

NATURAL FIBER REINFORCED POLYMER COMPOSITES FOR AUTOMOBILE APPLICATIONS: RECENT TRENDS

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ABSTRACT: In recent years, natural fibers are receiving more interest due to its numerous advantages like light weight, biodegradability, high specific strength, reduced cost, recyclability, mainly eco-friendly nature and these natural fibers are abundant and easily affordable, since automobile industry desperately need an eco-friendly product for their production. and for environmentally friendly future, natural fibers have a vital role to play. So Automobile industry not only finding it more convenient and feasible to use it as a reinforcement material but also a replacement for most of the synthetic fibers. and natural fillers in composite materials have not only reached the environmental appeal but also helps in developing materials with low density and improved properties. This study attempts to review the significance of natural fibers along with the natural fillers. And also this disclosure includes some different methods to improve the properties of natural fiber and a brief information about sustainable products that can be obtained by natural fiber reinforced polymer composites for different automotive applications in recent trends.

Keywords: natural fibers, natural fiber reinforced polymer composites, automobile applications.

INTRODUCTION

From the past few years, automobile industries excessively using synthetic fibers, because of its various good properties, but synthetic fibers are neither bio degradable nor eco-friendly and they are expensive. generally, the common synthetic fibers used for automobile industries are glass fibers, carbon fibers and kelvar. but due to their high cost, researchers have changed their interest into developing materials from natural fibers. Since natural fibers are light weight, eco-friendly, bio degradable and have high specific strength. There are different types of natural fibers available in the environment like jute, sisal, hemp, kenaf, ramie, banana, coir, bamboo, abaca etc. which have their own significance properties. Natural fibers are generally categorized based on their origin like plant, animal and mineral and following that plant fibers further can be categorized on the basis where they are extracted from ie seed, leaf, skin, fruit, stalk and the composite which is reinforced by these natural fibers also have properties like renewable, unbreakable, durable, fire retardant, maintenance free and water resistant, less abrasive, acid-and alkali-resistant, less costly, with low thermal conductivity. Natural fiber reinforced polymer composites have strength properties comparable and almost twice as stiff as glass fiber reinforced polymer composites.

These Natural fibers reinforced composites can be fabricated by using suitable matrix with addition of the filler to get the desired properties. enhancement of properties of natural fibers can also be done by different chemical treatments. Since the recycling ability of thermosetting polymers which is reinforced by synthetic fibers are low, but this problem can be overcome by natural fibers reinforced polymer composites which has tremendous recycling ability which is one of the main requirements of the automobile industries. And also fillers play a important role in fabrication since it has the ability to enhance the property of the material and desired properties for a particular material can be obtained by adding suitable fillers.

Nowadays all the international automotive manufacturer companies have adopted new models of Natural fiber reinforced polymer composites for the production of different interior and exterior parts like panels of door, trunk liners, dashboard, seat backs, package trays, boot lining, rear storage shel, hat rack, spare tyre lining, headliner panel, spare wheel compartment cover, boot lining, noise insulation panels, moulded insulation.etc

These Natural fibers reinforced polymer composites has not only have applications in automobiles but also in railway, truck industry, aircraft. And also in food industries, house hold products, and in different types of electrical, electronic products, and medical applications.

NATURAL FIBERS USED IN AUTOMOTIVE APPLICATIONS

Now-a-days natural fibers have become the replacement for synthetic fibers in almost every field, especially in the automotive sector, because of the high strength and compatibility offered by the natural fibers. On the other hand automotive industry demands certain characteristics which are not met by neat materials. And those requirements can be fulfilled by composite materials through their proper mechanical properties by the synergetic action of the components, matrix and reinforcement, which support the load stress.

Natural fiber reinforced polymer composites being used in various applications is the proof of a natural fiber which has the potential to be a perfect alternative for the synthetic fiber. Low density and satisfactory high specific properties of natural fibers are the prominent reasons for it. Attempts for the natural fiber's implication in automobile sector was done back in the 90s, when Mercedes -Benz manufactured door panels containing jute fibers. Flax fibers has been the most predominant and relevant natural fiber for the German automotive industry for years, hemp fibers are the next most important natural fibers for the automobile industry.

Moreover, automobile industry are under high pressure to fulfill environmental, performance demands and higher fuel efficiency at reasonable costs. And also they have requirement to reduce waste disposal and greenhouse gas emission.

Properties of natural fibers also depends on composition it is made of and their composition relay on certain factors. For example, The chemical composition of vegetal fibers relies on several factors like comprising fiber variety, harvesting time, climatic background, characteristics of soil and fiber processing technology.

Natural fibers are made up of chemical constituents such as cellulose, hemicellulose and lignin which has its own significant influence upon the whole properties of the fiber and so does for their application. for example, hemicellulose in the natural fibers is the reason for the biodegradation, moisture absorption and also the thermal degradation of the fiber. And also Strength of fibers is controlled by a different other factors including the ratio and perfection of crystalline cellulose in the fiber and fiber asymmetry

Some of the properties of different natural fibers is listed in the below table

Fiber	Density (g/cm ³)	Diameter (µm)	Stiffness/ Young's modulus (GPa)	Tensile strength (MPa)	Elongation at break(%)	Specific Young's modulus (GPa-cm ³ /g)
Flax	1.38	5-600	27 - 100	343 - 183	1.2 - 3.2	18 - 53
Kenaf	1.2	12-36	22-60	295-930	1.6-6.9	18-50
Ramie	1.44-155	18-80	44-128	400-938	1.2-4	29-85
Jute	1.23-1.5	5-200	10-55	187-800	1.16-3.1	7.1-39
Hemp	1.35-1.51	10-500	30-70	550-1100	1.6-4.5	20-47
coir	1.1-1.46	7-460	4-62	130-580	15-40	3.3-5.2
Sisal	1.23-1.5	7-200	9-28	468-855	1.9-7	6-20

Table no. 1

Above table is just the description of few properties for some natural fibers. similarly, there are lot of other natural fibers which are available in abundance in our nature which have their own significant properties, based on the need of the manufacturers for the particular product, selection of suitable nature fiber is recommended. Even some of the desired properties can be obtained by adding suitable filler while fabrication. And also by different chemical treatments.

NATURAL FIBER BASED POLYMER COMPOSITES FOR AUTOMOBILE APPLICATIONS

The need for natural fiber based composites for automobile industries are comparatively high than other synthetic fiber based composites. Because of various advantages it offers, in order to remain stable and competitive, automobile industries have no options left rather than to go with usage of renewable resources as raw materials and because of the renewability and bio

degradability, offered by these natural fibers based polymer composites has made the replacement of petroleum based synthetic materials to agro based natural fibers based polymer composites in automobile applications. And addition to that usage of these natural fiber based polymer composites reduced the total cost reduction by 20% and weight reduction by 30 %. Further the continuous hike in the oil prices has led to the more usage of these natural fiber based polymer composites, since lower the use of petroleum based synthetic materials better will be ecofriendly environment. The main requirements that made automobile industries to run behind these natural fibers based polymer composites are high demands in lightweight materials which eventually ends in lower fuel consumption and chances of stable recyclability.

Some other reasons that made these natural fibers based polymer composites as their first priority for the automobile applications are as follows

Reduction of CO₂ emission

Gas such as CO₂ which causes greenhouse effect would be controlled only when the usage of biomaterials in automobile industries increases, which eventually rises the interest in developing new classes of materials which are purely based on the renewable sources.

Economical

Automobile industries have already developed some automotive parts using composites with non-wood fibers such as flax and hemp, as well as cellulose, as a replacement to fiber glass. German car industries used natural fibers and cellulose for Volkswagen, Audi, BMW and Daimler Chrysler as a raw material to manufacture parts like interior door panels dash boards, which are lighter, and they are more economical compared to other glass fibers.

Other examples are eco-plastic made from sugarcane was developed by one of the car manufacturing company Toyota. And other top company Volvo developed seats and implemented in its C70 and V70 models with natural fibers which is extracted from soya based foam linings and with one step further they succeeded in producing a cellulose based cargo floor tray to improve the range of noise reduction.

Technical pros

Better wear protection, high tool life are the important technical aspects which live up to the expectation of the manufacturers and also which is economical for the automobile industries.

Chances of agricultural Growth

After realizing the commercial importance of these natural fiber based polymer composites for the automobile industries, there is a more chances of growth in agriculture field which is always a good thing for any nation's economical stability.

In these days, Value of natural fiber based polymer composites in the marketing filed is very high, but it's the fruit of advancement done in the natural fiber reinforced composites in 1990's. European Guideline 2000/53/EG' that set a goal of improving automotive recyclability to 85% of a vehicle (by weight) being recyclable by 2005. but that percentage kept increasing till today which is the good thing in the aspect of environmental concern and also for the consumers to get a product of good quality. Similarly japan and united states had made the rules to use these biomaterials in certain fixed percentage in their production by keeping an eye in the environmental awareness.

CHALLENGES IN USE OF NATURAL FIBERS FOR AUTOMOTIVE APPLICATIONS

Natural fibers are the most significant materials in the field of engineering. Since it has numerous advantages, but at the same time there are some challenges that one has to face while using it in the applications of any field, and mainly there are some challenges to face when it comes to automobile application. This review explains some of the challenges that are facing while using natural fibers in the automobile applications. First and foremost, thing natural fibers deals with a number of problems in terms of attaining good quality, mechanical properties, water absorption, fiber variation, flammability, toughness, and other changes depends upon environmental circumstances. some quality of natural fiber like hydrophobic which can be a drawback, because In humid conditions, the natural fibers which absorbs water from the environment, eventually causes fiber bumps

within the composite making it a bit challenging to use for the interiors of automobiles. Many research has done on this aspect and the results were clear that the strength of a natural fiber based polymer composite is 12% to 30% lower when it is completely immersed in water in comparison to other synthetic fibers based composites. There is also a research shown the relation between a water absorption and mechanical properties of a composite, it was shown that tensile and flexural properties decreased with the increase of the moisture content within the composite.

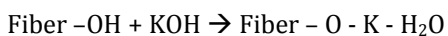
There are several examples like this and one among those is effect of weathering and hydrothermal circumstances on characteristics of jute fiber composites. The rise in the humidity will eventually rise the weight and thickness which correspondingly leads to the swelling of the jute natural fibers and also similar research regarding the water absorption has done, the sisal based composites have absorbed more water compared to the jute based composites. Generally, this is because of the amount of cellulose content present in the natural fibers. Higher the cellulose content better will be the water absorption ability of the natural fiber based composites. These can be overcome by delicately working on the weaker aspects like ecological and dimensional reliability on the natural fibers, better properties of natural fibers can be obtained. And there are some chemical treatments to overcome this and also addition of the suitable fillers enhances the properties.

There are some main issues that natural fibers deal with, few amongst them are hydro thermal, humidity and common weathering, generally the toughness of the fiber is highly associated with the internal adhesion And surface that too within the composite. There are not many research and study related to selection of appropriate natural fibers for the particular application has done yet. The mechanical properties may vary with the effect of changing external conditions such as time exposure and modification in the humidity and addition to that many research have shown that effect on mechanical properties like tensile and flexural. And the results were, reduction of 35% in tensile strength by exposing it to the humidity. And also reduction in the other mechanical property like flexural strength by 45% in the similar exposure. Along with this, on the external surface of the jute based composites, there was a black dots and white patches were observed in the SEM analysis, these are nothing but the fungal hyphae, these fungal hyphae were also seen developed after some days on the jute fiber based composites when it is exposed to the slightly moisture contented area. There is a way to prevent the processes like these. That is only through the proper coating and various fiber modifications. Since water absorption is the main issue that natural fibers encounters in the automobile industries, which can make a manufacturer worried about the product, so to overcome this, a various chemical treatments should be done, some among them are as follows

- Silane treatment
- Permanganate treatment
- Etherification of natural fibers
- Alkaline treatment
- Acrylation maleic anhydride, and titanate treatment of natural fiber
- Isocyanate treatment

Alkaline treatment is most oftenly used technique to reduce the moisture absorption of the natural fibers. This treatment is also known as mercerization, which is one of the most accepted treatment. This process involves use of chemicals like potassium hydroxide, lithium hydroxide or sodium hydroxide which reduces the hydrogen content of the cellulose of the natural fibers and also it uses the crystalline cellulose to increase the amorphous cellulose which eventually decreases the water absorption ability of the natural fibers and it not only decreases the hydrogen content of the cellulose parts but also the non-cellulosic components like lignin, pectin and hemicellulose which are also modified by the alkali treatment. Absorption of the moisture is reduced by the modification of most water absorbing part i.e. non other than hemicellulose by the mercerization process.

The equation for the chemical reaction that occurs during this process is as follows



Another most common method of chemical treatment is acetylation, which is also called as esterification process, which reduces the chemical hygroscopic nature of the fibers and also which increases the dimensional stability. It is generally used in the surface treatment of the natural fibers. Modification using this process not only increases the surface morphology but also the moisture resistance of the natural fibers. Along with, this treatment also enhances the some of the mechanical properties with a rise in the acetylation degree of 15% to 20%.and it will start decrease with further increase in the

acetylation, the main drawback of this treatment is, it involves the higher ph levels, high mechanical degradation of natural cellulose fibers.

Thus there are some more challenges involved while using natural fibers in the automobile industry, but its hard to find solutions for every challenges, but still in this review most common challenges that deals with having natural fibers in automobile applications and its solutions were discussed.

APPLICATIONS OF NATURAL FIBER REINFORCED POLYMER COMPOSITES IN AUTOMOBILES

From past decade, the use of natural fiber reinforced polymer composites are high because of the various advantages it offers like nontoxic, favorable processing properties, good acoustic properties, favourable eco balance, occupation health benefits compared to glass fiber during production and also life cycle consideration. In addition to that, other factors which increases the application in the automobile sector are as follows

- Less emission of greenhouse effecting gases
- Renewable and bio-degradable
- More safety and crashworthiness
- Greater tool life and good wear protection
- Low cost production

Because of the above reasons, we can see natural fiber reinforced polymer composites ruling all over the automobile industries, and these can be used in many interior applications like door cladding, seatback linings and package shelves, and some other natural fibers like coconut fiber which is used in making seat bottoms, head restraints and also fibers of abaca which is used in underfloor body panels. Nowadays technology allowing the use of 10 to 12 kg of natural fibers per automobile.

Weight of some natural fibers incorporated in automotive components is listed in below table 2

Automotive components	Approximate Weight of natural fibers (kg)
Front door liners	1.5
Parcel shaves	1.8
seatbacks	1.65
Sunroof interior shields	0.3
headrests	2.4
Noise and vibration materials	0.8

Table no 2

The mechanical performance of a natural fibers are comparatively good than that of the synthetic fibers, hence they are being used in press mould panels which can save manufacturer's cost and also reduces weight.

There are several example of natural fibers being used in automobile industries from past 2 decades, some of them are listed as follows,

Daimler Benz, a German top car manufacturing company which has been using the products made from natural fiber based composites since 1998, and many natural fibers like flax, hemp, sisal were used to make 50 Mercedes Benz E class components which is shown in figure 1, and also they are using a wide range of natural fibers like sisal, kemp, jute and many others as a reinforcement material which is a perfect replacement for synthetic and glass fiber based composites.



Mercedes Benz E class components (figure 1)

Perfect example for how to make a most use of natural fiber based composites is recent Mercedes S-Class vehicle which has around 25 components made from these natural fibers based polymer composites which weighs around 40 kg, which is effective usage of natural fiber based composites.

Toyota developed a composite with natural fibers and biodegradable plastic which is extracted from potatoes and other plants, this was done mainly for the purpose of the making fuel efficient ES3 concept pillar garnish. And Kenaf being used to make package shelves and which is also incorporated into the structure of Toyota's i-foot concept vehicles. And kenaf imported from Bangladesh which is used by Ford, a German automobile company in their model called Monedo for door panels.

Johnson Controls automotive launched its Eco-Cor™ material and process for use on door trim panels.

BMW is one of the company which uses a large amount of these renewable materials into their automobiles, it was estimated around 10000 tonnes of natural fibers were used by them, and also each BMW 7 series car endorsed with around 25 kg of renewable raw materials, with jute, flax, sisal in the interior door linings and panels also they used cotton for the sound proofing and fibers of wood for the seatback cushions. Some automobile manufacturing company not only wants their production cost to be low but also they need to take an initiative in the environmental awareness, this was done by Bayerg F semi-rigid (PUR) elastomer from Bayerb and 60% of a blend of fax, hemp and sisal. but not to forget this is one of the luxury car manufacturer company and this is the evidence that how far a company can go when it comes to a eco balance.

Audi launched A2 mid-range car which has some commercial applications of natural fiber composites.

Some of the applications of the natural fibers in different interior components of automobiles is listed in the below table

Model	Manufacturer	Applications
pilot	Honda	Cargo area
L300	Saturn	Package trays
Alpha Romeo 159	flat	Door panels
Raum	Toyota	Floor mats, spare tier cover
Cadillac DeVille,	General motors	Seatbacks

Table no. 3

Natural fiber based polymer components has wide range of automotive applications not only for interior components but also for exterior components. but to an extent.

Natural fibers as a reinforcing material with a high performance resins along with incorporation of suitable natural filler have helped these composites to meet the standard in terms of performance and quality. different automobile components such as dashboards, doors, bumpers and exterior body panels are produced by these natural fibers based components, but as we mentioned earlier the water absorbing capability of natural fibers has restricted its applications for an extent in the exterior components of the automobiles.

FUTURE SCOPE OF NATURAL FIBER REINFORCED POLYMER COMPOSITES IN AUTOMOBILE INDUSTRY

Natural fiber composites are in a commandable position for a lot of benefits like environment friendly nature, less dependence on non-renewable material sources, less pollutant emissions, lower greenhouse gas emissions, recyclability bio degradability and along with that, the thrive for the fuel efficiency in cars and a growth of environmental awareness in public are leading to further developments of new natural fiber based composites. Since these natural fibers reinforced polymer composites are competing with the synthetic fiber based petroleum components in a small part of the automotive companies. There is a chances of many more natural fibers based composite components might soon enter the automobile market. Since there is continuous hike in the petroleum oil price, which leads to a number of commercially viable companies to produce natural fiber components for use in thousands of automobiles. Addition to that several European, Japanese, and US companies currently making natural fiber based composites which is the good thing in the economical point of view because of being independent on the price of oil than other materials. Making these natural fibers reinforced composites from different plants and other crops should be highly encouraged, because these bio materials would be asset to the material world not only as a answer to ever rising environmental threat but also a solution to uncertainty of the petroleum and oil supply.

Natural-fiber reinforced composites have developed significantly over the past few years because of their high specific strength, recyclability and renewable nature. but yet drawbacks of water absorption and interfacial adhesion should be improved with different chemical treatments and modifications. It is extremely important for a material to have good mechanical performance and a good interphase, so that when a axial load is applied, it should have the ability to transfer that load from the matrix to the fibers. By having these enormous advantages natural fiber reinforced polymer composites are becoming perfect replacement for the glass and carbon fibers. And still a lot of research should be needed to solve the problems like water absorbtion, dimension reliability and more long term stability for use as exterior components. More advancement is needed in every aspect like selection of materials, manufacturing, production, economy management and also in the basic science and engineering of natural fibers composites. Specifically, when it comes to automotive components, improvement is needed in areas such as construction of very large panels and doors, and structural design. If these areas somehow manage to find a way, then these natural fibers based composites would surely rule the world one day.

CONCLUSION

As discussed in this review, for eco-friendly and long term sustainability, whole industrial world mainly automobile industry has to take small steps towards a sustainable environmental friendly way of producing products by using more and more natural fiber based composites. This study has shown that replacement of synthetic fibers like glass and carbon by natural fibers like jute, hemp, flax, ramie, sisal is just a small step to the enhancement of quality and sustainability of the whole automobile industry. Nevertheless due to the low cost of the natural fibers, automobile industries has already in their way to make this a world a better place to live by contributing as much as possible by using these natural fiber based composites in their production, but there is also need for research on selecting specific natural fibers for specific application with a detailed properties of a fiber and also improving certain properties of the materials by a proper chemical treatment and modification, There is a need for more advancement in the field of these natural fiber based composite's processing. There should be an improvement in different techniques for improving a properties of a natural fibers. Thus if these problems managed to get solutions then there will be higher chances for automobile industries to use even more natural fiber based composites in their production than the current automobile field.

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