To Increase Performance in Construction use of Carbon Fiber

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***Abstract*:- Over the past few decades, our research and technical skills has increased a lot. Even today we are innovating and developing the new trends in technology in pursuit of a safe and sustained future as the innovation leads to invention. Throughout this evolution, engineers are in constant research for new and better building materials and carbon fiber is one of these materials, which is used with some other fibers and a specific polymer to form a high performance composite mixture. The aim of this research paper is to study the benefits of using carbon fiber in different types of industry &this paper also overcomes the drawbacks of using other building materials. The amazing properties of carbon fiber such as high tensile strength, high stiffness, low weight & high resistance to chemical and temperature makes it one of the most popular materials in construction industry due to these properties it has enormous applications in military, medical science, construction, automobile, aircraft industry etc. It actually works as a robust building material. It produces the structure that possesses both flexibility and durability. It is incredibly strong that's why it can also withstand earthquakes. It is more flexible in wind than the regular structures. It is also listed in the top 20 engineering achievements of 20th century. It is definitely the next generation building material as it can replace steel in the many structures and can reduce its construction and maintenance cost.**

Keywords: Carbon fiber, building material, steel, polymer, tensile strength, stiffness.

I. INTRODUCTION:

A. HISTORY

In the 18th century, Thomas Edison carbonized cotton and bamboo to make filaments for his early incandescent light bulbs.

In the late 1950s-ryan made high tensile carbon fiber and in early 1960s first and commercial and practical use of carbon fiber is made in aircraft which makes them lighter and faster due to the light weight and high stiffness of carbon fiber. During 1970's experimental work to find alternative raw materials led to the introduction of carbon fibers made from petroleum pitch derived from oil processing. Unfortunately they have only limited compression strength and were not widely accepted.

The 20th century saw a tremendous increase in the demand for carbon fiber. Threats to peace increased the demand for carbon fiber for defense purposes, mid-century.

By the beginning of 21st century, new applications and new market sent the production of carbon fibers on an upswing.

Despite a global downturn in 2008-2009, worldwide demand for carbon fiber increased up to 45,000 metric tons in 2010. According to the global market forecasts, the annual growth rate of carbon fiber is expected to be around 17% by 2017.

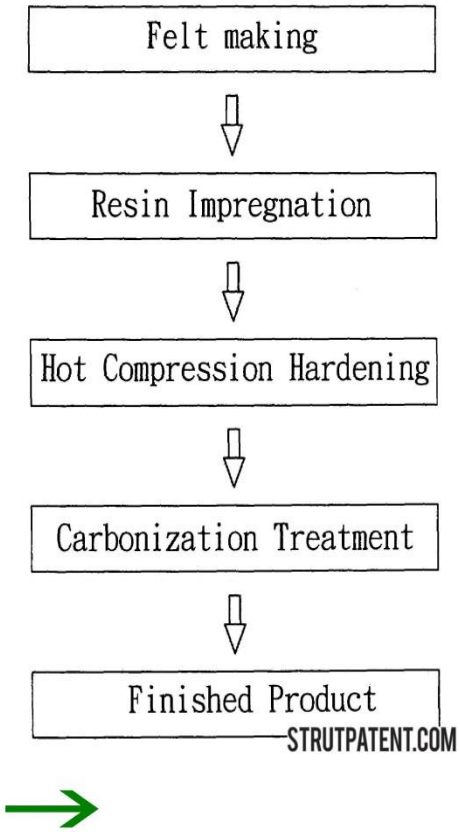
B. WHAT IS CARBON FIBER?

a) METHODOLOGY

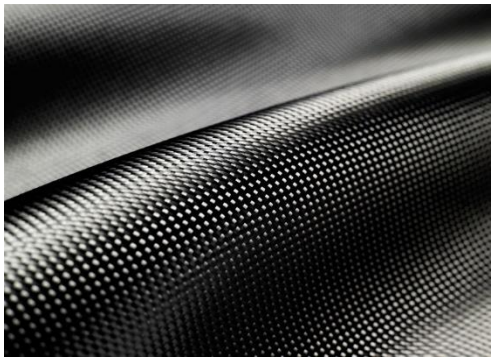
Carbon fiber is a composite mixture of fiber such as aramid, aluminum or glass fibers bound together by a polymer which is most often epoxy or may be polyester, nylon etc.

The raw material used to make carbon fiber is the precursor. About 90% of the carbon fibers produced are made from polyacrylonitrile (pan). The remaining 10% are made from rayon. All these materials are organic polymers having long strings bound together by carbon atoms. During the manufacturing of carbon fiber variety of liquids and gases are used and the process is part mechanical and part chemical. Each fiber is 5-10 microns in diameter. Carbon fibers are 2 times stiffer than steel and has high tensile strength. In fact the carbon fiber might be the strongest material.

Carbon fiber is mostly used where the combination of high strength and light weight is required.5 steps of production of carbon fiber are shown in the figure.



Carbon fiber



b) PROPERTIES OF CARBON FIBER:-

1) CARBON FIBER HAS HIGH SPECIFIC STRENGTH:

Strength of a material is the ratio of force per unit area at the failure to the density. Any material which is strong and light such as aluminum, titanium, carbon, glass etc. has always high specific strength. The strength to weight ratio of carbon fiber is much more than that of steel, aluminum, or glass fiber. Table showing the specific strength of various materials. The units are in KN.m/Kg.

Spectra fiber	3619
Kevlar	2514
Carbon Fiber	2457
Glass Fiber	1307
Spider Silk	1069
Carbon Epoxy Composite	785
Balsa axial load	521
Steel alloy	254
Aluminum alloy	222
Polypropylene	89
Oak	87
Nylon	69

2) CARBON FIBER IS ELECTRICALLY CONDUCTIVE:

This property of carbon fiber is both useful and bit harmful too. In construction of ships, this property comes into play. Carbon fiber's conductivity can increase the galvanic corrosion in electrical fittings but proper and careful installation can reduce this problem. Carbon fiber dust is also harmful, which can cause short circuit in electrical appliances.

3) FATIGUE RESISTANCE IS GOOD:

Carbon fiber has a good resistance to fatigue. Carbon fibers when placed perpendicular to the direction of applied stress produced the most favorable condition of increased resistance to bending and to flexural fatigue. Resistance to fatigue greatly depends upon the orientation of fibers. Damage in tensile fatigue will lead to the reduction in stiffness with large no. of stress cycles

4) CARBON FIBER HAS HIGH TENSILE STRENGTH:

Tensile strength is the maximum stress that a material can withstand safely while being stretched before failing. Carbon fiber does not losses its shape and dimensions on stretching. It is highly flexible and after stretching it regains its shape almost completely.

5) FIRE RESISTANCE:

Fire resistance of carbon fiber is excellent. Depending upon the type of process and the type of precursor used, carbon fiber can be made into protective clothing for fighting fire. Carbon fiber blanket is also used in welding.

6) LOW COFFECIENT OF THERMAL EXPANSION:

This is a measure of how much a material expands or contracts under the application of temperature when it goes up and down. As compared to steel, aluminum or glass, ithas comparatively low thermal expansion, which makes it ideal for applications where small movement can be critical.Table showing the thermal expansion of various materials. The units are in inch.

Steel	7
Aluminum	13
Kevlar	3 or lower
Carbon Fiber woven	2 or less
Carbon fiber unidirectional	minus 1 to +8
Fiberglass	7-8

7)HIGH CORROSION RESISITANT:

Carbon fiber is chemically inert and stable. It does not corrode easily by the environmental factors such as temperature, humidity, moisture etc. although epoxy polymer used in carbon fiber is sensitive to light and needs protection.

8) CARBON FIBER IS VERY RIGID:

Rigidity or stiffness of any material is measured by its young modulus; it measures how much a material deflects under stress. Reinforced carbon fiber plastic is 4 times stiffer than glass and around 20 times stiffer than pine.

C. APPLICATIONS OF CARBON FIBER:-

1) CIVIL ENGINEERING:

Carbon fiber is used in several structural engineering applications due to its construction benefits and optimum cost. The applications include strengthening of structures made with concrete, steel, timber, cast iron etc. it can also replace steel due to its high tensile strength and light weight. It is also used to increase the shear strength of old structures like bridges.

2) INDUSTRIAL AUTOMATION & ROBOTICS:

Carbon fiber reduces the motor and actuator loads and increases the response time. In the business of automation, where machines often run as fast as 24x7, carbon fiber reduces the inertial loads by replacing heavy metal components, which further reduces part fabrication time and which in turn increases the profit. In developed countries carbon fiber is used in making car's roof, alloys and other accessories

3) AIRCRAFTS AND SPACECRAFTS:

It is widely used in aircrafts and spacecraft components where its strength to weight ratio exceeds much more than that of any other material. It is applied in helicopters, gliders, flying jets where high strength and low weight is required. Carbon fiber increases the durability and lowers the maintenance cost.

4) SPORTS GOODS:-

It has wide applications in sports goods and equipments such as stiffening of shoes, hockey sticks, tennis racquets, golf balls etc. it is also to make helmets which act as a protector while playing games. It has high damage tolerance which can be very useful to save lives

5) MILITARY:-

Military has various types of rough and tough equipments which are very hard and durable and act as a safeguard. Most of them are made from very strong materials like carbon fiber, examples- planes, tanks, missiles, helmets, soldier's personnel gear, machine guns, protective shield etc.

6) HOUSEHOLD APPLICATIONS:-

The applications of carbon fiber in home are far beyond our imagination starting from style, comfort, luxury or practical use. Carbon fiber is used in in bathtubs, coffee table, phone cases, pen stands, bow ties, chairs etc. The look of black carbon fiber is very attractive.

7) MEDICAL APPLICATIONS:-

Carbon fiber offers several applications to medical field. The most important is artificial limbs. It is also used in x-rays and appears black on x-ray images. It is also used to strengthen damaged ligaments in the knee. Carbon fiber is used for welfare equipment such as wheel chairs, care beds and portable slopes.

II. CONCLUSIONS:-

- Carbon fiber plates are very thin, strong, flexible and durable. They can be installed to provide the optimum cost solution and to give a sustainable future design.
- It has high tensile strength, high stiffness, low thermal expansion, high resistance to fire and corrosion than any other material like stainless steel, glass or aluminum thus making it one of the most important composite materials in industry.
- The golden factor of carbon fiber is that it possesses strength up to 5 times than that of steel and weight one third to that of steel.
- It has enormous applications in civil engineering, medical field, sports, military, automobile and music industry.
- The history of carbon fiber in India is nearly of two decades. Though the technology has been developed mainly in defense and aerospace, its foray into other industrial sectors is only a matter of time. In India there is a complicated situation between either to reduce the production cost of carbon fiber or increase its fiber properties. But challenges like cost reduction, tensile and compressive strength improvement and alternative precursor development still remain.

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