

CARBON FIBERS AND THEIR USE IN RACING CAR INDUSTRY.

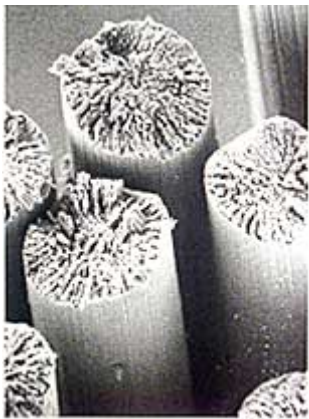
Introduction

This year's formula one season is over with one of the most exciting finishes in the history of racing .Michael Schumacher clinching the championship at the very last moment .Everyone hails him as a hero, but the real heroes are the ones behind the scenes .Just imagine building a road vehicle whose acceleration is more than a F16 fighter, the amount of air drag and friction it has to sustain and also protect the driver in case of an accident, is no job for a mere automobile engineer. It is the fruit of years of research done by material scientists who came up with this magic material CARBON FIBERS.

What are Carbon Fibers?

Carbon fiber is a synthetic fiber that results from the heating, oxidizing, and carbonizing of polyacrylonitrile polymer fibers. The polymer polyacrylonitrile includes long connecting chains of carbon molecules. To turn this polymer molecule into a fiber, it is subjected to heat (heat and pressure in sufficient quantity will change anything). Recall how a microwave oven makes three-day-old pizza edible, changing it from shoe leather to food.

It is a fibrous carbon material having a micro graphite crystal structure made by fibrillation of Acrylic resin, a well known textile material, or from oil/coal pitch and then by being given a certain heat treatment.



X1,500



X3,000



X20,000

Discovery of Carbon fibers.

The discovery of carbon fiber dates back to the late 1800s when Thomas Edison was testing thousands of different materials to use as a filament in the lightbulb. Edison repeatedly superheated a piece of plain

cotton thread to produce a pure carbon fiber and then presumably fashioned the tailgate of his horse-drawn wagon in carbon fiber and epoxy to impress the ladies at the town pump.

Types of Carbon Fibers.

Carbon Fibers, having supreme characteristics, are adopted in wide varieties of uses. Suppliers are able to provide, by using different raw material and applying divergent production processes, wide diversity of the fibers having different specifications. Please find below diversified types and respective features of the fibers.

Two Types Carbonfibers

1.PAN Type Carbon Fiber (PAN: Polyacrylonitrile)

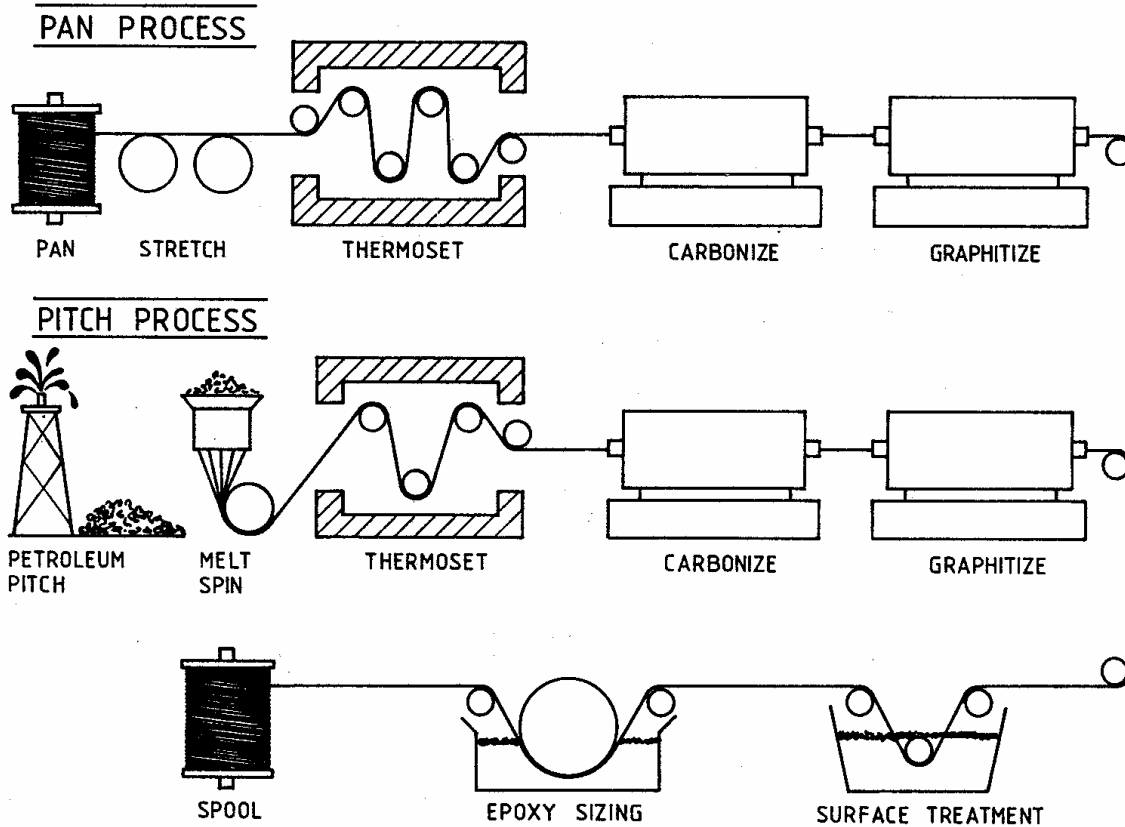
A type of the fiber, produced by carbonization of PAN precursor, having high tensile strength and high elastic modulus specifically designed for structural material composite

2.Pitch Type Carbon Fiber

Another type of the fiber, produced by carbonization of oil/coal pitch precursor, having high heat conductivity, electric conductivity and also high tensile strength and high elastic modulus being adopted in such various uses as utilizing those features

The Manufacturing Process of Carbon Fibers

Carbon fibers are manufactured from synthetic fibers through heating and stretching treatments, and a simplified schematic of this manufacturing process can be seen in Figure. Polyacrylonitrile (PAN) and pitch are the two most common raw products used to produce carbon fibers. PAN is a synthetic fiber that is pre-manufactured and wound onto spools, and pitch is a coal-tar petroleum product that is melted, spun, and stretched into fibers. First, in the thermoset treatment, the fibers are stretched and heated to no more than 400° C. This step cross-links carbon chains so that the fibers will not melt in subsequent treatments. Second, in the carbonize treatment; the fibers are heated to about 800° C in an oxygen free environment. This step removes non-carbon impurities. Third, the fibers are graphitized; this step stretches the fibers between 50 to 100% elongation, and heats them to temperatures ranging from 1100° C to 3000° C. The stretching ensures a preferred crystalline orientation, which results in the desired Young's modulus around 300-600 GPa. Finally, the last two treatment steps, surface treatment and epoxy sizing, are preformed to enhance the carbon fiber / epoxy bonding strength. Several different methods can be used in these last steps.



What actually happens at the molecular level.

The polymer is subjected to an oxidation treatment (the liberation of electrons on the molecular level) at between 200 and 300 degrees Celsius that heat the polymer molecules until the cyano part of the molecule repeat units to form cycles. Then the molecules are heated again to around 700 degrees Celsius and a point where the carbon atoms release their hydrogen units. Later, additional slow roasting frees hydrogen gases and these ringed polymers begin fusing together like ribbon. The hottest portion of the temperature exercise is done in a nitrogen gas environment; otherwise the result would be ash, not carbon. As the carbon molecules carbonize completely, the heat creates wider molecule ribbons, and even more heat releases the nitrogen gas in the molecule, as the ribbons get wider. The result is a long ribbon that is almost pure carbon in graphite form. The strands of carbon fiber are composed of at least 92 percent carbon. The temperature used to heat the fiber is governed between 1,000 and 2,500 degrees Celsius to obtain the desired properties of these fibers (flexibility, thickness, etc.) that usually get woven into sheets. A finished carbon-fiber strand is typically about five times thinner than the average human hair. The resulting fibers are like a thread but exceedingly strong and can be formed into woven mats for the composite construction of components from molds such as body panels and hoods. Such fibrous

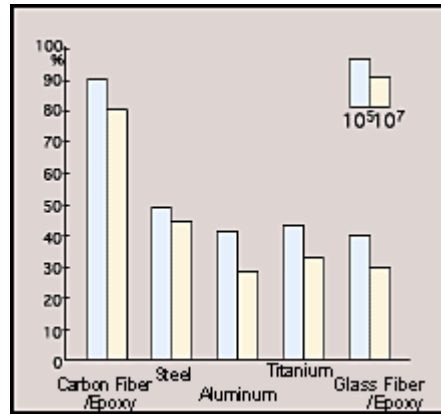
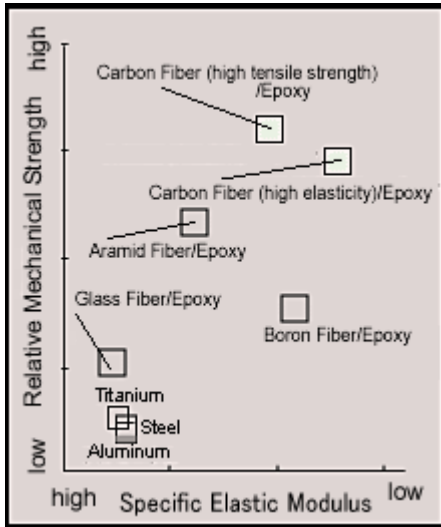
mats, when combined with the appropriate resin agent, can form structures up to 10 times stronger than steel, but which are still five times lighter. Carbon-fiber composite construction's superior fatigue, corrosion, and durability properties have made it the darling of the aerospace and race car industry. In addition, the low cost of tooling allows the carbon-fiber composites to be molded into complex shapes and designs at a relatively low cost. The mats of woven fabric are available in a variety of weights (thickness of weaves) for wet lay-up, in addition to "pre-preg" format which is a heat-activated, pre-saturated woven mat. Lighter weight fabrics are more flexible and easier to drape over more complex mold contours. In addition to weight, the weave of the mats can be arranged in a particular orientation to place the strength exactly where the structure requires it the most. Twill patterns offer that attractive herringbone pattern no one seems to want to paint over. These mats are typically joined with thermoset (polyester, vinyl ester, or epoxy) resins that began as liquid polymers and are then converted to a solid during the curing process.

Carbon Fiber's Special Features and Characterising Performances.

"Light in weight, Strong and Durable!" Carbon Fibers are nothing but a 21st. century high technology material. The fibers have low specific gravity, exquisite mechanical properties (high specific tensile strength, high specific elastic modulus, etc.) and attractive performances (electric conductivity, heat resistance, low thermal expansion coefficient, chemical stability, self-lubrication property, high heat conductivity, etc.). Those features have been stimulating Carbon Fiber users to develop numerous kinds of applications.

Light in Weight and Strong.

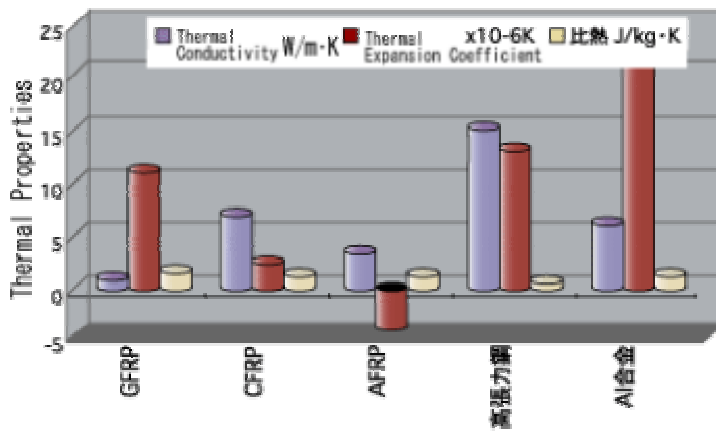
Carbon Fiber Reinforced Plastics (CFRP) is superior to steel or glass fiber reinforced plastics (GFRP) in its specific tensile strength and specific elastic modulus (specific rigidity). That is to say, CFRP is "Light in Weight and Strong" in its mechanical performances. Carbon fiber composites have amazing structural properties. Carbon fiber composites are ten times stronger than steel, yet are still five times lighter. In comparison to aluminum, carbon fiber composites are eight times stronger, two times stiffer, yet still 1.5 times lighter. Carbon fiber composites have superior fatigue properties to all known metallic structures, and when coupled with the proper resins, carbon fiber composites are one of the most corrosion resistant materials available.



Fatigue Resistance

Moreover, fatigue resistance of Carbon Fiber surpasses that of other structural materials.

Excellent Dimensional Stability and Heat Resistance.



Comparison of thermal characteristics

GFRP:

Glass Fiber Reinforced Plastics

CFRP:

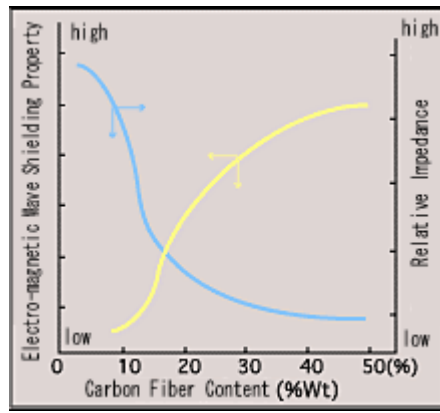
Carbon Fiber Reinforced Plastics

AFRP:

Aramid Fiber Reinforced Plastics

Carbon Fibers have low heat expansion ratio and high dimensional stability, and sustains those excellent mechanical performances even under high temperature region.

Highly Electric Conductive and Excellent EMI Shielding Property.



Electromagnetic Wave Shielding Property

Carbon Fibers have high electric conductivity (volumetric impedance) and at the same time have excellent EMI shielding property. This successfully brings CFRP to the field of EMI shielding.

Application in racing cars.

Requirements for a good formula one car.

There are three important factors when searching for F1 car materials:

- Materials must be light to guarantee ideal weight distribution.
- Components must be able to withstand extreme forces during a race to avoid any defects occurring.
- The race car has to comply with both the Fédération Internationale de l'Automobile (FIA) safety standards and crash tests.

High tech materials are a must.

High load-bearing capabilities, fast availability and reliability at low weight – all necessary characteristics of a F1 car - can only be achieved by using hi-tech materials. One such material is Composite Material Carbon.

Roughly 60 percent of a F1 car consists of carbon fibers, embedded in epoxy resin (also known as CFRP). The following car parts are all composed of CFRP:

- The monocoque
- Nose assembly
- Wings
- Parts of the suspension
- Clutch and brake disks

This list demonstrates that one of the main advantages of carbon is its versatility. The carbon-fiber layers, consisting of individual fibers that are woven together, can be shaped to suit almost any requirement. Carbon only weighs one quarter of a comparable quantity of steel, but it can bear twice the load and has an impressively high level of rigidity.

Process of conversion of carbon fibers in to racing car body parts.

- 1) Firstly the fibers are woven into a sheet, just like textiles.
- 2) All the body parts have their respective moulds made out of fiber glass.
- 3) A large sheet of woven carbon fiber is cut and laid over the mould so that a few inches of fabric drape over each corner.
- 4) Then the epoxy resin is mixed with a reactive catalyst which will harden the carbon fibers.
- 5) The dreamy, smelly resin is then laid over the woven mat using paintbrushes to thoroughly saturate the weave.
- 6) A large section of fiberglass mat is then laid over the back of the wet carbon fiber, and covered with additional helpings of epoxy resin.
- 7) Once moistened, this fabric does not stay intact. Adding structure to this fiberglass back in a fiberglass fabric that aids as reinforcement and facilitates the removal of trapped air bubbles.
- 8) The backside of the structure gets the “squeegee” treatment, as more imperfections and air pockets are removed and the saturation of the epoxy resin and woven materials is made more thorough.
- 9) After hardening, the hood is separated from the mould.
- 10) And finally the part is polished and all the parts are put together .

Some future projects.

1) New Carbon Fibers Made out of Nanotubes.

The structure of carbon nanotubes means that their properties include high strength and acting as conductors or semi-conductors. Thus their potential in the fields of high performance materials and microelectronics is enormous. Until now, though, preparing and forming carbon

nanotubes has been tricky, making large-scale testing of their properties difficult. The CNRS team at the Paul Pascal Research Center (CRPP, CNRS-University Bordeaux 1) has patented a process for producing fibers and strips from carbon nanotubes produced by an electric arc technique developed by another CNRS team, the Condensed Phases Dynamics Group in Montpellier (CNRS-Languedoc University of Science and Technology). A company called Nanoledge is being formed to exploit this know-how.

2) A study is being done on the way in which the parts fly off during a crash so that the projectiles do not injure the driver and also research is being done to control the direction.

Conclusion.

Hence we see that carbon fibers are a high tech 21st century material which is a result of loads of research done by material scientists using state of the art technology.