Green composite materials for green technology in the automotive industry

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Abstract: The utilization of inexhaustible assets is a significant achievement towards viable individual versatility. Using natural fibers is a worthwhile input towards the ecological mindful of individual transportation. There were numerous advantages related with green initiative which includes better acoustic properties, weight and cost saving potential along with better working conditions. This research contributes a review in the expansive field of green composites searching out for materials with possibilities to be applied on vehicle body parts. The usefulness of the regular fiber composites for car industry was outlined. In addition, this work distinguishes a different method for assessing natural fiber composites compared with general desired criteria. This leads to a situation that natural fiber is no longer an environmental waste by its large scale industrial application which is being discussed here. Here different criteria levels were given to the categorize natural fibers. This criteria serves as a basic tool for the engineers while selecting the natural fiber composites based on its practical application. The automobile business is in the driving seat of green composites since it is here that the need is most prominent. Today we’re not offering materials that will change the landscape in the way that metal replacement did, but we are beginning to offer natural fiber composites that will present improvements, particularly in areas such as impact resistance, chemical resistance and, in some cases, process cost.

1. INTRODUCTION

The quest for higher quality at the same price point or retained quality at a lower cost has driven the automotive industry forward for a century. Yet in recent times, the game has dramatically changed. Through a combination of legislation, changing market demands and, to a lesser extent, integrity, environmental responsibility has become critical to vehicle manufacturers and suppliers. Many other industrial sectors have followed suit, but the guidelines outlining the requirements for product improvement in the automotive industry are unique. Aerodynamics and tribology might nibble at the periphery, but the main agent of change has been materials science. Light weighting and a greater use of recycled material have become massive drivers in production, though each has to co-exist within the ‘cheaper or better’ mantra and fit the established development framework. All things considered, it makes for one of the most interesting upheavals in automotive history. This research aims to provide a thorough knowledge on different types of natural fiber polymers that were used in the manufacturing of various automobile components.
1.1. Green technology
The greening of the automotive industry is usually viewed as one unified effort to make vehicles more environmentally sympathetic. In reality, the legislative requirements of different ‘green’ objectives are often at cross purposes, sometimes requiring a manufacturer to compromise one environmental programs to satisfy the needs of another. High cost and high weight of automotive components are the two major issues that faced by the automotive industry [1]. A few years ago, introducing recycled material was relatively straightforward, because anyone could create recycled parts weighing the same as virgin material. Now, with the onus on using lighter materials, manufacturing something from recycled materials isn’t always the most suitable course of action. It isn’t impossible to use recycled material in lightweight applications, but it is tougher and demands greater creativity. Traditional metal automotive components can be replaced by the use of lightweight biomaterial components. A lot of research studies are undergoing in this lightweight biomaterial components. The return of developers to the use of composite materials was noted by experts quite recently and coincided with the appearance on the market of hybrid cars and “clean” electric vehicles. The electric drive in most promising models implies the presence of a significant additional mass of electric batteries or fuel cells. Composite materials reduce structural weight by up to 30%, and heavy batteries, located in the lowest possible position, shift the position of the center of gravity of the machine to guaranteed safe. In this case, the use of composite materials gives a tangible economic effect.

1.2. Natural fiber composites
The notion of automotive components being recycled into new automotive components certainly has an admirable neatness, and the industry is quick to highlight such success, but often it isn’t the preferred route. Verities of cellulose, grass, seed, roots, and woot and sheath fibers were used to make natural fiber automotive components [2]. Natural fiber composites give more benefits over synthetic fibers especially in the areas of lower weight, cost, surface finish property and biodegradability [3]. Previously technical demands were the main area of focus of automotive companies but now they are mainly focusing on weight reduction by the application of natural fibers [4]. Germany is the most predominant nation with an outstanding excellence in automotive engineering. They were the pioneers for using natural fibers in automotive components [5]. Mercedes-Benz used jute-epoxy matrix composites for door panels in E-class series vehicles. Audi too used flax-sisal-polyurethane reinforced materials. Eco plastic materials from sugar cane was developed by Toyota for car interiors [6].

2. MATERIALS AND METHODS IN THE AUTOMOTIVE INDUSTRY
Composite materials are primarily carbon fiber products that have been used, for example, in the automotive industry for many years, and the volume of use of such materials is growing every year. The most important advantage of carbon fiber is its low density and high strength. Slowly these carbon fiber components changes to natural fiber components and the combination of both fibers. The total weight of the vehicle can be reduced by 20-25% by using natural fiber composite materials and thereby reducing the fuel conception also. Carbon fibers are made from synthetic and natural fibers based on polymers. Depending on the processing mode and feedstock, materials of different structures and with different properties are obtained. This is the main advantage of composite materials that can be created with initially specified properties for specific purposes [7]. Observing technological progress in the field of development and application of composite materials, we can confidently say that in the near future there will be production cars with a fully composite body and many components and assemblies. The technologies for the production of parts from composites have also changed. Currently, they are manufactured (like metal components) on robotic lines. To simplify installation at the interface with other parts, the metal fasteners are pressed into the assembly during moulding. This method allows the use of welding, bolted and riveted joints. Any vibrations and alternating loads are perceived by such products (as well as metal ones) without the risk of fatigue cracks and delamination of the panels [8].
3. GREEN COMPOSITE MATERIALS

Green hybrid natural fibers composites will improve the various characteristics of the automotive components than being added as a single type fiber. Glass fiber and sugar palm fiber increases the mechanical properties of the composites in boat fabrication [9]. Ishak et al. [10] compared Kenaf bast fiber with kenaf core fiber, bast fiber shows better mechanical properties than core fiber. High specific strength and stiffness were the main upsides of green composites [11, 12, 13].

![Figure 1. Natural fiber composite components of Mercedes-Benz E-Class](image1)

The natural fiber composites consumes only little energy for production at the same time it can reduce emission of carbon dioxide [14]. Cost is the main concern for automotive manufactures to use natural fibers over synthetic fibers [15]. Joshi et al. [16] analyse the properties of glass fiber with natural fiber and it shows that natural fiber were more relative to ecological execution. Mechanical properties of the composites can be increased by the pre-treatment of natural fibers with NaOH [17, 18, 19]. From the literatures it is observed that kenaf, coir, jute, hemp and flax are the main fibers that can be used in the automotive industry [20, 21]. Figure 1 shows the natural fiber composite components of Mercedes-Benz E-Class [22]. Natural fibers like hemp and flax are used mainly used for floor and door panels. Initially natural fibers were added to less complex geometric parts but nowadays automotive parts with difficult geometries are at the production stage. Figure 2 shows the front-end grill of Ford Montagetrager produced from polypropylene-hemp composite [23]. Compression moulding technique is commonly used in the automotive industries for the production of natural fiber composites. Figure 3 shows a compression moulded underbody panel of Daimler Chrysler A-class [24].

![Figure 2. Ford Montagetrager front-end grill](image2)
Mechanical properties of natural fiber composites depends mainly on its tensile strength, tensile modulus, flexural strength, flexural modulus, impact strength and hardness properties [25, 26]. Density of natural fiber is two times lesser than the density of glass fiber [27]. Specific stiffness of natural fiber is higher than that of glass fibers [28]. The use of natural fiber composite materials in the manufacturing of automotive parts is found to expanding every year. The use of natural fibers in the manufacture of technical products provides, reduction of the mass of the structure with its high strength, high level of safety in electric strength, tracking resistance, arc resistance, high level of resistance to UV radiation and the ability to use dyes to create a colour gamut of products. Currently, new natural fiber composite structural materials are being tested in detail for medium-sized sedans, but in the near future it is planned to produce springs for heavy trucks operating under heavy loads. Such materials need special strength, elasticity and rigidity [29, 30, 31]. This task can be dealt with using twisted natural fiber and glass fiber, reinforced with epoxy resin and other components. Unlike steel springs from complex high-tech polymer composite materials, they are not subject to corrosion, neutral to the reagents and chemicals used in car washes [32, 33]. In addition, such springs are more economical to manufacture, since the process is less energy intensive. For their production, large capacities with steel furnaces are not needed, but rather small workshops. Natural fiber composites that are widely used in automotive industry and their applications are detailed in Table 1 [42, 43, 44, 45].

| Natural fiber | Applications in automotive industry |
|---------------|-------------------------------------|
| Jute          | Roofing Panel, soft armrests        |
| Coir          | Floor mats, seat upholstery (cushions) |
| Kenaf         | Trays(rear deck), door panels, rear walls |
| Flax          | Seat backs, consoles (centre)       |
| Oil palm      | Decking, roofing panel              |
| Hemp          | Hard armrests                       |
| Ramie         | Insulation (sound proofing)         |
| Bagasse       | Seat surfaces                       |
| Rice husk     | Roof panels                         |
| Sisal         | Door panel, roofing sheets          |
5. DISCUSSION

Composite materials are the most intensively developing segment in the material market. Increased strength, ductility, heat resistance and low density were the major advantages that allow composites to mainly replace those classic materials. Composites are intensively entering the familiar world of every person, their use in the automotive industry, aircraft manufacturing and other sectors of the economy is increasing every year. In order to continue the further successful implementation of green composite materials in the automotive industry, it is necessary to solve several problems. Firstly, to reduce the manufacturing cycle of parts to several minutes, which will allow for their mass production and reduce the number of necessary equipment. Secondly, to ensure their acceptable market value, which is associated both with the solution of the first problem and with a reduction in the cost of raw materials. And finally, it is necessary to create modern automated production facilities for specialists to design and develop modern technological processes, as well as to support structures made of natural fiber composites throughout the entire life cycle - up to disposal.

6. CONCLUSION

The role of green composite materials in the automotive industry is clearly analysed. From the analysis it is clear that mainly seven natural fibers namely hemp, jute, flax, sisal, kenaf, coir and oil palm are used in the automotive industry for making natural fiber composites. There are yet more natural fibers to be explored in this field and Abaca fiber is mainly one among them. Certain investigations [34, 35, 36] states that abaca fiber exhibits significant properties in tensile strength, tensile modulus, flexural strength, flexural modulus, impact strength, hardness and wear properties. Abaca is also termed as manila hemp. Some of its major outstanding properties include seawater resistant and durability [37, 38]. A fully grown stem of abaca fiber contains lignin (13–17%), cellulose (~ 61%), hemicelluloses (~ 22%) and pectic substances (~ 1.5%) [39, 40]. Both lignin and pectic substances were associated with the age and middle lamellae of the abaca fiber respectively [41]. Light weighting and a greater use of recycled materials had become massive drivers in production, though each has to co-exist within the ‘cheaper or better’ mantra and fit the established development framework. All things being considered, it makes for one of the most interesting upheavals in automotive history. While metal replacement was the hot topic for natural fiber composite manufactures, in many cases the replacing materials had their own usage issues. A significant reduction in body weight (almost half) gave considerable advantages, but for record-breaking figures had to pay a significant increase in price and complexity of manufacturing technology. Now those metals are increasingly being super ceded by newer engineering natural fiber composites designed with modern applications in mind. Observing technological progress in the field of development and application of composite materials, we can confidently say that in the near future there will be production cars with a fully green composite body, many green components and assemblies.

ACKNOWLEDGMENT

The authors would like to thank Centre for Engineering Research and Development (CERD) of APJ Abdul Kalam Technological University for providing financial support, (Order no: KTU/RESEARCH 2/4068/2019, date:22.11.2019) for conducting this research.

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