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Significance of Composite Materials for Making Better Future Society

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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. The materials that humans have chosen to use for engineering projects throughout history, including the Stone, Iron, and Silicon ages. However, in order to meet today's difficulties, new materials must be discovered and developed with the necessary qualities at a cost that is affordable. Materials can be utilized for a variety of tasks, such as building construction, machine manufacturing, electricity production, message transmission, and control devices. These materials come in a variety of forms, including glass, rubber, alloys, mica, iron, copper, and aluminum, as well as cement. The understanding of materials and their characteristics is crucial for an engineer with design skills. These materials come in a variety of forms, including glass, rubber, alloys, mica, iron, copper, and aluminum, as well as cement. The understanding of materials and their characteristics is crucial for an engineer with design skills. The materials used to make machine parts should have qualities appropriate for the operating environment. A design engineer also needs to be aware of the impacts that manufacturing processes have. 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. Nature contains a wide variety of composite materials. Wood, for instance, is a fibrous natural composite made of cellulose fiber in a lignin matrix. Bone is an additional instance of a natural composite. When compared to individual materials, composite materials are stronger, lighter, or less expensive, hence these are selected. These factors have led to the replacement of separate materials in engineering and building applications with composite materials. 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.

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INTRODUCTION

We don't know how important materials are to our civilization. Numerous technologies, including those related to health, information, and communication, textiles, agriculture, food science, space exploration, and the environment, have benefited from the development of materials. 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).

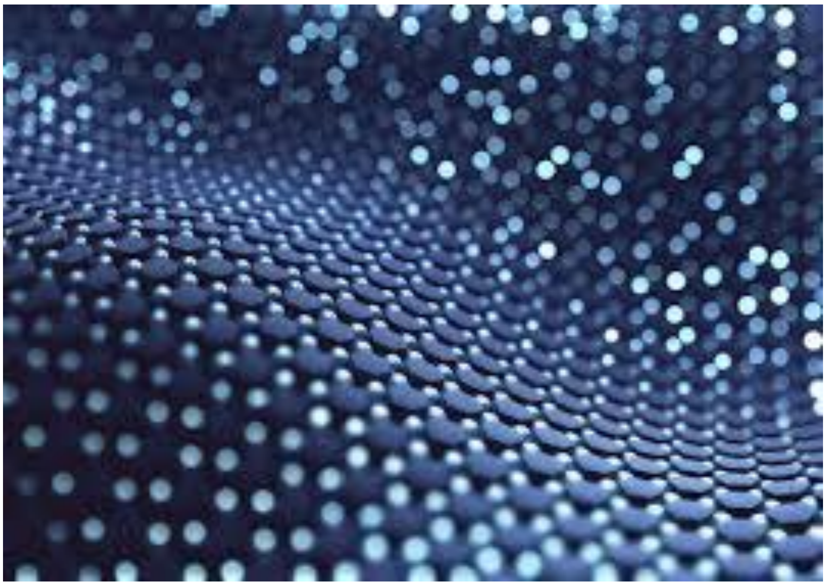

Figure 1. Composites.

Applications for Metals:

- *Construction:* Structural support is provided by metals like steel and aluminum. Pipes, insulation, and tiles are made of ceramics and polymers.
- *Automotive:* Body panels are made of metal, primarily aluminum and steel. Bumpers and interior parts are made of polymers.
- *Aerospace:* The production of integrated circuits and microchips requires macroconductors, such as silicon. Carbon fiber composites are utilized for airplane components to reduce weight and increase fuel efficiency, while ceramics are used for insulation and metals like copper and gold are used for materials like titanium.
- *Medical:* Prosthetics and implants for medical purposes use materials like titanium alloys and certain polymers. Bone grafts and dental implants are made of ceramic.
- *Energy:* To transmit and distribute power, electrical wiring is made of metals like copper and aluminum. Turbine blades are one example of a high-temperature application for ceramics and composite materials.
- *Consumer goods:* Because polymers are inexpensive and versatile, they are frequently used in consumer items like toys, household appliances, and packaging.
- *Defence:* To provide protection and longevity, military vehicles, aircraft, and body armour are made of high-strength metals and composites.
- *Environmental engineering:* To lessen the influence on the environment, eco-friendly building and packaging use materials such sustainable composites and recycled plastics.
- *Sports:* To enhance performance, lightweight materials like carbon fiber composites are utilized in golf clubs, bicycles, and tennis rackets.

Characteristics of Metals:

The mechanical characteristics of metals are related to their capacity to withstand loads and mechanical forces. Strength, stiffness, elasticity, plasticity, ductility, brittleness, malleability, toughness, resilience, creep, and hardness are some of the metal's mechanical characteristics. Now, let's talk about these qualities as follows:

1. *Power:* It is a material's capacity to withstand forces applied from outside without cracking or giving way.
2. *Hardness:* It is a material's capacity to withstand deformation in the face of stress. The modulus of elasticity is used to calculate stiffness.
3. *Flexibility:* When external forces are eliminated, a material with deformation can return to its previous shape. Tools and machinery-making materials might benefit from this feature. It should be mentioned that rubber is less elastic than steel.
4. *Flexibility:* A material's ability to permanently hold onto the deformation it produces under load. This material's characteristic is required for forgings, coin stamping, and ornamental work.
5. *Ductility:* It is a material's characteristic that allows it to be pulled into wire when a tensile force is applied. A ductile material needs to have both plasticity and strength. The words "percentage elongation" and "percentage reduction in area" are typically used to quantify ductility. The following ductile materials are frequently used in engineering practice: mild steel, copper, aluminum, nickel, zinc, tin, and lead, in decreasing order of ductility.
6. *Tensile Strength:* This property allows the material to withstand a tensile force. The material's interior structure provides the internal resistance needed to endure the tensile force.
7. *Hardness:* The level of resistance to wear, abrasion, and indentation or scratching. Heat treatment and alloying methods aid in achieving the similar results.
8. *Corrosion resistance:* The ability of metals and alloys to endure the corrosive effects of a medium, meaning that corrosion processes occur in them at a comparatively slow pace.
9. *Thermal Properties:* The qualities of a material that depend on temperature are called its thermal properties. Heat capacity and thermal conductivity are two ways to describe a solid's thermal characteristics. Knowing the thermal parameters of a machine allows one to forecast how it will perform during regular operation. Specific heat, latent heat, thermal conductivity, thermal expansion, thermal stresses, and thermal fatigue are some of the most important thermal properties of materials., etc. When choosing a material for an engineering application, such as one involving high temperatures, these characteristics are crucial.
10. *Electrical qualities:* A few significant electrical qualities of a material are electrical conductivity, resistivity, dielectric strength, and the stimulus's electric field. A substance that provides minimal obstruction to the flow of electrical current is considered a good electrical conductor. Metals are generally good conductors. Insulators are highly resistive materials. The most prevalent kind of insulators are ceramic ones, which are found in car spark plugs, Bakelite electric iron handles, and plastic coatings for home wiring lines.

Engineering materials are necessary in numerous industries, such as the automobile, aerospace, construction, electronics, biomedical, and more. They perform a wide range of specialized tasks that are unique to the requirements of each application, including structural elements, electrical conductivity, corrosion resistance, thermal insulation, and more [1–6]. A composite material is composed of two materials: a matrix and a reinforcement. The system comprises multiple phases. When two or more different materials are combined, a "composite" is produced. The matrix of a composite can be ceramic, metallic, or polymeric. A "matrix material" is a continuous phase made up of various matrix materials, such as metal matrix composites, polymer matrix composites, and inorganic non-metallic matrix composites. Composite materials are made by combining components to achieve specific structural properties. The constituent materials do not completely dissolve or combine to form the composite; rather, they operate as a single entity. The components are usually physically identifiable as they interact with one other. When compared to the individual materials used to create it, the composite material's qualities are superior.

Composites are materials made up of two or more different types. While offering a multitude of advantages like low weight, high strength, resistance to corrosion, high strength-to-weight ratio, directional strength, high impact strength, high electric strength (insulator), radar transparency, non-magnetic, low maintenance, long-term durability, parts consolidation, dimensional stability, and quick installation, the constituent elements of a composite maintain their individuality. The matrix phase and the reinforcing phase are the two phases that they typically consist of.. They are made to guarantee a blend of the finest qualities found in each of the constituent elements. The two types of engineering materials—structural materials and functional materials—are likewise becoming more and more separated. As the name suggests, structural materials are those that are utilized to construct bodies, parts, and structures. For example, structural materials are used to build an automobile's body, frame, wheels, seats, interior lining, engine, and different mechanical transmission parts. Composite materials are utilized in tissue healing and reconstruction. The demand for artificial human tissues and organs is clearly rising these days [7–9] (Figure 2).

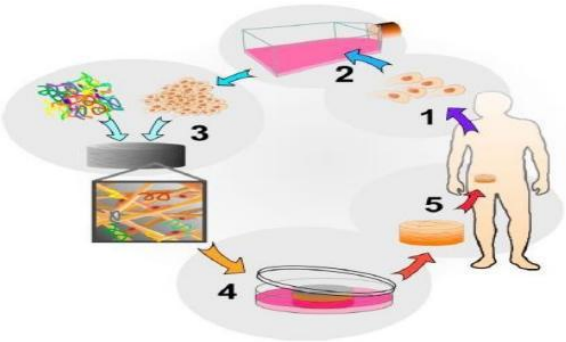

Figure 2. Composites used in Tissue Engineering.

Applications of Composites

- *Aeronautical applications:* military rocket army missiles, aircraft fuel, and structural parts including the wings, body, and stabilizer.
- *Applications in the maritime domain:* hulls, spars, shafts, and other ship parts
- *Automotive industries:* auto parts, such as tires, mud guards, spray nozzles, engine components, etc.
- Sports gear, including tennis racquets, golf clubs, and other protective gear
- The *communication industry*, which includes electrical circuit board construction and antenna assembly.

Constituents of Composites

Two essential constituents of composites are:

1. *Matrix phase:* The composite is surrounded by this continuous body ingredient, also known as the dispersion phase, which gives it its bulk form. It could be made of ceramic, metal, or polymer.
2. *Dispersed phase:* The bulk form and internal structure of the composite are determined by the structural ingredient, or dispersed phase. It could be whiskers, flakes, fiber, or particulate matter.

The primary classification of composite materials is based on the kind of reinforcement and matrix that are utilized.

Types of Composites [10–12]

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

Fiber Reinforced Composite

- It consists of a continuous or dispersion phase polymer, metal, or metal alloy with a bonding agent, and a scattered phase fiber. The fiber can be used in whiskers, staples, or continuous lengths.

- These composite materials exhibit elevated specific strength, specific modulus, stiffness, resistance to corrosion, and reduced density.

Some important types of Fiber reinforced composites are:

Glass Fiber Reinforced Polymer Composite

By correctly inserting continuous or discontinuous glass fibers within a plastic matrix, fiber glass reinforced composites can be created. The most used matrix material is polyester. It is the most widely used fiber reinforcing material because it is readily accessible, simple to make, extremely affordable, and offers stiffness, strength, resistance to impact, corrosion, and chemicals.

Applications: include plastic pipes, storage tanks, and auto parts.

Carbon Fiber Reinforced Polymer Composites

Carbon fibers scattered throughout the polymer matrix, such as graphite or carbon nanotubes.

They offer superior resistance to corrosion, a lower density, and the ability to retain desired qualities at high temperatures.

Applications: include fishing rods, sporting goods, and aircraft structural parts like wings and bodies.

Alumina Oxide Reinforced Metal Composites

Carbon or alumina fibers scattered in a metal or metal alloy matrix with increased specific strength. stiffness, resistance to creep, wear, and heat distortion, among other things.

Example 1: Fiber Al_2O_3 and carbon in a matrix metal alloy are used to create engine parts for automobiles.

Example 2: Al_2O_3 fibers embedded in a Ni or Co-based alloy matrix are used to create turbine engine parts.

Particulate Composite

Solid metal oxide or carbide particles, varying in size and shape, dispersed inside a liquid matrix composed of metal, metal alloys, ceramics, or polymers.

Two other categories for particle-reinforced composites are as follows:

1. Large-particulate composites
2. Dispersion strengthened composites

Large-particulate Composites

Large particle composites are utilized with metals, polymers, and ceramics—the three main material categories.

Examples: 1. Concrete, for instance, is made up of sand and gravel particles mixed with a cement matrix.

Tires for cars with carbon black particles scattered throughout the rubber.

Dispersion Strengthened Composites

This is made using very fine particles (10–100 nm in size), which increase hardness and strength. The uniform dispersion of a high-volume percent of very hard and inert materials can strengthen and harden metals and metal alloys. The dislocations within the matrix interact with the particles to produce this strength.

Structural Composites

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

These are of two types

1. Laminated composites
2. Sandwich composites.

LAMINATED COMPOSITES

Two-dimensional sheets or panels with a desired high-strength direction make up a laminar composite. These sheets or panels are stacked and then cemented together in a way that changes the orientation of the high strength with each subsequent layer. For instance, sandwich panels, plywood, and copper-bottom steel products two Typically, these are made up of two robust outer sheets called faces that are divided by a layer of less dense, less stiff, and less strong material called core. Materials for the face: steel, aluminum alloy, plywood, and titanium.

Challenges and Opportunities of Engineering Materials

The path taken in the development of novel materials has varied based on the type of problem being addressed and the methods used for research. Innovations in the search for novel materials have varied from pure serendipity methods to system-by-system design via analogy. These methodologies will remain important in the creation of materials as the demands and challenges for new materials get more complex, even while the requirement to design and manufacture new materials from the molecular scale through the macroscopic end product will expand [13–16]. There are still scientific challenges to be solved in the field of material science, despite the tremendous advancements made in recent years. These include the need to produce more advanced and specialized materials as well as consider the effects of material manufacturing on ecosystems. Additionally, it is critical to discover new, affordable energy sources and to utilize current energy supplies more wisely. It appears that the fuel of the future will be hydrogen. The most potential advantages to the environment and energy supply come from hydrogen. Similar to electricity, hydrogen is a multipurpose energy carrier that may be produced from a wide range of accessible primary energy sources, such as coal, natural gas, waste, biomass, wind, and solar energy. While methods for producing hydrogen already exist, more optimization is needed before using them in carbon-free energy systems. Materials will surely be important to these advancements. We know that our ability to manage pollution of the air and water is what determines the quality of the environment. Diverse materials are used in pollution control approaches. Techniques for refining and processing materials need to be developed in order to lessen their detrimental effects on the environment [15–18].

CONCLUSION

The worlds of today and the future will always rely heavily on engineering materials. Economic and cost considerations, environmental regulations, development patterns, the depletion of conventional materials, technological advancements in research, market forces, etc. are pertinent aspects that will impact this. Everything around us, including humans, is made of materials; to cease discussing or utilizing materials would be to deny the fundamental nature of life itself. Therefore, there is hope for even better, more advanced, and more affordable materials in the future. Problems in a variety of spheres of life and the economy can be resolved by materials science, technology, and engineering. where a result, where needed, wise nations are swiftly carving out niches for themselves by producing resources with a comparative and competitive edge. Due to its appealing mechanical and physical qualities, composites are currently being widely used in the global aerospace and automotive industries. New fibers, polymers, and processing techniques are constantly being developed for all classes of composites. Additionally, studies are being conducted to enhance recyclability, bonding between fibers and matrix materials, and repair methods.

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