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A Review: Sisal Fibre Behavior as Reinforcement in Composites

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Abstract—*Natural fibres are eco friendly and biodegradable substance. Law enforcing agencies and environment awareness pushed the world towards materials that are compatible with environment as well as does not produce any harmful effect on human. Now a day's natural fibres based composites (green composites) are attracting the scientist as a new hope in lieu of synthetic fibre for safe guards of environment. This article is emphasis on sisal fibre(natural fibre) as reinforcement for new applications like automobile sector, structural engineering & furnishing of Indian Railway coaches where aesthetic and strength both are having prime importance. Sisal fibres are receiving immediate attention as reinforcement in polymer materials due to its eco friendly & bio degradable behaviour. It posses low density and cost with satisfactory level of properties. The aim of this paper review to provide a brief report on behaviour of sisal fibre as reinforcement in composites with effect of moisture absorption.*

Keywords*: Polymer matrix composites, moisture absorption, sisal fibre, mechanical properties.*

1. INTRODUCTION

In the modern world natural fibres are became the modern material which attracts the researchers because of its advantages over conventional reinforcement materials. These natural fibres possess the unique properties like low density, biodegradability, low-cost nonabrasive unlike other reinforcing fibres. **[1].**Mankind has been solely depends upon plants and its fibres for their needs, resulting areas of natural fibres (oil, palm, sisal & jute) are increasing day by day in Industrial and human applications. Composite are prepared either by synthetic fibres or by natural fibres. Synthetic fibres based composites are can be manufactured according to their constituents and their proportions. The properties mainly based on material and method involved to manufactured the composites.

All these material and method are universally adopted & its behaviour not changed with change of sources of availability. Fibre reinforced polymer composites are suitable replacement of conventional materials such as steel or concrete in the infrastructure application such as aircraft, turret base, poles, signpost, & guardrails. This enunciated the FRP composites application in civil and military infrastructure [2].Several works were carried to analyze the effect of glass fibre over mechanical & electrical properties in view of their fabrication conditions. The longer impregnation time helps to improve the tensile properties, although cooling period does not produce significant effect over the properties & fracture toughness could not be determined because formation of ridges on the surface [3].The orientation of glass fibre influence the electrical and mechanical properties of the glass fibre reinforced polyethylene and found that there is an appreciable decrease in the conductivity value[4].A new method opening polymerization was used for fabrication of continuous glass fibre reinforced polyamide-6 composite. It was found that both molecular weight and high degree of crystallinity of resin matrix leads to higher tensile & flexural strength. [5].A study was also done to analyze the flexural behaviour with help of two different glass fibre (high strength and low electrical conductivity) and carbon fibre (high strength and high modulus) with reinforced epoxy hybrid composite and it was found that when shear failure occurs, the flexural strength is 20-30% lower to other modes of failures[6]. Now going with eco friendly, biodegradable & economical scenario natural fibres are prominently used in place of synthetic fibres. The natural fibres have possesses unique characteristics. Its properties may vary with change of source of generation, because natural fibres are produced in different environmental conditions. The land, water, sun intensity & air vary with change of location & natural conditions are varying place to place & season to season which affect the inbound properties of natural fibres based composites [7].The use of natural fibre derived from annually renewable sources, a reinforcing fibre in both thermoplastic and thermo setting matrix composites. This advantage can be obtained by introducing these natural fibres into polymeric matrix as an alternative to organic and inorganic counterparts. The surface modification also carried out in order to improve properties of the fibres in the composite material. In this pattern surface modification like dewaxing, alkali treatment and grafting also have been made to improve mechanical properties of jute fibre with polymer in comparison to pure biopol [8].Novel pulp fibre reinforced

with thermoplastic composites show remarkable improvement in tensile strength & Young's modulus as compared to plain polymer material[9]. It also evaluate the effect of chemical treatment by the ratio of natural fibres (Alfa) chemically treated and untreated. By an SEM observation of the fibres morphology and of the interfacial characteristics of the material during test & found that increase in Young's modulus (28% to 132.22%) & traction resistance (11.34% to 30.14%) observed [10].The effect of reinforcement of corn fibre into polypropylene matrix was also investigated. Maleic anhydride grafted polypropylene is added to the matrix and it was found that tensile and flexural strength increases with addition of MAPP [11].The chemical treatment of the natural fibres improved the adhesion between the fibre surface and the composite matrix which ultimately enhanced the mechanical and thermo-chemical properties of the natural fibres. The natural fibre can be extracted from plants or animals. The plant fibres are can be classified based on their source of generation. Cellulose fibres (jute, kenef), seed fibres (cotton, coir), leaf fibres (sisal, pineapple), grass and reed fibres (rice, corn wheat) & core fibres (hemp, jutes). Wood dust also treated as fibre substances [12]. Bast fibres (banana, jute) are also used as reinforcement in place of synthetic fibres with polymer composites. Banana after aging treatment shows improvement in flexural & impact strength but reverse effect in tensile strength. Jute fibres show significant improvement in mechanical properties with epoxy in comparison to jute polyester composites [13].Among the different types of natural fibres, sisal fibres is a promising reinforcement material for use in composites due to its low cost, low density, high specific strength, low modulus, no health risk, easy availability & renewability. In recent years there is increasing interest in finding new applications for sisal fibre composites for making ropes, mats, carpets, fancy articles, etc.

2. SISAL FIBRE, SOURCE AND GENERATION:

Sisal fibres are extracted from agave sislana Perrine leaves. Sisal plants, Agave sisalana, The shape of fibre plant having sword-shaped leaves about 1–2 meters tall. Normally young leaves having a few minute teeth along their margins, they lose them when gets matured. The sisal plant has a 7–10 year life-span and typically produces 200–300 commercially usable leaves. Each leaf contains an average of around 1100 fibres. The fibres account for only about 3% of the plant by weight. Sisal is considered a plant of the tropics and subtropics, its production benefits from temperatures above 25 degrees Celsius and sunshine. Sisal fibre can extracted from the plant after two year growth. Sisal leaves are ripe when they reach a length of 80-100CM, which provide high extraction rate and superior mechanical properties. During the extraction process which is known as decortications, sisal leaves are crushed & beaten until leaves remains. For extraction of sisal fibres ratting is done followed by scarping. After extraction the fibres are washed thoroughly in water to remove the surplus wastes such as chlorophyll, leaf juices and adhesive solids.

3. CHEMICAL COMPOSITION OF SISAL FIBRE:

Generally sisal fibre consist of 67-78% cellulose, 10-14 % hemicelluloses, 8-10% lignin, 2%waxes, 1%ash & 1% water. The colour of dried fibre matches with cyan or similar to ivory having length approx 100-150mm & diameter approx 100-300microns. The composition of external surface of the cell wall is a layer of loganiaceous material and waxy substances that bond the cell to adjacent neighbours, Cellulose is a hydrophilic glucan polymer consisting of linear chain of 1,4B bonded anhydroglucose units & this large amount of hydroxyl group makes sisal fibres hydrophilic.

4. THERMAL PROPERTIES:

Being a hydroxyl group of fibre, the thermal properties of sisal fibres are vary with increase of temperature. Generally moisture absorption behaviour does not change below the 100 degree centigrade. But, fibre losses its weight slightly above the 100 oC because of evaporation of moisture/ water posses by fibre. Although below 190oc, no significant changes in absorbed in chemical structure of fibre. Under normal circumstance thermal treatment are carried out below the 200 oc.

5. FABRICATION OF SISAL FIBRE REINFORCED COMPOSITES:

The conventional fabrication technique of fibre reinforcement polymer composites are hot pressing / compression moulding and simple hand laying method. The curing of composites depends upon ambient temperature. Sisal fibre used as reinforcement material (filler) and polymers are used as matrix material to form composites. The hydroxyl nature of sisal fibre produced poor interface & poor moisture absorption as it possesses large amount of water.

6. MECHANICAL BEHAVIOUR OF SISAL FIBRES COMPOSITES:

The tensile strength, modulus & fracture strain of sisal fibre is not uniform along its length [14].The Hemicelluloses is responsible for bio degradation, thermal degradation & moisture absorption of the fibre and has lower mechanical resistance while lignin is thermally stable but is responsible for the UV degradation. It was observed that mode of degradation of sisal fibre depends upon the atmosphere involved. Both inert & air atmosphere shows different thermal process. The thermal degradation of sisal fibre is similar to natural's fibres like jutes & hemp [15].The tensile fatigue behaviour of individual sisal fibre was also investigated & behaviour was examined in terms of the stress versus cycles and stress-strain hysteresis behaviour of sisal fibre. There was no observed loss in strength, but an increase in Yong's modulus was observed with increase in fatigue stress [16]. The development of safe and environmental friendly flame retarded composite is of great importance. In sisal –

polypropylene composites, its mechanical properties and flammability was also examined by adding the flame retardant filler. It was observed that with the addition of flame retardant material (Mg (OH)2) & Zinc borate enhance the flame retardancy in sisal polypropylene composites without sacrificing their mechanical properties [17]. As received sisal fibres are also examined structural integrity & fatigue point of view with high load bearing capability [18]. Thermal & mechanical behaviour of sisal fibre with phenolic resin was also investigated. It was found that phenolic resin behaves as fragile material & having low tensile and flexural strength besides low elongation and low deflection. [19].Sisal epoxy composites are having longer fatigue life than sisal polyester composites. If sisal fibres are chemically treated (NAOH) than this treatment on fatigue life is positive for polyester matrix composite but less effect on epoxy matrix composite [20].Sisal fibre were also mercerized under tension and no tension to improve their tensile properties and interfacial adhesion with soy protein resin. Mercerization improved the fracture stress and Young's modulus of the sisal fibres while under fracture strain and toughness deceased [21].The effect of fibre content, interfacial compatibilization and fabrication process on the mechanical properties (tensile, impact and creep) of sisal fibre reinforced with high density polyethylene (HDPE) composites were also carried out & it significantly improved by modification by maleic anhydride grafted HDPE [22]. Hari Om maurya et.al[23] studied that 30 % weight percentage of weight sisal fibres with epoxy composites does not increased tensile strength irrespective of different fibre length, although flexural strength was improved 25% in case of 15mm sisal fibre length. Amuthakkannan et al [24] studied that short basalt fibre with polyester resin give optimum tensile and flexural strength with 10 mm fibre length & 50 mm fibre length gives better impact strength at constant percentage weight of fibre. Coconut coir fibres are also reinforced with epoxy to fabricate composites of different fibre lengths keeping 30:70 fibre epoxy ratio & it was observed that harness increased with increase of fibre length upto 20mm. The mechanical properties tensile strength, flexural strength & impact strength significantly improved [25].

7. EFFECT OF MOISTURE ABSORPTION:

The main concern of application of sisal fibre is their susceptibility to moisture, temperature & ultraviolet light with may cause the degradation of their physical, mechanical & thermal properties. The surface of composites produces poor strength due to formation of voids or vapour that deforms the surface only due to absorbed moisture. Sisal fibres are having unique characteristics, whenever water gets into the lumen and gets absorbed on the fibres and during application this will leads to variable expansion behaviour of fibre and matrix material would leads to generation of interface stresses and cracks.

8. GAIN AND LOSS TO USE SISAL FIBRE:

- The sisal fibres are easily available material.
- The easy extraction process saves time and cost of preparedness.
- Sisal fibres are smooth, straight, coarse & inflexible.
- Very less cultivation period and no ground preparation required for production of sisal fibres.
- No pesticides or fertilizers are required for cultivation of sisal.
- Sisal cultivation as a fibre crop does not cause environmental degradation.
- Eco-friendly and biodegradability nature of sisal fibre attract new hopes for environmental revolutions.
- It posses desired mechanical properties durability, energy absorbed, ability to resistance, resistance to flame retardant, resistance to deterioration in salt water.

The major loss occurred in use of sisal fibre is that moisture absorption behaviour. The strength of composites badly affected when it exposes to light, heat & water.

9. APPLICATIONS OF SISAL FIBRE – REINFORCEMENT COMPOSITES:

After going through the studies on sisal fibre composites, it is found that it has great potential use as a structural member & also areas where appearance of product is more important than its strength. It has good mechanical properties, tribology properties, economic and environmental properties. Automobile industries preferred for both automobile interior and exterior parts due to its low density, low cost, heat insulation properties. The construction industries are employing natural materials for light structural walls, insulation materials, floor and wall covering and roofing also.

10. CONCLUSION AND FUTURE DEVELOPMENT:

The sisal fibre reinforced composites possesses unique properties such as low density, low cost, smooth fibres orientation, easy availability, easy formation, eco friendly and biodegradability as compared to synthetic composites, thus create an area of wide application in the field of automobile sector (where aesthetic and strength is prime aspect), structural sector (where strength is prime cause of concern) & areas where insulation properties is the key factor of necessities. This paper evaluates the behaviour characteristics of reinforcement of sisal fibre in composites: mechanical, thermal, moisture absorption, biodegradability, flame retardancy and tribology properties are researched. Also application, gain and loss of sisal fibre in industrial purpose reported. The effects of chemical treatment to improve interfacial matrix fibre bonding were also reviewed. The

fatigue behaviour of sisal reinforcement also addressed. The Physical properties of composites can be improved by suitable treatment. Some of the restriction of sisal fibre reinforced composites lower durability and moisture absorption limited its applications. Moisture absorption of sisal fibre reinforced composite can be reduced through surface modification of fibres such as alkalization and addition of coupling agents.

In this current scenario, preparedness and usages of envoi mental friendly material can make a revolution in the field of engineering. Now it became a fast growing, most wanted technology for future building.The author is motivated for use of sisal fibres composites due to its much advantage over synthetic fibres, environment friendly composites, easy availability of fibres, and easy fabrication of composite & huge scope of applications in different areas i.e. automobile sector, aerospace, insulating material & in Indian Railways coaches.

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