

NATURAL FIBRE COMPOSITES REINFORCED WITH NANO-PARTICLES

Submitted in partial fulfillment of the requirements for the award of
Bachelor of engineering Degree in Automobile

By

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SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with “A” grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

APRIL 2023



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DEPARTMENT OF AUTOMOBILE ENGINEERING BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **M. AJAY ESHWAR (Reg. No.39860002)** and **V.DEV PRASAD (Reg.No.39860007)** who carried out the Project entitled **"NATURAL FIBRE COMPOSITES REINFORCED WITH NANOPARTICLES"** Under my supervision from November 2022 to April 2023.

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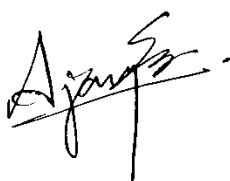
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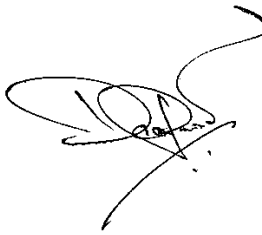
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DECLARATION

We **M. AJAY ESHWAR (Reg. No.39860002)** and **V.DEV PRASAD (Reg.No.39860007)** hereby declare that the Project Report entitled “**NATURAL FIBRE COMPOSITES REINFORCED WITH NANOPARTICLES**” done by us under the guidance of **Dr. JINO M.TECH., Ph.D.,** at is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Automobile.

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DATE: 26.04.2023

PLACE: Chennai

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ABSTRACT

Nowadays, products that are developed or invented are non-biodegradable which is against the environment which creates harm to nature. biodegradable products are very much welcomed and the demand for it is huge. Natural fiber does the job. They are biodegradable anti pollutant eco- friendly. this report is about the natural fibers and its application. natural fibers cannot be used as a raw material, to make it as a product it should undergo several processes. before using it should be converted into a composite material. A composite material is a combination of two or more materials composed together to make a matrix. This composite material is done by a compression moulding machine by hand lay-up method then testing the rigidity, tensile strength, flexibility etc. but there is an issue with natural fibers. They are not as good as glass fibers. they do not possess good physical and chemical properties. Here nanoparticles play a vital role to set this drawback. This report is about the process done to make these composites and how nanoparticles enhance the natural fibers composites.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

Natural fiber composites are gaining popularity as long-lasting and environmentally beneficial substitutes for conventional synthetic fiber composites. Natural fibers offer a high strength-to-weight ratio and are renewable resources, making them an appealing choice for a variety of industrial applications. Examples of these fibers include jute, kenaf, flax, and hemp. Natural fiber composites are still not as strong as synthetic fiber composites in terms of mechanical qualities, which prevents them from being used in high-performance applications. Natural fiber composites' improved mechanical, thermal, and physical properties have been improved by the use of nanoparticles. A thorough overview of the most recent developments in natural fiber composites enhanced with nanoparticles is the goal of this paper.

1.2 NANOPARTICLES FOR NATURAL FIBER COMPOSITES

Nanoparticles, defined as particles with a diameter less than 100 nanometers, have unique properties that make them attractive for reinforcing natural fiber composites. The high surface area-to-volume ratio of nanoparticles provides a large surface area for interfacial bonding with the natural fibers, resulting in improved mechanical properties. The most commonly used nanoparticles in natural fiber composites are carbon nanotubes (CNTs), graphene, and metal oxide nanoparticles. CNTs have exceptional mechanical and electrical properties, making them an attractive option for reinforcement. Graphene making it an excellent candidate for thermal and mechanical reinforcement. Metal oxide nanoparticles, such as titanium dioxide and zinc oxide, are used as fillers and are known for their excellent UV resistance and flame retardancy.

1.3 PROCESSING METHODS

Several processing methods have been employed to incorporate nanoparticles into natural fiber composites, including solution mixing, melt mixing, and in-situ Polymerization. Solution mixing involves dissolving the nanoparticles in a solvent and

mixing them with the natural fibers. Melt mixing involves adding the nanoparticles to the molten polymer matrix and then incorporating the natural fibers. In-situ polymerization involves polymerizing the monomers in the presence of the nanoparticles and natural fibers. The selection of processing method depends on several factors, including the type and concentration of nanoparticles, the natural fiber type, and the desired properties of the composite.

1.4 MECHANICAL PROPERTIES

Natural fiber composites' mechanical characteristics have been improved as a result of the incorporation of nanoparticles. It has been demonstrated that CNTs improve natural fiber composites' tensile strength, flexural strength, and impact resistance. Additionally, it has been suggested that graphene can make natural fiber composites more rigid and durable. Composites made of natural fibers now exhibit improved UV resistance and flame retardancy thanks to metal oxide nanoparticles. The stronger interfacial interaction between the nanoparticles and natural fibers, which results in improved load transmission and stress distribution, is what accounts for the improvements in mechanical properties.

1.5 THERMAL PROPERTIES

The incorporation of nanoparticles into natural fiber composites has also shown improvements in their thermal properties. CNTs and graphene have high thermal conductivity, which results in better heat dissipation and improved thermal stability. Metal oxide nanoparticles have been reported to enhance the UV resistance and flame retardancy of natural fiber composites, making them suitable for outdoor and fire-resistant applications.

1.6 PHYSICAL PROPERTIES

The physical characteristics of natural fiber composites have improved with the addition of nanoparticles. Natural fiber composites have been shown to have improved electrical conductivity thanks to CNTs and graphene, making them desirable for use in electrical and electronic applications. Natural fiber composites with metal oxide nanoparticles have been demonstrated to have improved water absorption and barrier qualities, making them appropriate for packaging and water-resistant applications.

1.7 APPLICATIONS

Natural fiber composites reinforced with nanoparticles have potential applications in various industries, including automotive, aerospace, and construction. In the automotive industry, natural fiber composites reinforced with nanoparticles can be used for interior parts, such as dashboard panels and door trims. In the aerospace industry, they can



FIG.1.1: Natural Fibers

CHAPTER 2

LITERATURE SURVEY

2.1 CHEMICALLY TREATED LINGO-CELLULOSIC COCONUT FABRIC- REINFORCED POLYMER ECO-NANOCOMPOSITE'S FIRE AND THERMAL RESISTANCE QUALITIES

Due to its great strength and inexpensive price, coconut fiber is a natural fiber that is frequently utilized in polymer composites. However, because to its low thermal stability and flammability, its usage in high-temperature applications is restricted. Researchers have investigated a number of methods, including chemical treatments and the inclusion of nanoparticles, to enhance the fire and thermal resistance qualities of coconut fiber-reinforced polymer composites in order to overcome these constraints.

Coconut fibers have undergone chemical treatments to increase their thermal stability and flame retardancy, such as NaOH and MAH treatments. NaOH treatment comprises soaking the fibers in a NaOH solution, removing the lignin and hemicellulose from the fibers, increasing crystallinity, and increasing thermal stability. By reacting the fibers with MAH, MAH treatment can increase interfacial bonding and flame retardancy by creating ester linkages between the fibers and the polymer matrix.

To increase the fire and heat resistance of coconut fiber reinforced polymer composites, nanoparticles like TiO₂ and ZnO have also been used. These nanoparticles are desirable for strengthening polymer composites due to their distinctive characteristics. They can, for instance, absorb and scatter UV light, which reduces the photodegradation of the polymer matrix. When heated, they can also release free radicals, which work as flame retardants by preventing combustion.

Solution mixing, melt mixing, and in-situ polymerization are a few of the processing techniques that have been used to incorporate nanoparticles and chemically modified coconut fibers into polymer composites. The kind and concentration of nanoparticles, the chemical treatment process, and the desired qualities of the composite are some of the variables that influence the processing technique choice.

The fire and thermal resistance capabilities of coconut fiber-reinforced polymer

composites have been improved as a result of the addition of chemical treatments and nanoparticles. For instance, it has been noted that treating coconut fibers with NaOH makes them more thermally stable and less flammable. It has been noted that MAH treatment of coconut fibers enhances the composites mechanical and flame-retardant qualities. It has also been demonstrated that the composites fire and thermal resistance qualities are improved by the inclusion of ZnO and TiO₂ nanoparticles.

Potential uses for these materials include the building, aerospace, and automobile industries. Due to their strong thermal resistance and flame retardancy, they can be utilized for roofing and insulation materials in the building industry. Due to their excellent strength-to-weight ratio and fire resistance qualities, they can be used for a variety of components, including panels and interior elements, in the aerospace sector. Due to their great strength and low weight, they can be utilized for a variety of components in the automotive sector, including door panels and dashboards.

In conclusion, coconut fiber-reinforced polymer composites' fire and thermal resistance qualities have been improved as a result of the addition of chemical treatments and nanoparticles. These materials are a sustainable and environmentally friendly alternative to conventional synthetic fiber composites and have potential uses in many industries.

2.2 STUDY OF NATURAL FIBER NANO REINFORCED POLYMER COMPOSITE'S MECHANICAL PROPERTIES AND TERMINOLOGICAL BEHAVIOR

Natural fiber reinforced polymer composites (NFPCs) have drawn a lot of interest recently because of their affordability and environmental friendliness. However, adding nanoparticles can enhance their mechanical qualities. Researchers have looked into the mechanical properties and lexical behavior of natural fiber nano reinforced polymer composites in this context.

Natural fiber reinforced polymer composites can have tensile strength and flexible strength and impact strength and improved by adding nanoparticles to them. Carbon nanotubes (CNTs), graphene oxide (GO), titanium di oxide (TiO₂), and other nanoparticles have all been investigated for their potential to reinforce natural fiber polymer composites. The composite desired qualities, the kind of the natural fiber used,

and the protection force all influence the nanoparticle choice.

The thermal behavior of polymer composites reinforced with natural fibers can also be influenced by the addition of nanoparticles. It has been demonstrated that the use of nanoparticles improves the thermal stability of the composites and lowers their thermal expansion coefficient. This is explained by both the improved interfacial adhesion of the polymer matrix and natural fibers, as well as the increased heat conductivity of the nanoparticles process.

Natural fiber nano reinforced polymer composites have been manufactured using a variety of techniques, such as solution blending, melt blending, and in-situ polymerization. In solution blending, the nanoparticles are first dissolved in a solvent before being combined with the polymer matrix and natural fibers. During the melt processing stage, melt blending entails combining the nanoparticles with the polymer matrix and natural fibers. Synthesizing the polymer in the presence of nanoparticles and natural fibers is known as in-situ polymerization.

Utilizing a variety of testing techniques, the natural fiber nano-reinforced polymer composites mechanical and thermal characteristics of the composites have been assessed using tensile testing, flexible testing and impact testing. To assess the thermal behavior of the composites, thermogravimetric analysis (TGA) and differential scanning calorimetry (DCS) have been used.

Natural fiber reinforced polymer composites' mechanical and thermal properties have been improved as a result of the use of nanoparticles. For instance, it has been noted that GO nanoparticles boost the composites' tensile strength, flexural strength, and impact strength. Additionally, it has been demonstrated that CNT inclusion improves the composites' impact and tensile strengths. Additionally, it has been demonstrated that the use of nanoparticles improves thermal stability and lowers the thermal expansion coefficient of the composites.

The automobile, building, and aerospace industries could all benefit from using the natural fiber nano reinforced polymer composites. Due of their great strength and low weight, they can be employed in the automotive sector for a variety of components, including bumpers and dashboards. Due to their great thermal stability and fire-resistant qualities, they are suitable for use as roofing and insulation materials in the building

industry. Due to their excellent strength-to-weight ratio and fire resistance qualities, they can be used for a variety of components, including panels and interior elements, in the aerospace sector.

In conclusion, the mechanical and thermal properties of natural fiber reinforced polymer composites have been improved as a result of the addition of nanoparticles. The production process and nanoparticle selection can have an impact on the composite's characteristics. These materials are a sustainable and environmentally friendly alternative to conventional synthetic fiber composites and have potential uses in many industries.

2.3 CHARACTERIZATION OF SWELLABILITY, COMPRESSIVE, AND IMPACT STRENGTHS OF MAIZEHUSK FIBER COMPOSITES

Maize husk fibers, a byproduct of the agricultural industry, have been used as a reinforcement material in polymer composites because of their low cost, renewable nature, and high availability. The swellability, compressive strength, and impact strength characteristics of maize husk fiber composites have been investigated to evaluate their potential for various applications.

The swellability of natural fiber composites is a critical characteristic since it impacts the material's ability to withstand moisture absorption and preserve its dimensional stability. It has been shown that composites constructed of maize husk fibers swell significantly because the surface of the fibers has hydrophilic functional groups. However, chemical treatments and coatings can be used to decrease the composites' swelling behavior.

The compressive strength of maize husk fiber composites has been evaluated using both compressive testing and micro-computed tomography (micro-CT) studies. It has been proven that including maize husk fibers into the polymer matrix improves the compressive strength of the composites. The improved compressive strength is attributed to the fiber orientation inside the matrix and the enhanced aspect ratio.

Impact strength is a critical characteristic for materials that are subjected to high-stress impact loads, such as those used in the construction and automotive industries. The impact strength of composites made of maize husk fiber has been evaluated using

both the Charpy and the Izod impact tests. It has been established that the addition of maize husk fibers to the polymer matrix increases the impact strength of the composites. The improvement in impact strength is attributed to the fibers' increased energy absorption capacity and the fibers' improved interfacial interaction with the polymer

corn husk fiber composites have been created using a variety of production techniques, including compression moulding, extrusion, and injection moulding. The preferred composite qualities and the kind of polymer matrix are taken into consideration while choosing the manufacturing procedure. For instance, extrusion is appropriate for making low-cost, large-volume composites, whereas compression molding is appropriate for producing composites with high strength.

Composites made of corn husk fiber could be used in a variety of fields, including construction, automotive, and packaging. Due to their great strength and low weight, they can be utilised for a variety of components in the automotive sector, including door panels and dashboards. Due to their high absorption capacity and soundproofing qualities, they can be employed in the building sector for a variety of purposes, including insulation and acoustic panels. Due to their low cost and biodegradability, they can be utilised in the packaging business for a variety of items, including trays and containers.

As a result of the assessment of the swellability, compressive strength, and impact strength characteristics of corn husk fiber composites, it can be concluded that they have the potential to replace conventional synthetic fiber composites with a more sustainable and environmentally friendly option. Corn husk fibers can enhance the compressive and impact strength of composite materials while chemical treatments and coatings can lessen the swelling behaviour of the materials. The type of polymer matrix utilised and the production technique both have an impact on the composite's characteristics. These materials can aid in the growth of a circular economy and have potential uses across numerous industries.

2.4 AN EXAMINATION OF THE BANANA PSEUDO-STEM'S MORPHOLOGY AND CHEMICALMAKEUP

An agricultural waste product called banana pseudo-stem has the potential to be

exploited as a sustainable and renewable resource for the creation of bio-based goods. Understanding the banana pseudo-stem's potential as a raw material for numerous use

Numerous analytical methods, such as Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD), and thermogravimetric analysis (TGA), have been used to investigate the chemical composition of banana pseudo-stem. The functional groups found in the banana pseudo-stem have been identified using FTIR spectroscopy, and the crystallinity of the cellulose fibers has been determined using XRD analysis. The pseudo-stem's heat stability and decomposition behaviour have been determined using TGA.

According to the findings of these investigations, cellulose, hemicellulose, and lignin, the main components of plant biomass, make up the majority of the banana pseudo-stem. Banana pseudo-stem has a cellulose concentration of between 40% and 50% and a hemicellulose level of between 15% and 25%. In comparison to other lignocellulosic materials, the lignin percentage of banana pseudo-stem is between 15% and 20%, which is comparatively low.

Additionally, utilising a variety of methods, such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM), the morphological structure of banana pseudo-stems has been investigated. The surface morphology of the fibers has been visualised using SEM, and their internal structure has been studied using TEM and AFM.

According to the findings of these investigations, banana pseudo-stem fibers have a distinctive shape that is distinguished by a hollow lumen and a thin, homogeneous cell wall. The diameter of the long, thin fibers ranges from 10 to 20 μm . The parallel and regular arrangement of the fibers is crucial for their prospective usage as a reinforcing component in composites.

The creation of bio-based composites, paper, and textiles are just a few uses for banana pseudo-stem, which has the potential to be utilised as a raw material for many more. Fibers are a good contender for usage as a reinforcing material in polymer composites due to their distinct shape and chemical makeup. Banana pseudo-stem is a good candidate for the manufacturing of high-purity cellulose fibers due to its low lignin content.

In summary, the study of the chemical make-up and morphological structure of banana pseudo-stem has shed light on its potential as a sustainable and renewable resource for a range of uses. According to the findings of these investigations, cellulose, hemicellulose, and lignin make up the majority of the banana pseudo-stem's material, and the fibers have a distinctive shape that is distinguished by a hollow lumen and a thin, homogeneous cell wall. Banana pseudo-stem is a good candidate for the development of bio-based composites, paper, and textiles due to these qualities.

2.5 REVIEW OF CURRENT CELLULOSE NANOCOMPOSITE PROCESSING ADVANCEMENTS

Due to its potential for usage in numerous applications, such as the packaging, automotive, and biomedical industries, cellulose nanocomposites (CNCs), a class of materials, have attracted a lot of attention recently. To enhance the mechanical, thermal, and barrier properties of the resulting composite material, CNCs are made up of cellulose nanocrystals (CNCs) or cellulose nanofibers (CNFs).

The dispersion and alignment of the nanofibers or nanocrystals inside the polymer matrix have improved as a result of recent major advancements in CNC processing techniques. The mechanical and barrier properties of the resulting CNC composites have been improved as a result of these improvements.

Achieving a consistent dispersion of the CNCs inside the polymer matrix is one of the major issues in CNC processing. To solve this problem, a number of methods have been created, including extrusion, high-pressure homogenization, and sonication. High-frequency sound waves are used during sonication to fragment CNC aggregates and enhance their dispersion inside the polymer matrix. In order to create a homogeneous dispersion, intense pressure is used to press the nanocellulose fibers through a small opening. In extrusion, the CNCs are mixed with the polymer matrix under high shear

The use of surface changes to enhance the compatibility between the CNCs and the polymer matrix has been another area of progress in CNC processing. To increase the dispersion and adherence of the CNCs inside the polymer matrix, surface modifications can comprise chemically treating the CNCs or applying surface coatings. To change the surface chemistry of the CNCs, chemical treatments can include esterification or acid

hydrolysis. To improve the compatibility between the CNCs and the polymer matrix, surface coatings may include surfactants, silanes, or other coatings.

There have been advancements in the utilisation of various cellulose nanocomposites in addition to processing methods. For instance, it has been demonstrated that CNFs, with their longer length and greater aspect ratio, outperform CNCs in terms of increasing the mechanical properties of the produced composites. Additionally, research has been done on using lignocellulosic biomass as a raw material to create CNCs and CNFs, which can lead to more environmentally friendly and sustainable processing.

In general, advancements in CNC processing have led to better nanofiber or nanocrystal alignment and dispersion within the polymer matrix, which has enhanced the mechanical and barrier properties of the resulting CNC composites. These advancements have involved surface changes, the use of various cellulose nanocomposites, and the utilisation of processing methods like sonication, high-pressure homogenization, and extrusion. These developments show promise for the creation of fresh and enhanced CNC materials for a variety of industrial uses.

CHAPTER 3

AIM AND SCOPE

3.1 AIM OF THE PROJECT

The aim of using natural fiber composites reinforced with nanoparticles is to improve the mechanical and physical properties of the resulting composite material. Natural fibers are a renewable and environmentally friendly alternative to traditional synthetic fibers, but their mechanical properties are often limited. By incorporating nanoparticles into the composite material, the resulting material can have improved strength, stiffness, and durability, making it suitable for a wider range of industrial applications. Additionally, the use of natural fibers and nanoparticles can also lead to more sustainable and environmentally friendly production processes, reducing the environmental impact of composite manufacturing.

3.2 SCOPE OF WORK

A wide range of industries and applications are covered by research on natural fiber composites reinforced with nanoparticles. In comparison to conventional synthetic fiber composites, the use of natural fibers as a reinforcement material has a number of benefits, including decreased weight, enhanced mechanical qualities, and higher sustainability.

One of the primary areas of research in this field is the development of new composite materials for use in the automotive industry. Lightweight and durable materials are highly sought after in the automotive industry, and natural fiber composites reinforced with nanoparticles have shown promise in improving the mechanical properties of these materials. This can lead to improved fuel efficiency and reduced environmental impact.

The creation of packaging materials is another field of study. Because they have better barrier qualities, natural fiber composites enhanced with nanoparticles are

appropriate for use in food packaging applications. Alternatives to conventional plastic packaging that are more environmentally friendly may be offered by these materials.

In the construction industry, natural fiber composites reinforced with nanoparticles can be used to create high strength building materials, such as roofing tiles and wall panels. These materials can provide a more sustainable alternative to traditional construction materials while also offering improved mechanical properties.

The work involved in developing natural fiber composites reinforced with nanoparticles typically involves a combination of material characterization, processing optimization, and mechanical testing. Researchers must first determine the optimal composition and processing conditions for the composite material. This involves identifying the best combination of natural fiber, nanoparticle type and concentration, and polymer matrix. The mechanical and physical properties of the composite material must be determined once it has been created. The performance of the material is enhanced by using this information to optimize the processing parameters. In order to determine the composite materials, suitability for different industrial applications, mechanical qualities including applications, mechanical qualities including strength, stiffness, and toughness are examined.

Overall, the scope of research on natural fiber composites reinforced with nanoparticles is vast, with applications ranging from automotive and packaging to construction and consumer goods. The work involved in developing these materials requires a multidisciplinary approach and often involves collaboration between researchers from various fields, including materials science, chemistry, and engineering.

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIAL

The methodology for developing natural fiber composites reinforced with nanoparticles typically involves several key steps, including material selection, processing, characterization, and mechanical testing. The first step in developing a natural fiber composite reinforced with nanoparticles is to select the appropriate materials. This involves choosing the natural fiber, nanoparticle, and polymer matrix that will be used to create the composite material. The selection process is typically based on the desired properties of the final composite, such as mechanical strength, thermal stability, and environmental sustainability.

4.2 PROCESSING

Once the materials have been selected, the next step is to process them into a composite material. This can be done using a variety of techniques, such as melt blending, solution casting, and compression molding. The processing method chosen will depend on the materials being used, the desired properties of the final composite, and the processing equipment available.

4.3 CHARACTERIZATION

The qualities of the composite material must be ascertained once it has been manufactured. Analyzing the material's physical characteristics, morphological structure, and chemical make-up is necessary for this. In order to characterize natural fiber composites reinforced with nanoparticles, methods including scanning electron microscopy, Fourier-transform infrared spectroscopy, and thermal gravimetric analysis are frequently used.

4.4 MECHANICAL TESTING

Finally, the composite material must be tested for mechanical properties, such as strength, stiffness, and toughness. This is typically done using standard testing protocols, such as tensile testing, compression testing, and impact testing. The mechanical properties of the composite material can be further optimized through the use of statistical design of experiments, which can help identify the most influential parameters in the composite fabrication process.

Allows researchers to create composite materials with improved properties that can be used in a wide range of industrial applications.

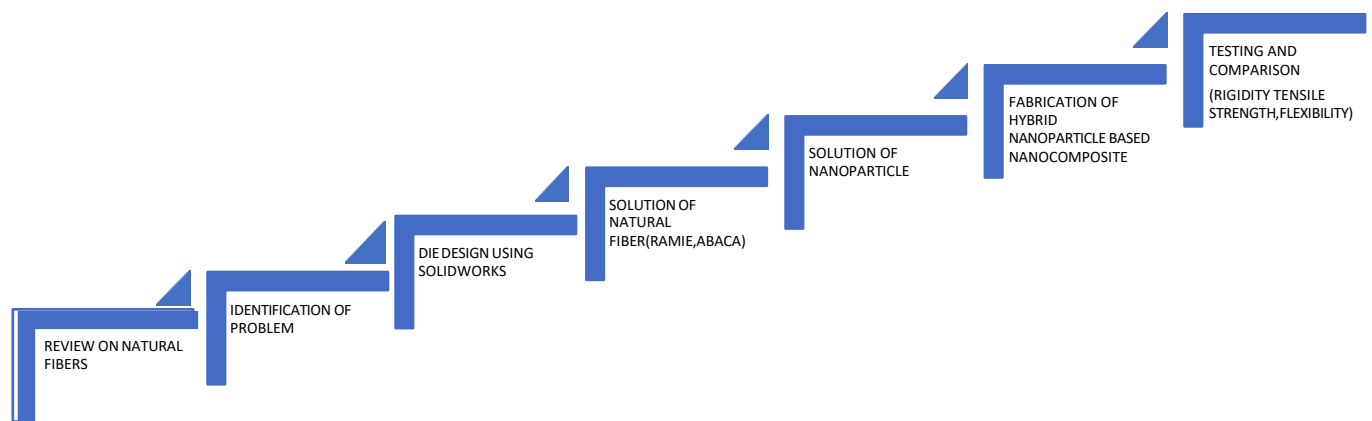


FIG.4.1: Methodology Chart

4.5 FIBERS RAMIE

Ramie fibers are natural fibers derived from the stems of the Ramie plant, also known as China grass (*Boehmeria nivea*). Ramie fibers are lustrous, highly absorbent, and strong, making them a popular choice for fabrics in warm and humid regions. Ramie fibers are also lightweight and breathable, making them ideal for use in clothing and home textiles.

4.6 ABACA

Abaca is a natural fiber derived from the leaves of the abaca plant, which is also known as Manila hemp (*Musa textilis*). It is a strong, durable, and versatile material that is commonly used in the production of textiles, paper products, and cordage. Abaca fibers are highly valued for their strength, flexibility, and resistance to saltwater damage. They are also lightweight, which makes them ideal for use in clothing, bags, and other fashion accessories.

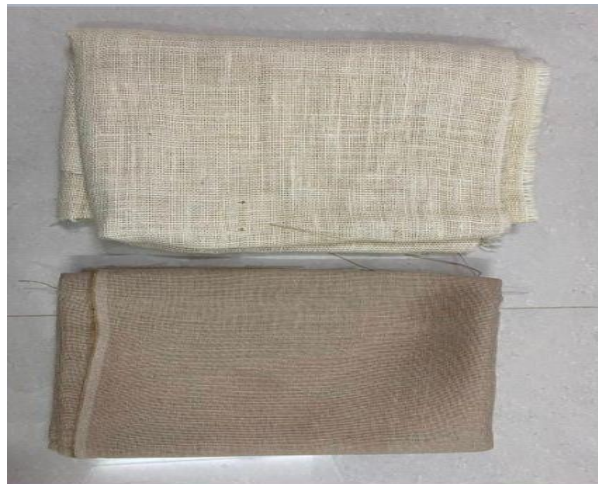


FIG.4.2: Ramie& Abaca (Below)

4.7 EPOXY AND HARDNER

Epoxy is a type of thermosetting polymer that is created by mixing two components - a resin and a hardener. The resin is a viscous, clear liquid that acts as the base of the epoxy, while the hardener is a catalyst that is added to the resin to initiate the curing process. When mixed together in the correct ratio, the two components undergo a chemical reaction that results in a hard, durable, and resistant material. Epoxy has a wide range of applications and is commonly used in construction, automotive, aerospace, marine, and electronics industries. It is a popular material for adhesives, coatings, and composites due to its excellent bonding strength, chemical resistance, and mechanical properties.



FIG.4.3: Epoxy And Hardner

4.8 PROCESS

4.8.1 Measurement Of The Material

The process of combining fibers such as ramie or abaca with epoxy and hardener using the hand lay-up method involves the following steps.



FIG.4.4 Measuring The Ramie And Abaca

4.8.2 Prepare The Fibers.

The ramie or abaca fibers need to be cleaned and dried before use. They can be cut to the desired length and laid out in a mold or on a surface.



FIG.4.5: Cutting The Ramie And Abaca In Square

This is the material obtained from nature. Which is come out from China grass. Which has various properties which will be useful for the product to withstand and provide good

durability of the fibers, which can be used in various industries.



FIG.4.6 The materials are ready for experiment.

4.8.3 Mix The Epoxy And Hardener.

The epoxy resin and hardener must be mixed in the correct ratio according to the manufacturer's instructions. The mixing process should be thorough to ensure a uniform mixture.



FIG.4.7 Mixing Process



FIG.4.8 Pouring Process

4.8.4 Apply The Epoxy Mixture.

The epoxy mixture is applied to the fibers using a brush or roller. The fibers should be completely saturated with the epoxy mixture to ensure good adhesion.



FIG.4.9 Setting Process



FIG.4.10 Layering Process

4.8.5 Consolidate The Fibers.

A roller or squeegee is used to consolidate the fibers and remove any air bubbles or excess epoxy. This step is crucial for achieving a strong and durable final product.



FIG.4.11 Settling Process



FIG.4.12 Rolling Process

4.8.6 Curing Process.

The epoxy and hardener mixture need time to cure and to become harden. The curing time will depend on the specific product being used and the temperature and humidity of the environment. Mostly 24 hrs.



FIG.4.13 Repeating the Process

4.8.7 Final Output Of The Composite

After all the processes such as plating, placing fibres and applying the mixture of epoxy, hardner, resin and nano clay we get this result after leaving it for 24 hours of curing at room temperature. This is the image of the product after all these processes are done. This is how the composite material look alike. This composite is the combination of abaca and ramie obtained from natural fibres.



FIG.4.14 Composite Material Of (Ramie Fiber & Abaca Fiber)

This the material has been cut from the composite material in measurement of for the testing of ILSS, through which we can conduct various tests such as delamination and shear strength, flexibility test etc.

CHAPTER 5

RESULT AND DISCUSSION

5.1 RESULT

I learned that the use of nanoparticles boosts natural fiber composites in many ways by virtue of their chemical properties after reading a great deal of review papers about natural fibers and their qualities as well as about nanoparticles and composites. As a result, we draw the conclusion that adding nanoparticles to natural fiber will improve the end product and give it a high-quality natural fiber that can be used in a variety of industries, including the automotive and aerospace sectors. We followed every step outlined in the protocol, and as a result, we received a product after compression.



Fig.5.1 Sample For Testing



Fig.5.2 De-Lamination Image

This image tell the exact report of delamination this the above small piece as mentioned is placed on this machine then the machine starts testing the levels of the product that up to what limit the product can withstand and how the fibers break and at what newton force it gets broken and up to what extend the product is flexible strong and brittle etc. at certain newton force the piece will get broke thus the delamination occurs and we know the breaking point of fibers. Which also helps us to further enhance the fiber material by adding or changing nanoparticle



FIG.5.3 Utm-Universal Testing Machine

5.1.1 Tensile Strength

The test result of the tensile strength. The polymer matrix composite was yesyed in different test levels of in different stress such as 2,4,6,8,10 up to 30 but the composite was fractured at strain of 0.4 and stress of 4.2 N/mm². hence the overall test result we received was 29.10N/mm². This fig tells the different stress and strain that the composite went through and yes it withstands up to 0.4 strain. And the overall result that we obtained was 29.10 N/mm².

Graph Type : Stress Vs. Strain

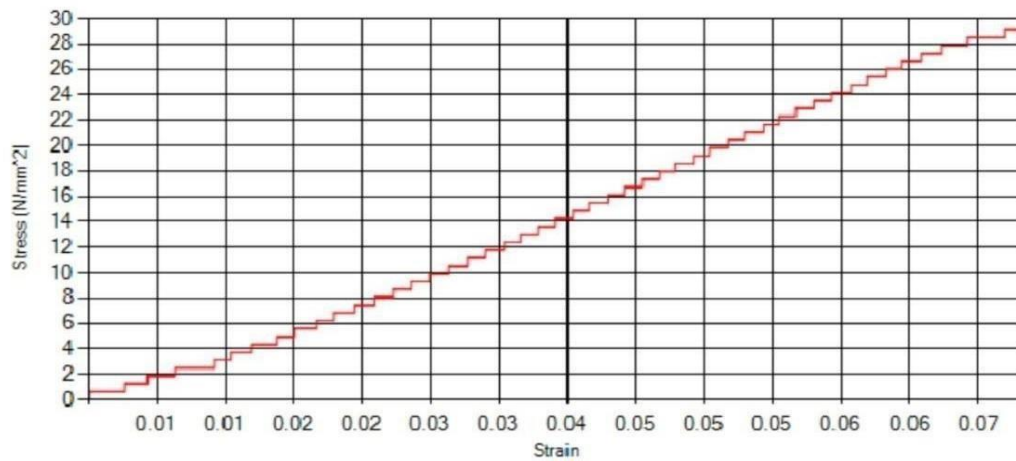


Fig.5.4 Tensile Strength Graph

5.1.2 Flexural Strength

This test tells the flexibility of the material in which the maximum limit of the product to bend without deforming. Hence this composite is treated differently. Ad conditions in ratio with displacement. Fig shows the test which the composite undergone. Staring from 100 N till 300N the fiber is flexible at 2.62mm and 300N it is flexible and then it drops down.

Graph Type : Load Vs. Displacement

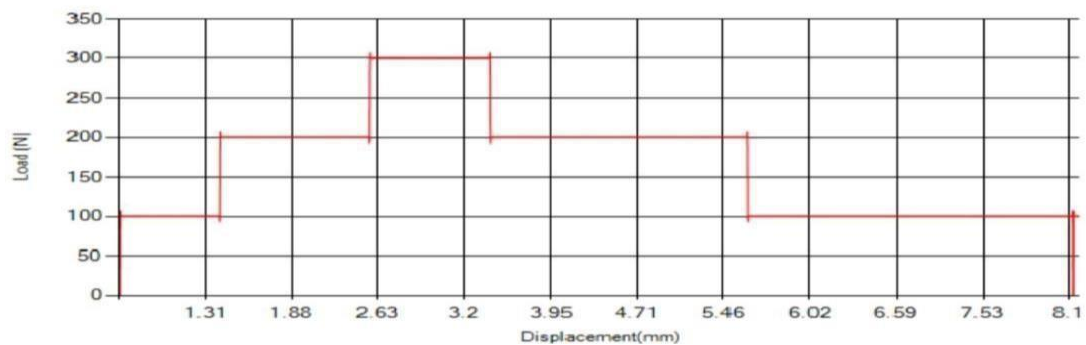


Fig.5.5 Flexural Strength Graph

5.1.3 Interlaminar Shear Strength

Here, the sample is examined in the same UTM device under various load and displacement circumstances. Figure 1 illustrates how nano clay-treated fibers' ILSS behavior exhibits better value as standards for composites. The ILSS increased for particles up to 1.56 mm displacement at 498N load and it decreased after the delamination at 2.63 mm at 500N load when the OMMT nano clay nanoparticles were introduced. This decrease in strength is brought on by the clustering effect of the particles within the matrix materials because they are not surface treated and are therefore unable to fully submerge in natural fiber composite. and the fig. depicts the delamination.

However, the shear strength increased significantly with the addition of the nano clay, reaching 49.05 N/mm² and being able to bear loads of up to 498 N. This improvement is the result of adding nano clay to epoxy during the surface treatment process of the resin. and epoxy, which strengthens the binding between the resin, epoxy, and reinforcing material, improving ILSS.

Graph Type : Load Vs. Displacement

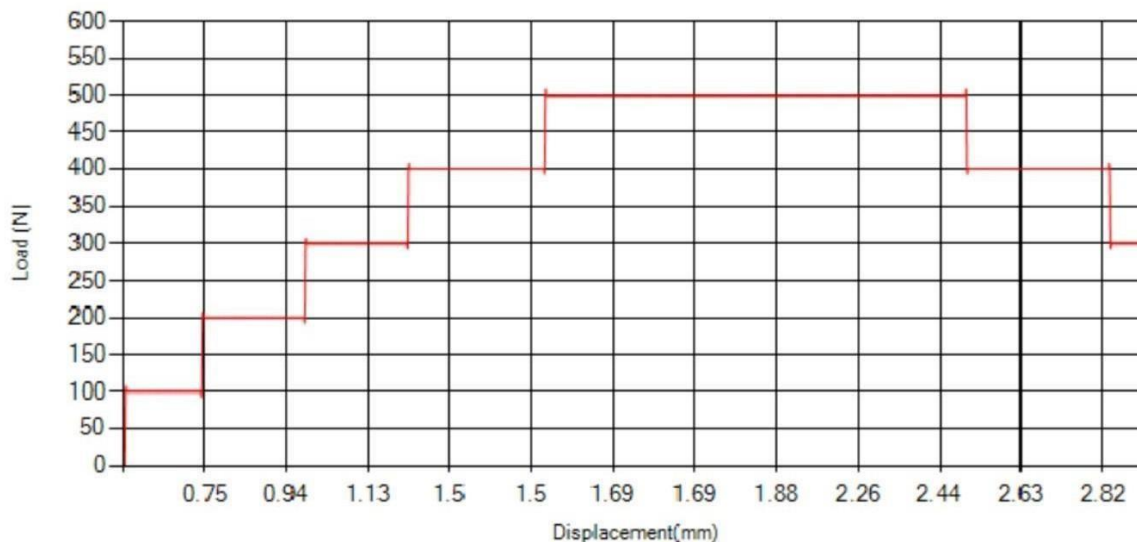


FIG.5.6 Interlaminar Shear Strength Test Graph

CHAPTER-6

CONCLUSION

6.1 CONCLUSION

Natural fiber composites reinforced with nanoparticles have shown great potential in improving the mechanical and physical properties of the composites. The addition of nanoparticles to natural fiber composites has resulted in enhanced tensile strength, modulus of elasticity, and thermal stability. The improved properties are attributed to the high surface area of nanoparticles, which creates a strong interfacial bond between the natural fibers and the polymer matrix. Additionally, the nanoparticles can act as a barrier against moisture and UV radiation, which can enhance the durability of the composites. However, the production cost of natural fiber composites reinforced with nanoparticles is still relatively high, and further research is needed to optimize the manufacturing process and reduce the production cost. Overall, the use of nanoparticles in natural fiber composites has shown promise in enhancing their mechanical and physical properties, and has the potential to find applications in various industries, including automotive, construction, and aerospace.

REFERENCES

- [1] Rajini, N.; Jappes, J.W.; Siva, I.; Rajulu, A.V.; Rajakarunakaran, S. Fire and thermal resistance properties of chemically treated ligno-cellulosic coconut fabric– reinforced polymer eco-nanocomposites. *J. Ind. Text.* 2016, 47, 104–124.
- [2] Ramu, P.; Kumar, C.J.; Palanikumar, K. Mechanical Characteristics and Terminological Behavior Study on Natural Fiber Nano reinforced Polymer Composite—A Review. *Mater. Today Proc.* 2019, 16, 1287– 1296.
- [3] Sari NH, Fajrin J, Suteja, Fudholi A. Characterisation of swellability and compressive and impact strength properties of corn husk fiber composites. *Composites Communications* 2020;18:49e54.
- [4] Zhang Z, Zhang J, Li S, Liu J, Dong M, Li Y, et al. Effect of graphene liquid crystal on dielectric properties of polydimethylsiloxane nanocomposites. *Compos B Eng* 2019:176.
- [5] Li K, Fu S, Zhan H, Zhan Y, Lucia L. Analysis of the chemical composition and morphological structure of banana pseudo-stem. *BioResources* 2010;5:576e85.
- [6] Joshi SV, Drzal LT, Mohanty AK, Arora S. Are natural fiber composites environmentally superior to glass fiber reinforced composites? *Compos. Part A* 2004;35:371e6.
- [7] Madhu P, Rangappa SM, Pradeep S, Subrahmanya Bhat K, Yogesha B, Siengchin S. Characterization of cellulosic fiber from Phoenix pusilla leaves as potential reinforcement for polymeric composites. *J. Mater. Res. Technol.* 2019;8:2597e604
- [8] Karima A, Ridho MR, Munawar SS, Adi DS, I, Damayanti R, Subiyanto B, Fatriasari W, Fudholi A. A review on natural fibers for the development of eco-friendly biocomposites: characteristics and utilizations
- [9] Dhaliwal JS. Natural fibers: applications. In: *Development and modifications of natural fibers*. Interchopen; 2020
- [10] Fatriasari W, Syafii W, Wistara NJ, Syamsu K, Prasetya B. The characteristic changes of betung bamboo (*Dendrocalamus asper*) pretreated by fungal pretreatment. *Int J Renew Energy Dev* 2014;3(2):133e43. [https://doi.org/ 10.14710/ijred.3.2.133-143](https://doi.org/10.14710/ijred.3.2.133-143).
- [11] Oksman K, Aitomäki Y, Mathew AP, Siqueira G, Zhou Q, Butylina S, et al. Review of the recent developments in cellulose nanocomposite processing. *Compos. Part A Appl Sci Manuf* 2016;83:2e18. <https://doi.org/10.1016/j.compositesa.2015.10.041>.
- [12] Gupta US, Dhamarika M, Dhakar A, Tiwari S, Namdeo R. Study on the effect of fiber volume percentage on banana reinforced epoxy composite by finite-element method. *Adv Compo Hybrid Mater* 2020. <https://doi.org/10.1007/s42114-020-00179-9>.
- [13] Sana AW, Noerati, Sugiyana D, Sukardan MD. Aplikasi serat alam biduri (*Calotropis gigantea*) sebagai bahan pengisi insulatif pada jaket musim dingin. *Arena Tekstil* 2020;1(35):1e12.

- [14]Ilaiya Perumal C, Sarala R. Characterization of a new natural cellulosic fiber extracted from *Derris scandens* stem. *Int J Biol Macromol* 2020;165:2303e13. <https://doi.org/10.1016/j.ijbiomac.2020.10.086>.
- [15] Pandit P, Pandey R, Singha K, Shrivastava S, Gupta V, Jose S. Pineapple leaf fiber: cultivation and production. In pineapple leaf fibers, green energy and technology. In: Jawaid, et al., editors. Singapore 189721: Springer Nature SingaporePte Ltd; 2020. p. 1e20.
- [16] Suparno O. Upaya potensi dan masa depan serat alam Indonesia sebagai bahan baku aneka industri. *Jurnal Teknologi Industri Pertanian* 2020;30(2):221e7. <https://doi.org/10.24961/j.tek.ind.pert.2020.30.2.221>
- [17].Girijappa YG, Rangappa SM, Parameswaranpillai V, Siengchin S. Natural fibersas sustainable and renewable resource for development of Eco-friendly composites: a comprehensive review. *Front. Mater* 2019;2:226. <https://doi.org/10.3389/fmats.2019.00226>.
- [18]. Korotcenkov, G. *Fundamentals of Sensing Materials Volume 2: Nanostructured Materials*; Momentum Press: New York, NY, USA, 2010.
- [9]. Alishahi, E.; Shadlou, S.; Doagou-R, S.; Ayatollahi, M.R. Effects of carbon nanoreinforcements of different shapes on the mechanical properties of epoxy-based nanocomposites. *Macromol. Mater. Eng.* 2013, 298, 670–678.
- [20]. Ayatollahi, M.R.; Shadlou, S.; Shokrieh, M.M.; Chitsazzadeh, M. Effect of multi-walled carbon nanotube aspect ratio on mechanical and electrical properties of epoxy-based nanocomposites. *Polym. Test.* 2011, 30, 548–556.

