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RESEARCH ARTICLE

A Review on Dominant Factors that Conclude Performance of Coir Fiber Reinforced Polymer Composites.

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Abstract

Modern technology requires materials with distinctive combination of properties to meet the requirements that is not met by conventional metal alloys, ceramics and polymer materials. Synthetic fibers such as E-Glass, carbon fibers are widely used due to their high stiffness and strength to weight ratio. These had a proclivity to reduce due to high cost and increased environmental awareness which have diverged attention towards organic/natural fibers composite adding advantages such as low cost, ease in availability, low density, enhanced energy recovery, co_2 neutrality, biodegradability and satisfactory mechanical properties as well. Commonly used organic fibers are coir, jute, banana, sisal, kneaf, pineapple, cotton, hemp. Natural fiber composites are employed in transportation, military, building, packaging, consumer products and construction industries for ceiling panelling, partition boards etc. The paper deals with review of research conducted on coir fiber reinforced polymer composites in its enhancement of properties based on various dominant factors.

Introduction:-

Over the past few years, composite materials have replaced many conventional materials due to its unique and improved characteristics. In composites materials, fibers are the major reason for the strength, whereas matrices maintain the bonding between the fibers and prevent form external harm. Synthetic fiber reinforced fibers have their vast application in multiple disciplines, due to increase in environmental awareness and concern towards global warming, natural fiber polymer matrix composites have gained attention in recent years. The specific properties of natural fibers are ease of availability, low density, Co_2 neutrality and biodegradability. This biodegradability factor results in healthy ecosystem. S V Joshi et.al [1] investigated that natural fiber composites are likely to be environmentally superior to glass fiber composites in most cases for the following reasons: (1) natural fiber production has lower environmental impressions compared to glass fiber production; (2) natural fiber composites have higher fiber content for equivalent performance, reducing more polluting base polymer content; (3) the light-weight natural fiber composites improve fuel efficiency and reduce emissions in the use phase of the component, especially in auto applications and (4) end of life incineration of natural fibers results in recovered energy and carbon credits.

Rajesh gunti and Ratna Prasad Atluri V [2], table 1 shows the classification of natural fiber (Renewable).Most commonly used natural fibers are plant fibers like coir, jute, sisal, kneaf, banana, hemp, pineapple etc. due to its ease of availability and low cost. D nabi sahib and J P Jog [3],table 2 shows the physical property of natural fiber composites. The major draw backs of natural fibers are weak adhesion with the matrix material as a result of incompatibility, reduction in mechanical performance was noticed and high water absorption rate due to its hydrophilic nature. Z. sarani [4] investigated that hydrophilic nature of fibers led to weak bonding between fiber and matrix, dimensional instability, matrix cracking, poor mechanical property and reduces the durability of the composite. Initial treatments are performed before the fabrication to roughen the fiber surface so as to improve on adhesion and reduce the moisture intake percentage.

TABLE 1: CLASSIFICATION OF NATURAL FIBER (RENEWABLE)

Animal fibers	***Plant fibers***
Goat hair Sheep wool Feathers	Coir Jute Sisal Kneaf Banana Hemp Pineapple

D verma et.al [5], Table 3 shows the chemical composition of some natural fibers. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. The present study deals with study on advancements in coir fiber reinforced polymer composites. The major cause for advancement in study is due to ease of availability of coir fiber, as it is abundantly available in India. Lignin content is higher in coir than any other natural fiber which adds up to durability and mechanical performance of coir fiber composites. U S Bongarde and V D Shinde [6]Coir fiber reinforced polymer composites are developed for industrial and socio-economic applications such as automotive interior, panelling and roofing as building materials, storage tank, packing material, helmets, post boxes, mirror casing, paper weights, projector cover and voltage stabilizer cover.

TABLE 2: PHYSICAL PROPERTY OF NATURAL FIBERS

Natural fibers	**Physical Property**	
	Tensile strength (Mpa)	***Density (gm/cm^3)***
coir	175	1.2
Jute	393	1.3
Sisal	510	1.3
Flax	344	1.5
Hemp	389	1.07
Pineapple	170	1.56

TABLE 3: CHEMICAL COMPOSITION OF FIBERS

Natural fibers	**Chemical Composition**	
	Cellulose (%)	***Lignin (%)***
coir	37	42
Jute	71	13
Sisal	70	12
Banana	64	05
Pineapple	85	12

Dominant factors involved in processing of coir reinforced polymer matrix:-

Processing of coir reinforced polymer composite

Coir reinforced polymer matrix composite is processed using various techniques like Hand-layup, Compression moulding, Injection Moulding, Vacuum bag etc. Hand- layup is the most common processing method used due tothe ease of fabrication and low cost. Different percentage proportion of fiber, Matrix, Filler by weight or volume is utilized for fabrication. The performance of the composite depends on several dominant factors.

Dominant factors influencing coir reinforced polymer composite:-

- Coir fiber length.
- Coir fiber loading.
- Coir fiber pre-treatment.
- Filler materials used in composite.

- Polymer matrix being employed in the fabrication of composite.
- Fabrication using woven coir mats and random coir.
- Curing time and compression loading on composites.

Effect of dominant factors on mechanical property of composites

The effects are reviewed and discussed based on the various dominant factors that are considered in fabrication.

Composite based on coir fiber length:-

Baiardo et al. [7] the mechanical properties of short fibre reinforced composites are expected to depend on (1) the intrinsic properties of matrix and fibres; (2) aspect ratio, content, length distribution and orientation of the fibres in the composite and (3) fibre-matrix adhesion that is responsible for the efficiency of load transfer in the composites. Abdul nazer [8] study showed that as the fiber length increases the tensile strength also develops. The study showed that as the coir fiber length increased up to 15mm, maximum tensile strength of 48 Mpa was observed. G kalaparasad et.al [9] increase in fiber length up to 20mm decreases the tensile strength due to the curling effect of long coir fiber. The curly nature of fiber results in improper alignment of fiber in composite. Contradiction to this study, SandhyaraniBiswas et.al [10] investigated that coir fiber length of 30mm exhibited a higher tensile strength of 13.05 Mpa and flexural of 35.42 Mpa in coir fibre reinforced epoxy composites. Higher strength was observed due to strong fiber-matrix adhesion so as to transfer higher load.

Composites based on fiber loading:-

B Sudharshanet. al [11] investigated that tensile strength of coir reinforced composites increased with the concentration of coir fiber loading. Chizobalobele et.al [12] showed that composite material made with 30 wt% coir fiber gave the highest impact strength 26.43 Kj/m^2, Tensile strength of 23.68 Mpa, coir reinforced epoxy composite was therefore selected for helmet fabrication. P.A Udaykumar et.al [13] showed that 20% of short coir reinforced polypropylene composite exhibited higher value flexural strength of 69 Mpa. This increase was due to effective bonding strength between coir fiber and polymer matrix.

Composites based on fiber pretreatment:-

The pre-treatment process removes the lignin content to some extent and surface impurities. This results in increased surface roughening of fiber so as to improve the adhesion between fiber and polymer matrix. S Jayabal et.al [14] investigated the effect of soaking time and concentration of NaOH in the improved performance of the coir fiber polymer composite. His studies showed that maximum tensile, flexural and impact strength of 23.56 Mpa (5% NaOH; 72 Hrs.), 49.08 Mpa (2% NaOH; 96 Hrs.) and 58.75 kj/m^2 (8% NaOH; 24 Hrs.) respectively. 45.7%, 27.5%, 42.6% increase in tensile, flexural and impact strength respectively was observed than the untreated fibers. Savita Dixit and PreetiVerma [15] investigated surface modification using different chemical treatments. Moisture absorption of 65%, 35%, 30%, 33%, and 60% was found for untreated, alkali treated, acetylation treated, permanganate treated and heat treated respectively. NaOH treatment and acetylation treatment resulted in removal of lignin and hemicellulose thereby reducing moisture uptake. A karthikeyan and K balamurugan [16] showed that coir fibers treated with 6% NaOH exhibited maximum impact strength of $27kj/m^2$, an increase by 54.2% in impact strength was noticed when compared to untreated coir fiber composites. T Balarami Reddy [17] treated coir with hydrogen peroxide chemical to improve the fiber surface which resulted in decrease in tensile strength by 17.3%. H_2O_2 failed to improve the fiber surface there by causing incompatibility with polymer matrix.

Composites based on filler materials:-

Addition of filler material generally reduces the polymer shrinkage and improves the mechanical property of the composites. R satheesh raja et.al [18] fillers enhance mechanical and tribological response of polymers. Mishra S and Shimpa N G [19] showed that reduction in filler size gives better enhancement in properties due to uniform distribution of particles in polymer matrix and increase degree of cross linking between matrix. Vasanta V Cholachagudda et.al [20] investigated mechanical property of coir fiber vinyl ester composite impregnated with rice husk. Tensile and flexural strength of 33.56 Mpa (5% filler) and 97.04 Mpa (3% filler) respectively was noticed. Tensile strength showed an increase of 49.2% and flexural by 3.7% with respect to coir polymer composite without filler. B Sudharsan et.al [11] studies the effects of egg shell in coir fiber epoxy composites. The study showed that maximum tensile strength of 64.69 Mpa was obtained. An increase by 27.49 % was noticed when compared to coir fiber epoxy without filler loading. BinuHaridas [21] showed that use of cow dung powder as filler in coir fiber epoxy composite led to an increase by 50% of tensile strength and 16.9% of hardness value than the one without filler loading. S Anil Kumar et.al [22] showed that maximum tensile strength of 26.75 Mpa and impact strength of 42.35 Kj/m^2 with coir husk and termite mound soil hybrid particulate (20% particulate, 50:50 ratio) impregnated in coir fiber polyester composites.

Composites based on type of polymer matrix being employed:-

Bonding strength between the fibers is brought about by the polymer matrix being employed in the composite. As the polymer matrix changes, the property of composite also changes. N Abilash and M Sivapragash [23] good resin must possess (1) Good impregnation through fibers allowing all fibers to bind and form a single material; (2) Control moisture content of natural fiber after processing; (3) Nontoxic. N AnupamaSaipriya et.al [24] determined that a tensile strength of 25.2 Mpa was obtained when polyester (percentage by volume) was used as matrix material for coir fibers. Polyester (1.34 gm/cc) has density higher than epoxy (1.2gm/cc), which resulted in improved bonding strength. Chizobalobele et.al [12] study showed that tensile strength of 23.68 Mpa was noticed when epoxy (percentage by weight) was used as matrix material for coir fiber reinforcement. Vasanta V Cholachagudda et.al [20] investigated mechanical property of coir fiber using vinylester polymer. Tensile strength of 22.48 Mpa and Flexural strength of 93.44 Mpa was noticed. Noor Hisyam Noor Mohammed and Mohd.Shahril Osman [25] studied that tensile strength of 17.2 Mpa was obtained in coir fiber reinforced polypropylene composites (percentage by weight) and water absorption of 16% was noticed. Coir reinforced polyester matrix composite showed higher tensile strength because polyester has higher density (1.3 gm/cc) than vinyl ester and polypropylene. Due to higher density, higher quantity by mass was used in composite fabrication, which improved the mechanical performance.

Composites based on woven coir mat and random coir fiber:-

Dr. ShajanKuriakose et.al [26] investigated study on mechanical property of woven and unwoven coir fiber composites. Woven coir fiber composite showed at tensile strength of 46.83 Mpa, Flexural strength of 63.2 Mpa and Impact strength of 9 Kj/m^2. Non-woven coir fiber composite showed a tensile strength of 43.98 Mpa, Flexural strength of 51.46 Mpa and Impact strength of 6 Kj/m^2. Woven coir fiber composite showed an increase by 6.48%, 22.8% and 50% of tensile, Flexural and Impact strength respectively over non-woven coir fiber composites.

Composite based on curing time and compression loading:-

Composite materials should be subjected to sufficient curing to develop higher degree of crosslinking between the hydroxyl groups, resulting in increased bonding strength. Sufficient compression loading is equally important for matrix to get through the fibers and for uniform distribution of matrix throughout the fiber volume. Fairuz I. Romli et.al [27] investigated impact of curing time and compression loading on coir fiber composites. A maximum tensile strength was determined at 15% fiber loading cured for 48 Hrs with compression loading of 0.5 Kgs.

Conclusion:-

The present review focuses on advancements in coir fiber reinforced polymer matric composites. Due to the increased environmental awareness development of bio-composites to replace synthetic composite materials is been a major concern in current society. Several dominant factors found to have major role in improving mechanical performance. Over the past few years handful researches has been conducted to improve upon the performance of coir fiber polymer matrix composites. The two major drawbacks: Incompatibility between the matrix and coir fiber, growth of moisture intake by coir fiber composites has been overcome to definite amount. The efforts to produce economically attractive composite components have emerged in several innovative manufacturing techniques currently being used in the composites industry. Sufficient amount of research on coir fiber polymer matrix composites has to be conducted to exhibit same or more strength than that of synthetic fiber composite.

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