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# Polymer Composites in Aviation Sector
## A Brief Review Article

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*Abstract*— **Modern aerospace industry is highly progressive and polymer composite materials have a positive and significant impact on it. At least 30-40 percent of modern airframes are now made of these composites, and this percentage is increasing rapidly due to technological advances in this field. Fiber-reinforced polymer composite materials are fast gaining ground as preferred materials for construction of aircrafts and space crafts. This review paper demonstrates brief about the components of polymer composites, its properties and its uses in aerospace industries. Polymer composites are highly efficient and environment friendly. Traditional materials are susceptible to fatigue and corrosion when composite materials provide resistance to both of this along with its significant amount of weight reduction. Due to high strength and stiffness of its fiber, polymer composite provides high "strength to weight" & "stiffness to weight" ratios. Apart from this, they possess good shear properties and low density .As a result, new generation aerospace engineers and aircraft designers are turning to polymer composite materials to make their flying vehicle and aircraft lighter, stronger and of course more fuel efficient. A brief introduction of composites usage in aerospace sector is given first. The nature of Polymer composite materials and special problems in designing and working with them are then highlighted. The advantages and disadvantages of polymer composites in aviation sector is discussed.**

***Keywords— Polymer Composite Materials, Polymer Matrix Composite (PMCs), Aerospace Applications, Fiber-Reinforced.***

## I. INTRODUCTION

Materials can be classified into the categories: Metals, Polymers, Ceramics and inorganic glasses and composites. Metals lose their strength at elevated temperatures. High-Polymeric materials in general can withstand still lower temperatures. Ceramics outstrip metals and polymers in their favourable melting points, ability to withstand high temperatures, strength and thermal expansion properties, but due to their brittleness they are often unsatisfactory as structural materials. This lead to the exploration of composites. One may define a composite as material as a materials system which consists of a mixture or combination of two or more micro constituents mutually insoluble and differing in form and/or material composition. Examples of composites are steel reinforced concrete (metals + ceramics), vinyl-coated steel (metals + polymers), fiber reinforced plastics (ceramics + polymers). Emergence of strong and stiff reinforcements like carbon fibre along with advances in polymer research to produce high performance resins as matrix materials have helped meet the challenges posed by the complex designs of modern aircraft. The large scale use of advanced composites airframes and in current programmes of development of military fighter aircraft, NASA aerospace structures, small and big civil transport aircraft, helicopters, satellites, launch vehicles and missiles all around the world is perhaps the most glowing example of the utilization of potential of such composite materials. [2][4][7][8].

### *A. The Definition of Composite Materials*

Composite material is a material that consists of strong carry-load materials which are embedded in a somewhat weaker material. The stronger material is commonly referred to as reinforcement and the weaker material is commonly referred to as the matrix. The reinforcement provides the strength and rigidity that is needed and which helps to support the structural load[2][8][9].

The matrix or the binder helps to maintain the position and orientation of the reinforcement and is somewhat more brittle.

### *B. Roles of the Matrix and Reinforcement in Composites*

The matrix is the continuous phase of the composite. Its principal role is to give the shape to the structure. Therefore, matrix materials that can be easily shaped and then hold that shape are especially useful. The matrix is the component of the composite that first encounters whatever forces might be imposed.

The principal role of the reinforcement is to provide strength, stiffness and other mechanical properties to the composite [2][7][8][9]. (See Fig. 1)[2]

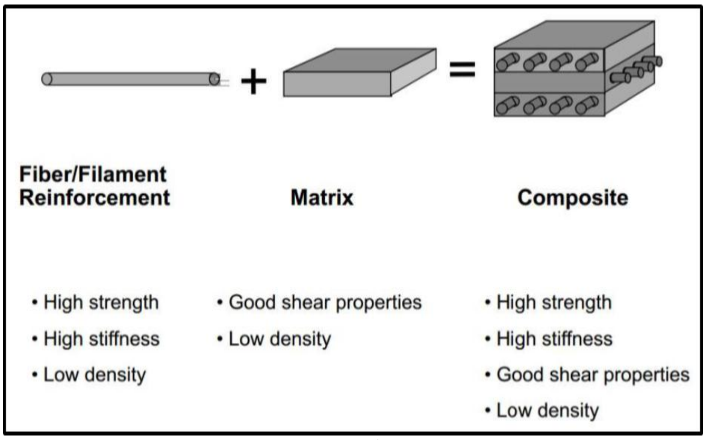


Fig. 1. Composition of Composites

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*C. Types of Composite Materials*

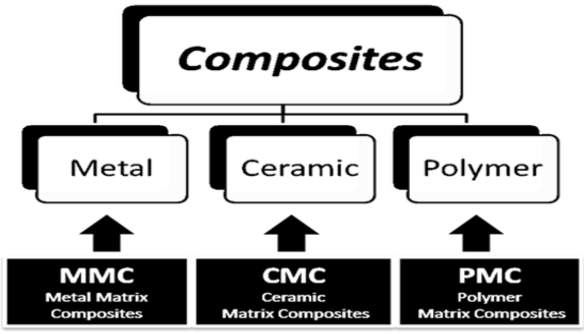

Fig. 2. On the Basis of Matrix Materials

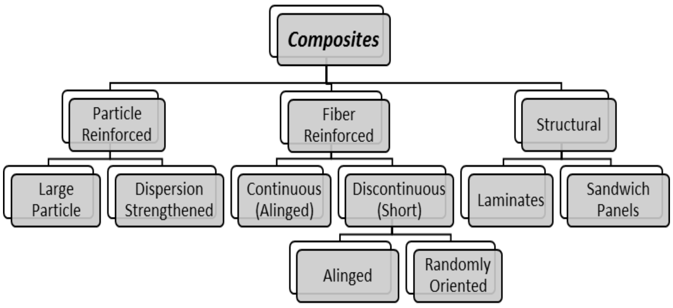

Fig. 3. On the Basis of Basis of Reinforcement

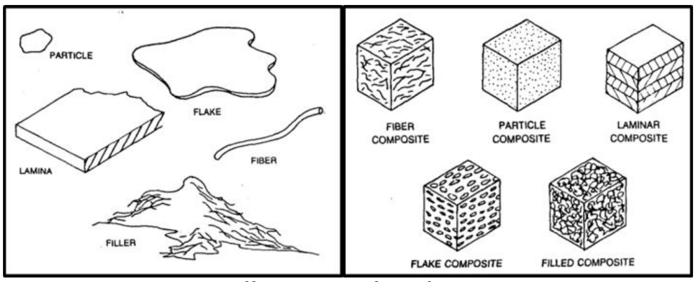

Fig. 4. Different Types of Reinforcement

## III. POLYMER COMPOSITES

Polymer composites are those composites in which at least one component is a polymer. In other words, Polymer composites are plastics within which fibers or particles are embedded. The plastic is known as the matrix, and the fibres or particles, dispersed within it, are known as the reinforcement.

Matrix in Polymer Composites: There are a large number of classes of polymer that can be utilized in fabricating a composite material. The selection of a polymer type is a function of many items including application, cost, fiber type, manufacturing method, supply etc[7][8][9].

Some of the resins that are available include[4]:

- Polyester
- Vinyl Ester
- Epoxy
- Bismaleimide
- Polyimide
- Phenolic
- Cyanate ester
- Nylon
- Polyether imide (PEI)
- Polyetheretherketone (PEEK)
- Polyphenylene sulphide (PPS)
- Polyamide imide (PAI)

Reinforcement (Fibers) in Polymer Composites: The principal choices for fiber reinforcement are[4]:

- Glass
- Carbon
- Aramid
- Boron

Properties of the composite are greatly influenced by orientation and nature of those fibres.

*A. Polymer Matrix Composites (PMCs)*

Polymer matrix composites (PMCs) are materials that use a polymer based resin as a matrix material with some form of fibres embedded in the matrix, as reinforcement. Both thermosetting and thermoplastic polymers can be used for the matrix material.

Common Polymer composite thermosetting matrix materials include:

- Polyester
- Vinyl ester
- Epoxy

Polymer composite thermoplastic matrix materials include:

- PEEK
- PEI
- PPS

Reinforcements include:

- Glass
- Carbon
- Aramid fibres

*B. Properties of Polymer Composites*

The matrix protects the strong stiff fibres and the composite material improves on the properties of either the matrix material or the fibres alone. A major driving force behind the development of composites has been to produce materials with improved specific mechanical properties over existing materials[7][8][9].

Properties which are generally improved in Polymer Composites are as follows[5];

- Corrosion Resistance
- Stiffness
- Thermal Conductivity
- Directionality
- Ultimate Elongation And Elastic Elongation
- Electrical Conductivity
- Replacability For Metals
- Heat Stabilizers
- Fire Resistance
- Chemical Resistance

And Properties based performance benefits are as follows;

- Strength - greater than strongest metals, Stiffness - similar to steel
- Density - light weight - half aluminum, fifth steel

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- Even in conservative designs, 30% weight saving is easily achievable
- Excellent fatigue and corrosion resistance
- Manufacture of complex shapes, reduced parts, easier assembly, reduced machining
- Dimensional stability
  - e.g. space structures

## IV. EVOLUTION OF AEROSPACE STRUCTURAL MATERIALS

Early aircraft design used a type of composite – a combination of wood, canvas & high tension wires with flight control achieved by twisting the tips of the wings and employing the use of a rudder (high DT and low mass). A composite design!

Carbon fibre and glass fibre reinforced polymers first included in aircraft during the 1970s.(See Fig. 5) [1][2][6]

The Aerospace industry is, however, inherently conservative resulting in a small step by step approach – composites have taken a long time to really 'take-off'.

Conservatism in design has also limited platform shape and construction to that of proven metallic designs rather than embracing and designing for the new materials, but this is changing. But composite usage is now increasing rapidly[1][2][4][11].

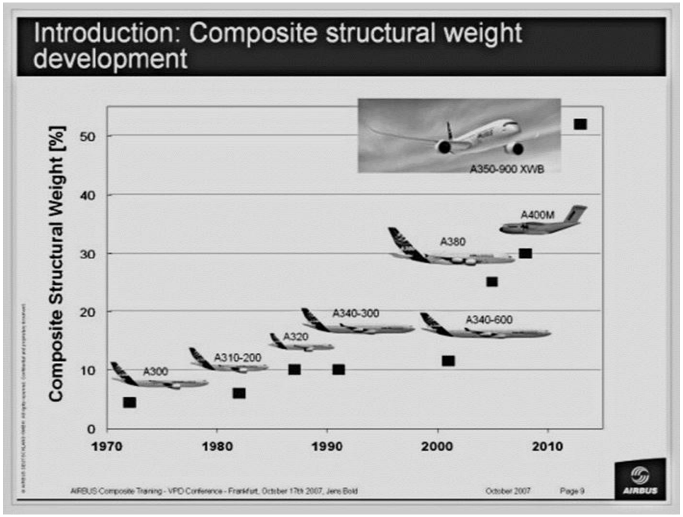


Fig. 5. Increase in Composite Material use in Aircrafts over past years

## V. THE AEROSPACE STRUCTURES AND FEATURES

On a broader scale firstly we have to understand the important requirements of an aerospace structure and their effect on the design of the structure. These structural requirements are presented in Table 1[6].

Further, the structure has to meet the requirements of fuel sealing and provide access for easy maintenance of equipment. Passenger carriage requires safety standards to be followed and these put special demands of fire-retardance and crash-worthiness on the materials and design used. For spacecraft the space environment–vacuum, radiation and thermal cycling-has to be considered and specially developed materials are required for durability.

Two key developments in scientific-technological world have had a tremendous influence on the generation and satisfaction of the demands raised by the aerospace community: one, the advances in the computational power and the other, composites technology using fiber reinforced polymeric materials.

It is to be realized that in order to meet the demands in *Table 1*, it is necessary to have materials with a peculiar property-set. The use of composites has been motivated largely by such considerations.

- The composites offer several of these features as given below:
- Light-weight due to high specific strength and stiffness
- Fatigue-resistance and corrosion resistance
- Capability of high degree of optimization: tailoring the directional strength and stiffness
- Capability to mould large complex shapes in small cycle time reducing part count and assembly times: Good for thin-walled or generously curved construction
- Capability to maintain dimensional and alignment stability in space environment
- Possibility of low dielectric loss in radar transparency
- Possibility of achieving low radar cross-section

TABLE I. FEATURES OF AIRCRAFT STRUCTURE

| REQUIREMENT | APPLICABILITY | EFFECT |
|---|---|---|
| Light-weight | All Aerospace Programs | ➢ Semi-monocoque construction<br>*Thin-walled-box or stiffened structures<br>➢ Use of low density materials :<br>*Wood, Al-alloys, Composites<br>➢ High strength/weight, High stiffness weight |
| High reliability | All Space Programs | ➢ Strict quality control<br>➢ Extensive testing for reliable data<br>➢ Certification : Proof of design |
| Passenger safety | Passenger vehicles | ➢ Use of fire retardant material<br>➢ Extensive testing : Crashworthiness |
| Durability-Fatigue and corrosion Degradation : Vacuum Radiation Thermal | Aircraft Spacecraft | ➢ Extensive fatigue analysis/testing<br>*Al-alloys do not have a fatigue limit<br>➢ Corrosion prevention schemes<br>➢ Issues of damage and self-life, life extension<br>➢ Extensive testing for required environment<br>➢ Thin materials with high integrity |
| Aerodynamic performance | Aircraft Reusable spacecraft | ➢ Highly complex loading<br>➢ Thin flexible wings and control surfaces<br>*Deformed shape-Aero elasticity Dynamics<br>➢ Complex contoured shapes<br>*Manufacturability NC Machining ; Molding |
| Multi-role or functionality | All Aerospace Programs | ➢ Efficient design<br>➢ Use : Composites with functional properties |
| Fly-by-wire | Aircrafts, mostly for fighters but also some in passenger a/c | ➢ Structure-control interactions<br>*Aero-servo-elasticity<br>➢ Extensive use of computers and electronics<br>*EMI shielding |
| Stealth | Specific military aerospace applications | ➢ Specific surface and shape of aircraft<br>*Stealth coatings |
| All-Weather operation | Aircraft | ➢ Lightning protection erosion resistance |

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## VI. POLYMER COMPOSITE IN AVIATION SECTOR

*A. Why Aerospace and Aviation industry?*

'Safety' and 'security' are the most important words in the field of aerospace. Imagine a structural failure in a car and an airplane. If the skin of the car gets ripped off while driving no disaster is going to happen. But in the case of the aircraft, a great disaster will occur.

Besides these, the performance of an airplane is highly influenced by its weight and overloading it will cause serious problem. By using composite materials, we can overcome this problem. Aircraft operate in very corrosive environment and inspection for corrosion damage are carried out often. Composites don't corrode. They also help to reduce the development of the crack[1][2][4].

*B. The Usage of Composite Materials in Aerospace and Aviation Industry*

Composite materials can provide a much better strength-to-weight ratio than metals: sometimes by as much as 20% better.

The lower weight results in lower fuel consumption and emissions and, because plastic structures need fewer riveted joints, enhanced aerodynamic efficiencies and lower manufacturing costs. The aviation industry was, naturally, attracted by such benefits when composites first made an appearance, but it was the manufacturers of military aircraft who initially seized the opportunity to exploit their use to improve the speed and manoeuvrability of their products.

Weight is everything when it comes to heavier-than-air machines, and designers have striven continuously to improve lift to weight ratios since man first took to the air.

Composites materials played a major part in weight reduction, and today there are 3 main types in use: carbon fibre, glass and aramid – reinforced epoxy.

There are others, such as boron-reinforced (itself a composite formed on a tungsten core). Composites are versatile, used for both structural applications and components, in all aircraft and spacecraft, from hot air gondolas and gliders, to passenger airliners or fighter planes.

The types have different mechanical properties and are used in different areas of aircraft construction.

Carbon fibre for example, has unique fatigue behaviour and is brittle, as Rolls Royce discovered in the 1960's when the innovative RB211 jet engine with carbon fibre compressor blades failed catastrophically due to bird strikes.

In an experimental program, Boeing successfully used 1500 composite parts to replace metal components in a helicopter.

The use of composite-based components in place of metal as part of maintenance cycles is growing rapidly in commercial and leisure aviation. Overall, carbon fibre is the most widely used composite fibre in aerospace applications[1][2][4].

## VII. MATERIALS FOR PLASTIC COMPOSITES IN AVIATION SECTOR

The materials systems which have been considered useful in aerospace sector are based on reinforcing fibers and matrix resins given in Table 2 and 3, respectively. Most aerospace composites use prepregs as raw materials with autoclave moulding as a popular fabrication process. Filament winding is popular with shell like components such as rocket motor casings for launch vehicles and missiles. Oven curing or room temperature curing is used mostly with glass fibre composites used in low speed small aircraft. It is common to use composite tooling where production rates are small or moderate; however, where large number of components are required, metallic conventional tooling is preferred. Resin injection moulding also finds use in special components such as radomes. Some of the popular systems are given in table 4 along with the types of components where they are used in a typical high-performance aircraft.

*A. Reinforcing fibers*

Fibers are widely used as reinforcements. Glass, aramid and carbon fibers are in extensive use amongst the fibers available. Boron or other exotic fibers are also used in modest quantities for applications requiring very high service temperatures like the ones which we need for the skinning of the aircrafts. The properties of glass, aramid and carbon fibers are given in the table (Table 2) [6].

TABLE II. REINFORCING FIBERS COMMONLY USE IN AEROSPACE APPLICATIONS

| Fiber | Density (g/cc) | Modulus (GPa) | Strength (GPa) | Application areas |
|---|---|---|---|---|
| **Glass** | | | | |
| **E-glass** | 2.55 | 65-75 | 2.2-2.6 | Small passenger a/c parts, air-craft interiors, secondary parts; Radomes ; rocket motor casings |
| **S-glass** | 2.47 | 85-95 | 4.4-4.8 | Highly loaded parts in small passenger a/c |
| **Aramid** | | | | |
| **Low modulus** | 1.44 | 80-85 | 2.7-2.8 | Fairings: non-load bearing parts. |
| **Intermediate Modulus** | 1.44 | 120-128 | 2.7-2.8 | Radomes, some structural parts; rocket motor casings |
| **High modulus** | 1.48 | 160-170 | 2.3-2.4 | Highly loaded parts |
| **Carbon** | | | | |
| **Standard modulus (high strength)** | 1.77-1.80 | 220-240 | 3.0-3.5 | Widely used for almost all types of parts in a/c satellites, antenna dishes, missiles, etc. |
| **Intermediate Modulus** | 1.77-1.81 | 270-300 | 5.4-5.7 | Primary structural parts in high performance fighters |
| **High modulus** | 1.77-1.80 | 390-450 | 2.8-3.0 | Space structures, control surfaces in a/c |
| | | | 4.0-4.5 | |
| **Ultra-high strength** | 1.80-1.82 | 290-310 | 7.0-7.5 | Primary structural parts in high performance fighters, spacecraft |

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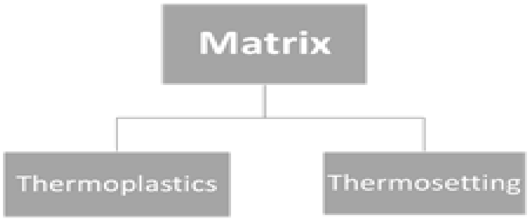
*B. Matrix*

Matrices are holders in which fibers are embedded. A matrix acts as binder which surrounds the fibers. For example; when we considering carbon fiber reinforced polymer, carbon fiber is the filler and polymer is the matrix. Matrix properties like Stress-Strain behaviour & adhesion properties are important factors which mostly determine the ability of the matrix to distribute stresses. Polymer Matrix can be divided into two groups[1][2][4] –




Both type of matrix are greatly used in industrial applications but thermoplastic system is preferred over thermosetting because of no involvement of chemical reaction as it results in release of gas or heat.

*C. Thermoplastics*

Thermoplastics are of very high molecular weight and their strength and stiffness are emerged from the properties of their monomer units. Amorphous and Crystalline polymer's properties have profound effect on the properties of thermoplastic composites. For Amorphous polymers chain slippage occurs and it leads to high strain to failure, toughness and damage tolerance. Crystalline polymers have increased strength and temperature resistance. Polymer composite thermoplastic matrix materials include[4]:

- PEEK
- PEI
- PPS

*D. Thermoset Resins*

In a thermosetting resin, the raw uncured molecules are cross linked through a catalytic chemical reaction. Through this reaction they are converted into hard brittle solids, creating strong bonds between one another through the formation of three dimensional networks of polymer chains. Once a thermosetting composite is formed; it cannot be reformed or reversed. That is why recycling of thermosetting composite is difficult. Thermosetting resins have excellent properties like resistance to solvents, corrosives, heat and high temperature and also have good fatigue strength, elasticity and adhesion properties. Epoxy resin, unsaturated polyester resin and vinyl ester are the most used thermosetting polymer matrices. Epoxy resins are better in case of stiffness properties as compared to polyester resins. The interface bond strength between epoxy resin and filler is also greater than the polyester thermosetting. Vinyl ester resins offer good process ability for liquid processing techniques such as RTM. Common Polymer composite thermosetting matrix materials include[4]:

- Polyester
- Vinyl ester
- Epoxy

*E. Properties of Matrix*

It is undoubtedly true that the high strength of composites is largely dependent on the fiber reinforcement but the importance of matrix material cannot be avoided as it supports the fibers and distribute the load evenly on the fibers. The desired properties of matrix material for the formation of a good composite are as follows[4][6];

- High toughness
- Room temperature cure preferable
- Low moisture absorption
- Low shrinkage
- Low thermal expansion
- Higher elastic modulus (more than fiber)
- Excellent chemical resistance
- Easily process able
- Dimensional stability

TABLE III. POLYMERIC MATRICES COMMONLY USED IN AEROSPACE SECTOR

| Thermosets | | | | Thermoplastics |
|---|---|---|---|---|
| Forms cross-linked networks in polymerization curing by hearing | | | | *No* chemical change |
| **Epoxies** | **Phenolic** | **Polyester** | **Polyimides** | **PPS, PEEK** |
| • Most popular<br>• 80% of total composite usage<br>• Moderately high temp.<br>• Comparatively expensive | • Cheaper<br>• Lower viscosity<br>• Easy to use<br>• High temp. usage<br>• Difficult to get good quality composites | • Cheap<br>• Easy to use<br>• Popular for general applications at room temp. | • High temp. application 300°C<br>• Difficult to process<br>• Brittle | • Good damage tolerance<br>• Difficult to process as high temp. 300-400°C is required |
| • Low shrinkage (2-3%)<br>• No release of volatile during curing | • More shrinkage<br>• Release of volatile during curing | • High shrinkage (7-8%) | | |
| • Can be polymerized in several ways giving varieties of structures, morphology and wide range of properties | • Inherent stability for thermal oxidation<br>• Good fire and flame retardant<br>• Brittle than epoxies | • Good chemical resistance<br>• Wide range of properties but lower than epoxies<br>• Brittle<br>• Low $T_g$ | | |
| • Good storage stability to make prepregs | • Less storage stability-difficult to prepreg | • Difficult to prepreg | | • Infinite storage life but difficult to prepreg |
| • Absolute moisture (5-6%) causing swelling and degradation of high temp. properties<br>• Also ultra violet degradation in long term | • Absorbs moisture but no significant effect of moisture in working service range | • Less sensitive to moisture than epoxies | | • No moisture absorption |

*F. Sandwich Structures*

In aerospace industry the effectiveness of composite materials in reducing component weight and increasing fuel economy has greatly been proved. The idea of sandwich structure has become increasingly popular because of the development of man-made cellular materials[6]. (See Fig. 6) [6][9]

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Sandwich structure consists of

- A pair of thin stiff, strong skins (faces, facings or covers)
- A thick, lightweight core to separate skins & carry the loads from one skin to other
- An adhesive attachment which is capable of transmitting shear and axial loads to and from the core. Sandwich structures are very light and stiff which are the main demands of aerospace industry.

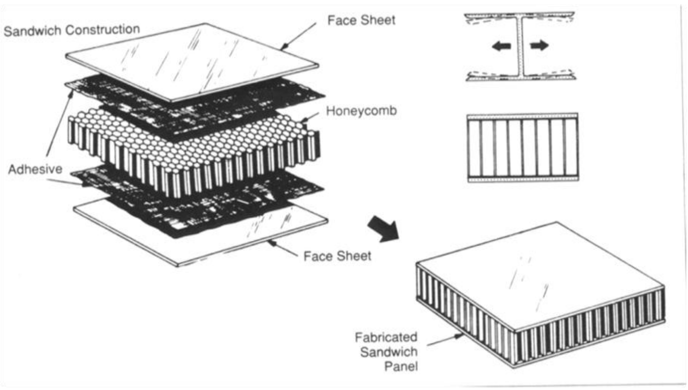


Fig. 6. An Illustration of layer orientation of a sandwich

## VIII. CURRENT SCENARIO

Polymer composite materials are widely used in the aircraft manufacturing industries and it has allowed the aerospace engineers to overcome the obstacles that have been faced by them when they used the traditional materials individually. As the polymer composite provides the properties of light weight, high temperature resistance etc. so that during the last few decades its application in aerospace industry has rapidly increased to design high performance and economical aircraft.

Further we will discuss the recent scenario in the form of development(s), i.e. Structural, Manufacturing Materials based enhancement(s) and etc., in different commercial aviation aircrafts[1][2][4].

### *A. Boeing 787/Dream liner*

Boeing a leading aircraft manufacturing industry has used a significant amount of composite at their new passenger aircraft “Boeing 787/Dream liner”. The Figure 7 shows us the amount of composite with respect to other materials used in Boeing 787/Dream liner. The figure shows that now a day’s around 50% material used in Boeing 787 is composite material with comparison to the Boeing 777 which used only 12% of composite and 70% aluminum. Each 787 contains Approximately 32,000 kg of Carbon Fiber Reinforced Plastic (CFRP), made with 23 tons of carbon fiber. Carbon fiber composites have a higher strength-to-weight ratio than traditional aircraft materials, and help make the 787 a lighter aircraft. Composites are used on fuselage, wings, tail, doors, and interior[2]. (See Fig. 7) [2][11]

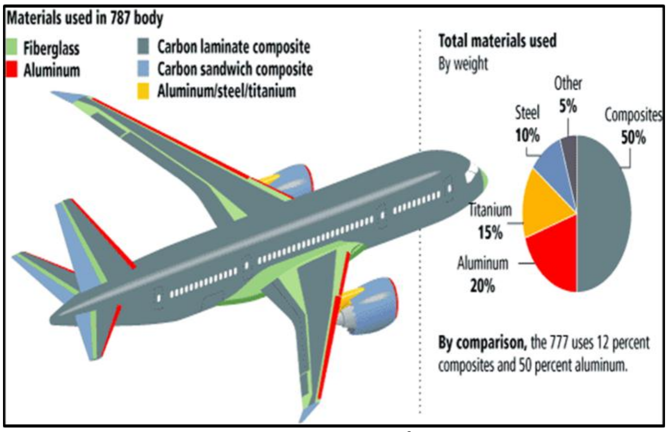


Fig. 7. Composite structure of Boeing 787

### *B. Airbus A350-XWB*

The A350XWB consists of 53% composites, 19% AL/AL-Li, 14% Titanium and 6% steel. Composite skin panels are placed over composite frames and the cross section remains ovoid.

Aluminum strips in the frames ensure best results in dissipating lightning strikes. The rear fuselage section is a carbon fibre structure, as the horizontal stabilizer and fin / rudder assembly. (See Fig. 8) [2][11].

Its fuselage panels, frames, window frames, clips and door are made from carbon fibre reinforced plastic (CFRP), with a hybrid door frame structure consisting of this material and titanium being used for the first time.

By applying composites on the A350XWB, Airbus has increased the service intervals for the aircraft from six years to 12, which significantly reduces maintenance costs for customers.

The high percentage of composites also reduces the need for fatigue – related inspections required on more traditional aluminum jetliners, and lessens the requirement for corrosion-related maintenance checks[2].

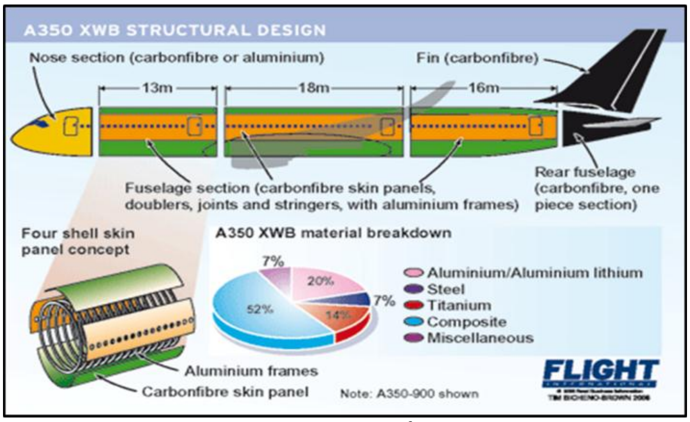


Fig. 8. Composite structure of A350XWB

*C. Airbus A380*

Part of the goal in each aircraft company is to select the most appropriate material for the specific application, which would lead to the lightest possible structure. For this purpose, composite materials are good competitors, and their use is foreseen on many areas of the airframe[1][2]. (See Fig. 9) [2][11]

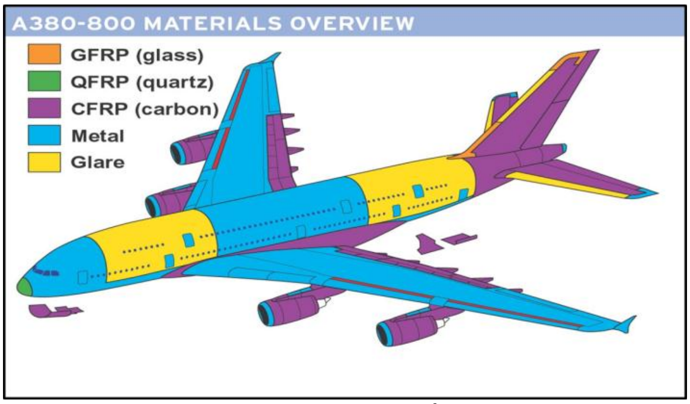


Fig. 9. Composite structure of A380

The A380 is the first aircraft ever that boasts a CFRP (Carbon Fibre Reinforced Plastic) composite central wing box, representing a weight saving of up to one and a half tonnes compared to the most advanced aluminium alloys.

The upper deck floor beams and the rear pressure bulkhead are made of CFRP. For this last component, different technologies were tested such as Resin Film Infusion and Automated Fibre Placement.

## VIII. Advantages and Disadvantages of Polymer Composite Materials

*A. Advantages*

- *Weight reduction* – savings in the range 20% - 50% are often quoted
- *Mechanical properties* can be tailored by 'lay-up' design, with tapering thicknesses of reinforcing cloth and cloth orientation.
- *High impact resistance* – Kevlar (aramid) armor shields planes, too – for example, reducing accidental damage to the engine pylons which carry engine controls and fuel lines.
- *High damage tolerance* improves accident survivability.
- *'Galvanic'* - electrical – corrosion problems which would occur when two dissimilar metals are in contact (particularly in humid marine environments) are avoided. Here non-conductive fibreglass plays a roll.

*B. Disadvantages*

- *Some higher recurring costs,*
- *Higher nonrecurring costs,*
- *Higher material costs,*
- *Non-visible impact damage,*
- *Repairs are different than those to metal structure,*
- *Isolation needed to prevent adjacent aluminium part galvanic corrosion.*

## IX. Future Scope of Polymer Composites in Aviation Sector

- With ever increasing fuel costs and environmental lobbying, commercial flying is under sustained pressure to improve performance, and weight reduction is a key factor in the equation.
- Beyond the day-to-day operating costs, the aircraft maintenance programs can be simplified by component count reduction and corrosion reduction. The competitive nature of the aircraft construction business ensures that any opportunity to reduce operating costs is explored and exploited wherever possible.
- Competition exists in the military too, with continuous pressure to increase payload and range, flight performance characteristics and 'survivability', not only of airplanes but of missiles, too.
- Composite technology continues to advance, and the advent of new types such as basalt and carbon nanotube forms is certain to accelerate and extend composite usage.

## X. Conclusion

It is always important to choose the right material for right job. For example, In order to designing a commercial gas cylinder metals can be a good selection because it provides sufficient strength, ductility and keeps the manufacturing cost moderate. Here, the weight is not a significant factor, so we can select a low alloy steel (ASTM A414-Grade G). On the other hand when we fall our focus on aerospace engineering here the weight reduction (light weight) is more significant than the cost. So, for manufacturing aerospace pressure vessel aerospace engineer choice is composite material which provides light weight along with strength and ductility. So, a wise aeronautical engineer/aerospace engineer will always choice a polymer composite (Kevlar 49 aramid fibers) for designing an aerospace pressure vessel. Since, aerospace/aeronautical is an advanced branch of engineering where the term "safety" & "reliability" is more important than cost and so, the use of fiber reinforced polymer composite is taking its strong position in this field very rapidly. When we make unique combination of safety, reliability, light weight, strength and efficiency then there is no alternative to this polymer reinforce composite because it is aerospace which requires a lot of care. Otherwise the consequences will be dangerous and drastic.

*A. Summarised Conclusion*

1. Composite Materials properties are outstanding
   - But still challenges to be met, especially in fabrication & design
   - Usage of Composites is growing at a rapid rate in Aerospace
   - Composite materials are becoming the first choice materials
   - New materials, however, bring new problems and challenges, for the materials engineer, designer and operators

2. Reducing cost at all stages remains a major challenge
3. B787, A350-XWB, A380 used more than 50% composite materials
4. Composite materials offer ability to build in smart and stealthy functionality

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