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Characterization and Applications of Natural Fiber Reinforced Polymer Hybrid Composites - A Review

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Abstract: The natural fibers are having enormous advantages and are of mainly renewable material. Natural fibers are getting boom because of the cost effective and easily available and now it is been proved that it can be used as alternate reinforcement material to synthetic fibers in composites. In this review journal a different types of natural fibers with their characterization, applications and properties of Natural fiber reinforced polymer matrix hybrid composite materials has been studied. The methodology and matrix material and also fillers added and for the improvement in mechanical characterization of various natural fiber composites have been summarized. This paper reviews the information on characterization of the natural fiber/fabric reinforced polymer matrix composites with filler materials. and the result shows that the natural fiber reinforced polymer matrix composites with particles having good strength with equivalent mechanical and chemical strength to synthetic polymer matrix hybrid composites. The results indicates that the fabrication of natural with filler materials enhance the properties and can be taken as good potential replacement for synthetic and glass, carbon, Kevlar fiber reinforced polymer composites in the overall Engineering and Automobile application.
Keywords - Natural fiber reinforced polymer Hybrid composites (NFRPHCs), Characterization, fabrication process, Applications

I. INTRODUCTION

The Natural fibers are using since from 1,500 years ago as a reinforcing material There is a tremendous increase in the field of Engineering and Automobile Applications of natural fiber reinforced composites by changing of natural fibers, resins as compared to the manmade fibers due to disadvantages in the manmade fibers. Cristiano Fragassa [6] state that composite materials consist of two or more materials combined in such a way that the individual materials are easily distinguishable. The new material which is having many reasons includes materials which are stronger, lighter or less expensive when compared to manmade materials. Most composites have two constituent materials that are matrix and reinforcement. The reinforcement is usually much stronger and stiffer than the matrix, and gives the composite its superior properties. The matrix holds the reinforcement in an ordered pattern. Because the reinforcement is usually discontinuous, the matrix also helps to transfer the load among the reinforcements. Considering the presence and the importance of fibers, these materials are also called fiber-reinforced composite materials Fiber-reinforced composite materials have gained popularity, despite their generally elevated cost, in high-performance products that need to be lightweight, yet strong enough to withstand harsh loading conditions. At the same time, traditional composites do not represent a valid solution for the environment [6]. Shrikant M. Harle [7] state that the use of FRP composites in strengthening solutions has became an efficient alternative to some of the existing traditional methods due to some advantages such as their features in terms of strength, lightness, corrosion resistance and ease of application [7]. In the recent new trend years the utilization of filler or particulate materials for hybridization is increasing due to its good performance results in the composite applications. P. Ashik [9] stated that Natural fibers are now dominate the automotive, construction and sporting industries by its good mechanical properties. These natural fibers are flax, hemp, jute, sisal, kenaf, coir and others. The various advantages of natural fibers are low density, low cost, low energy inputs, mechanical properties and elasticity of polymer composites reinforced with natural fibers, especially when modified with crushed fibers, embroidered, chopped and long fibers and short fibers. The use of natural fibers is improved drastically due to the fact that the field of application is improved day by day especially in automotive industries, marine industries, medical fields. Now days, natural fiber composites have gained increasing interest due to their eco-friendly properties. Lot of work has been made by researchers based on the natural fibers. Natural fibers such as hemp, jute, sisal, silk and coir are inexpensive, abundant and renewable, light weight, with low density, high toughness, and biodegradable. Natural fibers such as hemp, jute, sisal have the potential to be used as a replacement for traditional reinforcement materials in composites for applications which require high strength to weight ratio and further weight reduction. [9]Natural fibers such as hemp, kenaf, flax and ramie can be used successfully in composite components in order to realize reduction of weight and cost. These fibers are renewable, non-abrasive to process equipment, and can be incinerated at the end of their life cycle for energy recovery as they possess a good deal of calorific value. The properties of natural fiber reinforced polymers are improved by tensile and bending strength, greater ductility and greater resistance to cracking and hence improved impact strength and toughness [30].H. B. Jalageri [1] Utilization of filler in polymeric composites made the composite lighter and cost effective. However there is need to further increase in the strength and stiffness of these polymer composites [1] Venkateswara Rao T [12] studied material properties for a particular application, to know the material performance changes with filler materials. This natural fiber is having number of advantages over traditional synthetic fibers. The most attractive advantage is high strength -to-weight ratio [12]. This paper includes a survey of the past research already made involving the work which is used for the engineering and automobile applications and in Aeronautical Applications.

II. NEED FOR DEVELOPING COMPOSITE MATERIALS

Composites are highly beneficial because of the many benefits that can be realized as a result of their mechanical behavior. A composite offer the ability for light weighting, multifunctionality, creativity of design, innovative solutions, etc and thus offers the greatest near-term growth opportunities especially in Automotive, Infrastructure and Aerospace and other industries. Thermoplastic composites are increasingly deployed for potential decreased cycle times and increased recyclability. The choice of materials used in composites manufacturing is basically driven by industry requirements and government investments and regulations. Industrial requirements for materials focus foremost on cost reductions enabled by lowered raw materials costs, as well as attractive processing parameters, such as short cycle times, low processing temperatures and zero scrap rates. Primary focus is to increase sustainability via recycling efforts and bio-derived material sourcing and to substantially reduce the embodied energy. These factors have propelled modern designers to develop newer composite materials which are sustainable and replace synthetic materials.

III. NATURAL FIBERS

A. Advantages Of Natural Composites And Its Classification According To The Origin

Now a day the natural fiber's can be used for high-tech applications, such as composite parts for Automotive, Infrastructure and Aerospace. Compared to composites reinforced with glass fibers, composites with natural fibers have advantages such as lower density, better thermal insulation, and are non-carcinogenic. Further, unlike glass fibers, if the natural fibers is attacked by bacteria they no longer in use. The Natural fibers can be classified as follows according to the origin

Table 1. Natural fibers according to the origin

Category	Description
Seed fiber	Fibers collected from seeds or seed cases, e.g. cotton and kapok
Leaf fiber	Fibers collected from leaves e.g. abaca, datepalm, pineapple, banana and agave
Bast fiber	Bast fibers are collected from the outer cell layers of the plant's stem. These fibers are used for durable yarn, fabric, packaging, and paper. Some examples are flax, jute, kenaf, industrial hemp, ramie, rattan, and vine fibers
Fruit fiber	Fibers collected from the fruit of the plant, e.g. coconut fiber (coir)
Stalk fiber	Fibers from the stalks of plants, e.g. straws of wheat, rice, barley, bamboo and straw.

B. Benefits to India

India is having plenty of natural fibers such as Seed fiber, Leaf fiber, Bast fiber, Fruit fiber, Stalk fiber has focused on the development of natural fiber composites to explore value-added application. Such natural fiber composites are well suited as substitutes in the Automotive, Infrastructure and Aerospace and other engineering applications. The development of natural fiber composites in India is based on a two strategies, preventing depletion of forest resources and good economic returns for the cultivation of natural fibers. Due to an occurrence of a wide variety of natural fibers in the country, Indian researchers have directed efforts for quite some time in developing innovative natural fiber composites for different applications. While the national research agencies in India have good scientific achievements to their credit for development of natural fiber composites, efforts on their

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commercialization have been limited so far. In order to improve upon the laboratory-industry linkages towards application development & commercialization including the natural fiber composites, the Advanced Composites Mission programmed was launched by the Department of Science & Technology, Government of India. The Mission mode activities are being implemented by Technology Information, Forecasting and Assessment Council (TIFAC), an autonomous organization under Department of Science & Technology

C. Natural fibers in the world and Their World Production (66)

Table 2. Natural fibers and their world production

SL NO	FIBER SOURCE	WORLD PRODUCTION (10^3 TON)*
1	Bamboo	30.000
2	Sugar cane bagasse	75.000
3	Jute	2300
4	Kenaf	970
5	Flax	830
6	Grass	700
7	Sisal	375
8	Hemp	214
9	Coir	100
10	Ramie	100
11	Abaca	70

H. B. Jalageri et al. [1] studied the Utilization of cenosphere in polymeric composites made the composite lighter and cost effective. The Multiwalled Carbon nanotubes (MWCNT) is used as secondary reinforcement material in polymer based composites due to their superlative mechanical properties which enhance strength and stiffness of the composites. The mechanical properties of Cenosphere/MWCNT reinforced epoxy (LAPOX L-12) and a room temperature curing polyamine hardener (K-6) nano composites are investigated experimentally. The composites were fabricated using uniform dispersion of MWCNT and cenosphere in epoxy resin by ultrasonic energy method with the percentage of MWCNT varied from 0.1 to 0.5 wt% of epoxy. The specimens were tested for flexural, tensile and impact properties as per ASTM standards. The tests determines the flexural properties (135x15mm and 7mm depth), tensile properties (50x13x7mm), Izod impact strength (63.5x10x7 mm with depth of the notch 2.54mm and notch angle 45°) of ECC composites in accordance with ASTM D790. It was observed that good flexural and tensile properties were found for 0.1 to 0.2 wt% of MWCNT and composite with 0.5 wt% exhibits higher impact strength. M. R. Sanjayet al. [2] has studied on Hemp fibers an alternative reinforcement for fiber reinforced polymer composites due to its eco-friendly and biodegradable characteristics and evaluated the mechanical properties of hemp/E-glass fabrics reinforced polyester hybrid composites. Vacuum bagging method was used for the preparation of six different kinds of hemp/glass fabrics reinforced polyester composite laminates as per layering sequences. Matrix is prepared by mixing resin (Isophthalic Polyester Resin), accelerator (Cobalt Napthanate) and catalyst (Methy Ethyl Ketone Peroxide i.e. MEKP) in the ratio 100:10:1. The matrix must be used immediately after its preparation since it gets hardened if it is kept for too long. The tensile, flexural, impact and water absorption tests of these hybrid composites were carried out experimentally according to ASTM standards. Tensile test Specimen is prepared into Dog Bone shape of dimensions 115x19x3 mm3 according to ASTM D638 standard. Flexural test Specimen is prepared into Flat shape of dimensions 90x10x3 mm3 according to ASTM D790 standard. Impact test Specimen is prepared according to ASTM A370 standard of dimensions 63x12.7x3 mm3. It reveals that an addition of E-glass fabrics with hemp fabrics can increase the mechanical properties of composites and decrease the water absorption of the hybrid composites Layth Mohammed et al. [3] The properties of NFPCs vary with fiber type and fiber source as well as fiber structure.The effects of various chemical treatments on themechanical and thermal properties of natural fibers reinforcements thermosetting and thermoplastics composites were studied. A number of drawbacks of NFPCs like higher water absorption, inferior fire resistance, and lower mechanical properties limited its applications. Impacts of chemical treatment on the water absorption, tribology, viscoelastic behavior, relaxation behavior, energy absorption flames retardancy, and biodegradability properties of NFPCs were also highlighted.The applications of NFPCs in automobile and construction industry and other applications are demonstrated. It concluded that chemical treatment of the natural fiber improved adhesion between the fiber surface and the polymer matrix which ultimately enhanced physicomechanical and thermochemical properties of the NFPCs H Ku et al. [5] made a review work on the tensile properties of natural fibre reinforced polymer composites. Natural fibers have recently become attractive to researchers, engineers and scientists as an alternative reinforcement for fiber reinforced polymer (FRP) composites. Due to their low cost, fairly good mechanical properties, high specific strength, non-abrasive, eco-friendly and bio-degradability characteristics, they are exploited as a replacement for the conventional fiber, such as glass, aramid and carbon. The tensile properties of natural fiber reinforce polymers (both thermoplastics and thermosets) are mainly influenced by the interfacial adhesion between the matrix and the fibres. Several chemical modifications are employed to improve the interfacial matrix-fibre bonding resulting in the enhacement of tensile properties of the composites. In general, the tensile strengths of the natural fibre reinforced polymer composites increase with fibre content, up to a maximum or optimum value, the value will then drop. However, the Young's modulus of the natural fibre reinforced polymer composites increase with increasing fibre loading. Cristiano Fragassa et al. [6]The rising concern about environmental issues and the need to find a realistic alternative to glass or carbon-reinforced composites have led to an increased interest in polymer composites filled with natural-organic fibers, derived from renewable and biodegradable sources. The scope of this article is to raise awareness regarding the current scientific and technological knowledge on these so-called green composite materials in order to support their larger application in a number of industry sectors. The general state-of-the-art in terms of green composites is proposed, together with some experimental evidence on the mechanical properties of various ecological materials. As a practical demonstration of this sustainable technology, the adoption of green composites as a valid replacement for fiberglass in sailing applications is also described. The Natural fibers have recently become attractive to researchers, engineers and scientists as an alternative reinforcement for fiber reinforced polymer (FRP) composites. Due to their low cost, fairly good mechanical properties, high specific strength, non-abrasive, eco-friendly and bio-degradability characteristics, they are exploited as a replacement for the conventional fiber. The comparative study shows the difference between natural fibers and glass fibers as shown in table

D. Comparison Between Natural and Glass Fibers (39)

Table 3. Comparison between natural and glass fibers

CONTENTS	NATURAL FIBRES	GLASS FIBRES
Density	Low	Twice that of natural fibers
Cost	Low	Low, but higher than NF
Renewability	Yes	No
Recyclability	Yes	No
Energy consumption	Low	High
Distribution	Wide	wide
CO2 neutral	Yes	No
Abrasion to machines	No	Yes
Health risk when inhaled	No	Yes
Disposal	Biodegradable	Not biodegradable

The properties of natural fiber reinforced polymer composites (NFPCs) vary with fiber type and fiber source as well as fiber structure. The effects of various chemical treatments on thermo chemical and thermal properties of natural fibers reinforcements thermosetting and thermoplastics composites shown in the table

Table 4.The properties of natural fiber reinforced polymer composites

Fiber	Density (g/cm3)	Tensile strength (MPa)	Young's modulus (GPa)	Elongation at break (%)
Flax	1.4	88-1500	60-80	1.2-1.6
Hemp	1.48	550-900	70	1.6
Jute	1.46	400-800	10-30	1.8
Ramie	1.5	500	44	2
Coir	1.25	220	6	15-25
Sisal	1.33	600-700	38	2-3
Abaca	1.5	980	-	-
Cotton	1.51	400	12	3-10
Kenaf (bast)	1.2	295	-	2.7-6.9
Kenaf (core)	0.21	--	--	--
Bagasse	1.2	20-290	19.7-27.1	1.1
Henequen	1.4	430-580	-	3-4.7
pineapple	1.5	170-1672	82	1-3
Banana	1.35	355	33.8	53

IV. EFFECT OF PROCESS PARAMETERS ON MECHANICAL CHARACTERISTICS

Over the last three decades, composite materials have emerged as an alternative material in the development of every day products to advanced engineering applications. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. For certain applications, the use of composites rather than metals can result in savings of both cost and weight. The natural fibers are hydrophobic in nature and thus are treated with suitable chemicals to decrease the hydroxyl group in the fibers. Chemical treatment reacts with hydroxyl group of the natural fiber and improves hydrophobic characteristic and improves interfacial adhesion with polymer matrix composites [1-5].Amar Patnaiet al. [9] studied the three body abrasive wear and mechanical properties of particulate filled glass epoxy composites. Dry sand/rubber wheel abrasion tests (RWAT) were carried out at 100 rpm test speed. The tests were carried out at 50 and 75 N loads by varying the abrading distance from 200 to 600 m. Experimental results of abrasive wear tests revealed that wear of composite was sensitive to variations of abrading distance and less sensitive to sliding velocity. Santram Chauhan et al. [10] studied the friction and wear characteristics of vinylester and cenosphere reinforced vinylester composites have been investigated under dry sliding conditions, under different applied normal load and sliding speed. Wear tests were carried using pin on a rotating disc under ambient conditions. The results showed that the coefficient of friction decreases with the increase in applied normal load values under dry conditions. On the other hand for pure vinylester specific wear rate increases with increase in applied normal load. The results showed that with increase in the applied normal load and sliding speed the coefficient of friction and specific wear rate decreases under dry sliding conditions. It is also found that a thin film formed on the counter face seems to be effective in improving the tribological characteristics. The specific wear rates for pure vinylester and vinylester composite under dry sliding condition were in the order of 10^{-6} mm3/Nm. The results showed that the inclusion of cenosphere as filler materials in vinylester composites will increase the wear resistance of the composite significantly. Soma Dalbehera et al. [11] deals with the effect of cenosphere as particulate filler on mechanical behaviour of woven jute-glass hybrid composites. The hybrid composite consists of jute and glass fiber as reinforcement and epoxy as matrix. The conventional hand lay-up technique is used to prepare composite specimens. Cenosphere of different weight percentage (5, 10, 15 and 20 wt %) was added to the hybrid composite. It is found that the mechanical properties are significantly influenced by addition of waste ceramic filler cenosphere up to 15 wt% and increases the tensile, flexural and interlaminar shear strength by 90.47%, 24.32% and16.75%, respectively, in comparison to unfilled composite. The morphologies of the composites studied by scanning electron microscope indicate good dispersibility of cenosphere in the matrix, which in turn improves the strengths appreciable. Venkateswara Rao Tet al. [12] investigate the mean tensile strength, tensile modulus, specific tensile strength, specific tensile modulus, mean flexural strength, flexural modulus and impact strength of bamboo fiber filled with Fly ash filler reinforced Hybrid composites. The specimens were prepared by Hand lay-up technique as per ASTM standards to perform Testand conclude that incorporation of fly ash will decrease the weight of the specimen and also improve the properties in wear and other strengths.Tara Sen et al.[13] reviewed that the application of composites in structural facilities is mostly concentrated on increasing the strength of the structure with the help of artificial fibers and does not address the issue of sustainability of these raw materials used for strengthening purposes. Priyadarshini Tapas et al.[14]studied the physical and mechanical properties of Al_2O_3 filled jute fiber reinforced Epoxy composites. They carried out experiment to identify the effect of filler on properties of composites. Jute and Al_2O_3 taken as reinforcement and epoxy as matrix, they have observed that filler makes significant changes on different properties of composites. In addition they have observed that Hardness, strength, flexural and tensile modulus increased with increase in the fiber and filler and inter laminar shear strength increased only by increasing fiber and decreased in addition of filler on composites. In the experiment by changing the volume fractions both in the filler and fiber material by 0%,5%,10%,15% weight in filler and 10%,20%,30%,40%weight. The hardness of the composites increased with the increase in fiber and filler loading. It has been observed that composite with 40 wt. % fiber and 15 wt. % filler exhibits maximum hardness value. The void content of composites increased with increase in fiber and filler loading. The composite with 10 wt. % jute fiber shows minimum void content. It is also observed that the composite with 30 wt. % fiber loading shows better strength properties. P V Senthiil et al. [18]studied the types of natural fibers which have been investigated for use in plastics including all natural fibers. Application of composite materials to structures has presented the need for engineering analysis, the present work focuses on the fabrication of polymer matrix composites by using natural fibers like jute, coir, and hay which are abundant in nature in desired shapes by the help of various structures of patterns and calculating the material characteristics by conducting tests like flexural test, hardness test, water absorption test, wear test, SEM analysis and their results are measured on sections of the material and make use of the natural fiber reinforced polymer composite material for automotive seat shell manufacturing. K.Rajasekar et al. [19] worked on Composite materials by combining two distinct materials to obtain enhanced properties. A specimen product of such a composite will be developed through layer by layer method at a certain temperature to suit the processes. The composite will be tested for its mechanical properties using conventional testing machines and the results will be recorded. The campsite will also be analyzed using ANSYS software for its mechanical properties and the result will be compared with the experimental results the resulting properties would help to identify the suitable applications for this composite. K. Naresh Kumar et al. [25] studied on Glass fiber reinforced polymer composites one of the most widely used composite materials. The addition of Coal ash to polymer matrix dramatically increases the overall mechanical strength of the composite material as compared to the polymer composite. In view of this, a method is proposed for mixing coal ash powder (size 52-75 μm) into resin and Ash reinforced polymer composites are fabricated by using hand lay-up technique in different weight percentages of coal ash in polymer such as 0%, 4%, 8%, 12%, 16% and 20%.The mechanical properties such as tensile, flexural, compression and Impact properties are studied as per ASTM standards. it was observed 20% ash reinforced polymer composite is having better tensile strength in comparison with other ash percentages. Similarly 16% ash reinforced composite is having better flexural strength in comparison with other percentages of ash. Similarly 12% ash reinforced composite is having better compression strength in comparison with others. Puttaswamaiah.et al. [26] studied and concluded that PMC's applications are slowly emerging form realm of advanced material & replacing conventional materials in a wide variety of applications. In this Work laminates are fabricated by a hand layup technique with and without fibres (Neat/pure matrix).The bi woven (WSM) glass fibre reinforced with polyester and epoxy resin as an adhesive. The casio- 4 filler material is added to resin to improve the mechanical properties. Hardener Hy-951 triethylenetetramine is added to epoxy/glass fibre& accelerator, catalyst are added to Polyester/glass fibre for activation purpose.The mechanical properties of neat matrix, Epoxy/glass and Polyester/glass composites are evaluated. The measured mechanical properties of neat matrix, Epoxy/glass and polyester/glass are compared with each other. The understanding of mechanical behaviour of composite materials is very essential in design and applications. P.S.Senthil Kumar et al. [29] studied the damping characteristics of Hybrid polymer composite, which can be used in many applications and in engineering structures. The investigation aims to develop glass-epoxy composite with addition of carbon (600mesh) fillers with different weight fractions and to characterize the mechanical and damping properties. The result indicates that the damping characteristics improved with increase in weight percentage of carbon reinforcement content. Further it was found that glass fiber –epoxy matrix with 5% carbon particles better damping properties which can be used for structural application. M. Nayeem Ahmed et al. [30] studied on Hybrid composite Materials that have extensive engineering application where strength to weight ratio, low cost and ease of fabrication are required. Hybrid composites are usually used when a combination of properties of different types of fibers have to be achieved, or when longitudinal as well as lateral mechanical performances are required. The investigation of the novel applications of hybrid composites has been of deep interest to the researchers for many years as evident from reports. In this work the mechanical properties of a hybrid composite [carbon fiber (37%) – E glass fiber (30%) –Graphite particulate (3%)–Epoxy resin LY 5052(30%)] are carried. Naveen. J et al. [32] worked on problem in distributing the fibers in layup process .the Natural fibers are receiving considerable attention as substitutes for synthetic fiber reinforcements such as glass in polymer due to their low density, low cost, acceptable specific strength, and reduced tool wear and respiratory irritation and renewable resources. The fibers are not uniformly distributed in the randomly oriented fiber reinforced hybrid composites due to manual lay-up and fibers agglomeration. This reduces the mechanical properties. The above problem can be solved by reinforcing the woven hybrid natural fiber laminated Composites. Polyester resin was used as a matrix. The work emphasis the sisal/cotton fiber woven mat reinforced polyester composites preparation and analyzing the tensile behavior (Dry and wet condition) by varying the fiber volume fraction (10, 20, 30 and 40%).At dry condition, while increasing the fiber content increases the tensile strength and modulus of the composites up to the volume fraction of 30%.Further increase in fiber volume fraction decreases the tensile strength and modulus. Water absorption was carried out for 24 hours with different condition. This reduces the tensile properties Gururaja M N et al. [33] Hybrid composite Materials have extensive engineering application where strength to weight ratio, low cost and ease of fabrication are required. The work reviews of the current status of hybrid composite materials technology, in terms of materials available and properties, and an outline of some of the trends, obvious and speculative, with emphasis on various applications including some details of smart hybrid composites. G. BhanuKiranet al. [35] studied on Green composites that are made from natural fibers, and biopolymers offer a potential alternative to the petroleum-based materials, that are currently being used in many non-structural applications. In spite of being biodegradable and eco friendly, range of applications is limited due to poor mechanical properties. In this work an attempt is made in this work to improve the mechanical properties of green composites by optimizing the hot press forming process parameters using Taguchi experimental design. Process parameters such as temperature, pressure, heating time, cooling system and recrystallization soak time were chosen for evaluation by Taguchi method. An L16 orthogonal array was chosen for the design of experiments. The optimum combination of process parameters is obtained by using the analysis of the signal-to-noise ratio. The levels of importance of process parameters on mechanical properties were determined by using analysis of variance (ANOVA). The variation of tensile, flexural and impact properties with process parameters were mathematically modeled using the regression analysis. Finally, the presented models are also verified by a set of verification tests. K. Poyyathappan et al. [36] worked on Glass fiber reinforced polymeric composite (GFRP), Carbon fiber reinforced polymeric composite (CFRP), glass-carbon-glass, carbon-glass-carbon hybrid composite laminates have been prepared by hand layup method. Six specimens with 0±90° orientation have been prepared for both the tests. The specimens have been subjected to low frequency cyclic load for specific duration prior to the flexural bending analysis. The results show that the hybrid composites have better flexural properties than the GFRP R.Sakthivelet al. [39] the hybrids composite has emerged and have the potential reinforcement material for composites and thus gain attraction by many researchers. This is mainly due to their applicable benefits have they offer low density, low cost, renewable, biodegradability and environmentally harmless and also comparable mechanical properties with synthetic fiber composites. A significant improvement in tensile strength was indicated by the woven fiber glass hybrid composites. In this hybrid composite laminates banana-glass-banana (BGB) and glass-banana-glass (GBG) exhibit higher mechanical properties due to chemical treatment to natural fibers. So, the hybrid composite material shows the highest mechanical properties. This High performance hybrid composite material has extensive engineering applications such as transport industry, aeronautics, naval, automotive industries. J.Santhoshet al. [40] studied both treated and untreated banana fiber and are taken for the development of the hybrid composite material. The untreated banana fiber is treated by sodium hydroxide to increase the wet ability. The untreated banana fiber and sodium hydroxide treated banana fiber are used as reinforcing material for both Epoxy resin matrix and Vinyl ester resin matrix. Coconut shell powder is used along with both untreated and treated banana fiber as a reinforcing material. The variation in mechanical properties are studied and analyzed. Here, the tensile strength has calculated by universal testing machine, impact strength has calculated by pendulum impact tester and flexural strength has calculated by universal testing machine with flexural test arrangement of the specimen. Then the treated and untreated specimens are analyzed and compared through Scanning Electron Microscope to study about its adhesion between fiber and resin matrix and surface morphology. M.A.M MohdIdrus et al. [45] studied on the mechanical and physical properties of chemically treated Kapok Reinforced Fibre glass composites (KRFs). Result shows that tensile, flextural, and impact strength decreased as the fibre content increased. The ultimate mechanical properties were achieved with a fibre content of 20 gram of Kapok. However, the water absorption and thickness swelling was found to be improve which is lower than fiberglass composites. This indicates, KRF were more water proof than fibre glass. SEM study was carried out to evaluate the microstructure of KRF composites. It shows that, as the resin and fibre content increased it became more brittle and ductility also decreased. Thus, lower the mechanical properties of KRF composites Parag A.et al. [47] studied on Cenosphere. Cenospheres are widely used as filler in thermoset plastics and concrete mainly for density reduction of the material. But there is no work noted of using cenosphere as filler in thermoplastics. In this work cenosphere concentration was varied from 0 to 10 phr of nylon 6 and the effect of the same on the mechanical, thermal, rheological and morphological properties of the composite were studied. Elongation was found to have increased by 83% and impact strength by 44% at 2.5 phr loading of cenosphere. Flexural strength increased upto 25% at 10 phr content of cenosphere. Olusegun David Samuel et al. [53] studied on Mechanical properties of ukam, banana, sisal, coconut, hemp and E-glass fibre reinforced laminates were evaluated to assess the possibility of using it as new material in engineering applications. Samples were fabricated by the hand lay-up process (30:70 fibre and matrix ratio by weight) and the properties evaluated using the INSTRON material test-ing system. The mechanical properties were tested and showed that glass laminate has the maximum tensile strength of 63 MPa, bending strength of 0.5 MPa, compressive strength of 37.75 MPa and the impact strength of 17.82 J/m2. The ukam plant fibre laminate has the maximum tensile strength of 16.25 MPa and the impact strength of 9.8J/m among the natural fibres; the sisal laminate has the maximum compressive strength of 42 MPa and maximum bending strength of 0.0036 MPa among the natural fibres. Results indicated that natural fibres are of interest for low-cost engineering applications and can compete with artificial glass fibres (E-glass fibre) when a high stiffness per unit weight is desirable. Results also indicated that future research towards significant improvements in tensile and impact strength of these types of composites should focus on the optimisation of fibre strength rather than interfacial bond strength

Arpitha G Ret al. [54] presents a brief overview of the tensile properties of fiber reinforced polymer materials. The tensile properties of the natural fiber reinforced polymer composites have been compared with that of synthetic fiber reinforced polymer composites and fiber reinforced composites with particles. Comparative evaluation of composites shows that Natural fibers and particle fiber composites results in lighter properties compared to SFRPCs with equivalent mechanical strength. Hence NFRPs are economical and new trends in composite materials. Dr A Thimmana Gouda et *al*. [57]studied the Mechanical Properties of Tensile, Compression and Bending Strength of the 12%, 24% and 36% of Hybrid Fiber as the reinforcement material with fiber weight fraction, randomly continuous long fiber orientation. By using the Hand Layup fabrication technique the specimen are prepared. This Research work concentrated on study of Femur Bone and collection of the strength and other parameters of bone and compared the experimental results of the 12%, 24% and 36% Hybrid Natural fiber Polymer composite material with the Femur bone. From the Experimental results all the strengths of 12%, 24% &36% Hybrid Natural fiber Polymer composite materials will match the femur Bone Strengths and also it is found that by increasing the weight fraction of the fiber or percentage of fiber which will increase the Tensile, Compression, Bending strength and increases the density and mass of composite of the specimen. Finally we suggest the 36% Hybrid Natural fiber polymer composite material for Femur bone Prosthesis and hence it is a Natural Bio-compatible Hybrid Natural fiber polymer composite material. Dr. K R Dinesh et al.[59]studied the Tensile strength and compression strength of 10%,20% and 30% Natural (Sisal) fibre reinforcement epoxy composite materials used as bio-material. An attempt has been made to develop 10%, 20% and 30% sisal fibre reinforcement epoxy composite materials with low density and economical, according to ASTM D – 3039 and ASTM D-1621 using resin -LY556 as a matrix material and hardener -HY 951 with 10%, 20% and 30% Sisal fibres as the reinforcement material (with fiber weight fraction) using hand layup fabrication technique. It is found that appreciable improvements in Tensile strength, compression strength properties of the 30% natural (sisal) fibers reinforced epoxy composites (SFRECM) when compared with 10 % and 20% SFRECM. This study suggests 30% SFRECM can be used for different applications in the human body bone replacement or orthopedic implant. In this research work it is found that the Tensile strength of 30% Natural (Sisal) fiber reinforcement epoxy composite material is 77 N/mm2 but compression strength of 30% Natural (Sisal) fiber reinforcement epoxy composite material is 64.66 N/mm2. Jagadish S P et al.[61] constitutes the wear study of 2%, 24% and 36% of Hybrid Fiber (Natural fiber- Sisal, Jute and Hemp) polymer composite material used as Bio-material. Characterization of 12%, 24% & 36% Hybrid Natural fiber polymer composite material with the low density, economical for prosthetic bone with respect to biocompatibility and the mechanical behaviour of long human bones, such as Femur Bone. According to the ASTM Standard G- 99 the specimen is fabricated by using the Epoxy resin- LY556 as the matrix material and the Hardener-HY 951 with the 12%, 24% and 36% of the Natural Fibers (Sisal, Jute and Hemp) as the reinforcement material with fiber weight fraction, randomly continuous long fiber orientation. By using the Hand Layup fabrication technique the specimen are prepared. The study was conducted by using a pin-on-disk apparatus and is issued under the standard ASTM G- 99. For the PIN-ON-DISK wear test conducted, the specimens were a pin with a rounded tip, which is positioned perpendicular to a flat circular disk. It is found that appreciable improvements in tribological properties of the 36% Hybrid Natural fiber polymer composite material when compared with 12% and 24% Hybrid Natural fiber polymer composite material. This study suggests 36% Hybrid Natural fiber polymer composite material can be used for different applications in the human body bone replacement or orthopedic implant Kotresh Sardar et.al [62] studied the Mechanical Properties like Tensile Strength of 10%, 20%, 30% and 40% KFRPC material used as Bio-material. An attempt is made to develop the 10%, 20% 30% and 40% KFRPC material with low density, economical for tissue implant with respect to biocompatibility and the mechanical behavior of human tissues, The tensile tests are conducted by preparing varying percentage of standard. It is found that there is appreciable improvement in Tensile Properties of 10%, 20%, 30% and 40%

KFRPC material. This Study suggests 40% of KFRPC material may be suitable for the different application in the replacement of human tissues. From the Experimental results it is found that by increasing the weight fraction of the fiber or percentage of fiber which will increase the Tensile strength and also increases the density and mass of composite of the specimen. This paper is concentrated on study of tensile strength of tendon and compared the experimental results of the 10%, 20% 30% and 40% KFRPC material with the Tendon. This study suggests that the KFRPC material is less cost, low density and high strength biocompatible material and may be suggested for implant, especially for Tendon. From the Experimental results the strengths of 10%, 20%, 30% and 40% KFRPC materials will match the Tendon Strength. Finally 40% KFRPC material can be suggested for Tendon. Further it can be tested for remaining mechanical tendon properties.

V. CONCLUSIONS

A review on investigation, characterization and applications for natural fiber reinforced polymer hybrid composite is presented in this literature work. The usage of natural fiber as reinforcement in polymer composites was made a brief study of natural fibers. The fabrication of natural fiber with and without adding the filler or particulate material with different fillers and properties will change in the natural fiber based polymer composite. Comparing natural fiber and glass fiber reinforced composites found that natural fibers is having more advantages but the strength of the natural fibers is low as compare to the manmade fibers. The NFRPC's have been proven alternative to SFRPC's in many applications in transportation, construction and packaging industries. Ongoing researches find varieties of natural fibers, which improve the mechanical strength of polymer composites. From the comparative study Natural fibers and particle fiber composite results in lighter properties compared to SFRPC's with equal mechanical strength. The Production of natural fiber is more labor intensive and hence NFRPC industry will create new employment and increases the economy Moreover, due to the usage of natural fibers in different engineering, automobile application and construction industries and it gives the way for economic development in rural areas. The results in the investigation tells that, there is a possibility to extend the work in natural fibers like hemp, abaca, flax and other natural fiber reinforced polymer composites. But very few investigations carried on hemp and flax as studied by the literature review. The new Development of hybrid composites with suitable applications in automobile industry is for weight and cost reduction, this leads way for the investigation on mechanical properties of hemp fiber reinforced epoxy hybrid composites by investigating with adding the filler materials to the natural composites and tries to match to the suitable application in engineering and automobile applications. The Applications of NFC's have extended dramatically including engineering Applications like load bearing and outdoor applications such as automotive interior & exterior under floor paneling, sports equipment and marine applications. Further research is still required to extend their application range to a higher level in the aircraft design, interior design in automobiles

VI. FUTURE CHALLENGES IN THE RESEARCH WORK

1) Though hemp fiber/fabrics possess superior properties than those of the synthetic fibers, but the mechanical properties of the HFRPs are still lagging behind than those synthetic fiber reinforced composites. In order to improve this, the investigation is to be done by change in the fiber in the form of long fibers, chopped fibers, and in fabrics and also in changing with different matrix is to be improved further using different fabrication methods.
2) Research is needed to come up with new techniques to further enhance the thermal stability of the natural fiber composites for its application at higher temperature applications.
3) The characterization and investigation of mechanical properties of hemp fiber reinforced composites were performed. The work is required to do more research on hemp fibers
4) The study of fillers materials from the literature tells that because of the more advantages in the material called as cenosphere which is the waste getting from thermal industry can apply for the research work which can increase the properties.
5) To the extent of this literature survey, only very few researches works have been done on hemp natural fiber with filler materials. More research works are still in need to be executed in order improve performance of the natural fiber reinforced composites.

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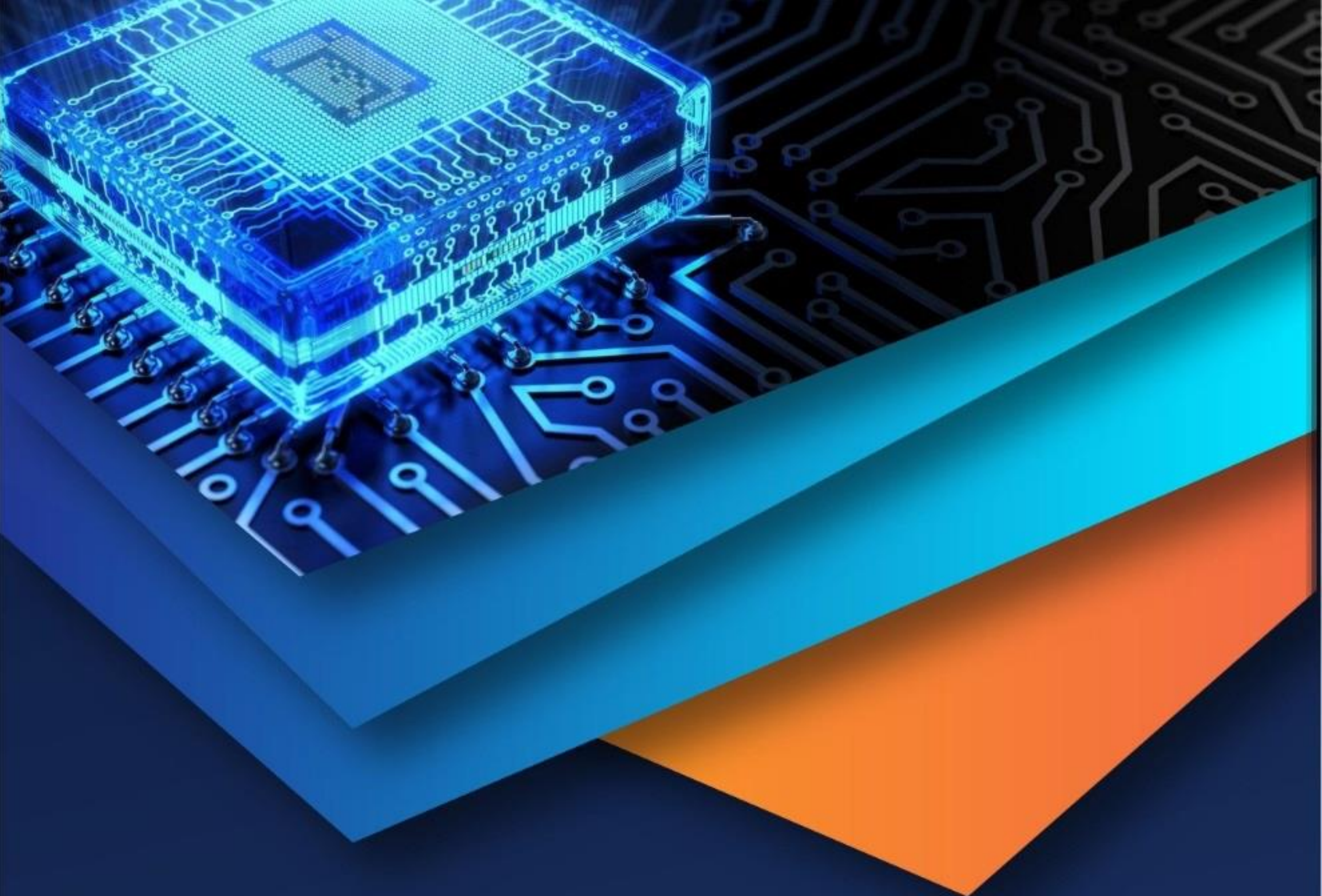

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