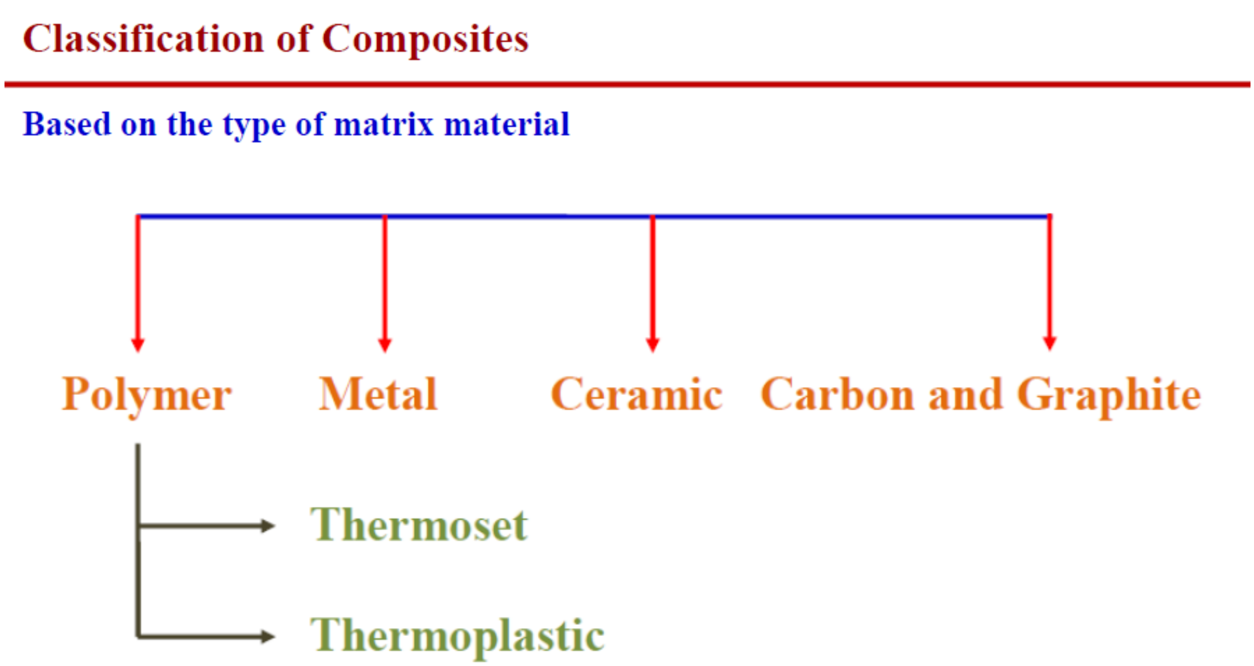
SHAMBHUNATH INSTITUTE OF ENGINEERING AND TECHNOLOGY
Subject: Composite Materials Subject Code: RME 070
B.Tech. – SEMESTER-VII
FIRST SESSIONAL EXAMINATION, ODD SEMESTER, (2019-20)
Branch: Mechanical Engineering

SOLUTION

SECTION - A

Q1.

a) Classify composite materials.



b) Classify natural fibers.

Types of Fibres

2. Natural Fibres:

a) Animal fibres

i) Silk	ii) Wool	iii) Spider silk
iv) Sinew	v) Camel hair	vi)

b) Vegetable fibres

i) Cotton	ii) Jute	iii) Bamboo
iv) Sisal	v) Maze	vi) Hemp
vii) Sugarcane	viii) Banana	ix) Ramie
x) Kapok	xi) Coir	xii) Abaca
xii) Kenaf	xiv) Flax	xv) Raffia palm…………..

c) Write down the different grades of glass fibers.

Ans: Types and forms of fiberglass:

Ans: Depending on the raw materials used and their proportions to make fiberglass, fiberglass can be classified into following major types:

- **A-glass**: A glass is also called as alkali glass and is resistant to chemicals. Due to the composition of A glass fiber, it is close to window glass. In some parts of the world, it is used to make process equipment.
- **C-glass**: C-glass offers very good resistance to chemical impact and is also called as chemical glass.
- **E-glass**: It is also called as electrical glass and is a very good insulator of electricity.
- **AE-glass**: This is alkali resistant glass.
- **S glass**: It is also called as structural glass and is known for its mechanical properties.

Properties of fiberglass

- **Mechanical strength**: Fiberglass has a specific resistance greater than steel. So, it is used to make high-performance
- **Electrical characteristics**: Fiberglass is a good electrical insulator even at low thickness.
- **Incombustibility**: Since fiberglass is a mineral material, it is naturally incombustible. It does not propagate or support a flame. It does not emit smoke or toxic products when exposed to heat.
- **Dimensional stability**: Fiberglass is not sensitive to variations in temperature and hygrometry. It has a low coefficient of linear expansion.
- **Compatibility with organic matrices**: Fiberglass can have varying sizes and has the ability to combine with many synthetic resins and certain mineral matrices like cement.

- **Non-rotting**: Fiberglass does not rot and remains unaffected by the action of rodents and insects.
- **Thermal conductivity**: Fiberglass has low thermal conductivity making it highly useful in the building industry.
- **Dielectric permeability**: This property of fiberglass makes it suitable for electromagnetic windows.

d) Explain viscoelasticity.
Ans: Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Synthetic polymers, wood, and human tissue, as well as metals at high temperature, display significant viscoelastic effects. In some applications, even a small viscoelastic response can be significant.

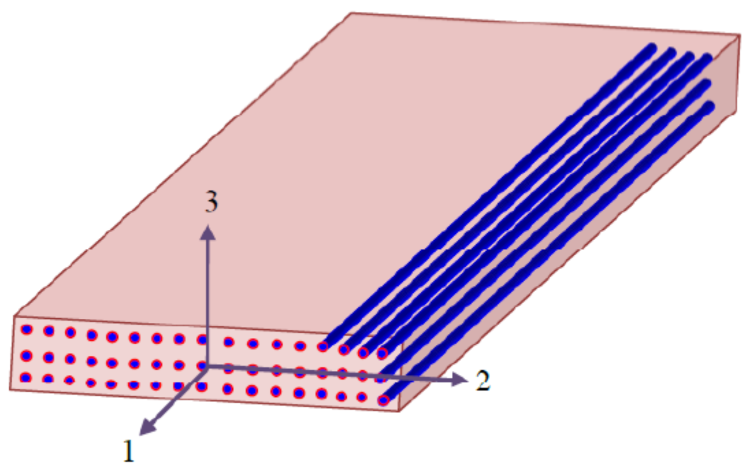
e) Explain the term "laminates".
Ans:

Layered composites:

Layer
Lamina **any of the term is used**
Ply

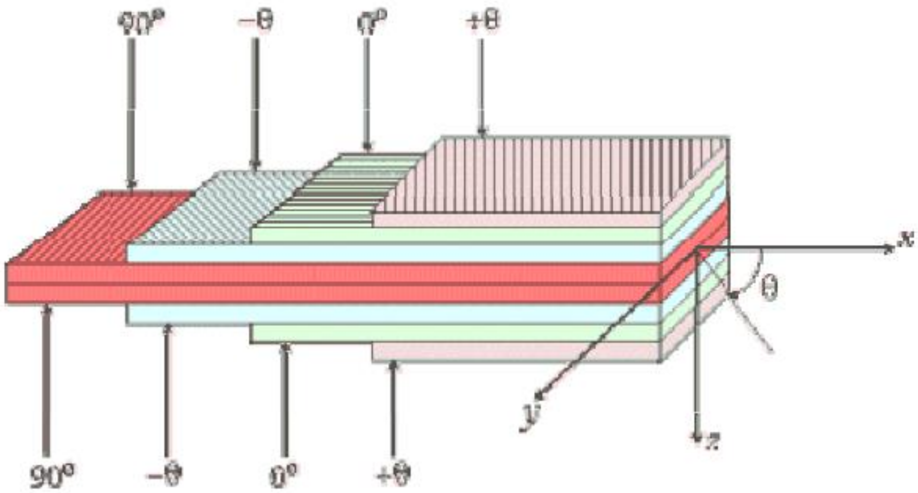
Axial – along fibre length (1)

Transverse – perpendicular to fibre length
2 – in-plane transverse
3 – out of plane transverse



Layered composites:

Laminate



SECTION - B

Q 2) Attempt any TWO parts from this section.

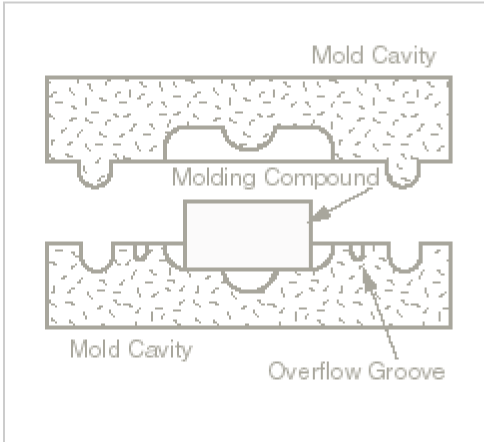
a. How composite material is different from conventional materials?

Ans: The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be moulded into complex shapes. The downside is often the cost. Although the resulting product is more efficient, the raw materials are often expensive.

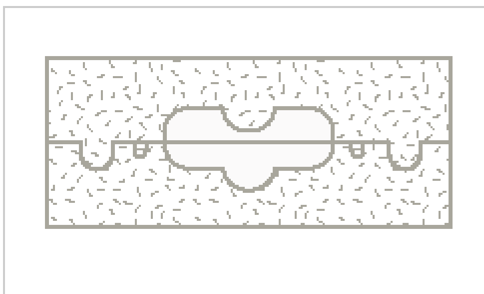
b. Explain compression molding process giving neat sketch.

Ans:

- Compression molding is one of the oldest processing methods for manufacturing plastic parts developed at the very beginning of the plastics industry. It is applicable to thermoplastics, compression molding is commonly used in manufacturing thermoset plastic parts.
- The raw materials for compression molding are usually in the form of granules, putty-like masses, or preforms. They are first placed in an open, heated mold cavity. The mold is then closed and pressure is applied to force the material to fill up the cavity.
- A hydraulic ram is often utilized to produce sufficient force during the molding process. The heat and pressure are maintained until the plastic material is cured.



Molding compound is placed in an open, heated mold cavity.



The mold is closed and pressure is then applied to force the material to fill up the entire mold cavity. Excess material is channelled away by the overflow grooves. The heat and pressure are maintained until the plastic material is cured.

The final part after the mold is removed.

There are two different types of compounds most frequently used in compression molding: Bulk Molding Compound (BMC) and Sheet Molding Compound (SMC).

- Compression molding is commonly used for manufacturing electrical parts, flatware, gears, buttons, buckles, knobs, handles, electronic device cases, appliance housing, and large container.
- Common plastics used in compression molding processes include
  - Polyester
  - Polyimide (PI)
  - Polyamide-imide (PAI)
  - Polyphenylene Sulphide (PPS)

- Polyetheretherketone (PEEK)
- Fiber reinforced plastics

There are four primary factors in a successful compression molding process:

- Amount of material
- Heating time and technique
- Force applied to the mold
- Cooling time and technique

Pros and Cons of Compression Molding

Pros

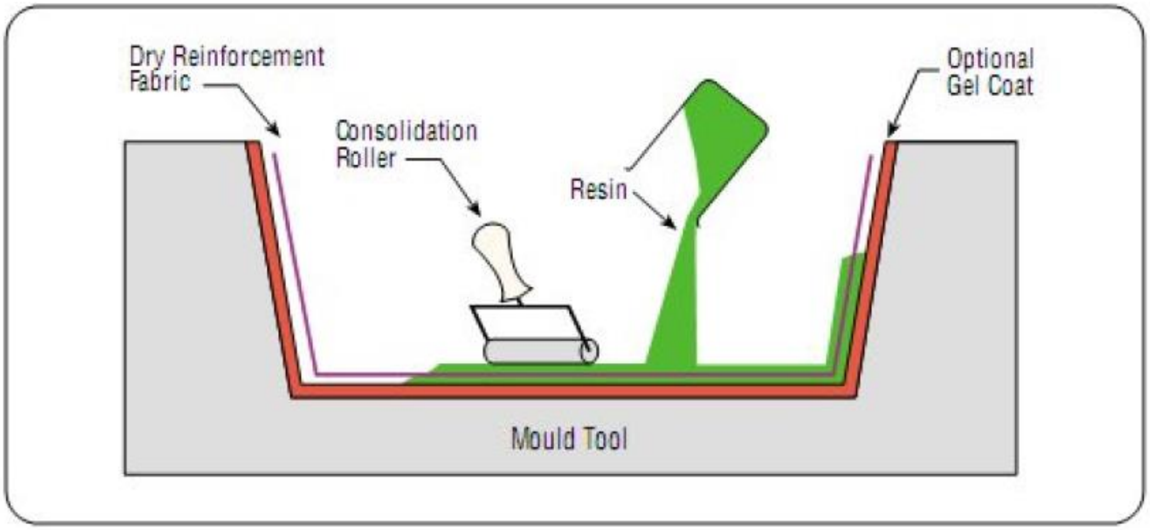
- Low initial setup costs
- Fast setup time
- Capable of large size parts beyond the capacity of extrusion techniques
- Allows intricate parts
- Good surface finish (in general)
- Wastes relatively little material
- Can apply to composite thermoplastics with unidirectional tapes, woven fabrics, randomly orientated fiber mat or chopped strand
- Compression molding produces fewer knit lines and less fiber-length degradation than injection molding.

Cons

- Production speed is not up to injection molding standards
- Limited largely to flat or moderately curved parts with no undercuts
- Less-than-ideal product consistency

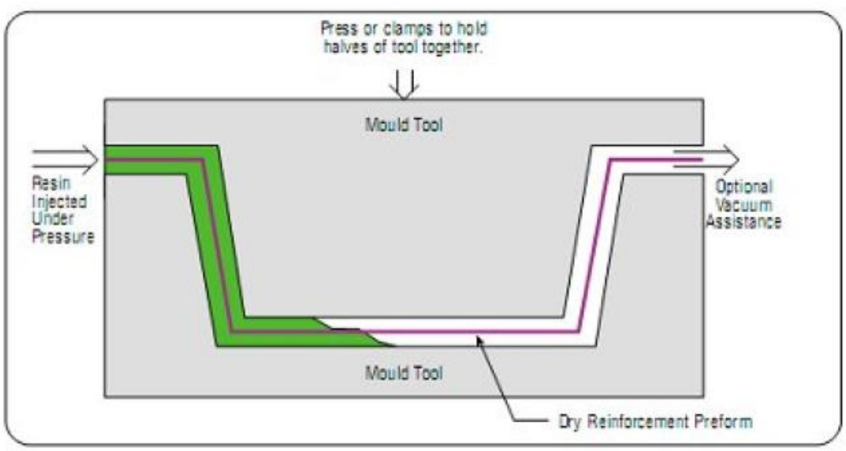
c. Write short notes on Hand layup technique and RTM process.
Ans:

• Wet/Hand Lay-Up



Fabrication Processes of Fibrous Composites

• Resin Transfer Moulding (RTM)



d) Differentiate between thermoset and thermoplastic.

Ans:

Difference Between Thermoplastic and Thermosetting Plastic

Thermoplastic	Thermosetting Plastic
Thermoplastic can be synthesized by the process called addition polymerization.	Thermosetting plastics are synthesized by condensation polymerization.
Thermoplastic is processed by injection moulding, extrusion process, blow moulding, thermoforming process, and rotational moulding.	Thermosetting Plastic is processed by compression moulding, reaction injection moulding.
Thermoplastics have secondary bonds between molecular chains.	Thermosetting plastics have primary bonds between molecular chains and held together by strong cross-links.
Thermoplastics have low melting points and low tensile strength.	Thermosetting plastics have high melting points and tensile strength.
Thermoplastic is lower in molecular weight, compared to thermosetting plastic.	Thermosetting Plastic is high in molecular weight.

These are some of the differences between thermoplastic and thermosetting plastic. Some examples of thermoplastics are listed below.

- Polystyrene
- Teflon
- Acrylic
- Nylon

Examples of thermosetting polymers include:

- Vulcanized rubber
- Bakelite
- Polyurethane
- Epoxy resin
- Vinyl ester resin

SECTION - C

Q 3.
a) What is a role of matrix and reinforcement in the composite materials?
1. Holds the fibres together
2. Protects the fibres from environment
3. Protects the fibres from abrasion (with each other)
4. Helps to maintain the distribution of fibres

5. Distributes the loads evenly between fibres
6. Provides better finish to final product

Functions of fibres:

1. The fibres carry the load to an extent of 65% to 90% in case of structural composites.
2. Reinforced fibres provide stiffness, strength and thermal stability to the composite.
3. Reinforced fibres may provide the electrical insulation and conductivity depending on the fibre type used.

b) Compare synthetic fiber with natural fibers. Give examples also.
Ans:

Difference between Natural and Synthetic fibres	
NATURAL FIBRES	**SYNTHETIC FIBRES**
Comes from nature	Man made fibres
Natural color	Color as per requirement is added in color bath
During spinning process spinneret is not necessary	During spinning process spinneret is necessary for the production of filament
Chances of containing dust or impurities	No chance of any dust or impurities
Less durable than synthetic	More durable than natural

4. Attempt any ONE part of the following.
a) Write down various types of matrices and their properties.
Ans: Polymer-matrix composites (PMCs) consist of a polymer resin as the matrix, with fibers as the reinforcement medium. These materials are used in the greatest diversity of composite applications, as well as in the largest quantities, in light of their room-temperature properties, ease of fabrication, and cost.
As the name implies, for metal-matrix composites (MMCs) the matrix is a ductile metal. These materials may be utilized at higher service temperatures than their base metal counterparts; furthermore, the reinforcement may improve specific stiffness, specific strength, abrasion resistance, creep resistance, thermal conductivity, and dimensional stability. Some of the advantages of these materials over the polymer-matrix composites include higher operating temperatures, nonflammability, and greater resistance to degradation by organic fluids. Metal-matrix composites are much more expensive than PMCs, and, therefore, their (MMC) use is somewhat restricted.

Ceramic materials are inherently resilient to oxidation and deterioration at elevated temperatures; were it not for their disposition to brittle fracture, some of these materials would be ideal candidates for use in high-temperature and severe-stress applications, specifically for components in automobile and aircraft gas turbine engines. Fracture toughness values for ceramic materials is low. The fracture toughnesses of ceramics have been improved significantly by the development of a new generation of ceramic-matrix composites (CMCs)— particulates, fibers, or whiskers of one ceramic material that have been embedded into a matrix of another ceramic.

b) Why composites exhibit superior strength in comparison to conventional materials? Discuss the mechanism of fatigue failure in composites.

Ans: Composites unite many of the best qualities that traditional materials have to offer. The two components of a composite include a reinforcement (often a high-performance fiber such as carbon or glass) and a matrix (such as epoxy polymer). The matrix binds the reinforcement together to merge the benefits of both original components.

Composites are improving the design process and end products across industries, from aerospace to renewable energy. Each year, composites continue to replace traditional materials like steel and aluminum. As composite costs come down and design flexibility improves, fiber-reinforced composites like carbon fiber and fiberglass open up new design opportunities for engineers.

1. Composites have a high strength-to-weight ratio.

2. Composites are durable.

3. Composites open up new design options.

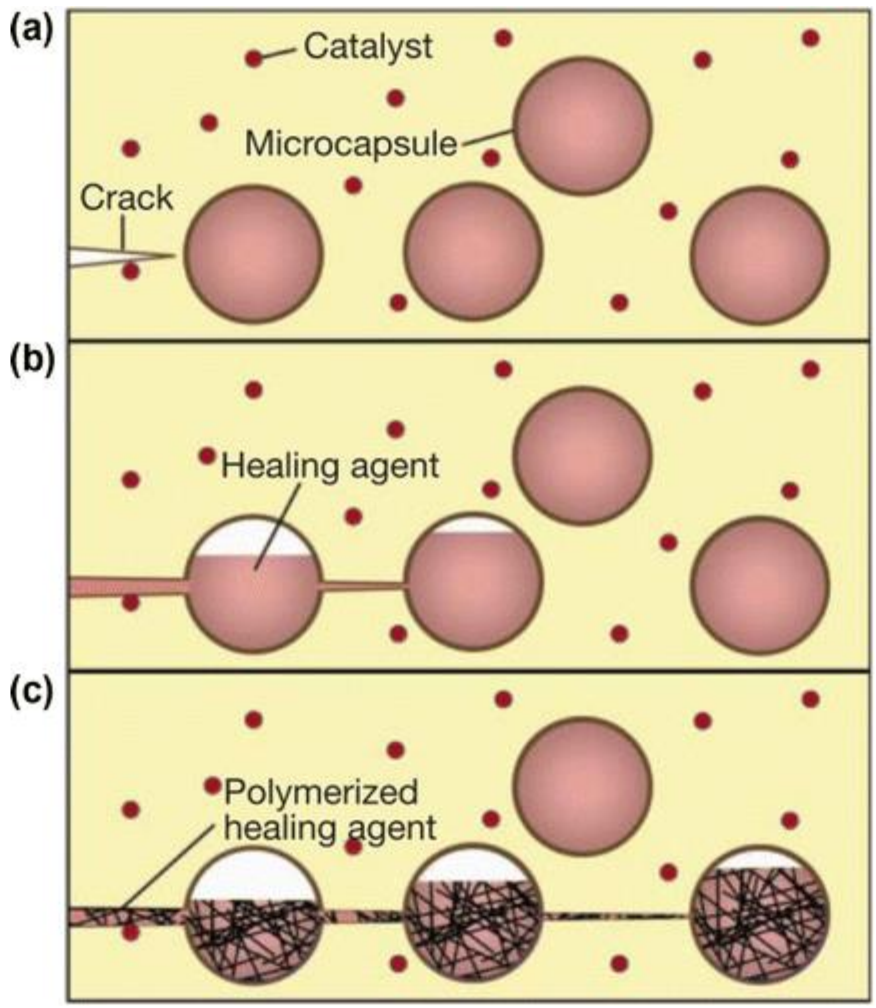
4. Composites are now easier to produce.

5.

a) Explain the healing mechanism involved in self repairing composites.

Ans: For centuries, man has been searching for and creating tougher and more durable structural materials. However, from the perspective of other natural creatures, protection and defense are not fulfilled only by their hard coats or shells, but also adaptively as in the healing of the human skin and the regeneration of the lizard’s tail. Inspired by this design, intelligent material systems defined as self-healing composites have been developed. They are capable of automatic recovery and adaptation to environmental changes in a dynamic manner, unlike traditional tough and static composites. Through self-healing, it is expected that safety and reliability will improve, the cost of maintaining artificial composites will decrease and material life will be extended. This area has rapidly developed for more than a decade and seen a number of significant achievements.

Current self-healing composites can be categorized into three groups: capsule-based, vascular and intrinsic self-healing materials. In capsule-based self-healing materials, small capsules containing a liquid able to fill and close cracks are embedded under the material surface. When the material is damaged, cracks cause some capsules to rupture, releasing the liquid and closing the gap. For vascular self-healing materials, the capsules are replaced by a vascular structure similar to a tunnel network, in which various functional liquids flow. These functional liquids will also fill the gap when a crack occurs and breaks the vascular network. The material contained inside a capsule or a vascular network is called a healing agent. The mechanism and behavior of healing agents are fundamental to the recovery process and restoration of mechanical properties. Intrinsic self-healing materials heal through inherent reversibility of chemical or physical bonding instead of structure design. Consequently, the healing mechanisms of intrinsic self-healing materials are fundamentally different from those of capsule-based and vascular self-healing composites.



b) Discuss about C-C composites.

Ans: The most important class of properties of carbon-carbon composites is their thermal properties. C-C composites have very low thermal expansion coefficients, making them dimensionally stable at a wide range of temperatures, and they have high thermal conductivity. C-C composites retain mechanical properties even at temperatures (in non-oxidizing atmospheres) above 2000°C. They are also highly resistant to thermal shock, or fracture due to rapid and extreme changes in temperature. The material properties of a carbon-carbon composite vary depending on the fiber fraction, fiber type selected, textile weave type and similar factors, and the individual properties of the fibers and matrix material. Fiber properties depend on precursor material, production process, degree of graphitization and orientation, etc. The tensioning step in fiber formation is critical in making a fiber (and therefore a composite) with any useful strength at all. Matrix precursor material and manufacturing method have a significant impact on composite strength. Sufficient and uniform densification is necessary for a strong composite. Generally, the elastic modulus is very high, from 15-20GPa for composites made with a 3D fiber felt to 150-200GPa for those made with unidirectional fiber sheet. Other properties include low-weight, high abrasion resistance, high electrical conductivity, non-brittle failure, and resistance to biological rejection and chemical corrosion. Carbon-carbon composites are very workable, and can be formed into complex shapes.

Shortcomings

The chief drawback of carbon-carbon composites is that they oxidize readily at temperatures between 600-700°C, especially in the presence of atomic oxygen. A protective coating (usually silicon carbide) must be applied to prevent high-temperature oxidation, adding an additional manufacturing step and additional cost to the production process. The high electrical conductivity of airborne graphite particles creates an unhealthy environment for electrical equipment near machining areas. Carbon-carbon composites are currently very expensive and complicated to produce, which limits their use mostly to aerospace and defense applications.