Issue 9 vol 3 ISSN: 2321-8134

IJFEAT

INTERNATIONAL JOURNAL FOR ENGINEERING APPLICATIONS AND TECHNOLOGY

COMPOSITE MATERIALS: A REVIEW

Ayush S. Gupta[1], Ankita A. Kundu[2], A. D. Shirbhate[3]

[1]*Student, Department of Mechanical Engineering, P.R.M.I.T & R, Badnera, Maharashtra, India,* ***ayushg879@gmail.com***

[2]*Student, Department of Mechanical engineering, P.R.M.I.T & R, Badnera, Maharashtra, India,* ***ankitakundu1123@gmail.com***

[3]*Associate Professor, Department of Mechanical engineering, P.R.M.I.T & R, Badnera, Maharashtra, India,* ***adshirbhate@gmail.com***

Abstract

Some materials are very strong and heavy such as steel. Other material can be strong and light, such as bamboo poles. The composite material can be designed to be both strong and light. This property is why composites are gaining importance nowadays. Today composite materials have changed all the material engineering. The evolution of composite materials has given an opportunity to various designers to use new and better materials resulting in cost reduction, increase in efficiency and better utilization of available resources. Composite materials can be used not only for structural applications, but also in various other applications such as automobiles, aerospace, marine, etc.

This paper presents the history of composite materials, different types of composite materials and application of composite materials in various sectors.

Keywords*: automobiles, aerospace, marine.*

***

1.INTRODUCTION

A **composite material** (also called a composition material) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger and lighter when compared to traditional materials. More recently, researchers have also begun to actively include sensing actuation, computation and communication into composites which are known as **Robotic Materials.**

Composites Materials are generally used for buildings, bridges and structures such as boat hulls. Swimming pool panels, race car bodies, shower stalls, bathtubs, storage tanks, imitation granite, and cultured marble sinks and countertops. The most advanced example performed routinely on spacecraft and aircraft in demanding environments.

2. HISTORY

Throughout history, humans have used composite type materials. One of the earliest uses of composite materials was by the ancient Mesopotamians around 3400 B.C. when they glued wood strips had different angles to create plywood. Egyptians used of Cartonnage, layers of linen or papyrus soaked in plaster, for death mask dates to the 2181-2055 B.C. Archeologists have found that natural composite building materials were in use in Egypt and Mesopotamians, since ancient builders and artisans used straw o reinforce mud bricks, pottery and boats around 1500 B.C.

Around 25 B.C. The Ten Books on Architecture described concrete and distinguished various types of lines and mortars. Reserchers have demonstrated that the cement described in the books is similar and in some way superior to the Portland cement used today.

3. THE FUTURE

Composites research is attracting grants from governments, manufacturer and universities. These investments will find new fibres and resins to create even more applications for composites. Environmentally friendly resins will incorporate recycled plastics and bio-based polymers as composites the feed the demand for stronger, lighter and environmentally friendly products.

Table-1: Types of Composite Materials [1]

Based on the type of matrix material	Based on the geometry of reinforcement
Polymer Matrix Composites (PMCs)	Particulate reinforced Composites
Metal Matrix Composites (MMCs)	Whisker/Flakes reinforced composites
Ceramic Matrix Composites (CMCs)	Fiber reinforced composites
Ceramic Matrix Composites (CMCs)	

4. LAMINATED STRUCTURE [2]

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. An advanced composite material is made of a fibrous material embedded in resin matrix, generally laminated with fibers oriented in alternating directions to give the material strength and stiffness. Fibrous materials are not new; wood is the most common fibrous structural material known to man.

4.1 Major Components of a Laminate

An isotropic material has uniform properties in all directions. The measured properties of an isotropic material are independent of the axis of testing. Metals such as aluminum and titanium are examples of isotropic materials. A fiber is the primary load carrying element of the composite material. The composite material is only strong and stiff in the direction of the fibers. Unidirectional composites have predominant mechanical properties in one direction and are said to be anisotropic, having mechanical and/or physical properties that vary with direction relative to natural reference axes inherent in the material. Components made from fiber reinforced composites can be designed so that the fiber orientation produces optimum mechanical properties, but they can only approach the true isotropic nature of metals, such as aluminum and titanium. A matrix supports the fibers and bonds them together in the composite material. The matrix transfers any applied loads to the fibers, keeps the fibers in their position and chosen orientation, gives the composite environmental resistance, and determines the maximum service temperature of a composite.

4.2 Fiber Orientation [2]

The strength and stiffness of a composite buildup depends on the orientation sequence of the plies. The practical range of strength and stiffness of carbon fiber extends from values as low as those provided by fiberglass to as high as thoseprovided by titanium. This range of values is determined by the orientation of the plies to the applied load. Proper selection of ply orientation in advanced composite materials is necessary to provide a structurally efficient design. The part might require 0° plies to react to axial loads, ±45° plies to react to shear loads, and 90° plies to react to side loads.

Because the strength design requirements are a function of the applied load direction, ply orientation and ply sequence have to be correct. It is critical during a repair to replace each damaged ply with a ply of the same material and ply orientation. The fibers in a unidirectional material run in one direction and the strength and stiffness is only in the direction of the fiber. Pre-impregnated (prepreg) tape is an example of a unidirectional ply orientation. The fibers in a bidirectional material run in two directions, typically 90° apart. A plain weave fabric is an example of a bidirectional ply orientation. These ply orientations have strength in both directions but not necessarily the same strength. The plies of a quasi-isotropic layup are stacked in a 0°, –45°,45°, and 90° sequence or in a 0°, –60°, and 60° sequence. These types of ply orientation simulate the properties of an isotropic material. Many aerospace composite structures are made of quasi-isotropic materials.

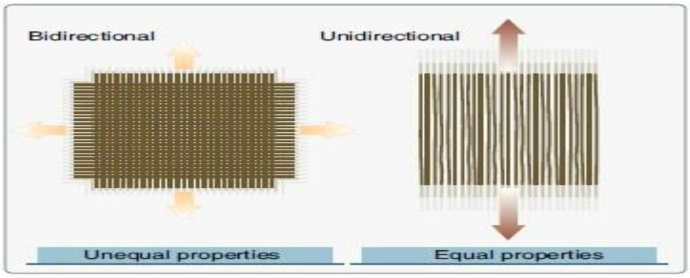

Fig. 1: Bidirectional and unidirectional material properties. [2]

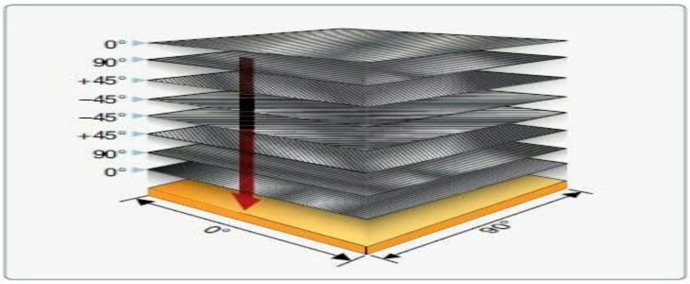

Fig. 2: Quasi-isotropic material lay-up. [2]

4.3 Fiber Forms

All product forms generally begin with spooled unidirectional raw fibers packaged as continuous strands. An individual fiber is called a filament. The word strand is also used to identify an individual glass fiber. Bundles of filaments are identified as tows, yarns, or rovings. Fiberglass yarns are twisted, while Kevlar® yarns are not. Tows and rovings do not have any twist. Most fibers are available as dry fiber that needs to be impregnated (impregs) with a resin before use or prepreg materials where the resin is already applied to the fiber.

4.4 Unidirectional (Tape)

Unidirectional prepreg tapes have been the standard within the aerospace industry for many years, and the fiber is typically impregnated with thermosetting resins. The most common method of manufacture is to draw collimated raw (dry) strands into the impregnation machine where hot melted resins are combined with the strands using heat and pressure. Tape products have high strength in the fiber direction and virtually no strength across the fibers. The fibers are held in place by the resin. Tapes have a higher strength than woven fabrics.

4.5 Bidirectional (Fabric)

Most fabric constructions offer more flexibility for layup of complex shapes than straight unidirectional tapes offer. Fabrics offer the option for resin impregnation either by solution or the hot melt process. Generally, fabrics used for structural applications use like fibers or strands of the same weight or yield in both the warp (longitudinal) and fill (transverse) directions. For aerospace structures, tightly woven fabrics are usually the choice to save weight, minimizing resin void size, and maintaining fiber orientation during the fabrication process.

4.6 Nonwoven (Knitted or Stitched) [2]

Knitted or stitched fabrics can offer many of the mechanical advantages of unidirectional tapes. Fiber placement can be straight or unidirectional without the over/under turns of woven fabrics. The fibers are held in place by stitching with fine yarns or threads after preselected orientations of one or more layers of dry plies. These types of fabrics offer a wide range of multi-ply orientations. Although there may be some added weight penalties or loss of some ultimate reinforcement fiber properties, some gain of inter-laminar shear and toughness properties may be realized. Some common stitching yarns are polyester, aramid, or thermoplastics.

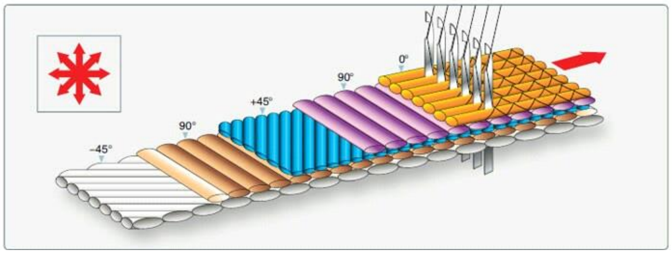

Fig- 3: Nonwoven material (stitched). [2]

5. APPLICATIONS OF COMPOSITE MATERIALS [1]

- Space craft: Antenna structures, Solar reflectors, Satellite structures, Radar, Rocket engines, etc.
- Aircraft: Jet engines, Turbine blades, Turbine shafts, Compressor blades, Airfoil surfaces, Wing box structures, Fan blades, Flywheels, Engine bay doors, Rotor shafts in helicopters, Helicopter transmission structures, etc.
- Miscellaneous: (1) Bearing materials, Pressure vessels, Abrasive materials, Electrical machinery, Truss members, Cutting tools, Electrical brushes, etc. (2) Automobile: Engines, bodies, Piston, cylinder, connecting rod, crankshafts, bearing materials, etc.

Table-2: Applications of Composite Materials

Materials	Applications
Borsic Aluminium	Fan Blades in engine, other aircraft and aerospace applications
Kevlar -epoxy and Kevlar -polyster	Aircraft and aerospace applications (including space shuttles), boat hulls, sporting goods (including tennis rackets, golf club shafts, fishing rods), flak jackets.
Graphite -polymer	Aerospace and automotive applications, sporting goods.
Glass -polymer	Lightweight automotive applications, water and marine applications, corrosion resistant applications, sporting good equipments, aircraft and aerospace components.

Fig-4: CFRP (Carbon fibre reinforced polymer) Application [1]

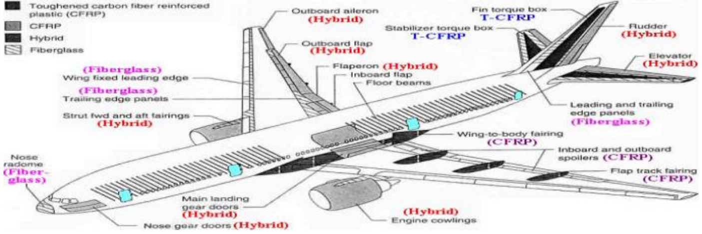

Fig-5: Composites in Boeing 777 [1]

5.1 Applications of composites on aircraft include

- Fairings
- Flight control surfaces
- Landing gear doors
- Leading and trailing edge panels on the wing and stabilizer
- Interior components

Floor beams and floor boards

- Primary wing and fuselage structure on new generation
- large aircraft
- Turbine engine fan blades Propellers

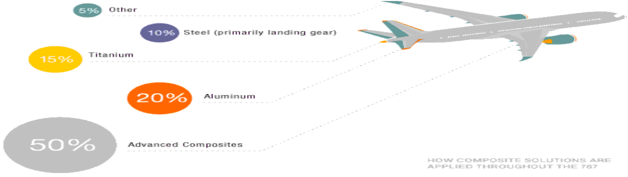

Fig- 07: The Boeing 787 Dreamliner Is 50% Composite Materials

Composites are popular in machining for their various chemical and physical traits, but they have economic advantages as well. In December 2009 Boeing flew the

787 Dreamliner for the first time. One of the major design features of the Dreamliner was its lightweight, a result of the use of composite materials. 50% of the Dreamliner's structure is made up of composite. Since June 2013 Airbus is flight testing the A350XWB. The latest Airbus now boasts a 53% usage of composite material among its long lists of new features. The use of composites not only saved the companies money on fuel and paneling, they also cut back on fossil fuel emissions by decreasing flight time in response to the ACARE's goal of 50% reduction in CO2, a 50% reduction in perceived noise and an 80% reduction in NOx. Composites have been a part of aircraft since the 1950's, but having the traits they do, composites have increasingly been added over the years so we see a jump from 12% to 70% in the A350 XWB.

6. CONCLUSION

Hence we can finally conclude that:

- Composite materials offer high fatigue and corrosion resistance.
- Composite materials have high strength to weight ratio.

So they are best suited for various aerospace applications. Over the next decade, the aerospace market for composite materials is anticipated to grow at elevated rates in comparison to years past.

Composite materials are also proving its importance in:

- Construction (external cladding, interior walling, street furniture)
- Marine (interior paneling, light weighting)
- Industrial (water tanks, grit bins, pipes)
- Energy (solar panel surrounds, wind turbines) etc.

Composites are being considered to make lighter, safer and more fuel-efficient vehicles.

Composite materials, after having raised hopes in the 80s and 90s, were a little "out of fashion". Today, composites once again appear as materials of the future and R&D is instilling them with a new dynamic.

ACKNOWLEDGEMENT

The making of the paper needed co-operation and guidance of number of people. We therefore consider it our prime duty to thank all those people who helped us through this venture.

It is our immense pleasure to express our sincere gratitude and heartily thanks to Dr. A.D. Shirbhate as our guide who provided us constructive and positive feedback during the preparation of this paper. We express our sincere thanks to respected Dr. S. S. Deshmukh (Head of Department, Mechanical Engineering) and all other staff members of Mechanical Engineering Department for their kind co-operation.

REFERENCES

[1] Composites and Applications – Session Delivered by Dr. Srikari S. (M S Ramaiah School of Advanced Study, Banglore).

[2] Aviation Safety Bureau Aviation Maintenance Technician Airframe Handbook - Volume 1 Chapter 7. Advanced Composite Materials.

[3] CNC Cookbook: Milling Composites Part 1: "What Are Composites?" by Laura Warfield.

[4] Piyoosh Thori, Pawan Sharma, Manish Bhargava, "An Approach Of Composite Materials In Industrial Machinery: Advantages, Disadvantages And Applications", IJRET, Volume: 02 Issue: 12 | Dec-2013.

[5] F. C. Campbell, "Structural Composite Materials-Introduction to Composite Materials", ASM International-2010, pp 1-30.

[6] Composite Airframe structures by Michael C. Y. Niu.

[7] Nikhil V Nayak "Composite Materials in Aerospace Applications", International Journal of Scientific and Research Publications, Volume 4, Issue 9, September 2014.

[8] A. Brent Strong, "Fundamentals of Composite Manufacturing Materials and Applications", Society of Manufacturing Engineers, MI, USA.World Academy of Science, Engineering and Technology International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:6, No:11, 2012 2432 International Scholarly.