AN APPROACH OF COMPOSITE MATERIALS IN INDUSTRIAL MACHINERY: ADVANTAGES, DISADVANTAGES AND APPLICATIONS

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Abstract

Carbon fiber Composites forecasts indicate several years of supply that will exceed the anticipated demand. Carbon fiber producers have used world leading technology to produce the most uniform and highest quality fiber. Carbon-fiber composites weight about one-fifth as much as steel, but can be similar or better in terms of stiffness and strength, depending on fiber grade and orientation. These composites do not rust or corrode like steel or aluminum. The aim of this paper is to present the current scenario of carbon fiber composites in industries and go towards the approach of carbon fiber composites in future direction with its advantages, disadvantages and applications in industrial machinery. Various type of composites based on reinforcement shape also presented in this paper. This paper also shows the Properties, Characteristics, Challenges, Opportunities and Future Trends of Composites towards industrial environment.

***Keywords**: Carbon Fiber Composites, Composites Technology, Strength, Stiffness and Applications.*

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1. INTRODUCTION

Composite material can be well-defined as an amalgamation of two or more than two materials (reinforce, fillers, and binder) different in composition on a very small scale. Composite materials (also called composition materials or shortened to composites) are materials made from two or more than two constituents or materials with considerably differ in physical and chemical properties, that when amalgamated, make a material with appearances different from the individual components. We can say that do not lose their individual identities but still impart their properties to the product causing from their mixture.

The core benefits of composite materials have their great strength and stiffness, for example Carbon Fibers have great specific strength, high modulus, good in fatigue resistance and dimensional stability and lower density Fibers. Composite materials have their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part.

The reinforcing phase of composite materials provides the durability, strength and stiffness. There are in many cases, the reinforcement is tougher, stronger, harder and stiffer than the matrix. The reinforcement is normally a fiber or a particulate. Particulate composites have dimensions that are almost the same in all directions. Particulate composite that consists of tiny particle of one material embedded in another material. Particulate composites tend to be feeble and less stiff than continuous fiber composites, but they are normally much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness.

The composite material industry, nevertheless, is novel. It has technologically advanced speedily in the earlier 35 years through the improvement of fibrous composites: to begin through, glass fiber reinforced polymers (GFRP) and, more recently, carbon fiber reinforced polymers (CFRP). Their use in boats and their growing replacement of metals in ground transport systems is an uprising in material usage which is still accelerating. It finds application in composite, Automotive, sport goods, medical equipment & packaging Industry.

2. TYPES OF COMPOSITES

Various types of composites are used in the industries:

- Particulate composites
- Flake composites
- Fiber composites
- Nanocomposites

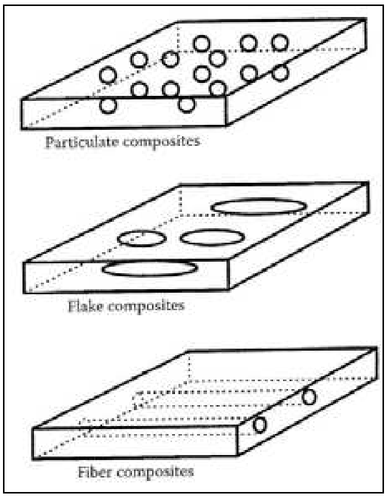

Fig-1: Type of Composites based on Reinforcement Shape

3. COMPOSITE MATERIALS IN INDUSTRIAL MACHINERY

A fiber has a diameter that is much smaller than its length. From their length to diameter (l/d) ratio is identified as the aspect ratio and can be differ significantly. Continuous fibers have their long aspect ratios, whereas discontinuous fibers have small aspect ratios. Continuous fiber composite materials generally have a desired orientation, although discontinuous fiber composite materials usually have a random orientation.

For examples of continuous reinforcements contain unidirectional, intertwined stuff, and helical windy (Fig. 2.a), whereas examples of discontinuous reinforcements are random mat and chopped fibers (Fig. 2 .b).

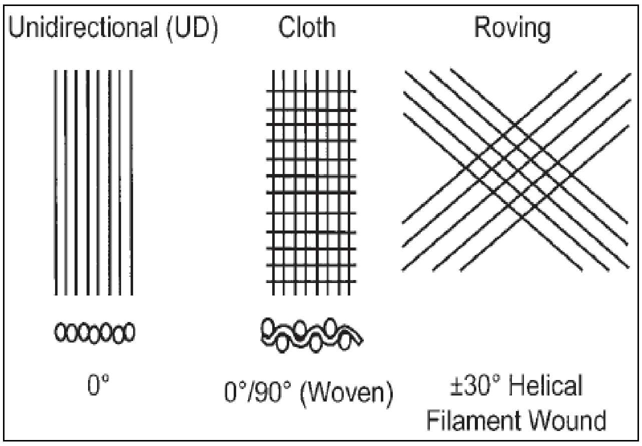

Fig-2 (a): Continuous Reinforcements

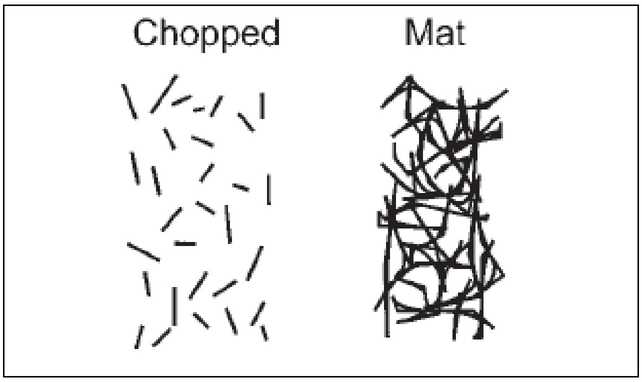

Fig-2 (b): Discontinuous Reinforcements

The quantity and kind of the reinforcement conclude the last properties. Figure 2 show that the maximum strength and modulus are acquired with continuous fiber composites. There is a practical limit of about 70% reinforcement that can be added to make a composite. At higher % (percentage), there is too little matrix to support the fibers efficiently.

The hypothetical strength of discontinuous fiber composites can methodology that of continuous fiber composites if their aspect ratios are more enough and they are aligned, but it is problematic in exercise to maintain worthy alignment with discontinuous fibers. Discontinuous fiber composites are usually to some extent random in alignment, which intensely decreases their strength and modulus. However, discontinuous fiber composites are normally not costly than continuous fiber composites. So, continuous fiber composites are used somewhere great stiffness and strength are required (but at a high cost), and discontinuous fiber composites are used where cost is more effective and strength and stiffness are less important.

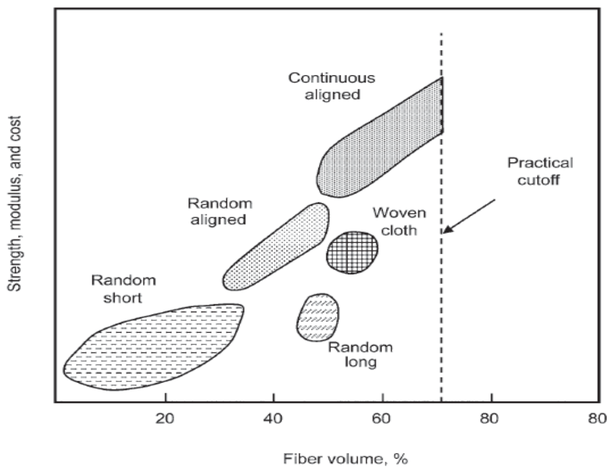

Fig-3: Influence of reinforcement type and quantity on composite performance

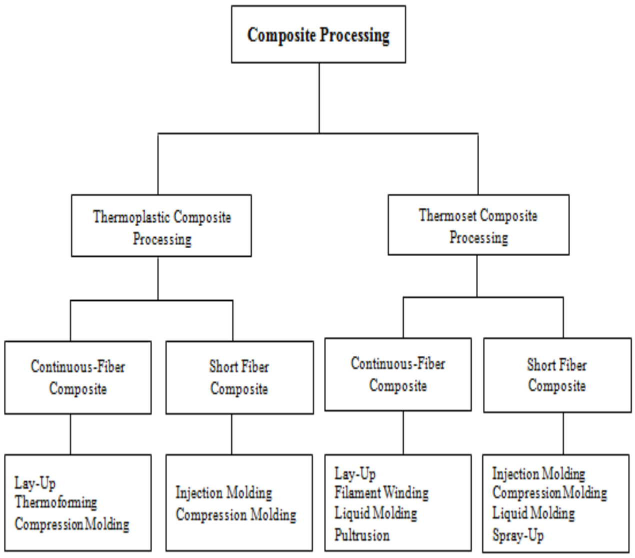

Fig-4: Major polymer matrix composite fabrication processes

4. PROPERTIES OF COMPOSITE MATERIALS

Composite as an industrial material, mostly used for their outstanding resistance to chemicals and most forms of corrosion This property, even though conventionally important, is hardly the only useful property. There are many other important and useful properties are:

- Low cost and low mass,
- Unequalled manufacturing and processing possibilities,
- Complex material body are easily produced,
- Tooling cost is very low,
- Appropriate to very small products and very large product,
- Satisfactory surface finish can be an integral feature.

5. CHARACTERISTICS OF COMPOSITE MATERIALS

The rudimentary characteristics of composite materials are:

- High fatigue scathe tolerance and high fatigue strength, in addition to high specific strength and modulus,
- Tailor able or designable materials for microstructure,
- Creation and production of both structure and material or component in a single operation manufacturing flexible, complex geometry and net-shape,
- durable and Corrosion resistance,
- Anisotropic,
- Other unique functional properties - damping, low CTE (coefficient of thermal expansion).

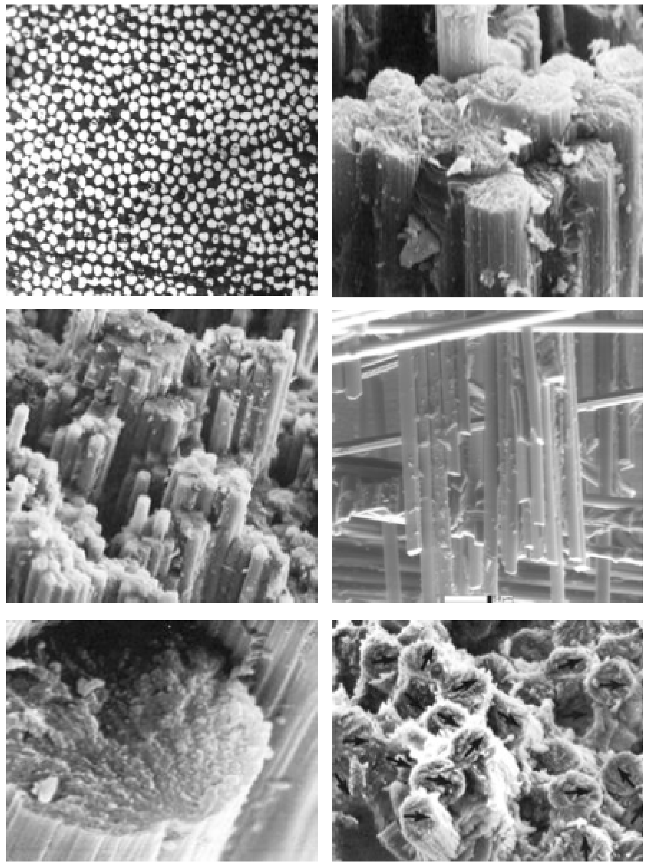

Fig-5: Fiber-Reinforced Composites

6. ADVANTAGES OF COMPOSITE MATERIALS

There are many advantages of composites, together with lighter weight, improved fatigue life, the ability to tailor the layup for optimum strength and stiffness, resistance to corrosion, and with beneficial in design practice, assembly costs is reduce due to less fasteners and detail parts.

The specific modulus (density) and certain strength of great strength carbon fibers are advanced than those of other comparable or equivalent aero-space metallic alloys. This converts into better weight savings ensuing in improved performance, fuel savings, longer range and greater payloads.

The many other advantages of composites are following:

- High temperatures and weathering resistance,
- High chemical stability,
- High durability due to long prepreg storage life,
- Low smoke density, low flammability, and low toxicity of decomposition products,
- Temperature resistance of course depends on choice of resin,
- Huge selection of possible component size and shape,

- Prepregs contain the variety of reinforcements and resin matrix amalgamations. They are manufactured on a high-tech fusible resin plant. Fusible resins have less volatile ingredients and increase the composite materials mechanical strength.

7. DISADVANTAGES OF COMPOSITE MATERIALS

The some disadvantages of composites are given below:

- Composite material structure has more complex mechanical characterization than a metal structure,
- Repairing process of composites is complex as compared to that for metals,
- Composites material do not have a the quality of high combination of strength and fracture toughness compared to metals,
- High cost of fabrication of composites,
- It is not compulsory that composites give greater performance in all the properties used for material selection: corrosion resistance, affordability, formability, join ability, strength, and toughness.

8. APPLICATIONS OF COMPOSITE MATERIALS TOWARDS INDUSTRIES

Composite materials contain construction, marine goods, aerospace, transportation, sporting goods, and further newly infrastructure, with construction and transportation being the biggest. Generally, more costly but high act continuous carbon-fiber composites are used somewhere light weight along with high stiffness and strength are required, and in fewer demanding applications where weight is not as critical then considerable lower cost fiber-glass composites are used.

8.1. Aerospace Applications

Aircraft applications are the maximum significant uses of composites. Unlike other vehicles, commercial aircraft, essential to lay greater stress on safety and weight. They are realized by using materials through great specific properties. A modern civil aircraft designed as to encounter the several criteria of power and safety. As a result of forward-thinking technology that has gone beyond the design and application the glass and carbon reinforced hybrid composites are the best preferred materials.

8.2. Smart Memory Hybrid Composites

Growing requirement on the carrying into action of materials used in engineering practical applications postulate the development of this material then so called adaptive, multifunctional, smart, or intelligent materials. The physical properties of the matrix materials are either upgraded by the SMA elements or can even be dynamically improved by controlling the progress of the martensitic transformation (MT) in the SMA elements.

Internal compressive stresses are generated in the surrounding matrix when the embedded strained SMA elements are heated. These stresses can tone up the composite, variation its natural vibration frequencies and increase its impact or damping properties. Exterior shape variations of the composites can be also realized.

8.3. Wind Power Generation

The applications of composite materials are used in wind power generation because the wind power engineering is a significance region of energy generation because of its resource saving and ecologically safe. The power monetary value mainly is determined substantially by simple power element blades. At present-day hybrid fibers (carbon, glass) are largely used for fabrication of the blades.

8.4. Composite Material used in Marine Applications

In marine applications ships are under unbroken attack, both from the elements of nature and the enemy. The huge majority of ship hulls are created from common carbon steels, that are noticeably vulnerable to corrosion, but they also make different thermal and electromagnetic signatures simply noticeable from long distances.

8.5. Hybrid Thermoplastic Application

Thermoplastic composites which used for mass producing lightweight structural parts because it has long held potential properties. On the other hand thermoset constructed composites, which undergo time consuming chemical cross linking throughout processing; thermoplastic based composites are typically treated using simply heat and pressure.

8.6. Composite Material Application for Civil Construction

From the previous decade, largely in several countries, the research and development of totally hybrid FRP structures in civil engineering has developed. All the structural elements have been made with Hybrid Fiber Reinforcement Plastics (GFRP & CFRP). The all HFRP solution was chosen for this bridge due to its heavily corrosive atmosphere someplace the bridge is surrounded through the ocean. It is believed that the inventive materials can be competitive to other conventional materials in the close future when life cycle cost of the material is taken into account; there is a vital requirement for research and development of this revolutionary technology.

8.7. Composites used for Telecommunication Applications

Telecom industries felt the need of explore the innovative product category known as hybrid cable because the reason behind that the requirement of power transmission along with data transmission are increasing in telecommunication industries. Hybrid aerial, underground cable is advanced and versatile cabling solution inside constructed power transmission required for network equipments with OFC cables. Hybrid Composite Cable is requirement of a period, primarily to support for Power transmission for always ON (Interrupt free) telecom needs.

8.8. Composite Material for Offshore Applications

Composite materials have a wide range of applications in offshore due to fast taking over as greater substitute to other conventional materials even in aggressive environmental and high pressure conditions. Composite materials applications are growing vastly along with the parallel need for knowledge invention in this field.

8.9. Composite Materials for Orthopedic Aids

People who were born with physical imperfections or who obtain disability, Orthotics and Prosthetics support by correct them with artificial supports. Prosthesis is an artificial replacement for a misplaced part of the body. Bio-medical prosthetic gimmick are artificial substitutes that are used in the human body to utility such as original parts. Materials intended for such prosthetic aids must non-toxic, chemically and biologically stable and have adequate mechanical reliability and strength to withstand physiological loads. Composite material has been known as the innovative class of synthetic bio-materials. A vital improvement has been the usage of carbon fiber reinforced polymer matrix for composite limb.

The reintegration industry is moving in the direction of composite material, as they are light- weight, comfortable to work with and more durable such as lighter prosthesis needs less energy consumption for the period of running, walking and other activities, weight is very important in an artificial leg.

8.10 Composites in Automobile/Transportation Sector

In spite of the potential benefits and many advantages of lighter weight and high durability resulting from corrosion resistance, advanced composites are not used widely in automotive applications. There must be some step's should be taken on a global level to make advanced composites material attractive for some wide-spread use in trucks, cars etc. and all other automobile applications. The main cause which is a barrier for composite material is its high cost of raw and fabricated material, since the existing material used is of law cost.

8.11. Composite Material used for Electronics and Electrical

The composites are fitted with high quality electric insulation, spark-free and good antimagnetic agents. They also have good adhesion toward glue & paint. Composite also possess self-extinguishing qualities due to which it is used for the construction of distribution pillars, link boxes and profiles for the separation of current-carrying phases to prevent short circuits etc.

8.12. Composites in Chemical Industry

The composite materials are one of the most popular materials used in chemical industry due to its various advantages of being light in weight, have better resistance against fire and show resistance to chemicals. Composite grips the wide use in chemical industry are used in the manufacturing of structural supports, storage tanks, exhaust stacks and blowers, columns, pumps, reactors etc. for acidic and alkaline environments.

8.13. Application in Nuclear Industry

Composite materials are used widely in nuclear industries due to its nuclear fuels require good specific fission gas retention properties. Due to use in metal matrices, ceramic fuels are used at a great level from last few years. The ceramic fuels used in fast reactors have been sensibly successful in stainless steel matrix as used in plutonium uranium dioxide solid solution in steel cermets.

8.14. Application of Composites in Nanotechnology

The Composite materials have a wide range of applications in the field of Nanotechnology. The Nanocomposites is a resourceful conception having fillers on a nanometer scale isolated in the resin. Because of the diffusion of very small fillers, flame retardance and inflexibility of the resin improves significantly with the addition of only a tiny quantity of fillers. Nanocomposite materials are greatly used in automotive, electronic parts and in industrial equipments etc.

9. OPPORTUNITIES, CHALLENGES & FUTURE TRENDS

Lots of challenges must be overcome with the goal of enhance the engineering usage of Hybrid composites. Design, research and business development skills and product development efforts and business development skills are needed to overcome these challenges. In this explore there is a strong necessity to address the following matters.

- There is demand to improve the damage tolerant properties mainly ductility and fracture toughness in Composites,
- There is a bigger need to assort different grades of composites based on manufacturing cost and property profile,
- Effort must be done to produce low cost and high quality reinforcements from industrial byproducts and wastes,
- Cognition of core processing of composites requisite to be understood more thoroughly, mainly factors affecting the micro structural integrity,
- Efforts should be made on the development of composites based on nonstandard matrices and fibers,
- There is a crucial requirement to grow economical, simple and portable non-destructive kits to quantify unwanted defects in Composites.

CONCLUSIONS

Manufacturing process of hybrid laminates is provided as applicable to various industries such as transportation industry, aeronautics, naval, automotive industries and components for the electronic industry. Considerable efforts have been focused on the applications of Hybrid composites for better understanding of the phenomena associated to the cutting edge technology.

As far as the material is concerned, glass and carbon fiber reinforced composites have been equally investigated; however, epoxy resin is preferred as the matrix material. An effort towards this literature on hybrid composites will throw some light on researchers and scientists pursuing work on hybrid composite technology.

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BIOGRAPHIES

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