What Industries Use Carbon Fiber?

by Leigh Ann Green

Carbon fiber's unique properties make it an ideal structural material choice in numerous industries. Not only have carbon fiber composites replaced standard structural materials (i.e. aluminum, titanium, and steel) in many existing applications, but they have also enabled new applications and technologies.

Carbon Fiber: A Unique Material

Rigidity, strength, and fatigue resistance are some of the most impressive properties of carbon fiber. Composites containing the fiber are twice as stiff and five times stronger than steel per unit weight. Carbon fiber also has better fatigue properties and corrosion resistance than other materials including high-strength alloys.

Most carbon fiber is fabricated from carbon-rich polyacrylonitrile (PAN). Producing the fiber from PAN involves multiple steps, one of which is pyrolysis at 1500-3000º C. This heat treatment changes the molecular structure of the carbon into layers of graphite. These graphite layers are formed from carbon atoms arranged in a 2-dimensional hexagonal ring pattern resembling chicken wire. The layers are packed tightly and aligned along the fiber axis.

The mechanical properties of the resulting fiber depend on the internal arrangement of these graphite layers which, in turn, is controlled by the pyrolysis process. Standard Modulus carbon fiber has a strength-to-weight ratio of approximately 230GPa and a tensile strength of 3.5GPa. The fiber can be processed to achieve a higher elastic modulus of 350-450GPa. Structures that require both high strength and high stiffness contain an intermediate modulus fiber.

The graphite fibers are embedded in a stable matrix, such as an epoxy resin, to form a carbon fiber composite. In addition to being strong, rigid, and lightweight, and depending on the resin type, the resulting composite may be chemical resistant, flame resistant, and exhibit a high-temperature tolerance with low thermal expansion.

A Raw Material in Industry

Carbon fiber composites initially found their niche in industries where aerodynamics was key. Aerospace was one of the first industries to make use of the material's high strength-to-weight and stiffness-to-weight ratios. Today, industries producing such items as drones, construction materials, robotics, tactical ladders, and sporting goods are taking advantage of this versatile fiber's rigidity combined with its lightweight characteristics.

Medical and optical industries also recognize the unique properties of carbon fiber. Because it is biologically inert and permeable to x-rays, carbon fiber composites are ideal for use in prosthetics, implants, and surgical equipment. Medical imaging tables made from the fiber maintain critical dimensions even after high doses of x-ray and gamma radiation. Additionally, carbon fiber composites have low coefficients of thermal expansion (near zero) prompting their application in such products as telescopes, optical benches, and waveguides for high-frequency precision measurement frames.

The music industry is also finding applications of carbon fiber's unconventional properties. Along with its high dimensional stability and resistance to humidity, carbon fiber is naturally damping to vibration. Musical instruments made using carbon fiber offer a full, rich sound, provide greater acoustic volume, and are not affected by changes in ambient conditions.

A Tool in Industry

While many industries have found applications for carbon fiber in their end products, it is also important to note that this material plays a significant role within the manufacturing process. For example, tools made with carbon fiber composites are up to 90% lighter than tools made from conventional materials. Inspection tools and machine parts that were previously moved with heavy equipment can be lightened with carbon fiber, improving ergonomic usage. Valves, seals, and pump components produced from the composite are tough, long-lasting, and highly resistant to corrosion. Carbon fiber idler rolls are more rigid than steel resulting in reduced bending and yielding issues. These rolls require less power to run and allow for faster line speeds, as well as limiting the amount of friction on bearings.

Industries using robotics and other automated systems are replacing metal end effectors with carbon fiber composites. These replacement effectors allow the automation to move faster, lift heavier parts, and function in environments containing corrosive chemicals.

Carbon fiber technology continues to evolve as the demand for higher quality products increases. Element 6 Composites recognizes that these emerging technologies combined with innovation and creativity will yield a cost-efficient, refined product. Contact Element 6 Composites to discover how carbon fiber can play a role in your industry's success.