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Feasibility of using Carbon Fibers and its Components in Automobiles

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Abstract: **Since many years, there were numerous attempts in search of alternatives to traditional materials like Aluminium, Steel and Plastics used excessively in vehicles. The objectives behind these trials were to increase the strength, durability of materials leading to safety along with increase in speed of automobiles. Carbon Fiber composites have emerged as excellent option in order to provide consumers with a lighter, higher-performing, and more efficient vehicle. Carbon Fiber Reinforced Polymers (CFRP) which are lighter than the conventional materials. Here we discuss about feasibility of usage of CFRP in each parts of car in Chasis-Frame, Bonnet, Body, Suspension etc.**

Keywords: **carbon fiber; composite; Strength Comparison, Efficiency.**

1. INTRODUCTION

Carbon fiber is defined as a fiber containing at least 92 wt % carbon, while the fiber containing at least 99 wt % carbon is usually called a graphite fiber [1]. The two most important precursors in the carbon fiber industry are polyacrylonitrile (PAN) and mesophase pitch (MP). The structure and composition of the precursor affect the properties of the resultant carbon fibers significantly.Carbon fibers generally have excellent tensile properties, low densities, high thermal and chemical stabilities in the absence of oxidizing agents, good thermal and electrical conductivities, and excellent creep resistance.

Microstructure of PAN carbon fibers (Orientation of fibers in matrix)

The estimated global carbon fiber consumption is increasing. A steady increase in both production and consumption in the future can be predicted. In fact, most of the carbon fiber manufacturers have plans for expansion to meet the market demand. The composite parts can be produced through filament winding, tape winding, pultrusion, compression molding, vacuum bagging, liquid molding, and injection molding.

In recent years, the carbon fiber industry has been growing steadily to meet the demand from different industries such as aerospace (aircraft and space systems), military, turbine blades, construction (non-structural and structural systems), light weight cylinders and pressure vessels, medical, automobile, sporting goods, etc. Carbon fiber reinforced plastics (CFRP) resulting material that is very strong as it has the best strength to weight for all construction materialsFor the automotive industry, fiber reinforced polymeric composites offer reduced weight and superior styling. Carbon fibers can find applications in body parts,chassis and suspension systems (e.g., leaf springs), drive shafts and so on.However, the large-volume application of carbon fiber in automotive industry has been hindered due to the high fiber cost and the lack of high-speed composite fabrication techniques.In this paper,the extent of use of carbon fibers in different parts of automobile is analysed.

2. METHODOLOGY

1. Benefits of Carbon-fibers over conventional materials:

In automobiles properties of a material used will directly influence the efficiency, safety, and performance of a vehicle. For carbon fiber, the most striking properties are that it is strong and lightweight. However, there are different types of carbon fiber, and the properties of each will vary depending on the production method used. For BMW, the carbon fiber produced is reported to be “at least as strong as steel and around 50% lighter”.Since the BMW i3 will be significantly lighter compared to other automobiles, it will not need use as much energy during transportation.

Also, the carbon fiber-based lighter vehicle will have improved performance because it will ‘accelerate faster, will be more agile through corners, and will brake to a standstill more quickly”. A vehicle’s safety rating is derived from different factors, one being the rigidity and strength of the material used for the body of the vehicle. The rigidity of a material is directly proportional to its structure. carbon fiber has a similar structure to graphite, with sheets of carbon arranged in a hexagonal pattern.

The materials such as CFRP can absorb 120kj/kg (approx.) of energy if made with thermoset matrix (epoxy) 250kj/kg in a thermoplastic matrix VS 20kj/kg (approx.) for steel. CFRP provides 20 percent mass of steel yet equally strong and 60 percent mass reduction, boosting fuel efficiency by as much as 30 percent via mass decompounding but no loss in performance.

Material	Carbon Fiber	Aluminum-Alloy (2024-T3)	Steel Alloy (4130)
Specific Strength (KN.m/kg)	2457	254	222
Ultimate Tensile Strength (GPa)	3.5	448	863
Modulus of Elasticity (GPa)	215	70	210

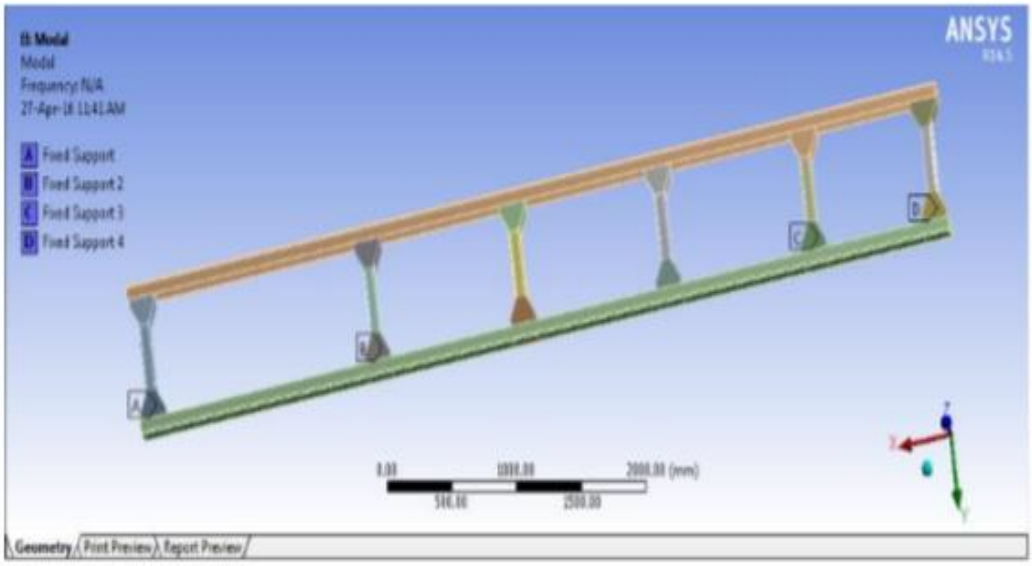
Comparison analysis of carbon fiber with steel and aluminum

From the above comparison, the effectiveness of use of carbon fiber can be defined.

2. Parts of Automobiles using Carbon-Fiber:

Frame:

Frame of a vehicle is act like a skeleton it holds all the important component of a automobile like engine, steering systems, suspension, drive line, differential and all the essential components which constitute together to form a chassis. Chassis Frame must be stiff enough to withstand all the forces and loads acting on it statically and dynamically and forces like shock, twist and vibration. Composite material like carbon-fiber recently gained a wide acceptance in the automobile industry due to their light weight and high strength as compare to conventional automobile frame which is manufactured from steel and its alloy. Modal analysis is used to judge the behavior of a body under vibrational conditions and corresponding natural frequency . To determine natural frequency of component it is basic design property. Natural frequency information is also helpful for avoiding resonance, reducing noise.



Boundary conditions for Modal Analysis

The modal analysis of EICHER 11.10 chasis frame led to following observations,

Steel -52

Natural frequency(Hz)	Deformation (mm)
42.5	3.3
91.5	3.8
143.1	11.1

Carbon Fiber

Natural frequency(Hz)	Deformation (mm)
84.107	7.56
175.22	8.88
258.12	23.719

Composite materials (Carbon Fiber) shows a less von misses stress as compare to structural steel- 52 at the natural frequency at which maximum deformation incur onto the chassis frame that and also the density of the composite material is very less which helps to drop down the weight of chassis frame and assist in increasing the efficiency of the automobile.

Body:

Automotive Body composed of CFRP require high strength and bending stiffness to ensure driver safety during roll over conditions. Therefore it should satisfy the critical requirements,one can be noted as bending stiffness conditions. According to researchers the 2-3mm thick panels is recommended to achieve the stiffness required.

Much weight can be reduced from the body of automobile, Simply replacing the roof of Alto K10 makes following changes :

Steel roof :12 kg

Composite roof: 6-6.5kg

Effective weight reduction: 5kg (approx.)

Carbon rein forced polymer used for bonnet can have about a one fifth of the density but all the strength of steel and stiffness of steel. They also provide automakers with greater design flexibility other than steel and aluminum. Production of bonnet with CFRP is around 60% lighter weighing less than 5 kg.

3. RESULTS AND FINDINGS

1. It was found that many studies only focused on a single factor of carbon fiber--cost, production, properties, etc. Therefore, it was beneficial to look at this technology in a more comparative and vast manner in order to truly understand it's potential.

2. After extensive research, there is evidence that both supports and contests the use of carbon fibers in the automobiles. The evidence that contests the use of this material includes the problems associated with recycling and an inevitably high price.

3. On the contrary, there is also indisputable evidence that the preferred properties it has when compared to other common materials used in automobiles, its ability to provide safety to the vehicles, and its energy efficient production method.

4. The lighter automobiles along with safety of the material provides outweigh on the cost and insignificant environmental factors.

4. CONCLUSION

- Carbon fiber is a composite material used for improving the vehicle performance by reducing its weight and increasing durability.
- They can be used in different parts of vehicles like Chasis, Body, Bumper, etc with some modifications.
- The use of carbon fibers in automobiles can lead to approx 58% reduction in weight as compared to Steel and approx 40% reduction in weight as compared to aluminium.
- Though there are some limitations, considering the benefits of carbon fibers its drawbacks can be overlooked.

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