



Materials Today: Proceedings

Available online 18 February 2023

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Advantages and applications of sisal fiber reinforced hybrid polymer composites in automobiles: A literature review

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Available online 18 February 2023.

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<https://doi.org/10.1016/j.matpr.2023.02.072> 

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Abstract

Highly performing polymers are widely used in automotive parts manufacturing due to their corrosion resistance, design freedom, flexible component integration, recyclability, etc. In present scenario, polymers are reinforced with fibers to enhance their properties as per the requirement in automotive sector. Literature shows that natural fibers like sisal is a commonly available fiber in most parts of the world which can play a key function in enhancing the thermal, mechanical and acoustic characteristics of polymers. Sisal cultivation requires low fiscal support and upkeep and can be cultivated in landfills. The reason for conducting this research is to examine the various advantages and applications of composite reinforcing material made out of sisal fibre is used in automobile parts. As per the literature Indian automobile manufacturers are not using the natural fiber including sisal fiber reinforced composites up to the level of leading automobile manufacturers worldwide. Hence

there is a need of more studies on sisal fiber reinforced composite materials which will also help in overcoming the environmental sustainability challenges of the future.

Introduction

Composites that are reinforced with natural fibres are used in a wide variety of contexts like consumer goods, building construction, transportation, packaging and many more. Now a days researchers are investigating the natural fiber reinforced composite materials in automobile applications because of their light weight density and high rigidity-to-weight ratio, high strength to weight ratio, high ratio of fatigue strength to weight, high recyclability and processing break resistance, low abrasion, safe handling, better energy recovery, ease of separation and carbon neutrality compared to other materials. When compared to synthetic fibre reinforced composites, natural fibre composites have been found to perform significantly better in the automotive industry as they are cost effective, lighter and sustainable [1], [2], [3], [4], [5].

As per the literature, researchers achieved up to 20% decrease in the cost and 30% reduction in weight by using natural fiber reinforcement in place of synthetic fibers [3], [6], [7]. Natural fibres including flax, sisal, hemp and other bio resins are becoming popular among researchers for automobile component applications [3].

During the course of recent years, natural fibre reinforced polymer composites have been increasingly popular among automobile manufacturing industries of European countries. This trend can be seen especially in the production of headliners, door panels, parcel trays, backs of seat, trunk liners, and dashboards. The United States of America, along with a number of countries in Asia, especially Japan, are currently experiencing trends in the field of natural fibre. Over the past century, the total number of automobiles produced has increased exponentially. This can be attributed to the improvement of the automobile industry as well as the massive economic expansion in Asia, Europe, and the United States. To stay competitive in the market, automakers all over the world are always looking for ways to cut costs without sacrificing quality. As a result, natural fibre composites are being explored more and more in the auto industry [8].

Natural fibers like sisal is a commonly available fiber worldwide which perform an extremely important function in enhancing the thermal, mechanical and acoustic properties of polymers. It can be grown at low financial input and maintenance even in wastelands also. The reason for conducting this research is to examine the various advantages and applications of sisal fibre as a composite reinforcing material in automobile parts. This literature review includes different studies of hybrid composite of Sisal fibres find application in a variety of automotive components.

The name "sisal" was originated in a Mexican port city and means "cold water [9], [10]. Sisal (shown in Fig. 1) is a plant that is a member of the family Agavaceae, and the fibre is harvested from the leaves of the sisal plant. Every year, production of sisal fibre on a global scale totals approximately 45 lakh tones. Two major global producers of sisal fibre are Brazil and Tanzania. [11], [12]. Sisal is also grown in countries like India, Haiti, East Africa, Brazil, and Indonesia [10]. Roughly A sisal plant can produce anywhere from 200 to 250 leaves, and each of those leaves contains between 1000 and 1200 packets of fibre. The leaves have a cuticle that is about 0.75%, fibre that is about 4%, dry matter that is about 8%, and moisture that is about 87.25%. The sisal fiber can be divided in three categories namely

mechanical, ribbon and xylem [13], [14]. Traditionally, sisal fibers were used to produce ropes, rugs, fishing net, cords, cushions, padding, etc. and was considered to be a textile fiber in 1947 [10].

Due to its extraction from lignocelluloses and hydroxyl groups that are highly polarised being present in the sample, sisal is hydrophilic in nature. The presence of impurities, such as natural oils and wax, is the primary problem with sisal fibre. The use of sisal fibre as reinforcement in polymer composites is significantly hampered by the fact that there is insufficient contact between the polar hydrophilic fibre and the non-polar hydrophobic matrix[15].

In many respects, the sisal fibre is superior to other naturally occurring fibres such as jute. It is stronger, has a bright and shiny colour, has a long staple, doesn't crimp well, has different properties and qualities depending on how it grows, and can only be processed at certain temperatures [16]. In recent years, sisal has been used to replace asbestos and fibreglass as a strengthening material. Sisal fiber is composed by different percentage of hemicellulose (10–24%), cellulose (47–78%), lignin (7–14%), pectin (2–10%), ash (0.6–1%) and wax (0.2–2%). as reported by various researchers [17], [18], [19], [20], [21], [22], [23], [24].

Three grades of sisal fibres are utilised in industry: low, medium, and high, and these grades have distinct applications. Sisal fibres of inferior quality contain a large amount of cellulose and hemicelluloses; hence they are utilised in the paper manufacturing industries. In the cordage industry, fibres of a medium grade are utilised for purposes including blare, binder twin, rope marking. These ropes and twines are predominantly utilised in the agricultural, maritime, and industrial sectors. After treatment, the carpet business utilises sisal fibres of superior quality [18], [21]. Traditionally, sisal fibre is being used for cat scratching posts, slippers, lumbar support belts, spa products, rugs, fabrics, filters for handicrafts, geotextiles, mattresses, and disc buffers.

Section snippets

Properties enhancement of sisal fiber

The sisal fibre's physical as well as mechanical properties change depending on the source, age, and location of the fibre, as well as the gauge length, experimental temperature, and fibre diameter. Physical properties (density and diameter) and mechanical properties (elongation, tensile strength and Young modulus) are shown in the Table1 reported by different researchers.

Asbestos and glass fibres are now being replaced by sisal fibres because of its higher strength and sustainability. The ...

Application of sisal fiber hybrid polymer composite in automobile sector

In general, hybrid composites integrate the qualities of their constituent materials. Hybridization of sisal fibre with other natural fibres greatly enhance the physical as well as mechanical qualities of the composites. A wide range of main components such as door panel, roof panel, floor lamination, wall insulation, structural application etc are prepared by sisal composites.

Mixing sisal fibres with other natural fibres to make new types of fibres was investigated with various researcher and ...

Conclusions

As per the comprehensive review of literature it can be concluded that sisal fibre is an excellent material for polymer reinforced composites. In addition to its traditional uses as ropes, carpets, and mats, it can be used in a variety of automobile applications. Furthermore, hybridization of sisal fiber with other fibers exhibit excellent properties and can be utilised within the vehicle components. Due to its excellent mechanical properties and recyclable nature, sisal fibre is a potential ...

CRedit authorship contribution statement

Sarita Choudhary: Conceptualization, Methodology, Writing – original draft. **Manoj Kumar Sain:** Supervision, Writing – review & editing. **Vikas Kumar:** Writing – review & editing, Data curation. **Praveen Saraswat:** Writing – review & editing. **Manish Kumar Jindal:** Supervision. ...

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. ...

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2024, Industrial Crops and Products

Citation Excerpt :

...To align the fibers and get rid of any leftover leaf material, the dry fibers are brushed. After drying and cleaning, the fibers are baled for storage and transportation (Rong et al., 2001; Choudhary et al., 2023; Senthilkumar et al., 2018). Lamina is a basic form of continuous fiber reinforced composites where a large number of fibers are impregnated into matrix whereas laminate is a stack of laminae....

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2023, Alexandria Engineering Journal

Citation Excerpt :

...Therefore, this current work focuses on studying and analyzing the water absorption behavior of palm fiber reinforced composites. As mentioned earlier, in contemporary times, bio composites enriched with plant fibers such as kenaf, jute, coir, hemp, sisal, ramie, flax, sugarcane, coffee, rice and palm [8–19] fibers are receiving great attention as an alternative to synthetic fibers. Where many studies have focused on the phenomenon of absorption of bio-composite materials reinforced with cellulosic fibers, among these studies: Tezara et al. [20] examine the mechanical properties and water absorption behavior of epoxy composites reinforced by jute-ramie hybridization....

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