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LITERATURE REVIEW ON MECHANICAL PROPERTIES AND WATER ABSORPTION OF NATURAL FIBER REINFORCED WITH EPOXY RESIN

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Abstract - *With the concept of an eco-material in mind, this paper deals with the review of previous research in the mechanical and tribological properties of natural fibers reinforced composite. Many composites fabricated from thermosetting polymers reinforced with synthetic fibers which have high mechanical properties heavy and expensive as compared with natural fibers. The use of a combination of natural fibers and synthetic fibers as reinforced in the polyester matrix for making low-cost engineering materials as the developed interest now these days. This paper reviews the literature on the effects of mechanical processes on fiber matrix and studied the various properties of natural fibers and also discussed the applications, advantages, and disadvantages of natural fiber polymers.*

Key Words: Plant fiber, composite, mechanical properties, treatments.

1. INTRODUCTION

The composite material prepared by mixing of two or more different elements in order to make the resulting material having superior properties from its parental materials. There are two parts of composite material, matrix and filler/fiber (reinforcing phase). We can reinforce in various phases, in the form of fiber, sheets, or particles. Metal, ceramic, non-metal, and polymer material can be used as a matrix material in the development of composite [1]. As of late, the enthusiasm of researchers and designers creates interest in using all-natural strands (tree) as viably or financially economic while conceivable for the delivery of great strand reinforced polymer composite in consideration of auxiliary, architecture, or other different wants. In this green planet, it's a result of the tremendous accessibility of organic assets. It prompted the advancement of elective material rather than traditional material. In a group different organic stands, roselle strands were utilized conventionally in old times as good-quality cables and ground mats and so forth. It's quite compelling in light of the fact that composite has high toughness in kenaf and hemp, rather than having modest impact strength characteristics contrasted along the organic strand. In recent decades, in numerous use, the composite based fabricated material has been utilized, for example, car, outdoor supplies, marine, electrical, modern development, and household machines. Among the different engineered materials, plastic materials guarantee a significant offer as a wood substitute [2]. organic strands are rising ease, lightweight, and ecologically better option than glass strands in the composite. Organic strand composites are probably better than glass strand composites in much of the cases for the accompanying reasons (explanation):

- When contrasted to glass fiber generation there is the low environmental effect of organic strands.
- Organic strand composite has a high strand percentage for identical execution, decreasing most of the contaminated based polymer contents.
- The organic strand composites which are Light in weight improve eco-friendliness, diminish emission in the auto sector.
- When the life of organic strands ends the incineration of organic strand brings about recouped vitality and carbon credits [3].

The organic strand has been inexhaustibly accessible on the planet. It has novel properties contrasted with synthetic strand and diminishes the plastic use. These polymers composite material offered a broad scope of characteristics whichever appropriate in many engineering operations. Normally accessible plants have many lignocellulose strands. Which can take as naturally existed composite [4]. Practically all-natural strands, with the exception of cotton, are principally made of cellulose in an invigorated fiber decides the firmness of the fiber, that is given through hydrogen securities (bond) along with different

links in cellulose. Natural plant strands incorporate various classes of stands, for example, leaf, straw, seed, stem, wood strands, and grass [5].

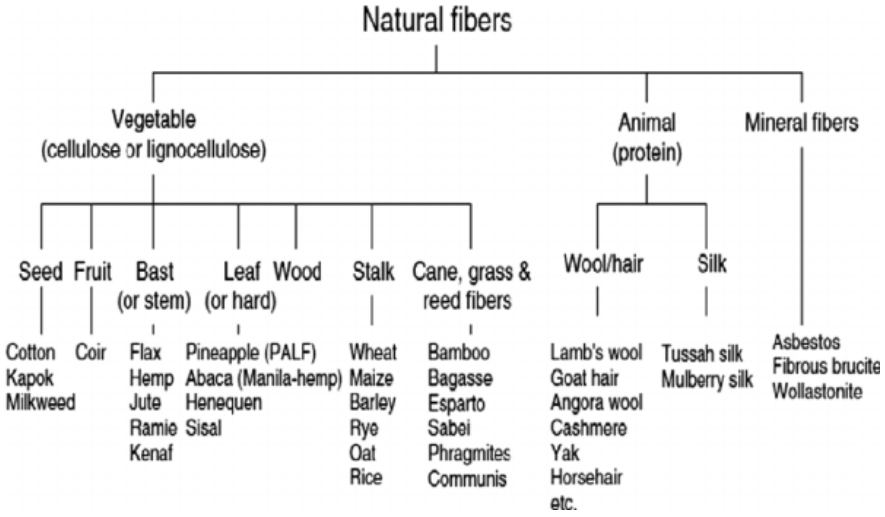

Fig -1: Classification of natural fibers [5]

The environment is a significant worldwide concern nowadays because of the increasing rate of ozone-depleting substance emissions. Synthetic material is typically liable for transmitting carbon dioxide gas during handling and use [6]. Now a day's plastic is utilized nearly for all-purpose starting with daily use articles like entangled construction, various parts of the machine, and so on. They find wide use because those are light in weight, and have minimum water assimilation, better stiffness as well as quality. As of late as an elective strand i.e. vegetable or plant strands substantiate itself over the synthetic strand. Organic strands have low cost. They have no wellbeing peril (health hazard), and they are bio-degradable. This is amazing to take remark of the organic strand, for example, banana, sisal, coir, jute, and many more are plentifully accessible in growing nations like Sri Lanka, a portion of African nations, and India, yet are not ideally used. A significant number of plant fiber, for example, palmyra, banana, coir, sisal, etc. find application as an asset for fabrication material. Table 1 shows some common strand and their properties like physical and mechanical [7].

Table 1: Properties of some natural fiber (Physical and mechanical [7]

Fibers	Width or diameter (µm)	Density (kg/m3)	Cell l/d ratio	Microfibrillar angle (degrees)	Initial modulus (GPa)	Ultimate tensile strength (MPa)	Elongation (%)
Coir	100-450	1150	35	30-40	4-6	106-175	17-47
Banana	80-250	1350	150	10 ± 1	7.7-20.0	54-754	10.35
Sisal	50-200	1450	100	10-22	9.4-15.8	568-640	3-7
Pineapple leaf	20-80	1440	450	8-14	34.5-82.5	413-162	0.8-1

Presently syntenic strand replaced along the organic strand in the auto sector can yield environment friendly, financial, or social advantages. This territory of investigation advances the prosperity with specialists, experts as organic strand composites turns an elective solution for non-renewable sources. Also, better resistance toward electricity, excellent mechanical characteristics, thermal characteristics, and soundproof characteristics has been discovered and have high protection from rupture. Organic strand composites, as tubes, sandwich plates, boards are utilized to supplant wood fitting, loud sound protecting boards in the most recent decade. As of now investigated modern applications incorporate frames for doors and windows, railroad sleepers, furniture, panels for car and planting things, racks, and many more applications in aviation, recreation, construction, sports, factories, and large applications that don't require exceptionally high mechanical resistance, however, decrease the cost of maintenance and purchasing. Strands are utilized as support material in composite, which is transformed into various forms, for example, roving, fabric, mats, and yarns [8]. The interest for wood items is constantly increasing regardless of the quick exhaustion of timberland all over the globe. Investigation around the zone of green innovation is going to give wood substitute that utilizes wood material blended along polymer to give a profitable, better execution or termite resistance substance. As organic strand reinforced polymer mix substance is quickly developing in terms

of modern application including basic examination like as inexhaustible, low, totally, and mostly reusable and ecological [9]. Strand strengthened polymer composite material is quick making progress favored material for the development of aircraft and rocket. Composite material offers high fatigue and corrosion resistance. Composite material has a high strength to weight proportion. In this way, they are most appropriate for different aviation applications. Their utilization as an essential auxiliary material in the ongoing year in a few innovations - demonstrator front line aviation ventures worldwide has given confidence to their acknowledgment as prime materials for aviation vehicles. The enormous scale utilization of advanced composites in the current program of improvement of military fighter crafts, launching vehicles, civil transport aircraft, helicopters, satellites, and rockets all around the globe is maybe the most glowing case of the use of the capability of such composite material [10].

The favorable circumstances, properties and usage of organic strand reinforced composites

1. Organic strand is delicate (soft) and there is an increment generally in overall life and proficiency of tools or equipment's.
2. Natural fiber is best option in contrast to E-glass fiber as the dispose of problem.
3. These are light in weight. Accordingly, they give huge weight saving, eco-friendliness for automobile usage. Few fiber display moderately high explicit quality, modulus, durability and ductility then E-glass.
4. Effective usage of agricultural residues produces income and openings for work.
5. Comparatively less preparing temperature.
6. NFRCs give great protection across noise and temperature.
7. First and principal, advantage of organic strand is environmentally safe because of organic strand's sustainability, neutrality of CO2 and biodegradability.
8. Organic strands are modest, all over expense of composites generally decrease.
9. Abundantly accessible and harmless buildups after improved vitality recuperation by incineration.

Likewise, the ill effects experience in organic strand and NFRCs are following

1. High absorption of moisture [depends upon the fiber type] prompting swelling, in this way affecting reliability and performance of products.
2. Large variety in fiber qualities along characteristics contribute straightforwardly towards enormous dissipate in NFRCs characteristics.
3. Susceptible to parasitic, insects' assaults.
4. Effectively combustible and relatively low degradation temperature.
5. Thermal conductivity of NFRCs is moderately less than that glass fiber reinforced composites.
6. Due to climate or crop yield there is variation in Price and supply.
7. These are frequently restricted to non-auxiliary segments due to less thermal stability or their service temperature is ≤200 [11].

The huge no of complex processes associated with the production of composite materials in regards to the conventional production procedures which involve large manufacturing time along with a high cost. Further the strategies, because of the sort of unprocessed materials utilized, infer the age of wastage called scrap. New procedures are investigated to overcome these issues. The perfect method to implement is, automated every phase in a single procedure. There is one option of the utilization of a technique named as Additive Layer Manufacturing (ALM). It is also called 3D printing. In this process material is laid up first, then compacted and allow to cure simultaneously. In transit material is stored layer by layer, cooled then solidify, accomplishing three-dimensional shapes beyond utilizing complicated molds. these inventions encountering a significant hike in the generation of aeronautical components. A portion of the benefits of this innovation contrasted with conventional production methodology are like:

1. There is no need of molds in production of components.
2. The scraps left after manufacturing is nil.
3. Produced components require lessen post treatment.
4. After the plan of part all the procedure is robotized, keeping away from human errors [12].

In most recent decades the focal point of attraction of investigation is the utilization of polymer of plant strand reinforced composite. Among organic strand composites, kenaf strand reinforced composites discovered application about cell-phone shell comprising 15-20% strands of kenaf. The one other model in the auto sector i.e. Toyota RAUM, is outfitted by an extra cover of the tire which is made with kenaf strand composites [13]. Contemporary innovations particularly identified with aviation, submerged and transportation applications require a typical combo of materials characteristics that can't be

accomplished by combinations of metals (alloys) or ceramics. The application identified with the avionics warrants high explicit structural material stiffness, which cannot acquire by utilizing traditional materials. Composite causes us to accomplish the required characteristics by prudently consolidating distinctive material. Hybrid composites are made by consolidating at least two strands in an individual matrix. Hybrid composites can produce using men made strands, organic strands with the blend of both men made, and organic strands. They can assist researchers in achieving a superior blend of characteristics then strand reinforced mix [14]. In the auto sector composites are being considered to make more secure with low weight and more eco-friendly vehicles. The weight saving necessity of vehicles has gotten progressively significant, since the rise in the environmental issues. For boosting the mileage, keeping up the safety and performance of present-day vehicles lightweight composite materials are necessary. Numerous components like controlling wheel, seat, rooftop, dashboard, mats, energy absorber, leaf spring, inside and outside panel, wheels, engine cover, etc. are created by composite materials [15].

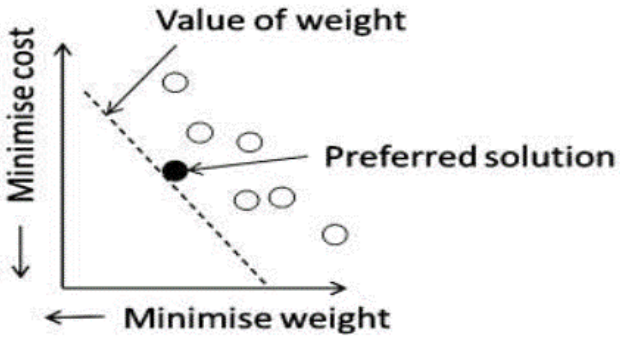

Fig -2: Weight reduction is inversely proportional to cost reduction [15].

Literature review

N. M. Mathur and K. Bairwa [1] has lifted the research and industrial attention towards the growth of natural fiber-based on green composite material. Research is going on to develop newer fiber-reinforced plastic composites to replace metals and alloys. Cost and quality control of natural filler reinforced composite is the major stone to use as alternative material by product designers and manufacturers. Besides all these, the main motive is to fabricate an economic natural fiber-based composite material for commercial usage.

M. Thiruchitrambalam et. al. [2] found that the roselle strand has great possibility due to reinforced in polymer composites. The roselle strands are not yet often as possible utilized as reinforcement filling in a polymer (thermoplastic and thermosets plastic) mix. On account of environment desires, minimal expenditure, light in weight and good quality, minimum density, good explicit characteristics of strands of roselle, composites dependent on these strands can have generally excellent implications in different uses. This organic strand composites can be utilized as an alternative for wood in domestic usage. Still, the low-cost machine components could be fabricated, this might discover usage in a few regions, for example, consumer articles, marine and mechanical application.

S. V. Joshi et. al.[3] discovered that organic strand composites probably going to be ecologically better than glass strand composites for accompanying intentions:

a. Organic strand production has less ecological effects contrasted to glass strand generation.
b. Organic strand composites have a high strand ratio for comparable efficiency, decreasing the all contaminating basic polymer composition.
c. Less in weight organic strand composites enhance eco-friendliness or lessen discharge in the utilization period of parts, particularly in automobile usage.
d. End of life cremation of organic strand brings about retrieved vitality as well as carbon credits.

T. P. Sathishkumar et. al. [4] found that organic strand-reinforced polymer composite substance proposed a broad area of characteristics in engineering applications. As compared to raw strand the chemically handled strands have high thermal properties, chemical properties, and mechanical characteristics. Natural strands treated with different chemical concentrations advances the interfacial holding in the middle of the matrix and fiber whichever upgrade thermal properties or mechanical properties. Treated fiber composites diminished water assimilation.

V. K. Thakur et. al. [5] concluded that the utilization of some of the organic strands got encouraging like in the green polymer as green reinforcement in industry usage. Viable usage of raw organic strand-like key part for creating novel minimal cost, eco-

friendly composites along with characteristics in polymers, for example, adequate explicit strength, minimum thickness, good toughness, better thermal characteristics and very much fast developing area of examination in engineering and science of polymers.

A. Moudood et. al. [6] analysis that the utmost environmental circumstances, e.g. hotness, moist, frosty situations, in between others, can diminish the mechanical characteristics of organic-composites when these are exposed to cruel conditions. In submerged usage, the life cycle of a composite can shorten likewise.

A. E. Venkateshwaran Narayanan [7] done a research to formulate green composites utilizing strands of banana as well as strands of soy protein like a matrix. This work showed that strands treated with alkali or untreated strands joined in soy protein isolate like plasticizer along with various measures of glycerol (22.50%). The outcomes demonstrate that with addition of 0.3 vol. fraction leads to increase in tensile strength and modulus. Degradability analysis display that composite is fully bio-degradable. Because of low thickness, high rigidity, as well as less elongation at the break of banana strands, material acts on those strands has excellent usage in different areas like the auto sector, civil works, in machines, and so forth.

M. R. Sanjay et. al. [8] carried out an investigation on organic strand composites based on plant exhibited like a significant substitute material for men made reinforced polymer composite because of their degradability nature. For composite materials expanded usage of organic strands as reinforced can decrease utilization of manmade strands and diminish ozone harming gas emission.

K. Rohit and S. Dixit [9] provided an information that many considerations given to those substances which are ecofriendly. which developing the interest for normal lignocellulosic substances and composites material dependent on them. Consideration of wood flour in polyester enhances the weight carrying limit and capacity to endure bending however along with the consolidation of metakaolin in wood flour polyester composite significantly decline tensile, flexural modulus and strength increase the water assimilation.

N. V Nayak [10] discovered that fiber-reinforced polymer composite materials got quickly gaining ground as a favored material for the development of aircraft, spacecraft. In an overall examination, it was discovered that composite materials offer high fatigue and corrosion resistance. The materials have a high strength to weight proportion. So, they are most appropriate for different aviation applications.

V. K. Balla et. al. [11] found that organic strand is a mixture or composite made with stiffed crystal-clear cellulose microfibrils with delicate, amorphous matrix whichever is a blend of lignin and hemicellulose. Characteristics of strands, and thus NFRCs characteristics, depending upon the mixing ratio, microfibril angle, translucent (crystallinity) along with inner architecture. Huge variation in organic strand dimension along with structure, for example, strand thickness, microfibril angle (MFA), direct influences those mechanical characteristics. An examination attempted to manufacture polymer mix reinforced along manmade material utilizing diverse AM technology.

J. Justo et.al. [12] done an investigation on the ALM process. It is utilized to make long fiber-reinforced composite parts. With an ALM machine, the mechanical profile of tall strand reinforced plastics has carried out. Also, the microscopic investigation of substances was finished. The result indicates the mechanical characteristics for ALM composites are dissimilar to particulars achieved with conventional techniques.

M. J. John et.al. [13] shows a test analysis on the utilization of Zein like joining medium in organic strand composite. Whereas with the help of Zein as joining medium Kenaf nonwovens deals, it's a type of protein obtained from corn. The outward face features of chemically treated as well as untreated kenaf strands were researched by FTIR. As a result, the characteristics of reinforced composites treated with chemicals were enhanced then the composite which is not treated with a chemical. In kenaf strand which was chemically modified composite, has found enhanced mechanical and viscoelastic characteristics.

S. Nunna et. al. [14] found that hybrid composite is fabricated by consolidating at least two strands in a single matrix. These composites produced from unnatural strands, organic strands, and by a mix of both organic or unnatural strands. The outcome shows that the handling of organic strands with NaOH plays a significant job in enhancing the interfacial bond among strands and matrix in this manner upgrading the mechanical properties.

M. Patel et. al. [15] found that for boosting the fuel economy, maintaining the safety and performance of modern automobiles the weight-saving requirement for automobiles has become more important. For achieving the requirement lightweight composite materials are essential. By replacing steel and cast-iron conventional components with lightweight composite

material such as Mg & Al metal matrix composite, carbon and glass fiber reinforced polymer composites can directly reduce the weight of parts of automotive. Finally, it was found that by the use of composite materials instead of traditional heavy cast iron & steel we can reduce the weight by 10-60%.

M. Asim et. Al. [16] explore pineapple leaves strands and its composite reasoned that the use of leaf strands of pineapple in the composite material is another resource that may be financially eco-friendly, reusable. Anyway, the hygroscopic nature of pineapple leaf fiber is its fundamental matter of concern, it creates a major obstacle as a strand used as a reinforced substance in polymer mix. Advancement in pineapple leaf fiber is needed for better interfacial adhesion of PALF with the polymer in the fabrication of polymer composites. The pineapple leaf fiber is broadly acknowledged in the textile area and already utilized in our daily life materials.

O. Arnould et. al [17] discovered that the aramid strands utilized in the examination were K48 grade Kevlar from DuPont. Green stem and develop flax strands samples were got dried out with of ethanol/deionized water (100%, 90%, 75%, & 50%) and afterward inserted in a blend contain a growing proportion of LR White acrylic resin/ethanol (100%, 75%, 50%, 25%), and wait for some time (hrs.) at every enclosed step, to manage strand and cell wall framework at the time of surface preparation. Finally, the polymerization of resin occurred in an oven (60 , all overnight). The outcome contributes to a good perceptive of flax strand development in a plant and the advancement of stem stability.

M. R. Bambach [18] shows a trial and explanatory investigation of organic strands composite plates area comprising flax strand, jute strand, or hemp strands and exposed to compaction. The mechanical characteristics demonstrated to be generally moderate. Buckling and Post- Buckling reactions demonstrated steady, the ultimate condition is come to steadily and predictably, and failure assures in a progressive, ductile manner. Those attributes show potential for utilization of organic strand composite areas in a lightweight framework, for example, in household or light business markets.

P. V. C. R. K. Santosha et. al. [19] explores the thermal characteristics of pineapple or banana leaf strand composite concluded that the benefits of natural strands are endless amount, simple or secure take care and degradable nature. In spite organic strands display splendid mechanical properties and physical characteristics, it alters with plant source, breed, geology, etc. The primary focal point of this examination is on the thermal conductivity or explicit heat ability properties of banana leaves, pineapple leaf's strands reinforced polyester composites w.r.t temperature, and strand content. The outcomes show that the composite's thermal conductivity diminished with an increase in strand quantity and quit inverse flow was seen along concerning temperature.

P. K. Paritala et. al. [20] done a research on digital manufacturing its application and future trends. The conventional process is an in-line process in which items planned. The design sent to assembling the model or prototype on the shop floor. Despite that traditional process, the advanced innovation is rupturing the dividers of manufacturing because of the ongoing improvements in zones, for example, artificial intelligence, 3D printing, human-machine interaction, robotization, etc. The gainful impacts and disruptive effects of digital on the tasks of organizations, for example, IT, broadcast communications, fabricating, publishing, and media, etc. are materialized.

S. H. Huang et. al. [21] researched on additive manufacturing and its social effect from a technical point of view and found the three decades into improvement, this has become a standard manufacturing process. The AM developed parts by depositing material each layer in turn on a computerized three-dimensional solid model. This doesn't require the utilization of fixtures, cutting equipment, heat removal liquids, and other ancillary assets. This AM technique is also called " third industrial transformation." many proofs were found to help the guarantees of AM in accompanying fields:

- Custom make medicinal production to enhance people's wellbeing or condition of life.
- Diminish environmental effect for manufacturing manageability.
- To get a hike in proficiency and responsiveness in fulfillment of demand.

G. Chabaud et. al. [22] discovered that the AM of auxiliary composites is disturbing innovation presently restricted with conservative mechanical characteristics. continued strand reinforcement has as of late been developed to make superior composites and open up empowering possibilities. To promote the outdoor application of these composite for utilization, different moist environment has been used (9-98%RH). Absorption of water can prompt the content of moisture about 5%-6% for carbon strand and glass strand composite. Moisture produces the orthotropic hygroscopic swelling affected along with the standard microstructure of composites just as hygroscopic character of substance.

M. R. Bambach [23] concluded the public concern about environmental change, vitality utilization, and greenhouse gas discharge placed a very hike in requests considering the utilization of viable substance in the surrounding. Regular strands, e.g. flax strand, jute strand, or strand of hemp recognized currently as strand resign composites, along with a significant inspiration for the execution being their outstanding viable qualities. This exploration shows the geometric enhancement of the channel segment utilizing the incorporation of an intricate web, flange edge, and flange interior stiffeners.

X. Tian et. al. [24] explores the intersection and execution of three-dimensional engraved uninterrupted carbon strand reinforced PLA composite. Three-dimensional printing of CFR PLA composites was proposed and analyzed in the present examination. The fast production of the composite part has been acknowledged by utilizing uninterrupted carbon strands as reinforcing stage and plastics as the matrix. Temperature and pressure are basic boundaries to the forming procedure, which decide the mechanical properties of composites. Subsequently, with the enhanced procedure, 3D printed CFR PLA composites with a strand ratio of 27% can accomplish the most extreme flexural strength of 335 MPa and flexural modulus of 30 GPa.

S. Requile et. al. [25] concluded that at the microscopic level hygromechanical nature of a single hemp/epoxy interface was researched via its properties. Curiously a decent discussion of bond quality at internal faces also friction and delamination characteristics in addition to the entire scope of RH. An increase in RH will build their commitment in addition to the stresses of radial type. Moist affectability of organic strands can be a potentially exotic variable with regards to the manner of strand/matrix interface achievement whenever restraint.

P. Parandoush et. al. [26] discovered that a novel laser helped AM system that uses prepreg composites such as glass strand-polypropylene along persistent strand reinforcement for manufacture articles of three-dimensional type with the help of laser assist binding, cutting. Microstructure examination exhibited no noticeable void substance as well as a superb bond between interfaces. With the help of a test i.e. proposed approach for bonding power the peel strength and lap shear power test which bring about 50% high peel strength as compare to hot compression technique, including the lap shear power up to 96% compression mold benchmark information. Tensile characteristics about objects made with our technique were better than FDM manufactured small strand composites along 150% & 300% increment respectively in modulus and tensile strength.

A. Le Duigou et. al. [27] focus on research to assess the advantages later aging the inclusion of excess PLLA coat to the external face of PLLA biocomposite, to prevent from marine aging the jelly layer is utilized for shielding old glass-reinforced composites. The investigation of a thermomechanical characteristic of biocomposite after the immersion displays the defensive layer diminishes the hydrolysis of the matrix and retained composite characteristics upgraded up to 100% contrast with the unsafe reference substance. It's the primary way to deal with improving the strength of biocomposites for navel applications while holding an environment-friendly methodology. The inclusion of thick PLLA covering brings about another damage mechanism, top layer cracking, and this feature requires an increasingly ductile and (UV safe) covering layer.

A. Le Duigou et. al. [28] done a work to assess the real strand surface engaged with the practical adhesiveness of the flex/epoxy framework. The distinction in practical adhesiveness assessed with a micro-scale bonding test among Hermes (app = 22.5 ± 1.5 MPa) and Electra (app = 13.2 ± 3.2 MPa). Results saw from micro bond tests prove that friction characteristic is likewise unique between the two frameworks with 6.7 ± 1.2 MPa for Hermes/epoxy and 1.3 ± 0.7 MPa for Electra. However, Electra strands with high surface roughness try not to display higher IFSS or friction strength.

J. L. Thomason and L. Yang [29] In the present study focus around the further examination of the theory that a significant portion of evident interfacial shear strength (IFSS) in strand reinforced composite can be ascribed to a mix of residual radial compressive pressure and static friction at the strand-polymer interface. The temperature reliance of interfacial characteristics of the glass strand-epoxy framework has been evaluated utilizing the TMA-micro scale bond technique. The temperature reliance of evident IFSS of the glass strand-epoxy in range 20 to 150 demonstrated a significant inverse reliance on testing the temperature with an advance change in the glass transition area of the epoxy matrix.

D. Dai et. al. [30] done investigation on novel fabrication utilized for the production of nano cellulose from strands of a natural type such as hemp and after that developed nanocellulose was utilized as a "coupling agent" for the modification of hemp strands themselves. Nanoparticle tracking analysis (NTA) was used for estimation of the size dissemination of nano-particles. As a result, mechanical testing indicates the modification in nanocellulose can enhance the mechanical characteristics of natural strands significantly.

A. Lefeuvre et. al. [31] represents an ecofriendly alternate to the glass strands in composite materials. The outcomes in the current work show that it is possible to upgrade the properties of FRCs through fiber surface change. The mechanical characteristics of composites of chemically treated areca strand show better outcomes when contrasted with natural untreated

strands. It is additionally worth notice that the quality of areca strand composites increases with increment in the volume of the strand in the composite and post composite solidification time.

V. Gager et. al. [32] explores the development of hygromechanical characteristics of flax/PP nonwoven composite in extensive scope with natural relative humidity circumstances starting with 10-98% relative humidity. Impact of the micro-scale structure against different porosity composition (5%,30%,50%) to study on hygroscopic and mechanical behavior contrasted with glass/PP composites like baseline. As an outcome, there is no critical variation in moist content as well as in the mechanical characteristics of glass-strand reinforced composite noticed. The tensile behavior along with characteristics are somewhat transformed above the scope of 10-75% RH negative impact somewhere in the range of 75% and 98% RH. The above-mentioned things are present to an unpredictable climate that consolidate temperature, moisture, mechanical stress at the time of automobile's life cycles.

M. N. Gururaja and H. Rao [33] in an investigation discovered that hybrid composite material has a broad engineering utilization where the simplicity of manufacturing, the ratio of strength to weight, and minimal cost are required. Hybrid composites give a blend of properties, for example, impact strength, tensile modulus, and compressive strength that can't acknowledge in composite substances. From the above study, hybrid composite has been set up as exceptionally productive, high-performance materials, and their utilization expanding rapidly.

Z. N. Azwa et. al. [34] done a review on polymeric composites degradability depends on the natural strands. In this research property of a few organic strand composite presented to moist, heat, fire, UV degradation via a literature survey. Hence, from the gathered information and different experimental outcomes, it was presumed that an ideal mix proportion of chemical added substances should be utilized to accomplish equity among quality, hardness, and endurance necessities for organic strand composites.

D. B. Dittenber and H. V. S. Gangarao [35] done an investigation on the utilization of natural composites in the foundation and observed that in contrast with most synthetic strands, natural strands are of minimal cost, simpler to handle, have great explicit mechanical characteristics, or needed just about 20-40% of vitality. organic composites demonstrating a decent capability in structural usage. The primary difficulties related to moist ingestion, imperviousness to fire, mechanical characteristics and toughness, fluctuation of organic FRPs are being tended with numerous ongoing investigation exercise. From the above survey, moist assimilation might be diminished via outer layer alteration of strands or by unique glazing. Protection against blaze can be enhanced with utilization of bloated glazing, whichever in the end likewise produced using reusable assets.

A. El Moumen et. al. [36] in a trial found that the AM technique, which is cited as 3D printing, is another advanced procedure of manufacturing metallic parts, ceramics parts, concrete material, plastic parts. The objective of this investigation is to give a survey of 3D printing manufacturing techniques and talk about their advantages and disadvantages. Recent utilization of this innovation in the territory of aviation and biomedical engineering was featured. In 3D printing, there are a few confinements that necessities to overcome dispute at every level.

- **Machine stage:** old setups are excessively slow or constrained. It's hard to produce larger size components. The latest three-dimensional production systems along quick handling of composites ought to be created.
- **Efficiency**: target of three-dimensional production was the production of composite along superb characteristics contrasted and polymer mix fabricated with mechanical procedure. However, printed items have less strength.

G. Biresaw and C. J. Carriere [37] done a research on mechanical characteristics and compatibility of mixes of polystyrene with biodegradable polyesters. Organic degradable polyesters permit the improvement with adequate organic-composites as well as organic-mixes from organic matter without harming the organic degradability or many more beneficial characteristics. The outcome indicated the tensile characteristics of the PS/biodegradable polyester mixes between the value of unmixed PS and relating pure degradable polyesters. the difference of the yield stress and modulus of the degradable polyesters with 25% PS demonstrated these properties diminishing in the request: PLA/PS > PCL/PS > EBU/PS. This pattern is inverse of the revealed pattern in the interfacial strains of these blends, for example, EBU/PS > PCL/PS > PLA/PS.

L. Yusriah et. al. [38] done an investigation on the impact of three distinct phases of strand development from the unripe stage, then ripe stage, and finally dried stage on physical properties, mechanical properties, or also morphological characteristics of betel nut husk (Areca catechu). The denseness examination, optical perception, moist ratio as well as water ingestion investigations done to assess the physical characteristics of BHN strands. As a result, the water ingestion was seen as the most

for the raw BHN strand, and the least water ingestion was seen in the dried BHN strand. The highest moist content was seeing in ready BHN strand and the least in dried BHN strand because of moist reduces at the fruit maturing (ripe state).

S. K. Ramamoorthy et. al. [39] In research found that hybrid natural strand composite was processed by joining distinct strand reinforcements, and water assimilation and mechanical characteristics were examined. The compression molding approach utilized to make composite overlays (laminates) against organic-based resin i.e. acrylate epoxidized soybean oil also organic jute strand of non-woven as well as woven type, the non-woven reproduced cellulose mat i.e. Lyocell and viscous, or also woven glass strand. composite overlays dried at pressure 40 bars and temperature 160 -170 , accompanying strand volume 40wt%. They researched the impact of pre-treatment among the re-produced cellulose strand utilizing 4% NaOH sol. As an outcome, the tensile, as well as flexural characteristics of an organic strand, reinforced composite largely influenced by the impact of water, yet it was enhanced impressively by hybridization with the glass and lyocell strand.

M. Boopalan et. al. [40] present an examinations to explore and look at the mechanical as well as heat-related characteristics of raw banana strand along with jute strand reinforced epoxy hybrid composite. To enhance the mechanical characteristics, the jute strand hybridized among the banana strand. Jute and banana strands set up along different weight proportions (100/0, 75/25, 50/50, 25/75, and 0/100) afterward consolidated in the epoxy matrix by molding method to shape composites. Various tests like the malleable test, flexural test, impact test, thermal test, or water assimilation tests were completed utilizing crossover composite examples. This examination showed expansion of the banana strand in jute/epoxy composite up to 50wt% brings about enhancing the properties like thermal characteristics as well as mechanical properties and diminishing the moisture retention properties. The inclusion of banana strands in composites brings about the 17% increment in tensile strength, also 4.3% increment in flexural as well as 35.5% increment in impact strength.

N. Verma et. al. [41] Presented a work which is engaged towards fabrication of nano-hydroxyapatite (nHA) reinforced polycaprolactone (PCL) composite by microwave route.The mechanical action of nHA-PCL foams was evaluated as ductility, flexural, hardness and Izod impact tests. The glass transition (Tg) temperature of microwave handled nHA-PCL foams was noticed by utilizing thermogravimetry investigation (TGA).As a result the pore size was procure in the assortment of 98–285 μm. It was seen that the tensile, hardness, flexural quality with 20 wt% of nHA was 145.90%, 52%, 96% more than flawless PCL foam.

N.Verma et. al. [42] done a study on the the current situation of each polymer handling industry which focussed towards the utilization of high quality materials having minimum cost. The disposing of the polymer part, makes an issue for nature because of its non-biodegradability. Also fabrication process take a long time. Thermal cured or microwave cured composite manufacturing might be an elective method to create biodegradable based polymer composite. This method of manufacture is a quick, having low-cost, and environmental friendly procedure to process polymers. The mechanical properties might be upgraded by changing wt.% of nano-HA.

3. CONCLUSIONS

It is concluded that the biodegradable reinforced composite is more advantageous than commercial materials. The parameters reinforcement ratio, curing temperature and curing time mostly affect the mechanical properties and the water assimilation.

1. With an increase in reinforcement, there is also an increase in mechanical properties like tensile strength, flexural strength, and impact strength.
2. With the increase in raw organic strand reinforcement in composite, water assimilation also increases but when treated organic strand used as reinforcement the water assimilation decreases subsequently.
3. The impact of water effects the mechanical properties likewise it reduces the tensile strength, toughness, flexural strength, and impact strength.

Future scope

The experiment may be conducted in the future by using the following parameters- curing method, curing temperature, different reinforcement ratios of the treated strand, or a raw strand.

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