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Design and Analysis of Composite Material by using Natural Fibers

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ABSTRACT:

In present year's natural and synthetic fiber composite material locale a major role in industries like aerospace and automobile. The composites formed by fibers gained attention due to their low cost, light weight, low density, high specific strength, non-abrasively, non-toxicity etc. in this project discussed the Composite material plate by using pineapple leaf fiber , fermented spinach, babul wood with Epoxy composite and to evaluate the Mechanical properties of pineapple leaf spring (Tensile strength, Impact and Hardness test) The fabricated composites are tested for mechanical properties such as Compression strength, Tensile strength, Impact strength, Bending, Torsion, and Shear expected to be improved by varying the composition of pineapple leaf fiber, fermented spinach, babul wood.

INTRODUCTION:

OVER VIEW OF COMPOSITE MATERIALS:

In the past few decades, research and engineering interest has been shifting from monolithic materials to fiber-reinforced polymeric materials at macroscopic level or even Nano level. The quest for light weight and high strength materials is never ending for due consideration owing to their wide applications. Therefore,a polymeric composite material has its importance in the applications of light structures. These composite materials are (notably aramid, carbon and glass fiber reinforced plastics etc.) Now dominate the aerospace, automotive, construction and sporting industries. However, these fibres have serious drawbacks such as no renewability, non-recyclability, non-bio-degradability etc. These shortcomings have been highly exploited by proponents of natural fiber composites. Though mechanical properties of natural fibres are much inferior to those of artificial fibres, their specific properties, especially stiffness, are comparable to the stated values of artificial fibres. Various kinds of polymer matrix composites reinforced with metal particles, fibres, whiskers and particles have a wide range of industrial applications. Composite materials are man-made materials which are manufactured with an aim of replacing the conventional materials by overcoming their disadvantages. A composite material has two main constituents namely, matrix and reinforcements. The reinforcements or fibers are the main load carrying elements and it provides strength and rigidity to composite whereas, matrix gives the shape to composite, maintains fiber alignment and protects them against the environmental and possible damage. Composite materials are broadly classified in to three types based on the matrices namely, polymer matrix composites (PMC), metal matrix composites (MMC) and ceramic matrix composites (CMC).

A polymer matrix composite is otherwise called as Fiber Reinforced Plastics (FRP) and uses polymeric resins like polyester, vinyl ester, poly-ether- ether-ketone (PEEK), polyurethanes, etc as their matrix.

A metal matrix composite uses metals as their matrix and a ceramic matrix composite uses ceramics as their matrix. The reinforcements in all types of composites may be synthetic fibers, metals, alloys, ceramics, natural fibers, etc. Among the composites classified earlier, fiber reinforced plastics are widely used as structural elements in aircraft, marine, civil and commercial sectors. Fiber reinforced plastics replace conventional materials in all applications due to its tailor.

Classifications of Composites

A composite is a structural material which consists of two or more constituents combined at a macroscopic level. The constituents of a composite material are a continuous phase called matrix and a discontinuous phase called reinforcement. Matrix gives shape and protects the reinforcement from the environment. It also makes the individual fibres of the reinforcement act together and provides transverse shear strength and stiffness to the laminated composites. The matrix factors which contribute to the mechanical performance of composites are transverse modulus and strength, shear modulus and strength, compressive strength, inter-laminar shear strength, thermal expansion co-efficient, thermal resistance and fatigue strength. Reinforcement provides strength and stiffness and controls thermal expansion co-efficient. It also helps to achieve directional properties. Reinforcements may be in the form of fibers, particles or flakes.

The fiber factors which contribute to the mechanical performance of a composite are length, orientation, shape and material.

The factor which influences the mechanical performance of composites other than the fiber and the matrix is the fiber-matrix interface. It predicts how well the matrix transfers load to the fibers.

OBJECTIVE:

The objective of our project is to make a composite material like composition epoxy; Pineapple, Glass Fiber and Babul wood for improve the fatigue loading capacity of the flat plate, compressive strength, ductility and tensile strength and weigh reduction to improve overall efficiency.

Merits of Composites:

- Chemical resistance
- Durable
- High impact strength
- Chemical Resistance
- Corrosion Resistance
- Design Flexibility

Characteristics of Composites:

- High strength to weight ratio
- Electrical property
- Translucency
- Low Thermal conductivity
- Fire Resistant.

Limitations of Composites:

- Material costs
- Fabrication/manufacturing difficulties
- Repair can be difficult
- Properties non-isotropic make design difficult
- Inspection and testing typically more complex

Natural Fiber:

Natural fibers are broadly classified in to three types namely, plant fibers, animal fibers and mineral fibers. The plants fibers are of cellulosic nature and animal fibers are of protein base which includes wool, silk, mohair etc and some examples for mineral fibers are asbestos, ceramics and metals. Plant fibers are further divided on the basis of their origin. For example, cotton, kapok and coir are originated as hairs borne on the seeds and inner walls of the fruit. Flax, jute, hemp and ramie are bast fibers which are taken from inner tissue of the plant stems. Sisal and henequen are fibers taken from fibro-vascular system of leaves. All plant fibers consist of varying proportions of celluloses such as hemicellulose, lignin, pectin and wax. These substances must be reduced or completely removed by processing in order to achieve better properties.

Properties of Natural Fibers:

Chemical properties

- Inhomogeneous and large variations, hydrophilic.

Physical structure

- Complex and heterogeneous, different properties on different size levels.

Mechanical properties

- Large variations among species, dependence on environment and geographical cultivation location, climate and age.

Surface properties

- Heterogeneous, Hydrophilic must be modified before processing.

Properties of Pineapple Fiber

- Mechanical strength,
- Electrical characteristics,
- Incombustibility,
- Dimensional stability,
- Compatibility with organic matrices,
- Non-rotting,
- Thermal conductivity,
- Dielectric permeability.

Pineapple Fiber:

A manufacture craft for arghan fabric, comprises the following steps:

(1) During pineapple leaf harvesting, break apart by chopping from the position of root 8-10 centimetre, then blocks of strip off, choose the withered blade of complete nothing as raw material,

(2) Above-mentioned pineapple leaves is carried out scraping process, and cleans, obtain ramie stripes,

(3) Above-mentioned ramie stripes being wrung out, takes uniformly and be placed on airing below the sun, the chlorophyll in dead plants cell, being decomposed once shining through the sun, can discoloration be played,

(4) By the pineapple fibre after above-mentioned drying by biological degumming process, obtain pineapple fibre suede,

(5) Above-mentioned pineapple fibre suede is processed into arghan fabric by textile technology.

The invention has the beneficial effects as follows: the manufacture craft of arghan fabric of the present invention utilizes the non-cellulosic material in micro bio enzyme catalysis, decomposition, degraded raw ramie, thus reach the object extracting pure flaxen fiber, obtained fabric novelty, environmental protection, natural, antibacterial, antiultraviolet, there is effect of hydroscopic fast-drying simultaneously, can be widely used in all kinds of textile product.

Detailed description of the invention.

Babul Wood

Acacia nilotica (linn), Wild ex del is known in India as babul, kikar, babur nilotica is truly a multipurpose tree. Its timber is valued by rural folks, its leaves and pod are used as fodder and gum has a number of uses. It tolerates extremes of temperature and moisture.

Babool wood has been one of the best wood on furniture making. One of the main reason leading to babool being highly durable is through its hardness. As a matter of fact, babool wood is taken to be 55% harder compared to the White Oak, 90% harder than the carbonized bamboo and 23% harder compared to hickory.

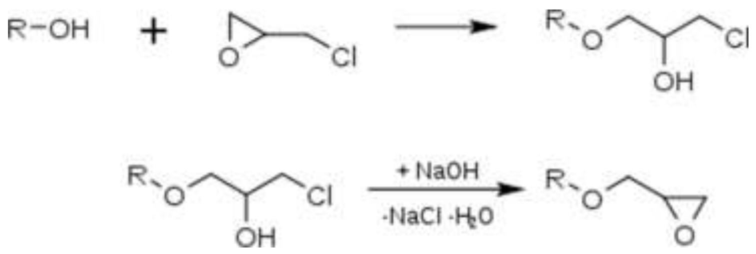
Epoxy Resin

Epoxy refers to any of the basic components or cured end products of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resins, also known as polyoxides, are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resinsmay be reacted (cross- linked) either with themselves through catalytic photopolymerization, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and thiols (usually called mercaptans).

These co-reactants are often referred to as hardeners or curatives, and the cross- linking reaction is commonly referred to as curing.

Reaction of polyoxides with themselves or with polyfunctional hardeners forms a thermosetting polymer, often with favorable mechanical properties and high thermal and chemical resistance. Epoxy has a wide range of applications, including metal coatings, use in electronics/electrical components/LEDs, high tension electrical insulators, paint brush manufacturing, fiber-reinforced plastic materials, and adhesives for structural and other purposes.

Most of the commercially used epoxy monomers are produced by the reaction of a compound with acidic hydroxy groups and epichlorohydrin:

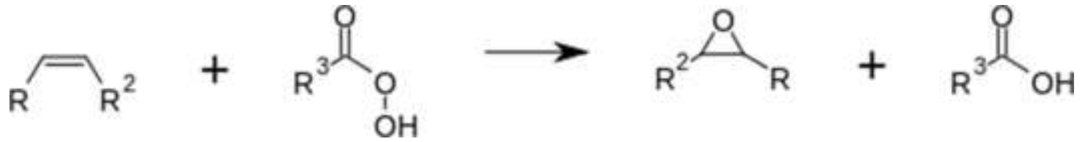


Molecular structure of hardener

First a 17 hydroxyl group reacts in a coupling reaction with epichlorohydrin, followed by dehydrohalogenation.

Epoxy resins produced from such epoxy monomers are called glycidyl-based epoxy resins. The 17hydroxyl group may be derived from aliphatic diols, polyols (polyether polyols), phenolic compounds or dicarboxylic acids. Phenols can be compounds such as bisphenol A and novolak. Polyols can be compounds such as 1,4-butanediol. Di- and polyols lead to diglycid polyethers. Dicarboxylic acids such as hexahydro phthalic acid are used for diglycide ester resins. Instead of a 17hydroxyl group, also the nitrogen atom ofan amine or amide can be reacted with epichlorohydrin.

The other production route for epoxy resins is the conversionof aliphatic or cycloaliphatic alkenes with peracids.



Molecular structure of epoxy resin

As can be seen, in contrast to glycidyl-based epoxy resins, this production of such epoxy monomers does not require an acidic hydrogen atom but an aliphatic double bond. The epoxide group is also sometimes referred to as a oxirane group.

IMPORTANCE OF THE WORK

Composite materials have been widely used as structural elements inaircraft structures due to their superior properties. Aircraft structure is a huge assembly of skins, spars, frames etc. The structure consists of an assembly of sub-structures properly arranged and connected to form a load transmission path. Such load transmission path is achieved using joints. Joints constitute the weakest zones in the structure. Failure may occur due to various reasons such as stress concentrations, excessive deflections etc. or a combination of these.

Therefore, to utilize the full potential of composite materials, the strength and stress distribution in the joints has to be understood so that suitable configuration can be chosen for various applications.

Analysis using FEA tool is necessary to standardize the experimental procedures and testing sequence.

LITERATURE REVIEW

1. **Amitava Ray et al.,** The natural fiber–reinforced polymer composites gaining substantial importance in recent years due to their unique properties compared to synthetic composites. In India (especially north eastern part), cultivars and industries mostly focus on pineapple fruits, leaving leaf to mainly compost or burn and decay as an agro waste. In this article, pineapple leaf–based (variety type Kew or Giant Kew from Silchar, Assam, India) short fiber–reinforced polymer composites as a function of fiber composition and composite thickness on mechanical properties are analysed. In this regard, short pineapple leaf fibers (≈ 1 mm to 2 mm) as reinforcement + epoxy resin (Lapox (L12) resin + K6 hardener) as matrix material are used for composites. Subsequently, six different fiber compositions (as 0, 1, 5, 10, 15, and 20 wt%) with composite specimen's thickness (as 3 and 5 mm) are prepaid. Later, mechanical properties like tensile strength, flexural strength, and toughness and hardness values for each of the composite specimens are evaluated. The result shows that the addition of short fiber can improve the mechanical properties and found in all the cases composites with 10% of reinforcement + at 5-mm thickness show better performance than the other combinations.

2. **M. Asim et al.,** Natural fibre-based composites are under intensive study due to their eco-friendly nature and peculiar properties. The advantage of natural fibres is their continuous supply, easy and safe handling, and biodegradable nature. Although natural fibres exhibit

admirable physical and mechanical properties, it varies with the plant source, species, geography, and so forth. Pineapple leave fibre (PALF) is one of the abundantly available wastes materials of Malaysia and has not been studied yet as it is required. A detailed study of chemical, physical, and mechanical properties will bring out logical and reasonable utilization of PALF for various applications.

From the socioeconomic perspective, PALF can be a new source of raw material to the industries and can be potential replacement of the expensive and non-renewable synthetic fibre. However, few studies on PALF have been done describing the interfacial adhesion between fibres and reinforcement compatibility of fibre but a detailed study on PALF properties is not available. In this review, author covered the basic information of PALF and compared the chemical, physical, and mechanical properties with other natural fibres. Furthermore, it summarizes the recent work reported on physical, mechanical, and thermal properties of PALF reinforced polymer composites with its potential applications.

3. **P. Sethuraman et al.,** This chapter discuss the different loading conditions and a suitable composite is selected for the research of luffa cylindrica, pineapple and e-glass fiber with epoxy composite for leaf spring. Our attempt is to test the mechanical properties of composites reinforce by varying study are tensile strength, hardness and toughness. In present year's natural and synthetic fiber composite material locale a major role in industries like aerospace and automobile. The composites formed by fibers gained attention due to their low cost, light weight, low density, high specific strength, non- abrasively, non-toxicity etc. in this project discussed the Composite material plate by using luffa cylindrical, pineapple and e-glass fiber with Epoxy composite and to evaluate the Mechanical properties of leaf spring (Tensile strength, Impact and Hardness test).

PROBLEM IDENTIFICATION

Convenience of natural resources is shrinking and the global demand for an alternative material to the existing materials is steadily growing. This condition has led to the improvement of Composite materials. Fibers set in in matrix of another material is the best example of present-day composite materials.

- Choices of composites, use of less pineapple fiber are the important parameters which affect the mechanical properties of the composites.
- The percentage of carbon fiber reinforced polymer used, will affect the strength of the material.
- A hybrid composite of Pineapple, fermented spinach and babul wood fiber affects the flexural properties and results in dominant failure.
- The inclusion of CFRP composite has significantly enhanced the ultimate tensile strength, ultimate flexural strength and peak load of the composite.
- Pineapple, fermented spinach and babul wood fiber hybrid composite fails with delamination at the interface of the Pineapple, fermented spinach and babul wood fiber layers
- Notable characteristics, sustainability concept and environmental issues, hybridization natural with synthetic fibers to fabricate composites have been rapidly gaining market share in different applications.
- The low stiffness and strength of the Kevlar composite are attributed to the fact that Kevlar fibers had lower wettability with epoxy resin than both glass and carbon fibers.

MATERIALS AND METHODOLOGY MATERIALS AND PROPERTIES

Analytical Method

Create a Composite material in CATIA and Simulation of composite materials by using ANSYS.

Experimental Method

Testing in UTM for tensile strength and it is observed that composite properties of test specimens.

Material Properties

Table 1

Properties	**Value**
Density (g/cc)	1.526
Young's Modulus (MPa)	6260
Tensile Strength (MPa)	170

Fig1 Pineapple Fiber

Table 2

Properties	Value
Density (Kg/m3)	1.2*10e3
Young's Modulus (GPa)	20
Tensile Strength (Mpa)	75

Fig 2 Epoxy resin

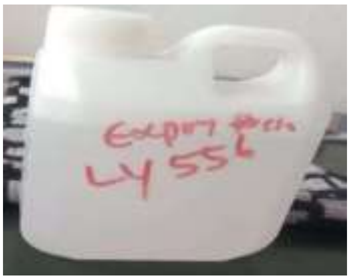


Table3

Properties	**Value**
Density (kg/m3)	**2500**
Young's Modulus (MPa)	**76000**
Tensile Strength (MPa)	**3445**

Fig 3 Fermented spinach

Table4

Properties	**Value**
Density (kg/m3)	**410**
Young's Modulus (MPa)	**373**
Tensile Strength (MPa)	**981**

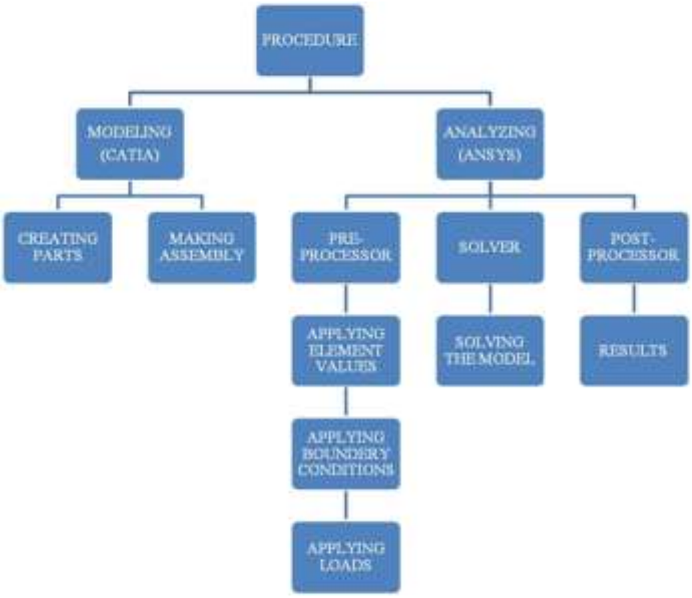
Fig 4 Babul Wood

Table 5

Properties	**Values**
Density	1 g/cm³ (25°C)
Viscosity	10 to 20 mPa s (25°C)
Flash Point	110°C
Vapour Pressure	0.3 Pa (20°C)
Boiling point	>200°C
Appearance	Clear Liquid

Fig 5 Hardener (HY951)

SOFTWARE OVERVIEW



METHODOLOGY:

- Literature review
- Problem identification
- Material selection
- CAD Model
- FEA Analysis
- Fabrication
- Testing
- Result and discussion
- Conclusion.

CATIA

CATIA is one of the world's leading CAD/CAM/CAE package. Being a solid modelling tool, it not only unites 3D parametric features with 2D tools, but also addresses every design through manufacturing process.

CATIA- Computer Aided Dimensional Interactive Application.

CATIA, developed by Dassault systems, France, is a completely re- engineered, next generation family of CAD/CAM/CAE software solution.

CATIA serves the basic design task by providing different workbenches, some of the workbenches available in this package are

- Part design workbench
- Assembly design workbench
- Drafting workbench
- Wireframe and surface design workbench
- Generative shape design workbench
- DMU kinematics
- Manufacturing
- Mold design.

PART DESIGN WORKBENCH

The part workbench is a parametric and feature-based environment, in which we can create solid models. In the part design workbench, we are provided with tool those convert sketches into other features are called the sketch-based features.

ASSEMBLY DESIGN WORKBENCH

The assembly design workbench is used to assemble the part by using assembly constraints. There are two type of assembly design,

- Bottom –up
- Top- down

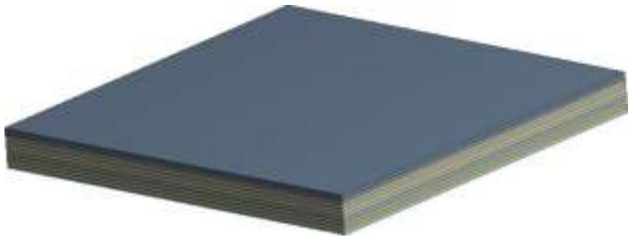
In bottom –up assembly, the parts are created in part workbench and assembled in assembly workbench.

In the top-down workbench assembly, the parts are created in assembly workbench itself.

DMU KINEMATICS

This workbench deals with the relative motion of the parts. DMU kinematics simulator is an independent CAD product dedicated to simulating assembly motions. It addresses the design review environment of digital mock- ups (DMU) and can handle a wide range of products from customer goods to very large automotive or aerospace projects as well as plants, ships and heavy machinery.

We created model of joints (bonded, riveted and hybrid) by using CATIA software. The models are shown below…



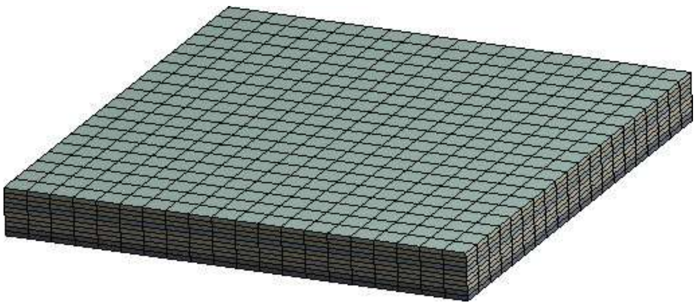
Model Of Composite layer

CAD Model

Composite Plate

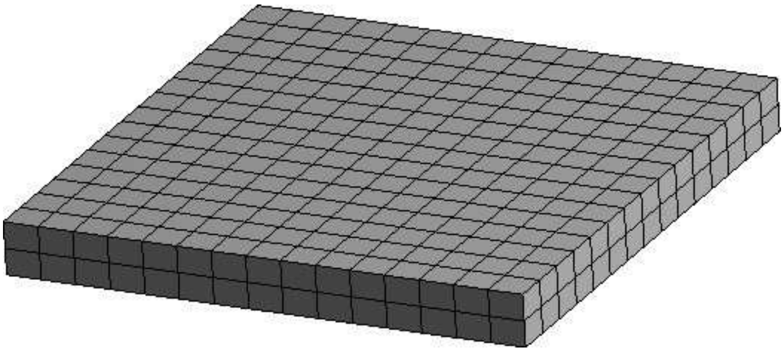
Composite plate can model with the help of CATIA tool. Composite plate has 8- layer arrangement of layer to single model.

Meshing



Meshing View of Composite Plate

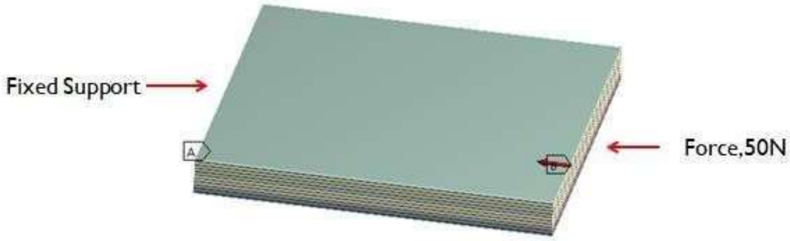
Description	Value
Quality	0.356
Skewness	3.008e-009
Aspect Ratio	5
Nodes	30030
Elements	4000



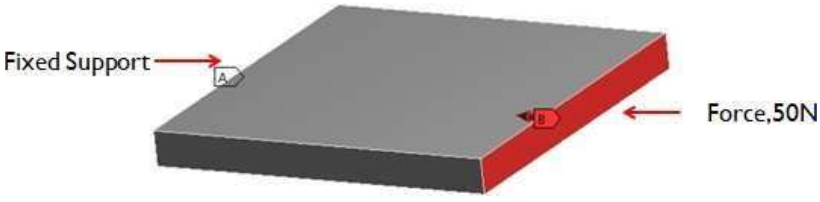
Solver Setup

Description	Value
Quality	0.95
Skewness	1.3057e-010
Aspect Ratio	1.33
Nodes	2720
Elements	450

Boundary Condition



One end is fixed support and another end is 50N force like compression stress in the Composite plate.



One end is fixed support and another end is 50N force like compression stress in the Aluminium plate.

ANSYS:

ANSYS is a complete FEA simulation software package developed by ANSYS Inc – USA. It is used by engineers worldwide in virtually all fields of engineering.

- Structural
- Thermal
- Fluid (CFD, Acoustics, and other fluid analyses)
- Low-and High-Frequency Electromagnetic.

Procedure:

Every analysis involves three main steps:

- Pre-processor
- Solver
- post processor.

Structural Analysis:

Structural analysis is probably the most common application of the finite element method. The term structural (or structure) implies not only civil engineering structures such as bridges and buildings, but also naval,aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machineparts, and tools.

Types of structural analysis:

The seven types of structural analyses available in the ANSYS family of products are explained below. The primary unknowns (nodal degrees of freedom) calculated in a structural analysis are displacements. Other quantities, such as strains, stresses, and reaction forces, are then derived from the nodal displacements.

Structural analyses are available in the ANSYS Multiphasic, ANSYS Mechanical, ANSYS Structural, and ANSYS Professional programs only.

- Composites
- Fatigue
- p-Method
- Beam Analyses

Load Types

All of the following load types are applicable in a static analysis.

These are DOF constraints usually specified at model boundaries to define rigid

- DISPLACEMENTS (UX, UY, UZ, ROTX, ROTY, ROTZ)

Support points. They can also indicate symmetry boundary conditions and

points of known motion. The directions implied by the labels are in the nodal coordinate system.

- FORCES (FX, FY, FZ) AND MOMENTS (MX, MY, MZ)

These are concentrated loads usually specified on the model exterior. The directions implied by the labels are in the nodal coordinate system.

- PRESSURES (PRES)

These are surface loads, also usually applied on the model exterior. Positive values of pressure act towards the element face (resulting in a compressive effect).

TEMPERATURES (TEMP)

These are applied to study the effects of thermal expansion or contraction (that is, thermal stresses). The coefficient of thermal expansion must be defined if thermal strains are to be calculated. We can read in temperatures from a thermal analysis [LDREAD], or we can specify temperatures directly, using the BF family of commands.

- FLUENCES (FLUE)

These are applied to study the effects of swelling (material enlargement due to neutron bombardment or other causes) or creep.

- GRAVITY, SPINNING, ETC.

These are inertia loads that affect the entire structure. Density (or mass in some form) must be defined if inertia effects are to be included.

- APPLY LOADS TO THE MODEL

Except for inertia loads, which are independent of the model, we can define loads either on the solid model or on the finite element model.

Composites in Ansys:

Composite materials have been used in structures for a long time. In recent times composite parts have been used extensively in aircraft structures,

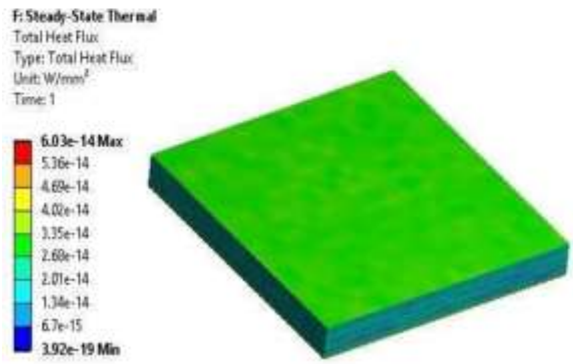
automobiles, sporting goods, and many consumer products. Composite materials are those containing more than one bonded material, each with different structural properties. The main advantage of composite materials is the potential for a high ratio of stiffness to weight. Composites used for typical engineering applications are advanced fiber or laminated composites, such as fiberglass, glass epoxy, graphite epoxy, and boron epoxy. ANSYS allows us to model composite materials with specialized elements called layered elements. Once we build our model using these elements, we can do any structural analysis (including nonlinearities such as large deflection and stress stiffening).

RESULTS AND DISCUSSION:

The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten. A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tensile test. The Specimen dimension is 50×50×10 mm is maintained during the testing.

ANSYS RESULTS

Thermal analysis:



TEST RESULTS:

Test material

Test Report:

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Ref. No: FT_T28_MAR_2021 **Date: 25-03-2021**

Provide To

Amarnath S, Athilingam S, Nivas V, Sivabala raja K

Jansons Institute of Technology, Coimbatore

TEST PARTICULARS

Description	Reinforced fiber materials
Material Specifications	Pineapple leaf fiber, Fermented spinach, Babul wood composites
Plate thickness	9mm to 10mm

TEST RESULT

Composite Material	Parameters	Tensile Stress	Compressive Stress	Torsion Stress	Shear Stress	Bending Stress
Pineapple leaf fiber, Fermented spinach & Babul wood composites	Total Deformation (mm)	1.426e-3	1.426e-3	0.068	0.015	33e-2
	Strain	2.704e-5	2.704e-5	436e-2	4753e-3	1.76e-5
	Stress (Mpa)	0.0445	0.0445	41.67	1.495	0.170
Steady state Thermal Analysis	**Total Heat Flux**					
	1.5e-13 maximum 1.5e-16 minimum					

- ***During the practical test for under our knowledge only.***

Yours sincerely,

SATHI ANAND S

Senior Engineer

THANK YOU FOR YOUR BUSINESS!

APPLICATIONS OF COMPOSITE MATERIALS:

- Weight reduction, which may be translated into improved fuel economy andperformance
- Improved overall vehicle quality and consistency in manufacturing
- Part consolidation resulting in lower vehicle and manufacturing costs
- Improved ride performance (reduced noise, vibration, and harshness)
- Vehicle style differentiation with acceptable or reduced cost

- Lower investment costs for plants, facilities, and tooling— depends oncost/volume relationships
- Corrosion resistance
- Lower cost of vehicle ownership.

CONCLUSION:

As a lot of work has been done in designing of leaf springs and babul wood which is discussed briefly in this text, on the basis of this study, problems in overall weight reduction by using composite materials are identified. Many of the authors suggested various methods of designing, manufacturing and analysesof composite leaf springs and babul wood. After studying all the availableliterature, it is found that weight reduction can be easily achieved by using composite materials instead of conventional steel, but there occurs a problem during the operation while using the composite leaf spring i.e., chip formation when the vehicle goes off road. Therefore, there is an immense scope for the futurework regarding use of (pineapple fiber, fermented spinach, babul wood) composite materials in leaf springs to reduce the overall weight of the vehicle as well as the cost of the vehicle.