APPLICATIONS OF COMPOSITE MATERIAL IN VARIOUS FIELDS

[1]R B Gunale ,[2]Dr. Sarang Joshi
[1]Research Scholar, [2]Associate Professor
[1,2]Mechanical Engineering Department
[1]JJT University, Rajasthan
[2] JSPM's ICOER, Wagholi, Pune

Abstract: Use of composite material is not new but it can be traced back many years back, the use of composite in bricks making, bow manufacturing and various other applications justifies the same. The constant advancement happened in the field of composite made its use wide with respect to time. The current scenario states the use of composite almost in all fields which includes sport, medical, thermal, electrical, aerospace, defence, military, navy and many more as such. The paper describes use of composites in various fields due to structural advancements happened in to it over the period of time. The use of composite not only cut down on the cost of product manufacturing (In few cases it is still on higher side) but it also offers other advantages such as high strength, high reliability, high stiffness, weigh reduction, material saving etc.

Keywords: Composites, material, automobile, aerospace, construction, electrical, thermal, industries etc.

1. Introduction: The use of composite is very old, during 13th century, Mongol used bows and bricks made of composites. Israelites used bricks in the construction made of straw reinforcements. Egyptian used sword and armour made of composite, and these few examples are enough to trace popularity of composites in older days.

Composite is composed of two or more than two materials still they are physically separable and mechanically distinct. Unlike conventional structure there is no chemical bond formation between elements mixed together and this is unique feature of composite material manufacturing. The resultant material formed possesses properties of its constituents which are still separable from each other and could not perform this better previously.

Composite material provides scope for receptiveness to design changes, material and manufacturing process.

Few of the domains where use of composites ever reached to the extent of satisfactory improvement are, aircrafts, space vehicles, offshore, electronics, medical, automobile, thermal. The development in such domains in the context of use of composite happened with use of polymeric, metallic, ceramics material used in the form of fibre and matrix both. In composite dispersed phase is fibre, hybrid composites consist of two fibres in single matrix, this micro-structural up gradations helped to improve mechanical properties and to reduce the cost of manufacturing.

Few natural sources of composites can be listed as, Bamboo, wood and bones etc.

Composite material possesses few benefits and advantage due to which use of it widely recommends in every new application on trial and error basis approach.

Composite are dimensionally stable material at high temperature conditions, they have good damping capacity, design flexibility, reduced permeability, less water absorption, recyclability, good electrical properties, high impact/toughness strength etc. and these properties can be improved by little percentage/concentration alteration of its constituent, and this widens the use of composites day by day. Few such broad domains who have adopted use of composite to large extent are discussed throughout the paper.

2. Aircraft & Space applications:

Structural behaviour of composites are different from metal so the approach of design of composite also different from metal or conventional materials. Unlike metals, composites need to pass through thousands of tests to qualify for certain assumption and process consumes lot of time and money.

First structural composite aircraft introduced during 1950 was made of glass fibre reinforced plastics. Boron fibre reinforced plastics and carbon fibre reinforced plastics are referred in aeroplane design instead of Aluminium. Composite aircraft components fabricated with sandwich structure which contains face sheets made of carbon, aramid, glass structure and inner portion made of honeycomb core. Pressurized part of the aircraft structure must meet flammability resistance requirement. Internal parts such as sidewall panels, floor boards, galleys etc. are generally made of fibre reinforced epoxy. Another important consideration for interior component is impact resistance.

Use of composites is extended to military, transport, aviation represents maturity of composite and its related technology which made one enable to use it in various fields as just mentioned. Reduced life cycle cost and operational cost are the reasons to use composite in various applications of aviation's. The composites are though best at several fronts such as mechanical performance, durability, reliability, the increased cost of manufacturing and testing were not encouraged various applications developer to use it that widely and popularly at earlier stage of its launching, and that sets new challenge to supplier to reduce or cut down the cost of material so that its actual intension would come true at lowest affordable price. The main focus of airframe manufacturer will be the development of structural design at minimum affordable cost which followed by its increased popularity too.

The details of composite in aerospace domain is depicted through following hierarchy diagram,

Use of composites in Aircraft Industry		
Civil Aircrafts	**Boeing Aircrafts**	**Helicopter Type**
Airbus A300	**Boeing 737**	**MBB BK 117**
Airbus A310	**Boeing 749**	**Bell 206 L**
Airbus A320	**Boeing 757**	**Dauphin**
Airbus A330	**Boeing 767**	**McDonnell Douglas MD 520 N**
Airbus A340	**Boeing 777**	**Light Helicopter etc.**

Table (2.1): Use of composite in making of different aircraft structure to best suit the different needs

The use of composite materials can be traced many decades back where it was used in bricks, muds, arrows etc. in later stage it started using in making of small doors, control surfaces, fairings etc. currently they are widely used in Air Force fighters.

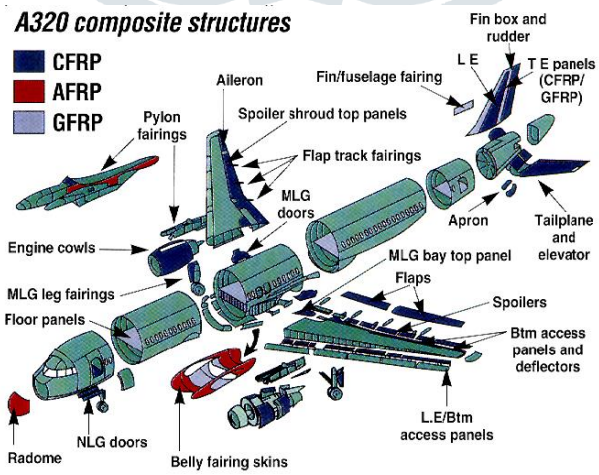
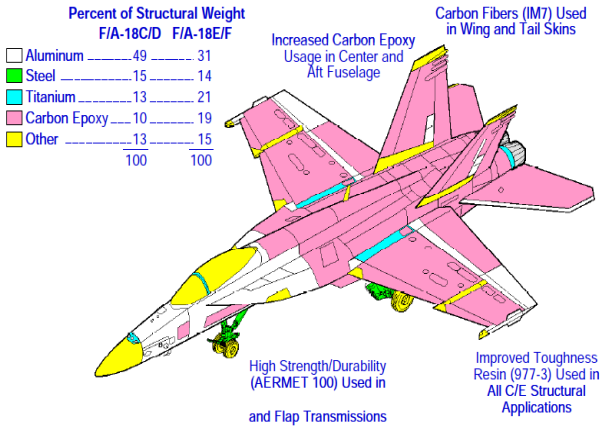


Fig (2.1): Composite material used in manufacturing of different parts of Aeroplane.

Use of composites also extended in the fighter aircraft structure, bomber, transport structure, general aviation and rotary aircrafts etc. Figures below are enough to understand detail and wide speared use of composites in the field of aerospace engineering.



Carbon fibres improves strength and stiffness property use in the wing and tail of skin. Composite material results in 25% weight reduction of airframe structure.

Fig (2.2): Use of composite in design and manufacturing of different parts US fighter aircraft

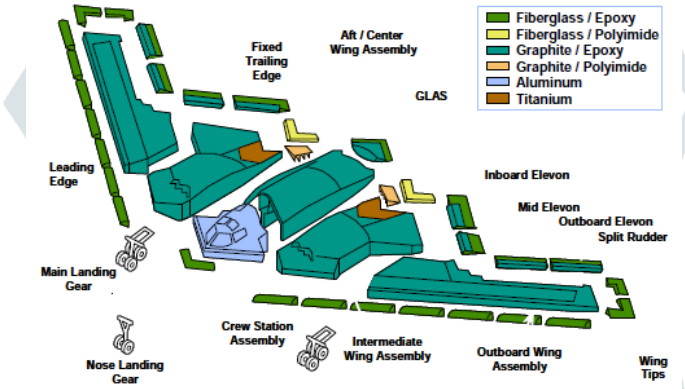


Fig (2.3): Use of composite in Bomber

Use of composites in designing of aeroplane structure was 2 to 3% at initial stage which found increased up to 25%-27% today.

3. In Automobile:

Use of composites in automobile is popularized due to its easy repairing, easy manufacturing, light weighting, easy joining, easy recycling, easy modelling, fire safety etc. apart to this, composites are fatigue resistant, reliable, mouldable and that made start the use of composite in various engineering applications since from the year 1953. If other side of composites are viewed, one would come across difficulty to predict accurate material characterization, coupling of composites with metal, and on rare occasion; difficulty in manufacturing etc.

Use of composite for sport car in structural and semi structural parts has demonstrated successfully. Rapidly growing market for composites in China, Europe, and Asia is the reason of shortage of Steel and relevant raw material now days. Though complete replacement of metal is not possible, composite materials can be used as best alternative in the case of conventional material scarcity.

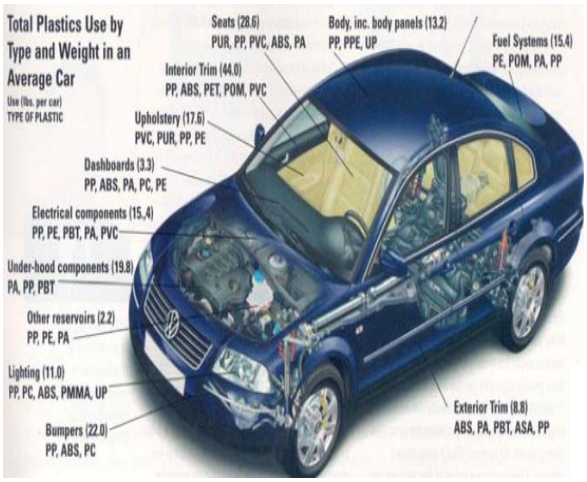


Image (3.1): Use of fibre reinforced materials in car

Developments happened over past few decades: The images below depicts the development happened in past few decades in terms use of composite for versatile automobile applications, the parts manufactured with composite gains several advantages over conventional material and few of them can be listed as, high strength, high part life, low maintenance, high efficiency, high stiffness, and low weight etc.

Image (3.2): Chevrolet fibre glass body

Image (3.3): Resign transfer moulded tailgate of Renault Escape

Image (3.4): Volvo tailgate

Image (3.5): Ferrari Chassis

Image (3.6): Fiat integrated bonnet

Image (3.7): BMW Side frame

Image (3.8): Composite trailer

Image (3.9): Bus chassis body

Despite this much of wide and popular use of composites in various fields, the researcher are still investigating their attention to enable the composite for high volume production, automation for accurate positioning of reinforcement, carbon fibre price reduction, stability of fibres, composite material testing, unique and specific design procedure for composites, new composite material failure prediction criterion etc.

4. In Sports:

In year 1997 the use of composite in the manufacturing of sporting goods was reached to 50000 Tones which was approximately 25% of its total usage in versatile fields.

There are following few aspects which enable the manufacturer to use composite in design and development of various sport equipment's,

- **Low density:** Most of the sport equipment's such as golf clubs, skies required to be light in weight to hit its operational intention, and composite material which has very less density than conventional metal serves this purpose very easily.
- **Good mechanical performance:** Sport equipment need to possess high damping capacity, such equipment's also needs to retain stability under various uncertain loads; composite material which is having high modulus of elasticity serves this purpose in better manner than conventional material.
- **Good moulding capacity:** Various advance and latest technologies are available to mould the composites at lowest affordable cost and minimum time.
- **General aspects:** Composite material can be recycled. They do not possess any harmful emissions.

Composites moulding's in different forms:

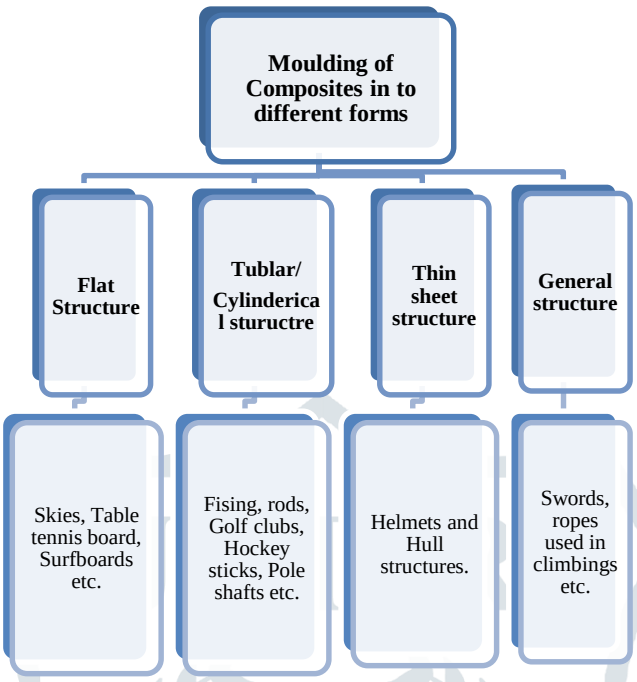


Fig (4.1): Composite moulding in different shapes

Glass fibres, carbon fibres, synthetic fibres are used in the manufacturing of sporting goods. The essential properties to be possessed by material can be listed as, high modulus, size stability, heat and chemical resistance, good bending, tensile and impact strength, low elongation, abrasion resistance, stiffness, low density etc.

5. In Bio-Medical:

Composite materials are used in reconstructions and healings of tissues. The demand for the human tissues and organs replacement has risen to considerable extent nowadays.

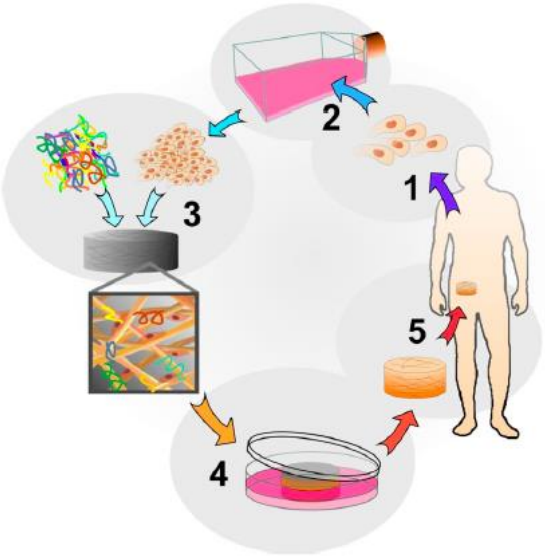


Fig (51): Tissue engineering

Tissue Engineering: "It is branch of science which applies engineering principal and life science towards development of biological substitute which restore, maintain and improve tissue functions".

Contents of human tissues & alternative biological material used in the replacement of human tissues.
Scaffolds: **1.** Mimic the mechanical and biological function of natural matrix. **2.** Stimulates delivery of cells and appropriate biological factors to specific body location as per the need.
Polymers: **1.** It is high mass molecule made of repetitive number of units called as Monomers. **2.** Polymer found in Protein, Collagen and DNA. **3.** Synthetic polymer can be engineering with properties such as inject ability, bio-compatibility, low concentration, Nano-scale fibres etc. **4.** Polymers can be produced and used in two different forms, Natural and synthetic. **5.** Natural polymers are, silk, collagen, gelatine, myosin etc. **6.** Synthetic polymers are hydrophobic polyester, polyglycolide etc.
Composites: **1.** Composites material composed of two or more than two physically, chemically distinct and mechanically separable phases. **2.** Composites are used in tissue engineering to enhance mechanical performance and release of certain molecules at appropriate body locations. **3.** Composite structure consist, biocompatible matrix with ceramics fillers, polymers are flexible, and ceramics are tough.
Carbon Nano-Tubes: **1.** It is carbon based Nano-material. **2.** Material possesses properties which are best suitable to process in commercial, chemical and medical environment. **3.** Mechanical, thermal, electrical, chemical properties are related to molecular structure. **4.** It is of two types, namely, single walled and double walled. **5.** Single walled carbon nanotubes consist single rolled up graphene sheet, where double walled carbon nanotubes structured with multiple groups of graphene sheets.

6. In Industries: Popularity of composites keeps motivating the researchers and investigators to finding the new scopes and applications to promote the use of composites to reach to the unattended advantages yet.

For example, use of graphite is very popular in Aerospace industries due to its good thermal conductivity and high strength.

Composites also used in nuclear industries as a fuel (Ceramics fuel in steel matrix nuclear). Ceramics composites also used in the process of separating core reactor from coolant.

Few of the applications where composites have used successfully are depicted through various images below,

Image (6.1): Artificial limbs

Image (6.2): FRP toilets for railway use

Image (6.3): Composite pressure vessel

Image (6.4): Piping system

Image (6.5): Ladder system

Image (6.6): Hand trails

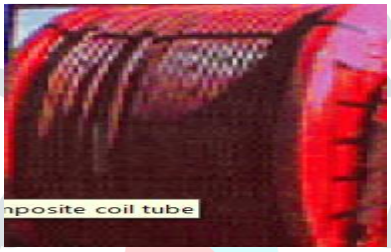


Image (6.7): Coil tubes

Image (6.8): Train made of composite material

Image (6.9): Sleepers for railways bridges/Tracks

Apart to above applications, composite also used in manufacturing of mechanical components such as, Bearing, Gear, Machine tools, Cranes etc.

Apart to the above applications, composite materials are widely used in the manufacturing of electrical and thermal component which gives superior performance in the comparison of conventional materials.

7. In Constructions: The properties of composites such as, corrosion resistance, low stress, low density and high strength to stiffness ratio made it enable to use in various applications, construction field is not even not lagging in taking benefit of it. The use of composite is extended in applications such as, building development, long span roof construction, bridges component and water storage tanks etc.

Following are the details of few composite materials (Natural or Synthetic) which are used in different applications,

Sr. No.	Name of Composite	Application
1	Jute, Sisal	Ceiling & wall panels.
2	Wood with polymer composites	Door shutters & Window frames.
3	Vegetable fibres	Shutters & roofing.
4	Jute fibre with polyester epoxy	Sheets, wall claddings, door shutters etc.
5	Coir fibre, ash and lime etc.	Bricks & block structure
6	Glass fibres reinforced polyesters	Partition, pipes, water storage tanks etc.
7	Glass fibres	Door hinges
8	Polyester with sisal fibres	Roofing, partition, door panels etc.
9	Acrylic resin and sand	Kitchen sinks

Table (7.1): Use of composites in various applications in vivid forms

Following few real life images depicts use of composites in construction field which justifies the extent of popularity composite have gained over the years in same field.

Image (7.1): Road Bridge

Image (7.2): Pultruded profiles

Image (7.3): FRP doors and door frames

Image (7.4): Composite building

Image (7.5): Composite furniture

8. In Marine Applications: Use of composites in structural design (Under water or surface applications) began from the World War-II. A little initiative taken by US Navy which was built surf boat by using composite material rather using timber, wood, steel or aluminium sort of material. The use of timber was getting costly those days, which is the scenario in today's date even, the degradation of timber due to sea water, sea organisms leads to yield high maintenance, the use of steel and aluminium results in heavy weight and corrosion, and thus composite was only the material which could perform well at such problematic fronts.

The material to be used in Marine or Naval applications needs to be strong, durable, light weight and most important corrosion resistance.

The material use in marine applications are, Glass reinforced polyester composites, sometimes, carbon , aramid, vinyl fibres with epoxy resin matrix also used.

Few of the applications where composites are recommended in Marine use are depicted in figure below,

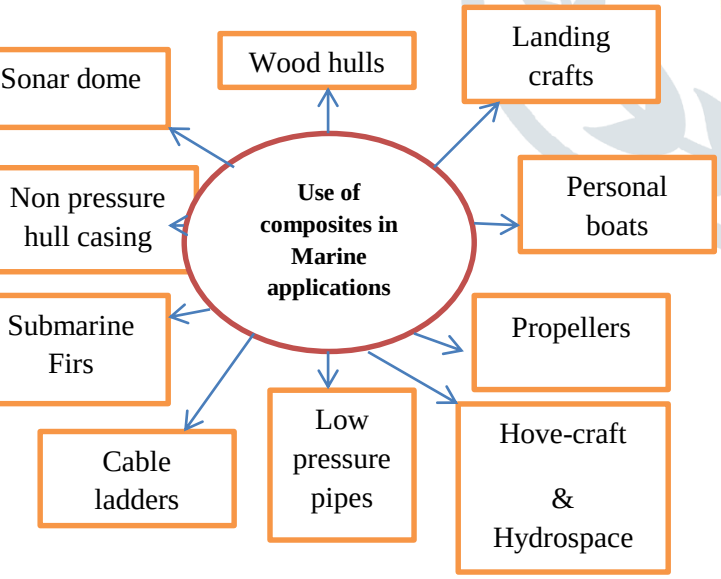


Fig (8.1): Composite use in various marine applications

9. Defence applications: In the manufacturing of defence aircrafts; Fibre Reinforced Epoxy Composites are preferred in most of the cases. Use of Composites in the Defence is detailed out below,

Use of composites in Defence				
Aircraft Type	F-14	F-15	F-16	Light combat aircraft
Components	Doors,	Rudder,	Vertical	Wing, fins,

made of composite	tails etc.	speed breaker etc.	and horizontal tail.	rudders, central surface etc.
Aircraft Type	F-18	B-1	AV-8B	Typhoon
Components made of composite	Door, tail, wing box etc.	Door, tail, flaps etc.	Door, tail, wings, box, body etc.	Wing, fin, rudder, fuselage etc.

Table (9.1): Use of composites in various defence applications

10. Conclusion: after going through various applications where composite can be used as substitute or total replacement material for conventional material, following study conclusions can be drawn out of the work undertaken,

- The use of composites in industrial applications or product making is not new but it can be traced for many decade back, only the difference structure of current composites is evolution and up-gradations happened in to material technology which was strongly recommended to cope up the need of ultramodern applications and associated needs.
- Light weight, less water absorption, less humidity effect enables the use of composites in to space, underwater, surface water, marine and naval applications.
- Easy mouldability and satisfactory coefficient of thermal expansion motivate industrial designer to think composite as alternative material in the applications such as, steam pipes carrying high pressure steam, pressure vessel and boilers etc.
- The less susceptibility to corrosion also facilitates the use of composites in the applications such as steam turbine, water based turbine, and fluid carrying pipes which leads to corrode the product at quite faster rate.
- The high strength to weight ratio, high stiffness, less density of composites gives the pleasure of its use in to application such as vehicle and its component building when operational efficiency exceeds the maximum benchmarked level noted in the case of conventional material.

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