Carbon fibre, the composite of the future?

Lighter, faster, and stronger. These three words sound like a description of the main character in a super hero movie. But they can also be used to describe what vehicle engineers are striving for when they design vehicles. Carbon fibre is one of the materials being used to do just that; make a vehicle lighter, faster, and stronger.

What is Carbon Fibre?

Carbon fibre reinforced composite (CFRC) is classified as a composite. A composite is a combination of two or more materials that, when combined, make up a stronger material. Other examples of composites include sheet-moulded compound (SMC) and fibreglass.

Traditional fibreglass parts are generally made using a polyester resin. Carbon fibre is a mixture of fibres made from carbon (see Figures 1 and 2) and a resin, usually consisting of an epoxy. When the resin is hardened, the carbon fibres reinforce the material, making it extremely strong.

The process is very similar to the processes used to make SMC. Composites are made by using a mould and glass fibres combined with a resin. With CFRC, the strength comes from having the correct concentration of resin to the amount of carbon fibres, as well as the orientation of the carbon strands (see Figure 1).

The excessive strength due to the strength of the carbon and the orientation of the strands allows vehicle engineers to build a lighter and thinner part, yet maintain the strength and rigidity of using traditional materials.

Applications

Most vehicles that have CFRC exterior parts are high-end sports cars where weight savings from using lighter materials has a positive effect on the horsepower-to-weight ratios. These vehicles are the proving grounds for new materials that may eventually enter the mainstream of vehicle production.

General Motors first used CFRC for the hood on the 2004 Commemorative Edition Corvette Z06. This created a weight savings of 56% over the traditional SMC hood, while maintaining or exceeding the strength of the part.

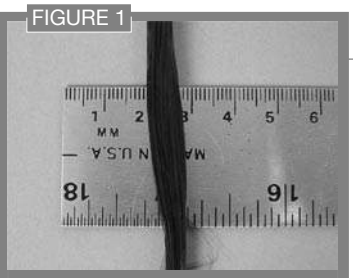
GM currently uses CFRC for the front fenders, the outer portion of the front wheelhouse (see Figure 3), and the floor boards of the 2006 Chevrolet Corvette Z06.

The fenders are 1.2 mm thick, as opposed to the traditional reinforced reaction-injected moulded (RRIM) plastic fenders from the previous Corvette Z06 that are 3 mm thick. The weight of each front fender is a mere 1.2 kg (2.7 lb).

Other vehicle makers using CFRC

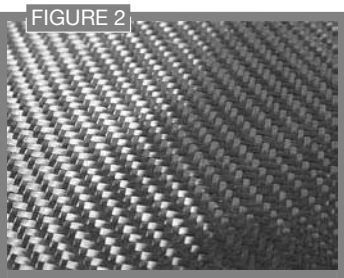
- 1997–2006 McLaren F1 for the complete body and chassis.
- 2003–2006 Mercedes-Benz SLR McLaren, which has a front structure made from CFRC (see Figure 5).
- 2003–2006 BMW M3 CLS, for the roof outer panel. Models with the carbon fibre roof are not available in the US at this time.
- 2004–2006 Acura NSX-R, for the hood and spoiler.
- 2004–2006 Aston Martin Vanquish for the structure of the vehicle (see Figure 6).

FIGURE 1



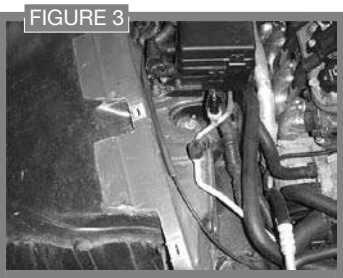
This strand of carbon fiber fabric contains 80,000 individual strands.

FIGURE 2



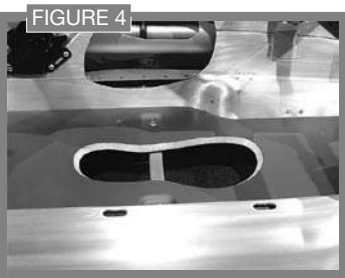
Carbon fiber is commonly woven into a fabric.

FIGURE 3



The outer portion of the front wheelhouse is made from CFRC on the 2006 Corvette Z06. Note that it is not painted. terminal connectors.

FIGURE 4



Balsa wood is encased in CFRC for the floorboard of the 2006 Corvette Z06.

The rigidity of carbon fibre for the fender application also reduces the need for reinforcements required for the thermal expansion characteristics of RRIM, thus creating a secondary weight savings. The floorboards are made with a balsa wood core encased in carbon fibre sheets (see Figure 4).

Repairability of CFRC

CFRC does offer some repairability, but the application, as well as the vehicle maker's recommendations, must be followed. When CFRC is moulded into shape, the mixture of the resins and carbon are considered the primary bond.

It is within this state that the part will be the strongest. All repairs to CFRC are considered secondary bonds, meaning the integrity of the repair depends on the adhesive properties of the repair resins or adhesives.

The application of the part is probably the most important consideration. CFRC parts made for structural purposes are generally replaced when damaged. There is no way to guarantee that the repaired part will have the same strength as the original part.

Parts used primarily for cosmetic purposes may be repairable. GM allows the front fenders on the 2006 Chevrolet Corvette Z06 to be repaired, provided that the damage does not extend to an edge. Damage such as a puncture or tear that protrudes through the part should be repaired using a two-sided repair.

This repair requires making a large taper to maximize the amount of surface area the repair materials can adhere to. When making the taper, the edges should be rounded without any sharp edges or angles.

A backing plate should be made on the inner panel, either from a piece of SMC or a piece of CFRC. If a backer plate is not available, an alternative is to construct a backer from fibreglass fabric and repair adhesive.

The front side is repaired using a pyramid patch technique, where layers of fibreglass reinforcement fabric are sandwiched with repair adhesive in the taper from the smallest to progressively larger (see Figure 7), until the taper is filled with the repair materials.

A roller is used to force any air out of the repair (see Figure 8), and heat is applied to cure the adhesive. After the repair has cured, it is sanded to contour and prepared for refinishing.

Conclusion

As vehicle makers continue to seek out weight-reducing materials for increased performance and greater fuel economy, CFRC is sure to be one of the materials that are looked at.

The repairability of CFRC depends largely on the vehicle maker's procedures and recommendations. Some adhesive product makers have developed procedures for repairing CFRC used on cosmetic panels, but structural parts made with CFRC will require replacement if damaged.

Although currently the use of CFRC is limited to high-end sports cars, technological advancements in the forming processes will make the product more available for vehicle parts. In the not-so-distant future, CFRC repairs may be as common as repairing SMC or sheet metal is today.

I-CAR

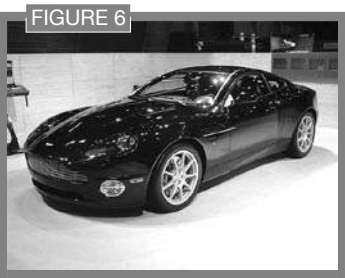
These articles first appeared in the I-CAR Advantage Online, which is published and distributed free of charge. I-CAR, the Inter-Industry Conference on Auto Collision Repair, is a not-for-profit international training organization that researches and develops quality technical education programs related to automotive repair. To learn more about I-CAR, and to subscribe to the free publication, visit http://www.i-car.com

For information on I-CAR training courses conducted throughout New Zealand, contact I-CAR NEW ZEALAND Phone 07 847 02168

FIGURE 5

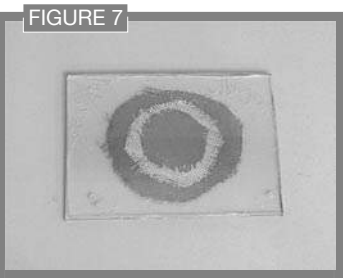
The 2003 Mercedes-Benz SLR McLaren has the complete front structure made from CFRC.

FIGURE 6



The 2004 Aston Martin Vanquish is built with a complete structure made from CFRC.

FIGURE 7



This example of a pyramid patch demonstrates how each layer of repair fabric goes from smaller to larger.

FIGURE 8

Plastic repair material is used to repair the damage on this Corvette Z06 fender.