ISSN 0976 – 1411

Available online at www.internationaleJournals.com

International eJournals

International eJournal of Mathematics and Engineering 71 (2010) 708 - 714

INTERNATIONAL eJOURNAL OF MATHEMATICS AND ENGINEERING

www.InternationaleJournals.com

APPLICATIONS OF FIBER REINFORCED COMPOSITE MATERIALS

D. Srikath Rao[1], V. Devender[2] N. Shyam kumar[3], B. Durga Prasad[4]

1 and 2 SR Engineering college, Warangal, ssy_dev@yahoo.co.in and deva_vs@yahoo.com
3. WITS Warangal, 4. JNTU Anantapur

Abstract:
Composite materials are having a unique possibility of and tailoring their physical properties. They can be designed according to our requirement of engineering properties. Hence they are widely used in engineering applications; day by day they are replacing the conventional metals. Lot of research is carried out on the composite materials; every day new materials are prepared and used in industry. In this paper we want to discuss the applications of composite materials and special focus given to Indian inventions and applications.

Key words: FRP Coposites, Radomes, carbon-carbon fibers, Dhruv, carbon-kevlar composites, Fishing rods, tennis racket

1. Introduction:

A composite material is the combination two or more distinctly different materials which are insoluble in each other and differ in form or chemical composition. One is binding material called resin and the other is a reinforcing material called fiber.

Glass + Polyester = G R P

Strength + Chemical resistance = Strong and chemical resistance

The unique property is that

Glass + Polyester = GRP

Brittle + Brittle = tough

Epoxy, Polyester etc are examples of resin and glass, carbon etc are examples of fibers. Thrust to weight ratio of the conventional metal alloys is 5 to 1 are achieved, FRP and metals leads to ratio as high as 16 to 1, the advanced fiber composites , the thrust to weight ratio is in the order of 40 to 1, hence the use of the composite materials is unavoidable in the modern applications.

2. In Missiles Field:

Light weight air combat vehicles use composite materials up to an extent of 45% of the components. Vikram sarabai space center Bangalore and DRDO doing lot of research in the field of composite materials applicable to space and air craft industry. Prudvi, akash, agni ASLV are using composite materials to a large extent. Carbon - carbon composites are used to make RADOMES, which are electromagnetically transparent hence, communication to the ground is possible. Agni II is having heating reentry nose tip which can withstand temperatures up to 2000 ^{0} C , it is made of Carbon - Carbon composites. This composite material is fabricated by ASL Hyderabad. Hypersonic vehicle will have surface reentry temperatures up to 600 ^{0} C to 3000 ^{0} C. The Carbon materials will exhibit unique properties because of strong bonds between the carbon atoms of hexagonal planes where as weak bond between the carbons – carbon atoms in vertical plane of graphite.

Agni III weighs 50 tons and its range is 2500 – 5000 km, the reentry heat shield is made of polyamide composites.

3. Aerospace Applications:

The composite materials are having good corrosion resistance and fatigue properties hence they are used in aerospace and space craft industry as structural and other components. A – 38 air bus after using FRP composite materials has eliminated 50,000 fasteners and other mechanical elements. This composite material decreases the weight considerably hence helps to increase the pay load in other words improves economy. The Boeing 777 is having only 12 % composite materials where as Boeing 787 are having 50% of composite materials thereby reducing 5000 joint parts. And also Boeing 787 is having smart composite structures and the stresses in the structure can be always communicated to the ground during the flight, hence the conditions of the components can be known and safety is increased. The space vehicles SLV, PSL, GSLV etc use composite materials.

Druv helicaptor : It is having various FRP Composite components. The Helicopter Division of the government-owned Hindustan Aeronautics Limited (HAL) has developed the Dhruv (Pole Star) advanced light helicopter (ALH), a light (5.5t class) multi-role and multi-mission helicopter for army, air force, navy, coast guard and civil operations for both utility and attack roles by day and night. The helicopter is of conventional design and about two-thirds by weight of composite construction.

It is having various FRP composte components :

a. **Kevlar and carbon-fibre cockpit**

The cockpit section of the fuselage is of Kevlar and carbon-fibre construction and is fitted with crashworthy seats.

b. The blades are mounted between cruciform-shaped carbon-fibre-reinforced plastic plates on a fibre elastomer constructed rotor head.

Druv helicaptor HAL Bangalore

3.1 Brakes: The use of FR composite materials can result in, pay load can be doubled, the range can be extended, operating efficiency can be improved , in all applications , improved fatigue life and reliability of composite material are welcome added attractions.

The CC composites will have same strength at room temperature and also at elevated temperatures. Air bus is having CC brakes. The reason to use C – C composites in brakes is,

the brakes are used to stop the airplanes on the ground, but in between when take off and landing they have nothing to do, hence carrying more weight is useless therefore to decrease the weight the C – C composites are used in the brakes of aero planes and space crafts. In an airplane the conventional steel brakes weighs about 1000 kg where as the C – C composite brakes weighs only 600 kg. The brakes will have two sets of discs, they rotate at 3000 rpm.
Carbon and Kevlar composites are used to make wing, fuselage and empennage components.

aircraft brakes

3.2 Helicopter blades :FRP with epoxy as resin is used for the manufacture of helicopter blades, this material can be tailored the dynamic frequency of the blades to operating conditions. Unlike the conventional metals blade of FRP any shape can be manufactured without any additional cost. FRP are also used in the manufacture of antennas, booms, support trusses and struts. Carbon – epoxy composite tubes are used in constructing truss structures for low earth orbit LEO satellites and interplanetary satellites.

Helicopter blades

3.3 Truss Hubble Space telescope: Graphite epoxy structures can be tailored to have zero coefficient of thermal of thermal expansion, when they are used as antennas, they must pass in and out of the sun, and yet they maintain dimensional stability for accuracy of pointing the signal. Graphite epoxy truss is used to support and stabilize the Hubble Space telescope

3.4 Electromagnetic shielding: Electromagnetic interface EMI is another area where highly conductive composites can be used these are made of carbon fibers. EMI is nothing but electronic pollution or noise caused by rapidly changing voltages
Examples: Nickel coated carbon fibers are used in shielding against electromagnetic and radio frequency interface.

Nickel confers excellent conductivity retaining the flexibility. This composite can protect you against lightening. Radar absorbing materials are used to reduce EMI , navy ships carry a large number of antennas, computer and telecommunications equipments.

4. Automotive field:

4.1 glass bodies : In 1930s Henry fords "corn cob car "used composite materials first time in the automobiles. The fiber glass bodies are used for Chevrolet Corvette vehicles in 1953. Chopped glass fiber reinforced polymers has been extensity used in body panels like ford thumbed .

Fiber glass body

Oshkosh trunk is having composite mixer drum which saves weight about 2000 lb, instead using cast iron / steel tank.

4.2 composite springs : The application of composite springs reduces the weight, the conventional springs weighs 9 kg whereas the E-glass reinforced epoxy FPR composites weighs only 3.6 kg in Chevrolet corvette leaf spring

4.3 Engine parts: In racing cars, the parts of engine are made of graphite epoxy. Connecting rods which are subjected to fatigue are now made of composites for better performance. The other like push rods, rocker arms, pistons, cylinders heads and engine blocks make the automobile weight reduction and production of more power.

5. Marine applications:

Glass reinforced plastics (GRP) are extensively used in the construction of boat hulls including yachts, lifeboats, dinghies, canoes, speed boats, fishing boats and passenger launches.

FRP is used in submarines for flooded nose fairings using planes and non –pressure hull decks.

6. Sporting goods:

Many sporting goods are made of FRPs now days.

6.1 : Tennis rockets or snow skis are made of sandwich structure- FRP with carbon – carbon fiber as the skin and the core formed by soft and light urethane foam which enables the structure to have a weight reduction with out any decrease in stiffness. FRP enables the damping of vibrations; therefore, shock resulting from the impact of the ball the tennis rocket which is transmitted to the arm of the player will dampen out at a quicker rate.

Tennis Rocket

Fishing rods, bicycle frames, archery bows, sail boats and kayaks, oars, paddles, canoes hulls, rackets, javelins, helmets, golf club staff, hockey sticks, athletics shoe soles and heels, surf boards and many other items.

7. Civilian application:

In case of civilian applications there are numerous applications; Indian railways are using composite materials for door panels, glass windows, and cushion seats. Turbine blades, windmill wings, CNG cylinder composite tanks are made of glass epoxy composites.

Conclusion: The composite materials can replace the conventional metal in engineering and structural applications. Due to properties of composites, they can have tailor made properties. In future the composite materials will increase their contribution in developments in engineering applications.

References:

a. Text books
1. M.Mukopadyaya "Mechanics of composite materials and structures "
2. Robert M.Jones " Mecahnics of composite materials"
3. D. Hull , T W Clyne " An introduction to compost material "
4. I. Nishizaki, T, Kishima and I. Sasaki "DETERIORATION OF MECHANICAL PROPERTIES OF PULTRUDED FRP THROUGH EXPOSURE TESTS"
5. Aveston J., Greenwood W.J. and Sillwood J.M., "Long Term Strength of Glass Fibre/Phenolic Resin Composites", National Physical Laboratory Report DMA (A) 98, February 1985.

Applications of Fiber reinforced composite materials

A composite material is defined as a material system which consists of a mixture or a combination of two or more distinctly differing materials which are insoluble in each other and differ in form or chemical composition.

Mainly they consists of Fibers and resin, Fiber is a reinforcing material and resin is a binding agent, other constituents like coupling agents , coatings and fillers are also used to fabricate the composite materials.

Glass + Polyester = G R P
Strength + Chemical resistance = Strong and chemical resistance
The unique property is that
Glass + Polyester = GRP
Brittle + Brittle = tough

To fabricate the carbon composites, the carbon fibers are available in tows, fabrics, chapped forms. We get them the carbon fibers by vapors by cracking the hydrocarbon vapors. The conventional materials can't withstand the higher temperatures, but CCC can with stand temperatures up to 3000 ^{0} C.

PMC = Polymer Metal composite materials can withstand up to 350 ^{0} C.
MMC = Metal Matrix composite materials can withstand up to 800 ^{0} C.
CMC = Ceramic Metal composite materials can withstand up to 1200 ^{0} C.
UHTC = can withstand up to 2800 ^{0} C.
CCC = Carbon- carbon composite materials can withstand up to 3000 ^{0} C.

The advantages of CCC are

1. High thermal integral structure
2. Thermal shock resistance
3. Shape stability
4. Light weight.
5. Stable frictional coefficient.

Fibers: Fibers are most important constituents of a fiber reinforced composite material. They also occupy the largest volume fraction of the composite material. Reinforcing fibers they take only the tensile load. Fibers have strong molecular or crystallographic alignment; they have low density and have high tensile strength

Matrix: The fibers are bounded together by the matrix, polymeric matrix. This enables the fiber to take the compressive, flexural or shear loads. The polymeric matrix is of two types, one is thermo plastic other is thermo set.

Thermoplastics are those which are softened by application of heat, they can be reshaped any number of times as we apply heat.

Thermo set polymers are those, which can be hardened by application of heat and they can't get or change the shape by re heating.

Types of fibers:

1. Glass fibers
2. Carbon / graphite
3. Kevlar
4. Boron
5. Quartz
6. Silica
7. Spectra
8. Vegetable based fibers (Flax, coir, sisal, banana, palm, hemp etc)

Glass fibers: This is the most common type of fiber generally used. The main advantage of this fiber is that they are of low cost, high tensile strength, excellent insulating properties. Among disadvantages they have low tensile modulus, high specific gravity, and high decree of hardness and reduction of tensile strength due to abrasion during handling. Moisture decreases the glass fiber strength; they can't withstand the loads for long time.

Types of Glass fibers:

E -glass: The name is given to it because of its excellent electrical and weathering properties, it is cheap, has good strength, S – Glass: The name is given to it because of its strength, it is costly 20 – 30 times costlier then the E glass and its tensile strength is 33% greater than E glass, Modulus of elasticity is 205 higher than E glass

1. High strength to weight ratio
2. Superior strength relations at elevated temperatures
3. High fatigue limit

   IT is used in

   1. Aerospace components

C – Glass: C stands for corrosion resistance, better resistance to corrosion than E – glass but higher strength, young's modulus and temperature resistance

Organic fibers:

Du Pont has developed high modulus polymer fibers from aromatic polyamide , named as aramid fibers and trade name is Kevelar, Aramid fibers are highly anisotropic and because of the weak inter-chain bonding, they split into much finer fibril and micro fibril.

There is a wide range of natural organic fibers which are potentially useful as reinforcement. The most common natural fiber is cellulose, which formed by the polymerization of glucose molecules. The most common natural composite is timber, which is essentially composed of crystalline cellulose fibers in a matrix of amorphous or partially crystalline hemi cellulose and lignin. These are arranged in various complex configurations in the cell walls of different plants.

Carbon fibers :

Carbon fibers, which are typically about 8 microns diameter, consists of small crystallites of "turbostrtic" graphite, one of the allotropic form of carbon. Turbostratic graphite closely resembles graphite

Glass + Polyester = G R P
Strength + Chemical resistance = Strong and chemical resistance
The unique property is that
Glass + Polyester = GRP
Brittle + Brittle = tough
The glass epoxy composites have

1. Corrosion resistance
2. Structural integrity
3. Efficiency
4. High strength to weight ratio
5. Improved aerodynamic