showed the natural interface of the flax fiber when combined with the zirconia nanoparticles at different ratios.

4.5 COMPARISON

The laminates made up of 5% and 10% ratio is compared with the Carbon glass fibre currently using in Aviation Industry, The flexural ,bending strength, Tensile strength and impact strength is the properties which is going to be compared, After comparison with carbon glass fiber the results shows that an improvement of the tensile strength by 65% and flexural strength by 26% and impact strength of 17.9%.

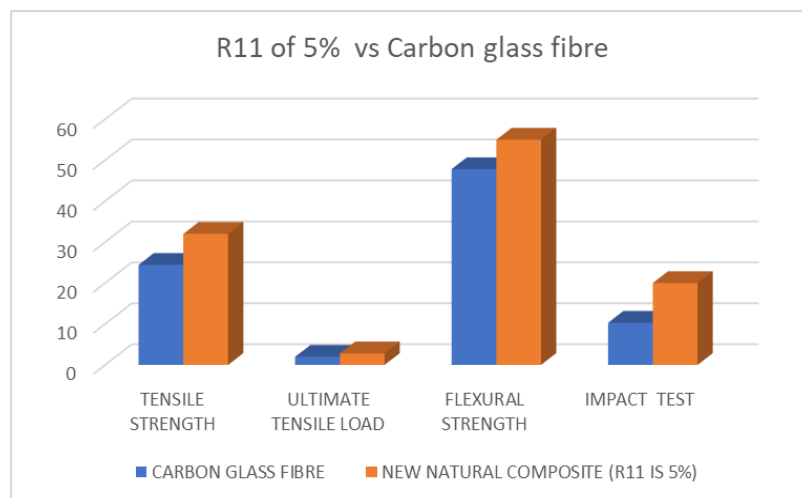


Fig 4.13 Comparison of tensile flexural strength and impact strength of R11 with carbon glass fiber.

In figure 4.13 by comparing we can clearly see that the tensile strength, flexural strength and impact strength of the R11 is comparatively higher than the carbon glass fiber

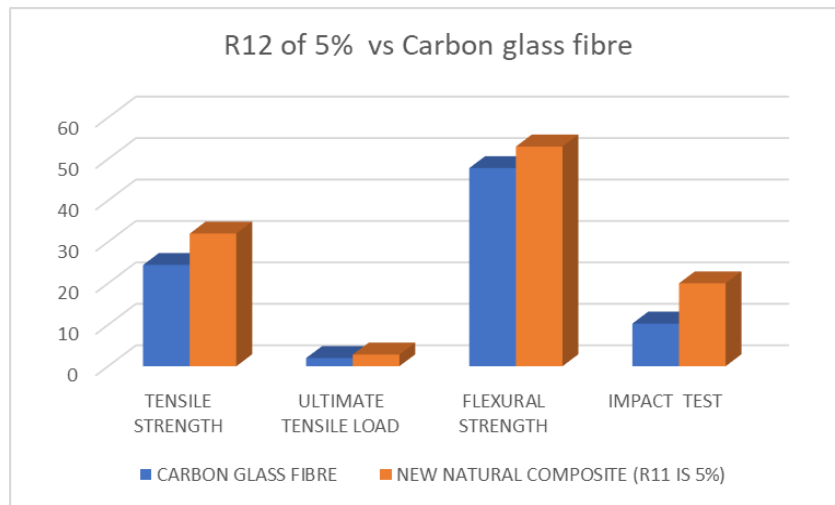


Fig 4.14 Comparison of tensile strength , flexural strength and impact strength of R12 with carbon glass fiber.

In figure 4.14 by comparing we can clearly see that the tensile strength, flexural strength and impact strength of the R12 is comparatively higher than the carbon glass fiber

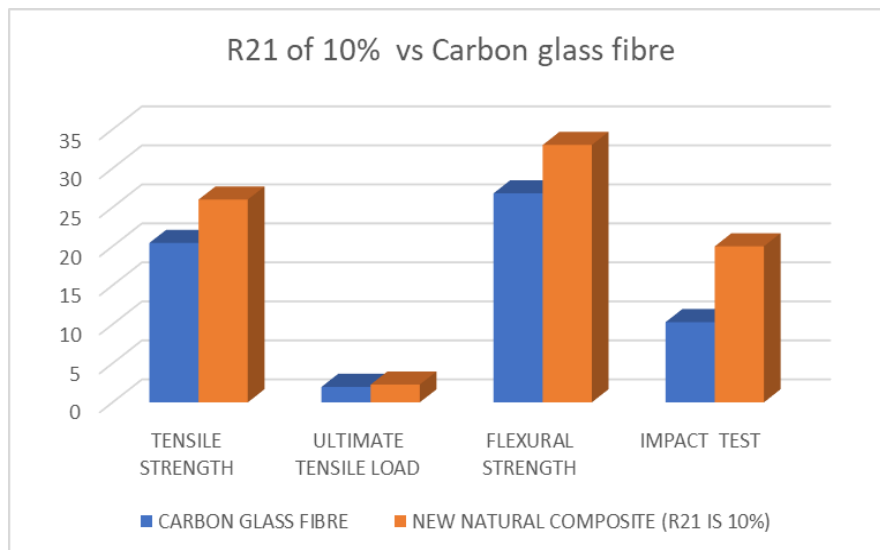


Fig 4.15 Comparison of tensile strength ,flexural strength and impact strength of R21 with carbon glass fiber

In figure 4.15 by comparing we can clearly see that the tensile strength, flexural strength and impact strength of the R21 is comparatively higher than the carbon glass fiber

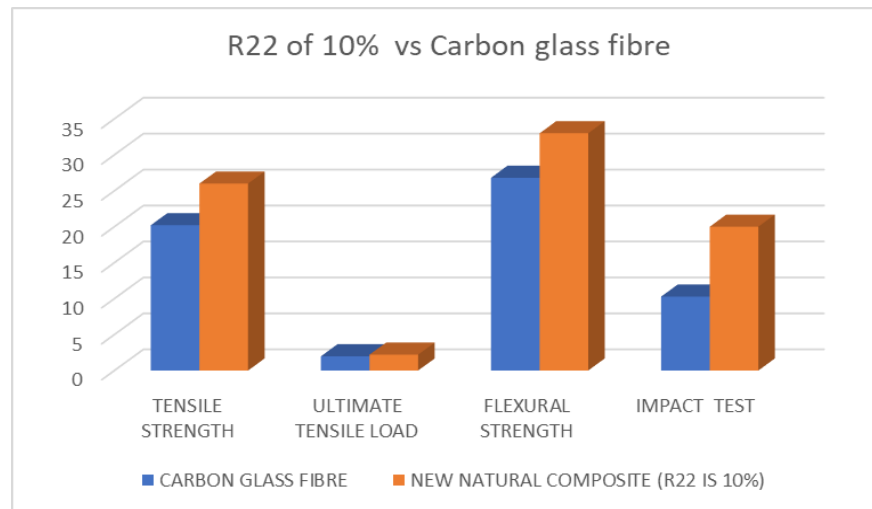


Fig 4.16 Comparison of tensile strength , Flexural strength and impact strength of R22 with carbon glass fiber.

In Figure 4.16 by comparing we can clearly see that the tensile strength, flexural strength and impact strength of the R22 is comparatively higher than the carbon glass fiber.

Table 4.4 Comparison of R11,R12,R21 and R22

Sample Names	R11 (sample one of 5%)	R12(sample two of 5%)	R21(sample one of 10%)	R22(sample two of 10%)
Ultimate testing load (kN)	2.80	2.81	2.28	2.21
Tensile strength (Mpa)	32	32	26	26
Flexural test (Mpa)	55	53	33	32
Impact test (J)	02	02	02	02

Table 4.4 shows the comparison between the tensile test ,flexural strength and impact strength of different ratio sample to identify which sample has comparatively higher strength when compared to other samples.

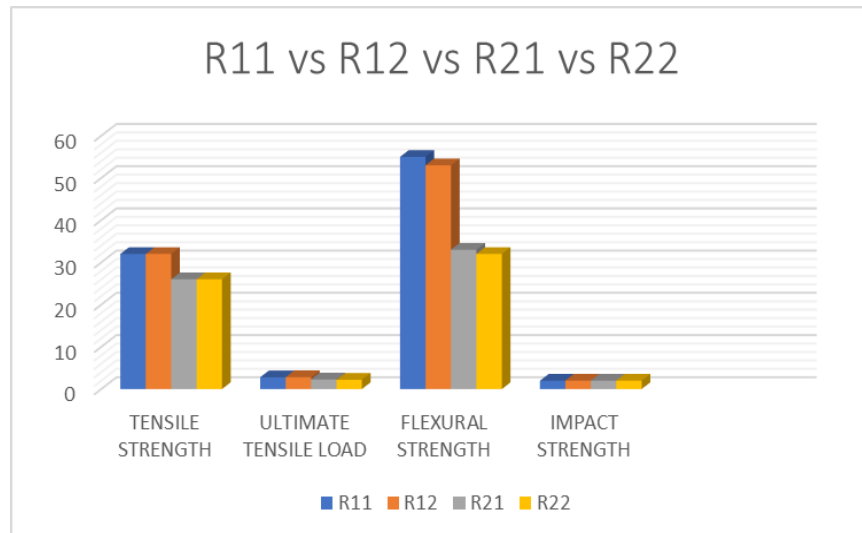


Fig 4.17 Comparison of tensile strength ,flexural strength and impact test between R11,R12,R21&R22.

In Figure 4.17 by comparing the tensile strength ,flexural strength and impact strength of the different sample of two ratio clearly shows that the R11& R12 have comparatively high tensile strength ,R11 has high flexural strength and all samples have same impact strength respectively.

CHAPTER 5

SUMMARY AND CONCLUSION

The profound knowledge materials are offered by this project along with some considerable features which include natural material and its stacking properties. These materials are made of zirconia and flax. To create a natural composite is the main objective of this project. firstly the flax fiber is obtained and the nano particle zirconia is synthesised by sol gel technique, Fabrication process is done by hand lay up process, bio epoxy resin and a hardener is used . The laminate are made in two different ratios 5% and 10% of the zirconia the ratio percentage is calculated according to the weight of the flax fiber taken. then the mixture of zirconia ,resin and hardener is applied on the flax sheets .myloor sheets are placed in between the flax sheets and aluminium to avoid sticking, finally the mixture is applied in two different ratios and let to dry until 24 hrs. The new laminate obtained is cut according to desired dimensions and named as R11(sample one of ratio 5%),R12(sample two of 5% ratio),R21(sample one of 10% ratio) and R22(sample two of 10% ratio).The laminates R11,R12,R21.R22 is subjected to certain mechanical tests which are tensile test,flexural test,impact test and Scanning Electron Microscopy(SEM) test .the results from tests are noted and plotted into graphs to observe the load vs displacement curve. And finally the tensile strength,flexural strength and impact strength of R11,R12,R21.R22 is compared with carbon glass fiber and also between themselves to identify which laminate sample has more strength in particular properties. Based on the comparison results we have carried out natural composite materials which is fabricated has been proved that they have a improved mechanical properties of tensile strength by 65% and flexural strength by 26% and impact strength of 17.9% than the carbon glass fiber used in aviation industry. Hence the new natural composite material has a possible ability to replace carbon glass fiber for aircraft interior and secondary parts of the jets.

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