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The Application of Carbon Fiber in the Vehicle Market

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ABSTRACT: The use of lightweight materials presently produces new and novel production materials in the automobile sector. High strength-to-weight ratios, high fatigue strength, low thermal coefficients, high electrical conductivity, low weight, high modulus elasticity-to-weight ratios, strong corrosion resistance, poor impact resistance, and high carbon fiber damping are all significant characteristics. For characteristics such as energy savings, durable facilities, greater flexibility and better ergonomics, manufacturers need innovative materials. Carbon fiber with excellent material characteristics is the best material with these attributes. That is why there is increasing demand for carbon fiber, particularly among sport vehicle makers and premium automobiles. This article focuses on the structure and applications of carbon fiber in the automobile sector. Although carbon fibers are an excellent material for manufacturers because of their exclusivity they were still utilized in limited terms, other issues were also addressed in the following article.

KEYWORDS: Automobile, Aerospace, Carbon Fiber, Lightweight, Polymer.

1. INTRODUCTION

Carbon fiber was initially produced by heating rayon strands in 1958 in OH, Cleveland and its result was poor strength and uniformity. After a few years the Japanese developed new manufacturing and chemical techniques that are still being utilized. These kinds of carbon fibers were much better to those of earlier radiation strands in force, uniformity and purity. Finally, in 1963, the British luxury firm Rolls Royce accomplished the innovative manufacturing method with high quality, industrial sales and power. At now, carbon fiber was economically viable for some certain uses, but the brittle properties of carbon fiber were not recognized and eventually caused aerospace engine problems. The production of carbon fibers is changing from one business to the next, although it solely concentrates on three chemical sources: PAN, Rayon and Pitch (Petrol refined product). Carbon fiber manufacturing takes a lot of energy, a very high temperature and ultimately a very expensive cost[1].

In recent years, the usage of lightweight polymers and composites in the automobile industry has increased because of regulatory and customer demands for cars that are lightweight and fuel efficient. Using these materials, the average vehicle weight has been reduced by 200 kg. In certain instances, plastics are replacing heavy ferrous components while, in other cases, plastics and composites are being introduced for consumer comfort reasons. These materials are not only lightweight but also resilient and readily molded. Substituting heavier materials with plastics leads to a decrease in total weight by 10 percent, which improves fuel economy by 3 percent to 7 percent. The growing usage of plastics transfers the environmental burden from the automotive phase of use (reduction of emissions) to end-of-life (ELV) (materials disposal). It may be disputed shortly whether light weighting causes an overall decrease in environmental effects. In a prior research, lightweight cars were concluded with better environmental performance even with 100% plastic components disposal. However, another research found that the ecological benefits of light weighting would break even after about 132,000 km of vehicle travel with negative ELV environmental effects. Even with the decreases in emissions during the use phase, it is crucial to understand and handle the ELV situation if plastics can really be regarded as a sustainable choice in the automobile industry[2].

Plastics and composites recycling is complicated and difficult in the automobile sector. Although basic plastic goods (e.g., water bottles, food containers) are easily recyclable, in automotive applications plastics and composites are heterogeneous and have strong links to other plastics and thus are difficult to release for recycling. Thermoset materials offer an additional difficulty since their permanent cross-link structure cannot be melted and recycled. Even though a substance may be recycled, it frequently remains deposited, since it cannot be physically retrieved. For instance, the placing of foam is usually in a location of the vehicle where it cannot be easily accessible and afterwards removed from other components (e.g., fluids). Moreover, there are other barriers to recycling, such as lack of technology and the recycling market. Finally, next-generation materials like carbon fiber impede further recycling because of their intrinsic complexity. It is usually found along with other materials and is hard to separate. Organic polymers provide an intriguing alternative to petroleum plastics, however before they are used the technology requires maturity.

The present ELV rehabilitation and recycling procedure for a wasted car comprises of disassembly, decontamination and shredding, physical and mechanical processing for shredders (SR) and energy rehabilitation for SR. Plastics and composites now contribute to SR and the quantity of SR produced rises as the usage of these materials is increased. The percentage of plastics per mass in an average car has dropped from 6% in 1970 to 16% in 2010 and is projected to grow to 18% by 2020. The automobile sector represents a large proportion of the demand for plastics, with estimations up to 30 percent and an increase. The identification of future improvements and alternatives in the plastics recycling chain is very important in Europe, since the laws in place will mandate that 95% of vehicles for —reuse and recovery and 85% for —reuse and recycling be processed by 1 January 2015. This law restricts the quantity of ELV to be treated by recovery and stimulates recycling whenever it is ecologically sustainable. An extra 6%-10% of the total ELV mass may be recycled by enhancing the recycling of plastics from SR, making this a major effort to comply with legislation. Although North America does not have a comparable law, several manufacturers have adopted global efforts to address regional environmental standards due to the worldwide nature of the automobile industry[3].

1.1 Structure of Carbon Fiber:

Graphite and carbon fibers share a similar structure consisting of layers of hexagonally organized graphene sheets of carbon atoms. Graphite, hybrid and turbostatical are the three kinds of carbon fiber layer planes that depend on development and precursor procedures. The layers are consistently organized in parallel in the graphic crystalline zone. Sp2 is utilized to link atoms in a plane while, on the other hand, contact between sheets is weak (Wander Waals forces). There is approximately 0.335 nm of d-spacing between the two graphene layers.

The lifting and gripper manufacturing sectors confront new difficulties to satisfy the high expectations both of customers and suppliers. Heavy equipment such as aluminum, steel or the blend of fittings and grippers are utilized for the geometry of body-in-white body fixing and transport. Another major inconvenience of employing heavy metals in fastening and clamping

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devices is that they cause material and time loss when they fall on the ground. Lighter equipment with greater tolerance is needed, resulting in a high tolerance and strong need for lighter content. Conventional is easier to use and the preservation and usage experience is widely recognized[4].

The function engineers have in designing and assembling them. Non-metals cannot be soldered and holes need to be boiled together. When utilizing composite carbon fiber, the boiling process may weaken the material by cutting the carbon fiber. The use of pasting or gluing may be another option, however the delamination technique is recognized as its own problem, leading to major problems.

In the present situation, most carbon fiber is produced utilizing PAN precursors utilized in the fields of sports vehicles, luxury cars, aerospace and protection. The precursor and rayon precursor of pitch carbon fibers are no longer utilized in most bikes and sports equipment in the production of carbon fibers. Various carbon fibers are presently being produced, such as high module, ultra-high module, interim modulus and low modulus. Companies like Toray Industries, Mitsubishi Rayon and Tenax account for nearly 50% of top carbon fibers. Carbon fiber is a composite material which is stronger than iron and lighter than aluminum. It is made of thermosetting resins and carbon fibers with greater flexibility than titanium[5].

These characteristics are very helpful in high-speed cars, another major advantage is that it does not expand or contract at low or high temperatures, which are of great advantage in the automobile body. Carbon fibers are strongly used in motorcycles, motorcycles and sports cars primarily in components such as handles, forks and frames that maintain their weight below aluminum and retain high strength. The weight loss of 70 percent of CF is 30 percent. Carbon fibers have an unsurpassed effect when it comes to light weight, protect the passengers at high speeds, improve sound dampening, prevent cracking and corrosion, minimize equipment expenditure, aerodynamic shapes, mass and promote smoothness. Carbon fiber, however, can deliver a mass reduction of 60 percent, but at the same time it is 5 to 10 times costlier. Small car safety is a serious concern.

1.2 Usage of Carbon Fiber:

1.2.1 Bumper:

Bumper is used at front and back ends of an automobile; therefore, it has a significant contribution to the overall weight of the car. Therefore, it requires strong compression strength and high tensile strength to safeguard the vehicle from collapse, thus reinforced carbon fiber polymers are suitable for bumper construction. Overall, the car's weight helps. Fiber is the primary load bearing component and are maintained in the right position and orientation by the neighboring matrix, which eventually helps to pass loads. It helps absorb a large quantity of kinetic energy during the collision and stays stable throughout the impact and simultaneously provides power. For this high level of impact toughness material to be supplied by the bumper, high flexural modulus and high bending strength should be high. In low fuel consumption, low weight plays an important function, with extremely light weight directional strong characteristics. The physical property and percentage of the arrangement of carbon fiber define the property, due to its low weight and high strength, of carbon fiber reinforced plastics as the primary rationale for utilizing this material in sports cars and other vehicles. These materials are now not extensively utilized owing to its expensive element and limited availability, but are still used in sports cars of high-end and luxury vehicles to minimize their weight and enhance their strength concurrently in comparison with other popular materials. In general, 3 mm wide bumpers are installed for the vehicles and save about half a kilogram of weight for each bumper[6].

1.2.2 Bonnet:

Bonnet is also one of the heavier components to take part in a collision along with the bumper. Compared to aluminum or steel, carbon reinforced polymer holes with a density of about 1/5 but all the strength of steel and aluminum are utilized. The high costs and the restricted availability of carbon-fiber reinforced plastic inconveniences are extremely expensive to form them into vehicle components, but it is about 60% lighter and weighs less than 6 kg.

1.2.3 Roof Panels:

Carbon fiber-reinforced plastic roof panels need stiffness in the bending and high strength to guarantee passenger safety in roll-over accidents. As mentioned previously, the characteristic of carbon fibers relies on its physical properties, which is its layout technique, so that the bending stiffness is satisfied. The finite element technique is utilized to assess the steadiness of the component and the 2 mm thick panel may reach the required rigidity after analysis.

1.2.4 Chassis:

The load-bearing framework of the whole structure must be robust and stiff so that vibration and motion are maintained and absorbed by the motor, axles and suspension. To enhance the vehicle's longevity, fuel economy and racing vehicles, the entire dynamics of the automobile should be made as light as feasible. Carbon reinforced plastic is twice the weight of aluminum or steel and is at the same time much lighter. Carbon fiber lacks flexibility, whereas metals may be sold and melted. Carbon fiber doesn't flex, is strong, may fracture and shatter under intensive force and, sadly, no reparation option is available. As we understand that acceleration is characterized as speed shift, reducing total weight may thus be stated to result in equal force and higher acceleration, which implies that racing vehicles that have less weight can accelerate more quickly.

The high-performance and light-weight characteristics of carbon fiber are generally preferred utilized in super cars above high prices. Only a piece of carbon fiber can be a frame. Carbon fibers can be recycled, but their strength is lost where aluminum and steel can be recycled[7].

1.2.5 Tailgate:

Tailgate is also produced using carbon fiber reinforced plastics and the standard should be 1.5 mm wide (thickness) to prevent torsion according to the research.

Due to improved stiffness and reduced mass, tailgate stabilizers may be removed which further lowered the vehicle's overall weight. Due to the consistency of the carbon fiber material that may be painted directly, internal trim removal is carried out. It must be designed to minimize the number of parts. It enables the quick construction and dissemination of complicated forms. Carbon and plastic combination lead to a total weight reduction of 7 kg or 37%.

1.2.6 Fender:

The fender is more flexible and robust than metal fibers, and since carbon fibers are much smaller than stainless steel fibers, they are lighter in weight, therefore enhancing fuel economy. The thermoset carbon fender resin coating makes them bright and fresh and the reflective fabric improves their look. The texture of carbon fibers is considerably more apparent than conventional metals with scratches. It offers power dissipation, excellent performance, modular design and easy benefits of replacement.

1.2.7 Side Doors:

The carbon fiber reinforced plastics variant utilizes a reinforced framework that is intended to resist various stresses, eliminating an additional weight of 4 kg per door in comparison with aluminum and up to 11 kg compared to steel. It is intended to cope with certain stressors. Because of the material mix, reinforced carbon fiber plastics provide high precision wall thickness, fiber orientation, and flexibility in layer structure design. If additional resistance is needed, the material may be reinforced or fiber-oriented without losing ultra-thin wall resistance in other places. Car manufacturers often employ carbon fiber composites in sports cars and luxury cars, but only in a limited manner for driver's vehicles in shaft, bumpers, roof, walls, fenders and interior structural systems, as stated above. A highly flexible composite is their composite material. Long production times and expense of fiber, expensive investment in equipment and a lack of knowledge of the industry's carbon fiber material are the main issues limiting today's development in polymers composites in cars[8].

2. DISCUSSION

For decades, carbon fiber reinforced polymers have been utilized in high-performance sports cars, but it has only lately started to be used in regular automobile manufacturing. The carbon fiber vehicle bodies are not only strong but also extremely robust and can endure tough driving conditions. Isotropic sheet metals bonded by welding are generally utilized by automakers. Composite materials such as CFRP feature a carbon-fiber laminated frame, which offers protection in two perpendicular directions. It is orthotropic/anisotropic. The anisotropic proprieties may be modified in the appropriate direction to specific applications using different kinds of fiber reinforcement. The protection of steel or aluminum at a high impact level may be provided by these CFRP designs. Complex kinds may also be provided as one component via the composite material and a minimum of machining processes and joints. However, since the coefficient differs from steel for thermal expansion, electrical conductivity and composite surface finishing, technical problems continue to be essential. For composite material characterization, designers require inexpensive and reliable simulation tools[9].

Much promise resides in the consumer perceived automobile sector. Seventeen million cars are produced in Europe every year. Each of them needs an average of 120 kg of plastics, with 20 percent being composites. Composites using recycled carbon fiber (RCF) may offer excellent surface and low weight. The disadvantages of RCF composites include processing time and expense. In the automobile industry, new developments concentrate on pollution reduction, new engines, driverless vehicles and electric cars and the transfer of vehicle data. The whole industry is being reorganized and new materials chosen. Car designers will certainly take into account the benefits of polymer composites, especially RCF composites. Some RCF makers said that vehicle manufacturers were hesitant to risk—the first to adopt new materials must always be someone.

The same manufacturers acknowledge, however, that the widespread usage of RCF in automobiles would quickly exhaust the capacity of the fiber recovery businesses. Therefore, they are now content with participating in modest projects, attempting to join the automobile sector in the same manner as the polymer composites, i.e. from less significant components and subsequently to pressurized tanks. BMW Group is an excellent example of usage of RCF in the automotive industry[10].

Carbon fiber enhanced polymers (CFEP) are being utilized more and more in many industries. Global CFEP consumption is projected to increase by 11 percent to 121,015 tonnes by 2020 (compared to 2019). The installation of, for example, electric engines in the vehicle increases the overall vehicle weight, therefore solutions must be developed to break the weight spiral. CFEP is primarily utilized in external components in the automobile sector. In recent years, the emphasis has moved more and more towards vehicle load-bearing components. When you look at the weight of the vehicle percentage, it can be seen that a significant part of the overall vehicle weight is the automobile body (40 percent). Investigations are thus under progress to decrease the weight of bodily structures. Following the introduction of CFEP in automotive engineering mass applications, development is progressively shifting to hybrid building techniques. CFEPs have directional material characteristics, and vary in fiber orientation in comparison to metallic materials.

Various applications exist in the automobile sector for the usage of recycled composite material. The BMW i3 and i8 models began manufacturing in 2013. Prior to this, BMW Group and Airbus agreed on collaboration on carbon fiber recycling. For both businesses, this collaboration is essential to develop carbon recycling and reuse techniques. The joint venture SGL Automotive Carbon Fibers LLC in Moses Lake, Washington State (USA) with the BMW Group and SGL Group is also an important collaboration in the development of techniques. The shredding process generates short fibers. Those goods may then be re-used for the manufacture of unwoven material and mats and are the most common half-finished products, which are particularly utilized in the manufacturing of semi-finished plating compounds (SMCs). For the manufacture of the reinforcement of the C-pillar, BMW Group uses recycled carbon fiber with SMC (sheet molding compound) material. Toyota uses SMC material from Mitsubishi Rayon (MRC) for the manufacture of the hatch door frame. In addition, nonwovens are utilized as coating layers in the manufacturing of components to improve surface quality, particularly for external parts.

In many fields of study and industry today's technological progress has made it necessary to seek for new materials with better advantage than materials typically utilized in various applications. Researchers from across the globe have developed several material systems in this area. Composites are one of the most important material systems. These composites include two or more components, which leads to the unique benefits of each composite complemented by one component. The integration in matrices based on carbohydrate, fiberglass and even natural fibers, for example, offers benefits in hardness, tensile strength, module elasticity and other mechanical characteristics. Additionally, other characteristics such as thermal conductivity, coefficient of thermal expansions, coefficient of friction, wear resistance, corrosion and fatigue resistance may be reduced and/or enhanced.

At present, thermomechanical characteristics are of significant significance for the automotive and aviation sectors owing to the many components utilized in these systems. Composite products based on graphene, carbon fiber, fiberglass and natural fibers have explored new applications in these two areas, from the manufacture of parts that comprise the external or internal structure of automobiles and aircraft to electronic applications to protect and dissipate the heat simultaneously. Carbon fibers are regarded to be one of the most mechanical and chemical stability carbon-based materials. Normally, 92 wt. percent of carbon is present in each fiber. These fibers have extremely good mechanical and physical characteristics, such as high voltage by a spectacular young module, low density, low thermal expansion and outstanding electrical and thermal conductivity. Carbon fibers are also not only four times lighter than steel, but also stronger than steel. All these qualities are important because carbon fibers are utilized for the development of lightweight composites in automotive and aerospace structural applications.

3. CONCLUSION

In an era where the usage of steel is widespread, it presents a significant challenge to use technologically superior materials. Carbon fiber, or carbon fiber reinforced plastic material, is one option that offers excellent performance characteristics. This article demonstrates that by using an alternate material, it is feasible to obtain both improved efficiency and lighter vehicles at the same time provided they are designed properly. There are many ergonomic advantages to having a lighter car body as well. Carbon fiber reinforced plastic is used in body parts such as the hood, roof, and boot of racing cars in order to reduce the overall mass of the vehicle and improve its dynamics. If the racing car is lighter, it will increase its power to weight ratio and improve its overall performance, and if carbon fiber reinforced plastic is used in body parts such as the hood, roof, and boot of racing cars, it will help minimize the vehicle's overall mass center and improve the dynamics.

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