ISBN: 978-81-972400-4-1

1. Significance of Composite Materials for Making Better Future Society

S. Chitradevi

Professor in Chemistry,
DMI College of Engineering,
Palanchur, Chennai.

S. Ravichandran

Professor in Chemistry,
Lovely Professional University,
Jalandhar, Punjab.

Karandeep Kaur

Assistant Professor,
Department of Computer Science Engineering,
Lovely Professional University,
Jalandhar, Punjab.

Pooja

Student, B.Tech. Aerospace Engineering,
School of Mechanical Engineering, Lovely Professional University,
Jalandhar, Punjab.

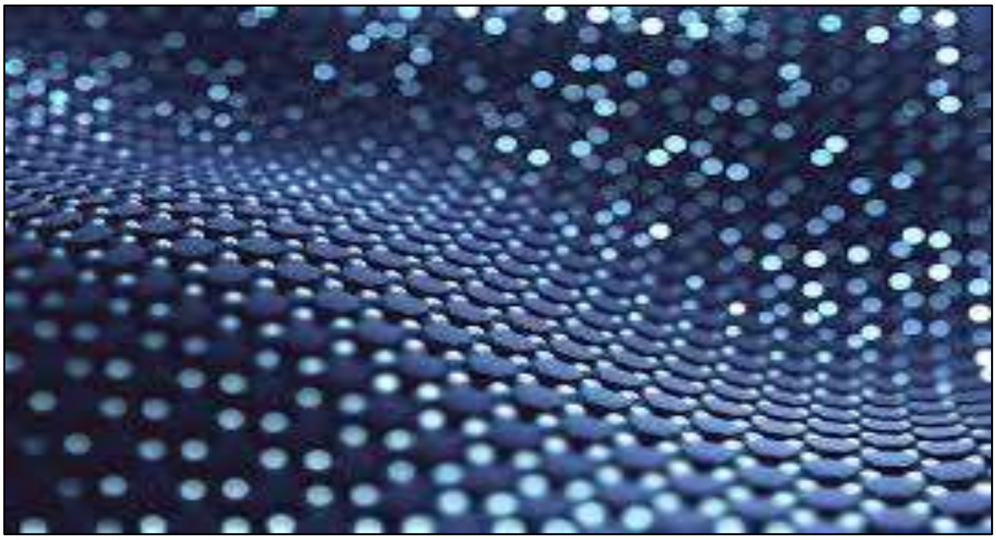

Figure 1.1: Composites

Abstract:

Since in the beginning of human history, Materials had been started in use. We can't imagine our world without materials. In fact, Materials has taken centre position in many developed and developing countries. Man's choice of materials for his engineering activities on earth like the Stone age, the Iron age and the present Silicon age, etc. But the challenges of today the need of discovery and development of new kinds of materials with the desired properties and the reasonable cost to meet the challenges. Materials may be used for the construction of a building, manufacturing of a machine, generation of electricity, transmission of message from one place to another or control instruments. These materials are of different natures like cement concrete, iron, copper, aluminium, mica, rubber, alloy and glass etc. The knowledge of materials and their properties is of great significance for a design skill engineer. The machine parts should be made of such a material which has properties suitable for the conditions of operation. In addition to this, a design engineer must be familiar with the effects which the manufacturing processes.

Thus, engineering materials encompass a broad range of substances used in various industries for construction, manufacturing and other applications. Metals, such as steel and aluminum are known for their high strength and conductivity. Polymers, including plastics and rubbers, provides flexibility, lightweight and corrosion resistance, making them perfect in packaging, automotive parts and consumer goods. Composite materials came to existence in 1992 due to their improved specific mechanical properties and industry demand for high performance for construction. Many composite materials can be found in nature; for example, wood is a fibrous natural composite (cellulose fibre in lignin matrix). Another example of a natural composite is bone. Composite materials are preferred as these are stronger, lighter or less expensive when compared to individual materials. Due to these reasons, composite materials are replacing individual materials in the engineering and construction applications. The use of composite almost in all fields which includes medical, electrical, aerospace, defence, transport, communication, military, sports etc., In this paper a review is being carried out on composite materials their classification and their importance in current world.

Keywords:

Material, advancement, engineering, importance, composites.

1.1 Introduction:

Materials are more significant in our culture than we realize. Materials have contributed to the advancement of a number of technologies, including medicine, health, information, communication, space, transportation, textiles, agriculture, food science and the environment. Engineering Materials including metals, polymers, ceramics, and composites can be defined as the substances used in various fields of engineering for the construction of structures, machines, tools and other applications. These materials possess specific mechanical, thermal, electrical and chemical properties in order to meet the requirements of different engineering application. Common engineering materials include metals, polymers, ceramics, composites (Figure 1.1). Engineering Materials plays a crucial role in various industries including automotive, aerospace, construction, electronics, biomedical and more.

They are used for structural components, electrical conductivity, thermal insulation, corrosion resistance, and various specialized purposes tailored to specific requirements of each application[1-18]. a composite material is a multi-phase system made up of a matrix material and reinforcing material. When two or more different materials are combined, the result is a "composite.

A composite has a matrix that is polymeric, metallic and ceramic. The term "matrix material" refers to a continuous phase made up of various matrix materials, such as polymer matrix composites, metal matrix composites, and inorganic non-metallic matrix composites.

Composite materials consist of a combination of materials that are mixed together to achieve specific structural properties.

The individual materials do not dissolve or merge completely in the composite, but they act together as one. Normally, the components can be physically identified as they interface with one another. The properties of the composite material are superior to the properties of the individual materials from which it is constructed.

1.2 Uses of Materials:

- **Construction**: Metals like steel and aluminum are used for structural support. Ceramics and polymers are used for tiles, pipes and insulation.
- **Automotive**: Metal such as steel and aluminum are used for body panels. Polymers are used for interior components and bumpers.
- **Aerospace**: Materials like titanium and carbon fiber composites are used for aircraft components to reduce weight and improve fuel efficiency.
- **Electronics**: Semiconductors such as silicon are essential for integrated circuits. Ceramics are used for insulating components, while metals like copper and gold are used for wiring.
- **Medica**l: Materials like titanium is used in medical implants. Ceramics are used for dental implants and bone grafts.
- **Energy**: Metals like copper and aluminum are used for transmission and distribution of electricity.
- **Consumer goods**: Polymers are widely used in consumer goods such as packaging, household appliances and toys due to their versatility and low cost.
- **Defence**: Composites are used in the manufacturing of military vehicles and aircraft to provide protection and durability.
- **Environmental engineering**: Materials like recycled plastics and sustainable composites are used in eco-friendly construction and packaging to reduce environmental impact.
- **Sports**: Lightweight materials like carbon fiber composites are used in sports equipment such as bicycles and tennis rackets to improve performance.

1.3 Properties of Materials:

The mechanical properties of the metals are those which are associated with the ability of the material to resist mechanical forces and load. We shall now discuss these properties as follows:

- **Strength**: It is the ability of a material to resist the externally applied forces without breaking.
- **Stiffness**: It is the ability of a material to resist deformation under stress. The modulus ofelasticity is the measure of stiffness.
- **Elasticity**: It is the property of a material to regain its original shape. This property is desirable for materials used in tools and machines.
- **Plasticity**: It is property of a material which retains the deformation produced under load permanently. This property of the material is necessary for forgings, in stamping images on coins and in ornamental work.
- **Ductility**: It is the property of a material enabling it to be drawn into wire with the application of a tensile force. A ductile material must be both strong and plastic.
- **Tensile Strength:** This enables the material to resist the application of a tensile force.
- **Hardness:** It is the degree of resistance to scratching, abrasion and wear. Alloying techniques and heat treatment help to achieve the same.
- **Corrosion Resistance:** Those metals and alloys which can withstand the corrosive action of a medium.
- **Thermal properties:** of solids can be represented in terms of heat capacity and thermal conductivity; the characteristics of a material. These properties play a vital role in selection of material for engineering applications, e.g. when materials are considered for high temperature service. Now, we briefly discuss few of these properties:
- **Electrical Properties**: Electrical conductivity, resistivity are few important electrical properties of a material. A material which offers little resistance to the passage of an electric current is said to be a good conductor ofelectricity. In general metals are good conductors.

Composites are mixtures of two or more types of materials.

The constituent elements in a composite retain their identities while providing a host of benefits such as light weight, high strength, corrosion resistant, high strength-to-weight ratio, directional strength - tailor mechanical properties, high impact strength, high electric strength (insulator), radar transparent, non-magnetic, low maintenance, long-term durability, parts consolidation, dimensional stability, rapid installation.

Usually, they consist of a matrix phaseand a reinforcing phase.

They are designed to ensure a combination of the best properties of each of the component materials. There is also an increasing trend to classify engineering materials into two further categories: structural materials and functional materials.

Structural materials, as the name indicates, are materials used to build structures, bodies and components. For instance, in a car the body,frame, wheels, seats, inside lining, engine and various mechanical transmission parts are all constructed from structural materials.

Composite materials are used in reconstructions and healings of tissues. The demand for the human tissues and organsreplacement has risen to considerable extent nowadays. (Figure 1.2).

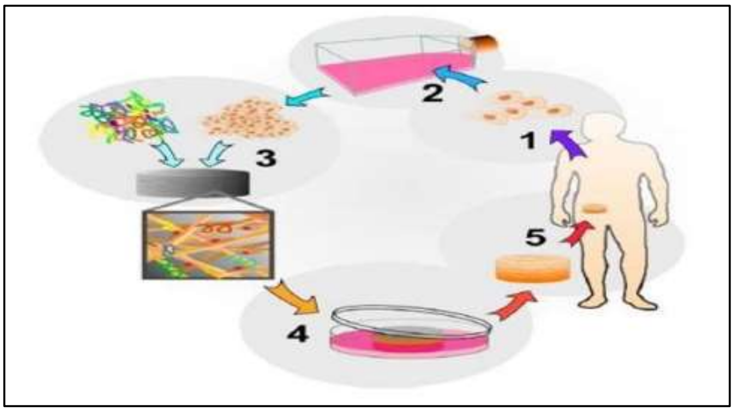

Figure 1.2: Composite Used in Tissue Engineering.

1.4 Applications of Composites:

- Automobiles industries: Automobile parts like components of engine, spray nozzle, mud guards,tires etc.
- Aeronautical applications: structural components like wings, body & stabilizer and fuel of aircraft,rocket army missiles in military etc.
- Marine applications: shaft, hulls, spars and other part of ships
- Safety equipment like helmets
- Sport equipment like tennis rockets, golf sticks, other safety equipment
- Communication Industry like preparation of antennae and electronic circuit boards

Constituents of Composites:

Two essential constituents of composites are:

- **Matrix phase**: It is the continuous body constituent (Dispersion phase) which encloses the compositeand gives its bulk form. It may be polymer, metal or ceramic material.
- **Dispersed phase**: It is the Structural constituent (Dispersed phase) which determines internal structure of the composite and gives its bulk form. It may be Fiber, Particulate, Flakes or Whiskers

Composite materials are mainly classified depending upon the type of the reinforcement and the type of the matrix used.

1.4.1 Types of Composites:

Based on the dispersed phase in the given matrix of composite they are classified as

A. Fiber reinforced Composite
B. Particulate Composite
C. Structural Composite

A. Fiber Reinforced Composite:

- It is Consist of dispersed phase fiber and a continuous or dispersion phase polymer or metal or metal alloy with a bonding agent. The fiber can be employed in the form of continuous length, staples or whiskers.
- Such composites possess high specific strength, specific modulus, stiffness, corrosion resistance and lowers density.

Some important types of Fiber reinforced composites are.

a. Glass Fiber Reinforced Polymer Composite:

Fiber glass reinforced composites can be produced by properly incorporating the continuous or discontinuous glass fibers with in a plastic matrix. Polyesters are most commonly used matrix material. most recently nylons are it is the most popular fiber reinforcement material due to Easily available, easily fabricated, highlyeconomical and which provides stiffness, strength, impact resistance and resistance to corrosion and chemicals.

Applications: Automobile parts, storage tanks and plastic pipes etc.

b. **Carbon Fiber Reinforced Polymer Composites:** Carbon fibers like (graphite or carbon nano tubes) dispersed in the polymer matrix. They provide excellent resistance to corrosion, lighter density, retention of desired properties even at elevated temperatures.

Applications: Structural components of aircraft like wings and bodies, sport equipment, fishing rods etc.

c. **Alumina Oxide Reinforced Metal Composites:** Fibers of alumina or carbon dispersed in metal or metal alloy matrix which possess improved specific strength. stiffness, wear resistance**,** creep resistance and resistance to thermal distortion etc.

Ex:1. Fiber Al_2O_3 / carbon in a matrix metal alloy find applications in the preparation of components of automobile engines.

Ex.2. Fiber Al_2O_3 in a matrix of Ni or Co based alloy find applications in the preparation of components of turbine engines.

B. Particulate Composite:

The solid particulates of metal oxides or carbides of varying size and form dispersed in metal, metal alloy, ceramic or polymer liquid matrix.

Particle reinforced composites are further classified into the following two types.

a. Large -particulate composites b . Dispersion strengthened composites

a. Large -particulate composites:

Large particle composite used with all the three major types of materials, namely metals, polymer and ceramics.

Example:

- concrete which is composed of cement matrix and particulates of sand and gravel.
- Automobile tire in which Carbon black particles dispersed in rubber matrix.

b. Dispersion strengthened composites:

Very small particles of the range 10-100nm size are used in this which improve strength and hardness. Metals and Metal alloys may be hardened and strengthened by the uniform dispersion of high-volume percent of very hard and inert materials, the strength is achieved due to interactions between particle and dislocations within the matrix.

C. Structural Composites:

Structural composites are prepared by Compressing the stacking of layers of fiber reinforce composites.

These are of two types a. Laminated composites b. Sandwich composites.

a. Laminated Composites:

A Laminar composite consists of two-dimensional sheets or panels that have preferred high- strength direction, successive oriented fiber reinforced layers of these are stacked and then cemented together in such a way that the orientation of the high strength varies with eachsuccessive layer.

Example: Plywood, Copper bottom steel articles2,

Sandwich panels: These usually consist of two strong outer sheets called faces, separated by a layer of less densematerial.

Challenges and Opportunities of Engineering Materials:

Development of new materials has followed a number of different pathways, depending on both the nature of the problem being pursued and the means of investigation. Breakthroughs in the discovery of new materials have ranged from pure serendipity approaches to design by analogy to existing systems. These methodologies will remain important in the development of materials but as the challenges and requirements for new materials become more complex, the need to design anddevelop new materials from the molecular scale through the macroscopic final product will become increasingly important.

In spite of the tremendous progress made in the field of material science within the past few years, there still remains technological challenges, including the development of more sophisticated and specialized materials, as well as the impact of materials production on ecosystem. Furthermore, there is an urgent need to find new, economical sources of energy and to make use of present energy resources more economically. Hydrogen seems to be the fuel of the future. Hydrogen offers the greatest potential environment and energy supply benefits. Like electricity, hydrogen is a versatile energy carrier that can be made from a variety of widely available primary energy sources including natural gas, coal, biomass, wastes, sunlight, wind, and nuclear power. Although hydrogen production techniques do exist, further optimization is desirable for use in energy systems with zero carbon emissions. Materials will undoubtedly play a significant role in these developments; we know that environment quality depends on our ability to control air and water pollution. Pollution control techniques employ various materials. There is a need to improve material processing and refinement methods so that they produce less environmental degradation.

1.5 Conclusion:

Engineering materials always continue to play a significant role in the current and upcoming future world. The relevant factors that will influence this are economic/cost, environmental requirements, development trends, depletion of traditional materials, advances in research and market drives, etc. The importance of engineering materials is in every aspect of life, therefore, need to be over emphasized. We ourselves are materials and so also is everything around us; to stop talking of and working with materials is to foreclose the essence of life existence. So, a bright future is that of even more sophisticated, better and cost-effective materials. Materials Science, Technology and Engineering of Materials has the capability of solving problems in different sectors of life and the economy. Therefore, smart nations are quickly creating areas for themselves by developing materials of both comparative and competitive advantage as required. Composites have attractive mechanical and physical properties that are now being utilized in automotive industry and aerospace on a grand scale world-wide. New fibers, polymers, and processing techniques for all classes of composites are constantly being developed. Research is also ongoing to improve repair techniques, recyclability, and the bonding between fibres and matrix materials.

1.6 References:

1. Ashby, M. F. and D. R. H. Jones (2005). Engineering Materials 1: An Introduction to Their Properties and Applications, 3rd edition, Butterworth- Heinemann, Woburn, UK.
2. Ashby, M. F. and D. R. H. Jones, Engineering Materials 2: An Introduction to Microstructures, Processing and Design, 3rd edition, Butterworth- Heinemann, Woburn, UK, 2005.
3. Flinn, R. A. and P. K. Trojan (1994). Engineering Materials and Their Applications, 4th edition, John Wiley & Sons, New York.
4. Jacobs, J. A. and T. F. Kilduff (2005). Engineering Materials Technology, 5th edition, Prentice Hall PTR, Paramus, NJ.
5. K. M. Ralls, T. H. Courtney, and J. Wulff, Introduction to Materials Science and Engineering, p. 22. Copyright 1976 by John Wiley & Sons, New York. Reprinted by permission of John Wiley & Sons, Inc.)

6. Murray, G. T. (1993) Introduction to Engineering Materials— Behavior, Properties, and Selection, MarcelDekker, Inc., New York.
7. Ralls, K. M., T. H. Courtney, and J. Wulff (1976). Introduction to Materials Science and Engineering, JohnWiley & Sons, New York.
8. Organising Committee for the Workshop on Materials and Manufacturing, Committee on Challenges for the Chemical Sciences in the 21st Century, National Research Council. Materials Science and Technology: Challenges for the Chemical Sciences in the 21st Century by ISBN: 0-309-51684-6, 98 pages, 6 x 9, (2003) Free PDF downloaded from: http://www.nap.edu/catalog/10694.html
9. Schaffer, J. P., A. Saxena, S. D. Antolovich, T. H. Sanders, Jr., and S. B. Warner (1999). The Science and Design of Engineering Materials, 2nd edition, WCB/McGraw-Hill, New York.
10. Sigma-Aldrich (2007). ―Advanced Metals and Alloys Material Matter, Vol. 2, No. 4.
11. Smith, W. F. and J. Hashemi (2006). Principles of Materials Science and Engineering, 4th edition, McGraw-Hill Book Company, New York.
12. Clyne TW, Hull D (1996) An introduction to composite materials. Cambridge university press 2: 1-4.
13. Matthews FL, Rawlings RD (1999) Composite materials: engineering and science. CRC press 20-25.
14. Jones R.M., 1990, Mechanics of Composite Materials, 2e, Mcgraw- Hill Book Company, New York.
15. Johan.W.. Engineers Guide to Composite Materials, American Society for Metals,1986.
16. Sukhwinder Singh Jolly (Nov 2012), "Advancement in composite material and their applications in engineering technology", Global research analysis, 1 (5).
17. Mallick, P. K. 1988. Fiber-Reinforced Composites-Materials, Manufacturing, and Design. New York, NY: Marcel Dekker, Inc.
18. Ranga P., Singha S., and Singh I. (2014), "A Review Paper on Natural Fiber Reinforced Composite," International Journal of Engineering Research & Technology, vol. 3, no. 2, pp. 467–469, 2014.