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Use of Carbon Fibre In Motorsport

Academic skills (ACHA4005)

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1. Introduction

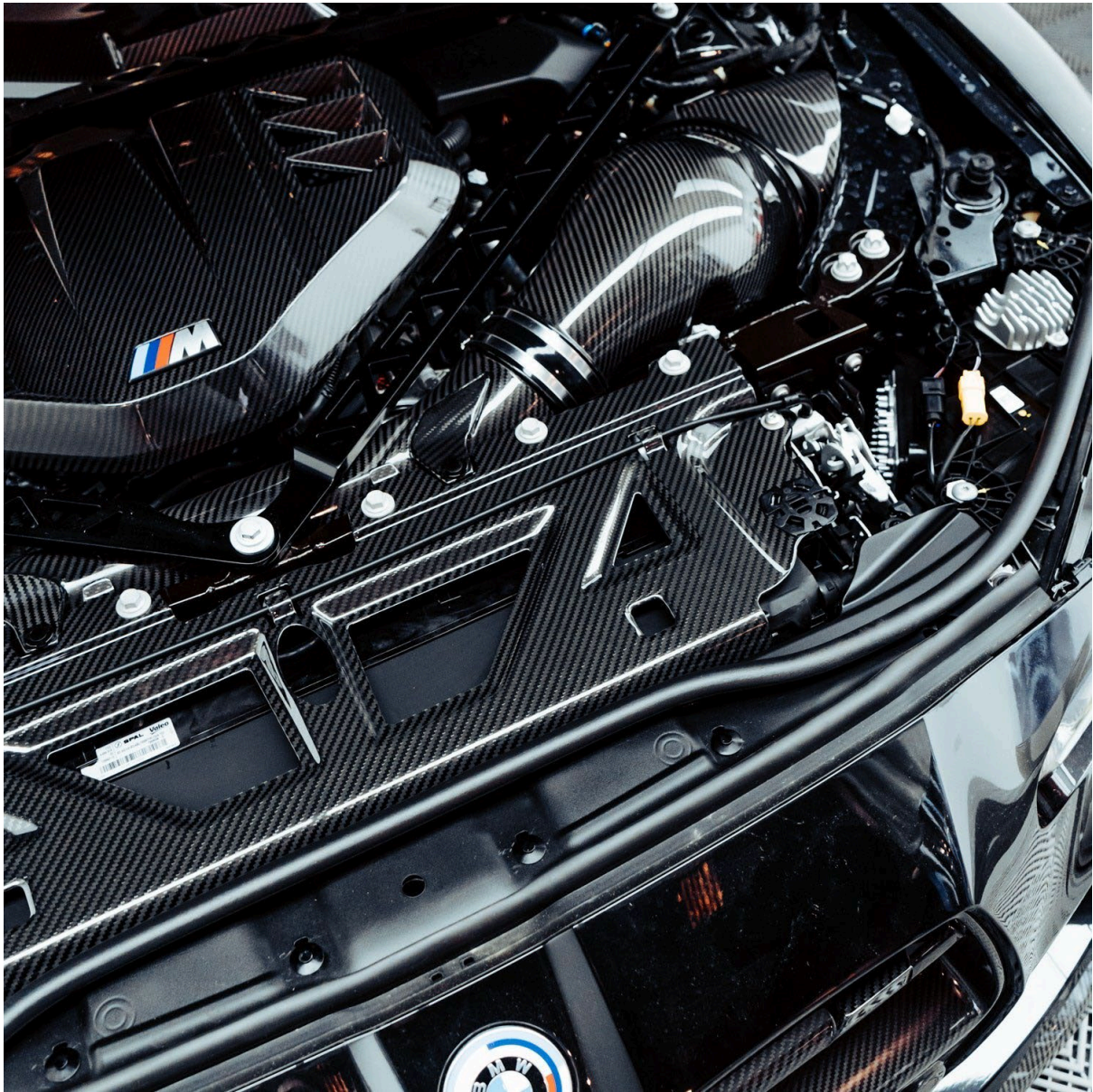


Figure 1 – image of an engine bay with Carbon fibre elements

The following document will cover an investigation into the evolution of the use of the material Carbon Fibre as a pivotal material in the world and industry of motorsport. It will dive into the various applications and comparisons between previously used materials to attempt to give a better understanding of why the material is such common space in today's racing scene.

2. Research/background

2.1

Before looking at the evolution and use of Carbon Fibre, it is important to first understand what the material is.

Carbon fibre is made of crystalline carbon atoms, which are made into thin strips of the material and then can be applied in various ways.

The process to make carbon fibre usually stems from one of 3 main ways. A precursor material is selected. One such precursor is Polyacrylonitrile. (PAN) This material is then processed to make long fibres, which then get heated in an oxygen free environment to stabilise them. This stabilisation then helps to prevent the material from deforming or burning. After this, they are then carbonised in a high temperature environment, which helps to filter out non-carbon elements, which then leaves the aforementioned crystalline structure of the carbon.

These materials are then woven in together, and then layered in a sandwich like method to create more surface tension. Different weave patterns have different applications in their respective uses. Figure 2 shows a Plain Weave pattern, commonly used in Automotive parts, and consumer goods, whereas figure 3 shows a Harness Satin Weave, which is more often used in high performance automotive parts, and various Aerospace applications.

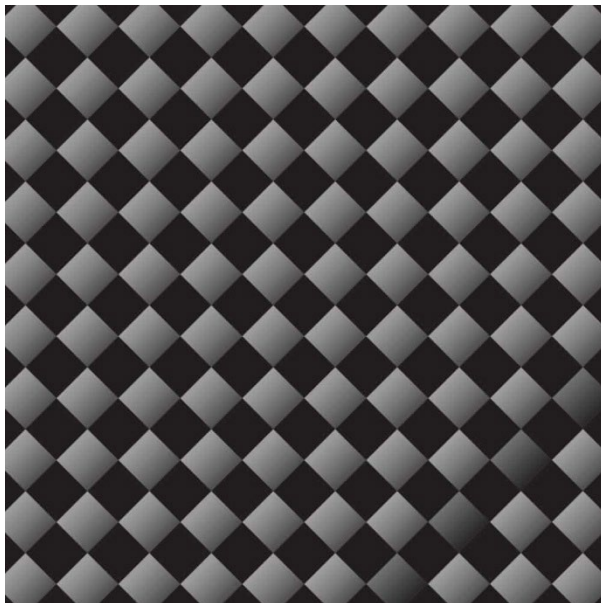


Figure 2 - plain Carbon Fibre Weave

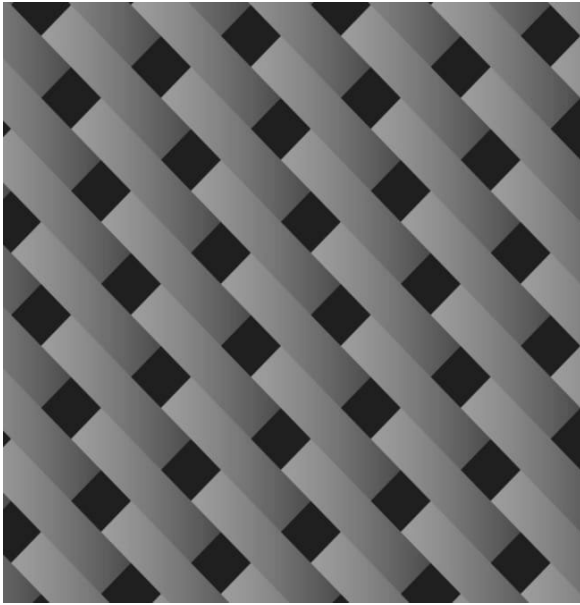


Figure 3 - Harness Satin Weave

2.2, why use Carbon Fibre?

Carbon fibre is a very strong material, which when put into its desired shape remains extremely lightweight. This is partly because of the process involved in moulding it into the required design. Often times, Carbon fibre is processed using an insert mould, then epoxy resin is layered on top to support it in keeping its new shape. The resin used can be tailored for specific uses, for example, a part made to go in the engine bay would benefit from an epoxy to increase the part's temperature resistance. Both the epoxy and the carbon fibre remaining lightweight once cured, along with the added benefit of the stiffness and strength of the material make it a clear contender for use in the world of motorsport.

With the knowledge that Carbon fibre has a low density; while offering its high strength, it becomes easy to see why many Motorsport teams currently use the material for a high percentage of their car's production. For example, the front wing of a Formula 1 (F1) car may previously have been made from a material such as steel or aluminium. This is a large area of the vehicle, which makes more downforce on the car by directing airflow. The benefits of Carbon Fibre making this part lighter make it almost a handicap to keep using the previous metals.

Contrarily however, it is wise to keep certain components of a vehicle made from metals for reparability reasons. Yes, Carbon Fibre is lightweight and strong, however when you reach the point of failure with carbon fibre, it will most often have a catastrophic failure, often meaning it will break completely or otherwise shatter. This is because of its structural similarity (partly due to its manufacturing process) to plastic. Essentially, the material is just a reinforced plastic. When carbon fibre is broken, it doesn't get repaired, it gets replaced.

Alternatively, if part of the metal chassis of an F1 car, for example, gets bent out of shape or damaged, you can cut away the damaged part, and weld a new length of the previously damaged component back onto the car without having to rebuild from scratch. This cannot be done with carbon fibre as you can't weld the material.

3. Discussion

Instead of having a full, 'front to back' carbon fibre vehicle, the more often opted for tactic is making structural parts out of a repairable lightweight metal (for example, aluminium) and then making the body panels out of carbon fibre. On a road production vehicle, this may be the frame being made fully out of metal, such as in figure 4, with carbon fibre body panels. (i.e. bonnet, boot etc)

If the driver were to reverse into a bollard in a parking area, they would crumple the body work, which could then be simply unbolted, and have the replacement part bolted on instead. However, if they were to get into a larger scale, front facing collision, this would likely damage the framework of the vehicle. The fact that this is made of metal means that the damaged frame can be cut away from the undamaged parts of the frame, and new parts can be welded on. In this example the structure around the engine bay and possibly one or more wheel arches may be damaged. If the frame was made from carbon fibre, every body panel would have to be removed, and then the whole frame would have to be replaced. The price for this, as well as the price of the replacement panels would be extremely expensive due to the cost of the carbon fibre materials.



Figure 4 – Vehicle Frame to show full metal body

If you were to scale this back up into a motorsport environment, such as F1, where the collisions happen at much larger speeds, you can imagine the cost of having to replace the entire car every time a driver spun out and crashed into the barriers where only one area around one wheel may have been damaged, versus being able to cut and weld one portion of the car.

Another aspect to look at when comparing carbon fibre to other materials is impact absorption. Carbon Fibre also dissipates energy by cracking and shattering, which is why it so often has

these catastrophic failures. However, this can help to divert some of the energy in collisions away from the driver. Plastics are often used in consumer cars to create crumple zones. Being that the material is a reinforced plastic, it can also be used for this same purpose. For example, a rally car with carbon fibre crumple zones could help to save a driver from some of the impact forces if they have a collision with a tree, for example.

The high brittleness of carbon fibre means it is wise for the motorsports teams to carefully balance what materials make up different portions of the vehicles.

The front wing is a part mentioned earlier in this paper, this part protrudes in front of the cars' front wheels, so oftentimes get damaged in various ways, and need replacing during races.

In order for damage like this to not cause the team's vehicles to be ineligible to race, the teams had to figure out a way to fix this damage.

One such example of this can be found in figure 5. This is a practice drill of what to do if a front wing is damaged during races.

As you can see, the front wing takes up a large area, however it is not essential to the safety of the driver or the structure of the car, however it is a big component of the aerodynamics of vehicles within this race series.

Teams found that they were able to make this part assembly lighter using Carbon Fibre for most of the design, and also able to connect it in such a way that a quick swap like this is possible, meaning that if the wing gets damaged, it is only the wing they need to spend money and time developing a replacement for. It is this type of integration of the material that is highly beneficial to any and all race teams, across multiple motorsports series.

<https://youtu.be/Zx5QQ5E9VYI>



Figure 5 - McLaren changes front wing

4. Conclusion

In conclusion, there are many uses of Carbon Fibre in motorsport ranging from reducing a vehicle's overall weight, to driver safety. There will likely be continued development for the material and other experimental uses, and it will be exciting to watch as different teams, or even different race series utilise the material differently within the future of motorsports, whether it be reinforcing existing aspects, parts or assemblies of cars, or innovating new ways to use Carbon Fibre to cement the team's position in their respective series.

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