The Use of Carbon Fibre in Automotive Sector

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***Abstract:** Innovative and innovative manufacturing materials are currently being produced in the automotive industry through the use of lightweight materials. High strength-to-weight ratio, high fatigue strength, low thermal expansion coefficient, high electrical conductivity, light weight, high modulus elasticity-to-weight ratio, strong corrosion resistance, low impact resistance and high damping are many important properties provided by carbon fibre. Manufacturers require new materials for features such as energy savings, durable facilities, increased flexibility and improved ergonomics. The best material with these qualities is carbon fibre with outstanding material properties. This is why the demand for carbon fibre is growing, especially among manufacturers of sports cars and luxury cars. This paper focuses on the structure of carbon fibre in the automotive industry and its applications. While carbon fibre is an ideal material for producers, because of its exclusivity it has still been used in limits, other factors have also been discussed in the paper below.*

***Keywords:** Aerospace, Body-In-White (BiW), Bonnet, Chassis, Fender Petrol Refined Product, Roof Panels.*

INTRODUCTION

Carbon fibre was first formed on heating rayon strands in 1958 in OH, Cleveland and its outcome was low strength and consistency. After a few years, the Japanese developed new production and chemical methods, which are now still used. These types of carbon fibres were much superior in strength, consistency and purity to those of previous iterations of rayon strands. In 1963, the British luxury company Rolls Royce finally achieved high quality, industrial sales production and power with a revolutionary production process. At this point, for some specific applications, carbon fibre was commercially feasible, but the brittle characteristics of carbon fibre were not understood and ultimately caused aero engine failures. Carbon fibre processing is currently evolving from company to company, but it is still focused only on three chemical sources, PAN, Rayon and pitch (Petrol refined product). The processing of carbon fibre requires a great deal of energy, a very high temperature and, eventually, a relatively high cost [1].

Carbon Fibre Structure:

Graphite and carbon fibre have a common structure that consists of layers of carbon atoms that are hexagonally arranged graphine sheets. The three types of carbon fibre layer planes that rely on the development and precursor processes are graphite, hybrid structure and turbostatic. In the graphitic crystalline zone, the layers are regularly arranged parallel to each other. Sp2 bonding is used to bind atoms in a plane, and contact between sheets, on the other hand, is weak (Wander Waals forces). Between the two graphene layers, there is around 0.335 nm of d-spacing [2]. In order to meet high demands from both clients and suppliers, the lifting and gripper manufacturing industries face new challenges. Heavy equipment such as aluminium, steel or a mixture of both fixture and gripper equipment are used for geometry fixing and transport in Body-in-White (BiW). The other biggest drawback of using heavy metals in fixtures and gripper devices is that it results in material and time loss as they fall down on the floor. Lighter equipment with higher tolerance is required and this creates a high tolerance value and high strength demand for lighter content. Conventional is much simpler to use and well known is the experience of preserving and using them [3].

The role that engineers face is how to design and assemble them. It is not possible to weld non-metals and drilling of holes is needed to bolt them together. When using composite carbon fibre, by cutting the carbon fibre, the drilling process can weaken the material. The use of pasting or glueing may be another choice, but this method is known as delamination as its own issue, resulting in a big issue [4]. Most carbon fibre is manufactured in the current scenario by using PAN precursors used in the sports cars, luxury cars, aerospace and defence industries. Carbon fibres from pitch precursor and rayon precursor are no longer used in the manufacture of carbon fibres in most cycles and sports equipment. Various carbon fibres, such as high-modulus, ultra-high modulus, intermediate modulus and low modulus, are currently being developed. Companies such as Toray Industries, Mitsubishi Rayon and Tenax account for almost 50% of the share of leading carbon fibre manufacturers. Carbon fibre is a composite material which is much stronger than iron and lighter than aluminium and has higher elasticity than titanium, composed of thermosetting resins and carbon fibres [5].

In high-speed vehicles, these properties are extremely useful, another big benefit is that it does not expand or contract in high or low temperature, which is highly advantageous in the car body. In motorcycles, motorbikes and sports cars, carbon fibres are heavily used, primarily used in components such as handle bars, forks and frames to maintain weight lower than aluminium and still retain high strength. 70 percent of CF results in a weight loss of 30 percent. When it comes to light weight material, carbon fibres are unmatched, protecting occupants at high speeds, improving sound damping, preventing denting and corrosion, minimising expenditure in equipment, aerodynamic forms, mass and promoting sleekness. Carbon fibre, however, can deliver about 60 percent mass reduction, but it is 5 to 10 times more costly at the same time. Security in small cars is a serious concern [6].

Applications of Carbon Fibre:

- *Bumper:*

Bumper is used in an automobile's front and rear ends, so it has a large weight contribution to the total weight of the automobile. Therefore, it needs high compressive strength and high specific tensile strength to protect the vehicle from a crash, so carbon fibre reinforced plastics are well suited for bumper construction. Overall, the weight of the car helps. Fibers are the main load carrying part, while the neighbouring matrix holds them in the appropriate position and orientation and ultimately helps to pass loads. It helps to absorb a high amount of kinetic energy during the impact and to remain solid during the impact and to provide power at the same time. High flexural modulus and high flexural strength should be high for this high amount of impact toughness material to be provided by the bumper. Low weight plays a major role in low fuel consumption, with directional strength properties of very light weight. The physical property and proportion of the carbon fibre layout defines the property of the carbon fibre reinforced plastic, because of its low weight and high strength, the key reason for using this material in sports cars and other automobiles. Now, due to its cost factor and low availability, these materials are not used heavily, but despite this, it has been used heavily in high-end sports cars and luxury cars to minimise their weight and improve strength simultaneously compared to other mainstream materials. In general, 3 mm width bumpers are mounted for the cars and provide about half kg of weight savings for each bumper [7].

- *Bonnet:*

Bonnet is also one of the heaviest pieces that, along with the bumper, takes much of the effect during a collision. As compared to steel or aluminium, carbon reinforced polymer hoods are used that have around 1/5th of the density, but can have all the strength of steel and aluminium. Carbon fibre reinforced plastic disadvantages are its high cost and limited availability, it becomes very costly to shape them into auto parts, but it is around 60 percent lighter and less than 6 kg in weight.

- *Roof Panels:*

Automotive roof panels made of carbon fibre reinforced plastic require bending rigidity and high strength to ensure passenger safety during roll-over crashes. As discussed earlier, the property of carbon fibre depends on its physical property, which is its method of layout, so the bending stiffness condition should be fulfilled. The finite element method is used to evaluate the stiffness of the component and it was found after the analysis that the 2 mm thick panel can achieve the necessary stiffness [8].

- *Chassis:*

It is the load bearing structure of the entire structure, so the motor, axes and suspension have to be solid and rigid to maintain and absorb vibrations and motion. In order to boost the vehicle's durability, fuel efficiency and in race cars, it should be lightweight as much as possible to improve the overall dynamics of the car. Carbon fibre reinforced plastic is twice as heavy as aluminium or steel material and is much lighter at the same time. Flexibility is lacking in carbon fibre, whereas metals can be welded and melted. Carbon fibre does not bend, they are solid, they can crack and break under intense force and, unfortunately, there is no repair choice. As we understand that acceleration is characterised as velocity shift, it can therefore be said that decreasing overall weight results in the same force and greater acceleration, which means that racing cars with less weight have a greater ability to accelerate faster [9]. In super-automobiles, the high-performance and light-weight properties of the carbon fibre are usually used preferably over high costs. A frame can only be a piece of carbon fibre. Carbon fibres can be recycled, but where aluminium and steel can be recycled, their strength is lost.

- *Tailgate:*

With the help of carbon fibre reinforced plastics, Tailgate is also manufactured and the specification should have 1.5 mm of width (thickness) to avoid torsion according to the study. Because of the increased rigidity and decreased mass, it was possible to eliminate tailgate stabilisers, which further lowered the total weight of the vehicle. Interior trim removal is carried out due to the consistency of the carbon fibre material that can be painted directly. In order to reduce the number of pieces, it has to be planned. It will allow for fast assembly and distribution of complex shapes. The mixture of carbon fibre and plastic leads to a total weight loss of 7 kg or 37 per cent.

- *Fender:*

The carbon fibre fender is more versatile and strong than single metal fibres, and since carbon fibres are far smaller than stainless steel fibres, they are smaller in weight, which increases fuel efficiency. The thermoset carbon fender resin coating makes them shiny and fresh, and their appearance is enhanced by the reflective fabric. The textures of carbon fibres are much more visible with scratches than traditional metals. It provides power dissipation, high performance, modular construction and simple advantages of replacement [10].

- *Side Doors:*

The version of carbon fibre reinforced plastics uses a reinforced frame that is designed to withstand multiple stresses, removing an extra weight of 4 kg per door compared to aluminium and up to 11 kg compared to steel. It is designed to deal with particular stresses. Because of the material mixture, carbon fibre reinforced plastics give high precision wall thickness, fibre orientation and layer structure design versatility. The material can be strengthened or fiber-oriented without losing the ultra-thin wall resistance in other areas if more strength is required. Car manufacturers have commonly used carbon fibre reinforced plastic composites in sports cars and luxury cars, but as mentioned above, only in a small way for the driver's cars in shafts, bumpers, roof, walls, fenders and interior structures. A very flexible composite is their composite material. Long periods of production and fibre costs, high investment in machinery and a lack of familiarity with the carbon fibre material of the industry are the major factors restricting today's growth of polymer composites in automobiles.

DISCUSSIONS

For decades, carbon fibre reinforced plastics have been used in high-performance sports vehicles, but it has only recently begun to be introduced in conventional automotive production. Not only are the carbon fibre car bodies powerful, but they are also highly durable and can withstand harsh driving conditions. Isotropic sheet metals that are joined by welding are usually used by automotive manufacturers. Composite materials such as CFRP have a carbon-fibre laminated frame, which provides protection in two perpendicular directions. They are orthotropic/anisotropic. The anisotropic properties can be adapted to particular applications with various types of fibre reinforcements in the directions desired. The protection of steel or aluminium at a high crash level can be given by these CFRP designs. Complex types can also be given by the composite material as one component and the number of machining operations and joints can be minimised. Nevertheless, as the coefficients for thermal expansion, electrical conductivity and composite surface finish differ from steel, there are still essential technical problems. Designers need cheap and reliable simulation tools for composite material characterization.

CONCLUSION

In an age where the use of steel is in full swing, it is a very big challenge to use highly advanced material. One alternative that has outstanding properties is carbon fibre or carbon fibre reinforced plastic material. This paper shows that it is possible to achieve both better efficiency and lighter cars at the same time if an alternative material is used. There are also many ergonomic benefits to the lighter vehicle body. Racing cars are intended only for the high speed and best stability provided by carbon fibre, if the racing car is lighter, it will increase its power to weight ratio and improve its performance overall, and if carbon fibre reinforced plastic is used in body parts such as the car hood, roof and boot, it will help minimise the vehicle's overall mass centre and improve the dynamics.

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