DEVELOPMENT OF POLYMER COMPOSITE MATERIALS BY USING NATURAL FIBERS

[1]Dr.Md.Ahasan, [2]M.Sri Harsha, [2]SivaSubramanyam , [2]P.Lakshmi Kanth
[2]T.Murthy
Email : [1]mdahasankhan@gmail.com
[1]Associate Professor , Department of Mechanical Engineering , Aditya College of Engineering & Technology (A), Surampalem,A.P-533437, India.
[2]B.Tech Students , Department of Mechanical Engineering , Aditya College of Engineering & Technology (A), Surampalem,A.P-533437, India.

ABSTRACT

It's fascinating to see how researchers are tackling the challenge of finding structural materials that combine high strength, low weight, and cost-effectiveness. Composite materials indeed offer a promising solution by leveraging the strengths of different components. The process of determining the tensile and impact strengths through testing machines is crucial for understanding the performance of these materials.

The shift towards bio-fiber reinforced plastic composites reflects a growing awareness of environmental concerns. These composites offer a compelling alternative to traditional materials, boasting advantages such as low cost, lightweight properties, eco-friendliness, and recyclability. This shift aligns well with the broader trend towards sustainable practices across various industries.

The aim of the project is fabrication a various compositesJute+10grms Walnut powder, Hemp Fiber+10grms Walnut powder, Kenaf+10grms Walnut powder, Jute + Hemp Fiber+10grms Walnut powder, Hemp + Kenaf Fiber+10grms Walnut powder, Kenaf+, Jute+10grms Walnut powder, Jute + Kenaf+ Hemp+10grms Walnut powder By the combination of all the three fibers .fabrication process done using 7 cases after complete experimental process find out the strength using Tensile strength, Flexural strength , Hardness, Impact Strength after create the Helmet in Catia software and analysis using the Ansys software. Which hybrid material have better results, observe the strength of two materials one is existing and present best properties materials based on the von-misses stress, total deformations, strain, shear stress etc. The fabricated samples are subjected to mechanical and physical tests as per the ASTM standards. The best combination is suggested for the manufacturing of sub marinepropeller using CATIA V5 and analyzed by using ANSYS 16.5.

1 INTRODUCTION OF FIBERS

Natural fibers, which occur in the vegetable or animal kingdom, exhibit a polymeric nature in terms of their chemical composition. In contrast, natural fibers found in minerals resemble crystalline ceramics. A distinguishing characteristic of natural fibers is their typically heterogeneous composition, consisting of various compounds, whether chemical or physical in nature. Synthetic fibers can be further classified into polymers, metals, ceramics, or glass, with a unique subclass known as whiskers. Whiskers, being monocrystalline and short, boast exceptional strength, approaching theoretical limits due to the absence of crystalline imperfections like dislocations and grain boundaries. These whiskers usually obtained through vapor phase growth, exhibit diameters of a few micrometers and lengths ranging from a few millimeters, resulting in aspect ratios (length/diameter) that can vary from 50 to 10,000. However, a drawback of whiskers lies in their non-uniform dimensions and properties. Recent research in Europe has intensified the exploration of natural fibers for technical composite applications. Many automotive components, particularly those based on polyester or PP, incorporate fibers such as flax, hemp, or sisal in natural composites. The motivation behind adopting natural fiber composites in this industry revolves around price, weight reduction, and marketing strategies emphasizing the use of renewable resources, rather than purely technical requirements. These composites are currently limited to interior and non-structural components, such as door upholstery or rear shelves.Observations on the behavior of composite materials during machining, especially drilling, have been extensively conducted. Drilling is commonly employed in secondary machining operations for fiber-reinforced materials due to the necessity of structural joining. The interaction of hard abrasive fibers and a soft matrix makes selecting appropriate cutting conditions challenging. Experimental findings suggest minimal plastic deformation during cutting, with fracture resistance significantly lower (10–100 times) than that of common steels. Twist drills, frequently used in the aircraft industry, play a crucial role in generating holes for riveting and fastening structural assemblies. Delaminating, a concern that has garnered significant attention, results from thrust forces applied during machining. Researchers have conducted numerous studies to understand and mitigate delaminating, particularly its occurrence and impact on the material. Natural fibers offer notable advantages, including low density, suitable stiffness, mechanical properties, and high disposability and renewability. They are recyclable and biodegradable, contributing to environmental sustainability. Over the past decade, there

has been increased interest in composites of polymers reinforced by natural fibers, such as Jute, Coir, and Hay fibers, which exhibit excellent reinforcing capabilities when compounded with polymers. The unique aspect of designing parts with fiber-reinforced composite materials lies in the ability to tailor mechanical properties to suit specific applications, aiming for an optimal weight-to-strength ratio. While conventional drilling remains the preferred technique, inherent qualities like anisotropy and brittleness in composite materials during drilling may result in damage phenomena such as delaminating, sapling, and crack formation. Therefore, ensuring the quality of drilled holes, including dimensions, surface finish, and roundness, plays a vital role in the overall performance of composite parts.

1.1 SOME FACTS FROM HISTORY ABOUT NATURAL FIBERS

Natural organic fibers have been around for a very long time, from the beginning of the life on Earth. The archeological artifacts suggest that human beings used these materials in fabrics many thousand years ago. A direct use of the strength of natural fibers is in lines, ropes and other one-dimensional products; miscellaneous applications include early suspension bridges for on-foot passage of rivers and rigging for naval ships in early times and into the nineteenth century. Many kinds of textiles, ropes, canvas and paper produced form natural fibers are in use today. It may seem surprising, but first natural fiber composites were used more than 100 years ago. In 1896, for example, airplane seats and fuel-tanks were made of natural fibers with a small content of polymeric binders. As early as 1908, the first composite materials were applied for the fabrication of large

quantities of sheets, tubes and pipes for electronic purposes (paper or cotton to reinforce sheets, made of phenol- or melamine-formaldehyde resins).

However, these attempts were without recognition of the composite principles and the importance of fibers as the reinforcing part of composites. The use of natural fibers was suspended due to low cost and growing performance of technical plastics and, moreover, synthetic fibers. A renaissance in the use of natural fibers as reinforcements in technical applications began in 90s of 20th century.

1.2 OBJECTIVE OF THE WORK

The primary objective of the work is to fabricate the polymer composite materials by using the natural fibres by the completion of the project the natural reinforced polymer materials are used in the society with less impact in the environment compared to conventional polymer composite materials.

The materials that fabricate will impact the environment greatly and the emission of the carbon content by burning the conventional polymer materials will decrease and creates a healthy environment and eco-friendly materials

in the selection of their fabrication methods. Many processing methods used for plastics can be applied to the fabrication of discontinuous fiber composites. This leads to the possibility of easier mass production.

Materials to process to composites, natural fibers are typically formed into some form of fiber mat. Banana fiber, Kenaf, hemp, sisal, coir, jute and some other fiber composites have been studied. But the flax fibers appear to have received more attention. Although thermal instability of fibers causes restrictions for matrices, both thermoplastics and thermosets are being used. Polypropylene (PP, melting temperature 160ºC) is the most popular thermoplastic matrix, also found to be the best for flax fibers. There is no distinct favorite among thermosets: epoxies, vinyl esters, polyesters, and other polymers are used. There are also attempts to use biopolymers, such as polyester amide, poly-L-lactic acid and others. The main attention in this area is focused on manufacturing problems. The properties of such bio composites seem very promising too. However they are not considered in the following review.

2 LITERATURE REVIEW

1. Cappelletto et al. (2001) showed the differences in chemical composition. The hemp fibres used for spinning yarns are the primary bast or phloem fibres. The single fibre cells are organised in bundles, which run longitudinally along the stem from bottom to top and can reach almost the full length of the plants (Van Dam and Gorshkova, 2003). As plants age, these primary fibres are gradually filled with cellulose, and their strength depends on the cellulose filling degree or 'ripeness' which progresses with time from bottom to top (Mediavilla et al., 2001; Schäfer and Honermeier, 2003; Amaducci et al., 2005, 2008a). 'Ripeness' in this sense is not so much a physiological stage, but a threshold value above which the fibres are strong enough to allow proper extraction. We do not expect to find a 'ripeness front' below which fibre filling has ceased, because Amaducci et al. (2005, 2008a) showed that even in the lowest internode fibre filling continues between full flowering and end of flowering. Possibly, the weight increase of the primary fibres in a certain stem part keeps pace with the weight increase of the wood, in which case the fibre/wood ratio would be constant with harvest time. The ratio in which total dry matter is split up into fibres and wood in a fixed way might be a variety characteristic.

2. Hann, 2005; Salmon–Minotte and Franck, 2005; Sponner et al., 2005 The fibers are liberated from the surrounding tissues by a controlled warm–water retting procedure hence retting losses can be determined under controlled conditions. During retting, bacteria degrade pectic substances, and in addition proteins, sugars, starch, fats, waxes, tannins, and minerals are removed showed that retting loss percentages gradually decreased with increasing stem weight, and this seemed irrespective the cause of the higher stem weight. It is therefore expected that the stem weight before retting is the only important factor accounting for the variation in stem weight after retting. This will be analysed with multiple linear regression.

3. Hemalata Jena et al. [8] the effect of bamboo fibre composite packed with cenosphere were deliberated and described that the shock property of bio-fibre resistant composite is very much influenced by adding of cenosphere as filler and lamina. The results expose the sensitivity of the

4. shock properties to the concentration of the fillers. Amid all 7 layers composite with 1.5 wt% of cenosphere has the maximum shock strength of 18.132 KJ/m2 . The impact strength is increased with addition of filler up to a certain limit and then it is reduced on additional adding for a given laminated composite.

5. Girisha, C. et al. [9] premeditated the mechanical properties of composites of chemically treated fibres from fruit of tamarind and fibres from the husk of areca nut. The treated fibres show better results when compared to untreated fibres. They also observed that the strength of the hybrid composites increases with increase in volume fraction of fibre in the hybrid composites. All the hybrid natural fibre composites shown maximum mechanical properties for 40% - 50% of the fibre reinforcements from the experiment initiated. Both fibres were reinforced with epoxy matrix and composites have been developed by manual hand layup technique in the investigation

6. Subramanian Raman*, Chattopadhyay Subhanjan Salil Kumar and Sharan Chandran M, Jute-Epoxy braided as well as short fibre reinforced composite which is of low cost, low density, high specific strength, no health risks, renewable, environment friendly and lower energy requirement for processing. The jute fibres used have undergone alkali treatment to improve their properties and blended with epoxy resin and cured. The later stage of

our work deals with the Tensile Test of both types of specimens ,Impact & Flexural test of Braided composite according to the ASTM standards for Plastics. Further an extensive comparison of braided & short fibre composite has been done along with finite element analysis to validate the results.

7. Senate Bill 1726 in 2017, leadership and researchers within UF/IFAS immediately began discussions to structure a hemp pilot project. The Office of the Dean for Research and the Department of Agronomy within UF/IFAS led the effort to organize a core team that included expertise in crop growth and development, pest mitigation, economics, and plant invasiveness. This team worked with UF/IFAS administration to produce a pilot project plan that was soon presented to interested parties within the hemp industry in Florida. This plan included efforts to identify hemp germplasm appropriate for Florida's diverse environmental and agronomic conditions, design and better understand cropping and controlled growth systems to serve a

8. diverse range of hemp industries in Florida's various agricultural environments, and to assess and mitigate the invasion risk of industrial hemp

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3 MATERIAL USED

HEMP FIBER

Hemp fabric is a type of textile that is made using fibers from the stalks of the *Cannabis sativa* plant. This plant has been recognized as a source of extraordinarily tensile and durable textile fibers for millennia, but the psychoactive qualities of *Cannabis sativa* have recently made it harder for farmers to produce this immensely beneficial crop.

Over thousands of years, *Cannabis sativa* has been bred for two distinct purposes. On the one hand, many generations of cultivators of this plant have selectively bred it to be high in tetrahydrocannabinol (THC) and other psychoactive chemical constituents called cannabinoids. On the other hand, other cultivators have consistently bred *Cannabis sativa* to produce stronger and better fibers and have purposefully reduced the levels of psychoactive cannabinoids produced by their crops.

KENAF FIBER

Kenaf fiber is a natural fiber derived from the bast of the kenaf plant (Hibiscus cannabinus). It is a member of the hibiscus family and is closely related to cotton and okra. Kenaf is native to Africa and has been cultivated for thousands of years for its fiber, seeds, and as a forage crop. The kenaf plant typically grows up to 3-4 meters in height within 4-5 months of planting, makingit one of the fastest-growing plants. Its fiber is found in the plant's outer bark, or bast, and is harvested by stripping the bark from the plant's stalks. Kenaf fiber is long, slender, and relativelystrong, making it suitable for various industrial applications.

JUTE FIBER

Jute fiber is a natural fiber derived from the jute plant, scientifically known as Corchorus olitorius and Corchorus capsularis. It is one of the most affordable and versatile natural fibers, primarily cultivated in the Indian subcontinent, particularly in India and Bangladesh. Jute fiber is extracted from the stem of the jute plant and is known for its strength, durability, and eco-friendliness.

WALNUT SHELL POWDER

Walnut shell powder, sometimes spelled as "walnut shell powder," is a natural exfoliant commonly used in skincare and cosmetic products. It is made by grinding the shells of walnuts into a fine powder. The texture of walnut shell powder is typically gritty, making it effective for removing dead skin cells and unclogging pores through gentle physical exfoliation.

Figure 1 walnut shell powder

EPOXY RESIN:

Epoxy resins are widely used in fiber-reinforced composites due to their excellent adhesion, high strength, and durability. They offer good chemical resistance and can be easily tailored to specific applications. Epoxy resin composites are commonly used in aerospace, automotive, marine, and construction industries. Epoxy resin belongs to the principal polymer under the term thermosetting resins, which covers a wide range of cross-linking polymers including unsaturated polyester resins, phenol-formaldehyde resins, and amino resins. Thermosetting polymers form an infusible and insoluble mass on heating, due to the formation of a covalently cross-linked and thermally stable network structure. They are generally amorphous and possess various desirable properties such as high tensile strength and modulus, easy processing, good thermal and chemical resistance, and dimensional stability. The term epoxy resin is applied to both prepolymers and to cured resins; the former is characterized by a three-membered ring known as the epoxy, epoxide, oxirane, or ethoxyline group.

HARDENER

Hardener was used as a binder during the fabrication. It has low viscosity, cure at room temperature, good mechanical strength and Good resistance to atmospheric and chemical degradation. HY951 is a type of hardener, also known as Aradur HY951 that is a low viscosity, unfilled epoxy casting resin system. It cures at room temperature and has a high filler addition possibility. It is also known for its good mechanical strength, resistance to atmospheric and chemical degradation, and excellent electrical properties.

Here are some of the common uses of HY951 hardener:

- Coating or encapsulating electronic components, especially those that work at low voltages
- Bonding ceramics, glasses, rubbers, plastics, and other substrates
- Casting applications where a low viscosity and good clarity are desired
- Creating adhesives with medium viscosity

It is important to note that HY951 hardener is a chemical and should be handled with care. Be sure to wear gloves and eye protection when working with it, and to follow all safety precautions.

4 FABRICATION BY HAND LAYUP PROCESS

HAND LAY UP PROCESS:

Hand lay-up technique is the simple and cheapest method of composite processing. The infrastructural need for this technique is also minimal..The standard test procedure for Mechanical properties of fiber-resin composites; ASTM-D790M-86 is utilized to according to the measurements. The mold is prepared on smooth clear film with 2 way tape to the required measurement. At that surface mold is prepared keeping the 2 way tape on the clear film.

The reinforcement in the form of long fiber are cut as per the mold size and placed on the surface of thin plastic sheet. Then the thermosetting polymer in liquid form is assorted thoroughly in appropriate proportion with a recommended hardener (curing agent) and poured onthe surface of clear .The polymer is uniformly spread with the help of brush.

STEPS INVOLVED IN THE FABRICATION OF SPECIMEN:

KENAF FIBRE WITH 10 GRAMS WALL NUT SHELL POWDER reinforced Epoxy Composite specimen was fabricated by hand layup technique. In this process 6 sheets of 300GSM Kenaf fibre (230/300mm) and 10grams of wall nut shell powder, 10 grams of hardener (HY951) is mixed with 100 grams of Epoxy (LY556) which is used as matrix in the composite. The thickness of the specimen is 4mm. For obtain 4mm thickness six sheets of KENAF with 10 grams of walnut shell powder used.

HEMP FIBRE WITH 10 GRAMS WALL NUT SHELL POWDER reinforced Epoxy Composite specimen was fabricated by hand layup technique. In this process 6 sheets of 300GSM HEMP fibre (230/300mm) and 10grams of wall nut shell powder, 10 grams of hardener (HY951) is mixed with 100 grams of Epoxy (LY556) which is used as matrix in the composite. The thickness of the specimen is 4mm. For obtain 4mm thickness six sheets of HEMP with 10 grams of walnut shell powder used.

JUTE FIBRE WITH 10 GRAMS WALL NUT SHELL POWDER reinforced Epoxy Composite specimen was fabricated by hand layup technique. In this process 6sheets of 300GSM JUTE fibre (230/300mm) and 10grams of wall nut shell powder, 10 grams of hardener (HY951) is mixed with 100 grams of Epoxy (LY556) which is used as matrix in the composite. The thickness of the specimen is 4mm. For obtain 4mm thickness six sheets of JUTE with 10 grams of walnut shell powder used.

JUTE WITH HEMP WITH 10 GRAMS WALL NUT SHELL POWDER reinforced Epoxy Composite specimen was fabricated by hand layup technique. In this process 6 sheets of 300GSM JUTE WITH HEMP fibre (230/300mm) and 10grams of wall nut shell powder, 10 grams of hardener (HY951) is mixed with 100 grams of Epoxy (LY556) which is used as matrix in the composite. The thickness of the specimen is 4mm. For obtain 4mm thickness six sheets of JUTE WITH HEMP fibre of 10 grams of walnut shell powder used.

closed with another thin plastic sheet after squeezer is moved with a gentle pressure on the thinplastic sheet to remove air .The consequential mold is cured for 24 hours at room temperature.

After fabrication specimens are cut form sheets according to the ASTM statndards165mm long, 12.5mm in width and 4mm in thick are fabricated for tensile testing. 100mm long, 25mm width and 4mm in thick are fabricated for flexural testing. 63.5mm long, 12.36mm width and 6mm thick are fabricated for impact testing.

Figure 2 Tensile test on natural fibers speciemens

- A 2-ton limits electronic tensometer is a device used to measure the tensile strength of materials. It works by applying a force to a sample of the material and measuring the amount of force it can withstand before breaking.
- Tensile strength is the ability of a material to resist breaking under tension. It is animportant property for many materials, such as metals, plastics, and fibers.
- Natural fibers are fibers that are derived from plants or animals. They are often used intextiles, ropes, and other applications where strength and flexibility are important.

FLEXURAL TEST ON NATURAL FIBERS SPECIEMENS

A flexural test, also known as a bending test, is a mechanical test used to determine the flexural properties of materials. When it comes to natural fibers, performing a flexural test can provide valuable insights into their mechanical behavior under bending loads. Here's some information about conducting a flexural test on natural fibers:

The primary purpose of conducting a flexural test on natural fibers is to evaluate their bending strength, modulus of elasticity (flexural modulus), and other related properties. This information is essential for understanding how natural fibers perform when subjected to bending loads, whichis relevant in various applications such as textile manufacturing, composite materials, paper production, and construction materials. The flexural test setup typically involves placing the prepared sample across two supports spaced a certain distance apart (span). The sample is then subjected to a bending load applied at its midpoint using a loading fixture or a specialized testing machine, such as a universal testing machine (UTM). The loading rate and testing conditions should adhere to relevant testing standards, such as ASTM or ISO specifications.

IMPACT TEST ON NATURAL FIBERS SPECIEMENS

Performing an impact test according to ASTM D256 on natural fiber specimens involves evaluating the material's resistance to sudden impact or shock loading. Here's how you might conduct such a test:
Cut or prepare specimens of the natural fibers according to the dimensions specified in ASTM D256. For example, the standard might specify the dimensions of the specimens as per the typeof material being tested. Ensure that the specimens are free from any defects or irregularities that could affect the test results. Set up the impact test apparatus according to the requirements outlined in ASTM D256. This typically involves a pendulum impact tester or similar equipment. Calibrate the equipment to ensure accurate measurement of impact energy. Place the conditionedspecimen in the specified position on the test apparatus. Adjust the pendulum or striker to the appropriate starting position. Release the pendulum

or striker to allow it to swing and impact the specimen. Record the energy absorbed by the specimen during the impact. This can be calculated based on the swing of the pendulum and its kinetic energy before and after impact. Repeat the test for multiple specimens to obtain an average value and ensure repeatability.

5 RESULTS

MECHANICAL CHARACTERISTICS OF COMPOSITES:

The properties of the HEMP, KENAF, JUTE, KENAF+HEMP, HEMP+JUTE, JUTE+KENAF, JUTE+KENAF+HEMP WITH 10 GRAMS OF WALL NUT SHELL POWDER in all compositions reinforced epoxy hybrid composites with of fiber under this investigation are presented in below Table. I have taken each composite for each test. Details of processing of these composites and the tests conducted on them have been described in theprevious chapter. The mechanical properties of Synthetic fiber reinforced composites are largely depends on the chemical, structural composition, fiber type and soil conditions and also on atmospheric conditions at the time of fabrication of the specimens.

S.NO	COMPOSITE	TENSILE TEST		FLEXURAL TEST(MPa)		IMPACT TEST	HARDNESS
		LOAD(N)	ELONGATION (mm)	LOAD (N)	ELONGATION (mm)	(J)	NUMBER
1	KENAF	8250	5.6	1290	8	3	101
2	JUTE	5500	6.9	390	8.6	5.2	63
3	HEMP	6520	4.3	830	6.2	6.7	93
4	JUTE/KENAF	9390	6.3	870	7.5	4.1	62
5	HEMP/KENAF	10850	6.4	1280	9.1	6.1	128
6	JUTE/HEMP	12100	5.9	520	5.3	6.5	127
7	JUTE/HEMP/KENAF	12750	4.2	1320	4.1	7.3	152

Table:1 Testing results

6 CONCLUSIONS & FUTURE SCOPE

6.1 CONCLUSION

The present work has been done with an objective to explore the use of hemp, kenaf, jute, kenaf+hemp, hemp jute, jute+kenaf, jute+kenaf+hemp with 10 grams of wall nut shell powder in all combinations are manufactured using hand lay-up method. Epoxy is used as matrix in the reinforced composite and investigated the mechanical properties like tensile, flexure, impact and hardness number of composites. This work is focused to find the best composite among the seven combinations. After all the tests has performed on the specimens the jute+kenaf+hemp with 10 grams of wall nut shell powder combination shows a best result in the tensile strength impact strength, hardness test and as well as tensile & flexural strength. Finally values to the for the above investigations we are proposed the JUTE+KENAF+HEMP WITH 10 GRAMS OF WALL NUT SHELL POWDER having good mechanical properties when comparing with other results.

6.2 FUTURE SCOPE

- The extension of this thesis work can be done by considering the following points: The fiber can also take in the form of powder to fabricate the specimen which may increases the strength.
- Different type resins can be used to find the mechanical properties like strength, wear resistance.
- By considering different process parameter and different composites which improves the properties of composites.

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