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# Advanced Composite Materials of the Future in Aerospace Engineering

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***Abstract:Though there is a tremendous progress in the discipline of material science and engineering,still remains technological challenges, including the development of even more sophisticated and specialized materials such as composite materials. Selection of material is a very critical issue when it comes to Aerospace Engineering. Now-a-days, composites are becoming increasingly important in the Aerospace industry because of its increased strength at lower weights, corrosion resistance, stiffness etc. This paper examines the advantages and disadvantages of using composite materials in airframe manufacturee and also reviews the advanced development in composites as structuralal materials. A continuing trend in development of composite materials and production of materials to either improve physical properties or to allow their application in new areas and roles for further usage in the future.***
***Keywords: composite materials, Aerospace materials, strength to weight ratio, future composites***

## I. INTRODUCTION

Since Orville and Wilbur Wright first decided to power their flyer, cast aluminum engine is used to meet the specific requirements for power to weight ratio, due to weight constraints of Aluminium, new materials have been necessary to improve and advance aviation.[6] Over the years, research in material science has geared up with new innovative materials. Especially the new materials have more capabilities towards thermal and chemical resistance with application of producing light weight structures.[3]

Planes have traditionally been made out of metals- usually aluminum and its alloys, steel and titanium alloys. Since the need raised for highly effective and efficient material which should also have concerned with the ecology-concerned world of finite resources has made advanced composites to be one of the most important materials in the high technology revolution in the world today. The increased availability of these light, stiff and strong material has made it possible to achieve a number of milestone in Aerospace industry.[2]

Composite materials are more resistant to fatigue from repeated take-off/landing cycles than any other materials like metals, resulting in less cost over the aircraft's lifespan and more time spent in the air making money. One great innovation in the field of composite materials for Aerospace Industry is the ability to produce complex parts in one piece, which will reduce the manufacturing costs.

The latest generation of airliners, such as the airbus A380 and Boeing 787 Dream liner used composite materials for structural parts. Airbus A380, the world's largest passenger aircraft, shows that composite materials have been employed extensively as a primary load carrying structure and sme parts like wings, which helps to enable a 17% lower fuel use per passenger than other comparable aircraft whereas the newest Boeing, the 787 Dream liner, has the highest content of composites as 50%.[5]

### *A. What are Composites*

The materials can be classified into the following categories as: Metals, Polymers, Ceramics and inorganic glasses and Composites. Metals lose their strength at very high temperatures. High-polymeric materials in general can withstand their strength only at lower temperatures. Ceramics outstrip metals and polymers have ability to withstand high temperatures, but due to their brittleness they cannot used as structural materials since fracture occurs suddenly. This lead to the explanation of composites.[4] A "composite" is made when two or more different materials are combined together to create a superior and unique material. Composite material consists of strong carry-load materials which are embedded in a weaker material. The stronger material is commonly referred as reinforcement and the weaker material is referred as matrix. The two metals works together to give the composites unique properties. However, within the composites the material do not dissolve or blend into each other.[5] The reinforcement provides the strength and rigidity which helps to support the structural load. The matrix or the binder helps to maintain the position and orientation of the reinforcement and is somewhat more brittle. The reinforcement materials such as Fibers are thin and but integrity is not maintained. In matrix materials, strength values are less and hence fibers or matrix alone cannot find its application as a

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structural material but when these two materials are combined we get a composite materials which is light weight, stiff, strong and tough.[2]

*B. Natural Composites*

Wood: It is made from long cellulose fibers (a polymer) which held together by a much weaker substance called lignin. The cellulose and lignin together form a stronger one called wood.
Bone: It is made from a hard and brittle material called hydroxyl apatite (which is mainly calcium phosphate) and combined with a soft and flexible material called collagen (which is protein)

*C. Early Composites*

People have been making composites for many thousands of years.
Bricks: It is made from mud and straw. Mud can be dried out into a brick shape to give a building material. It has good compressible strength but it breaks quite easily when tensile load is applied. Straw is very strong when it is stretched, but you can crumple it up easily. By mixing mud and straw together, bricks can be made which is resistant to both squeezing and tearing and make more excellent building blocks
Concrete: It is a mix of aggregate (small stones or gravel), cement and sand. It has good compression strength (it resists squashing). In recent times, it has been found that adding metal rods or wires to the concrete can increase its tensile (bending) strength. Concrete containing such rods or wires is called reinforced concrete.

*D. Classification of  Composites*

Fiber glass is made from a reinforcement material as glass that has been made into fine threads and often woven into a sort of cloth and the matrix is plastic. Glass is very strong but the nature of glass is brittle and it will break if bent sharply. The plastic matrix holds the glass fibers together and also protects them from damage by shear forces acting on them when bending.
Some advanced composites are now made using carbon fibers instead of glass. Carbon fibres materials are lighter and stronger than fiberglass but more expensive to produce. They are used in aircraft structures and expensive sports equipment such as golf clubs.
Carbon nano -tubes are even lighter and stronger than composites made with ordinary carbon fibers but they are still extremely expensive. It is used for making light cars and aircraft (which will use less fuel than the heavier vehicles)

*E. Why are Composites*

The important advantages of modern composites materials are light and as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made which is able to meet the requirements of a particular application. A composite also provides flexibility so these materials can be molded into complex shapes. The drawback is often the cost. Although the resulting product is more efficient, the raw materials are often expensive.

*F. Why Composites in Aerospace*

Composite materials are important to the Aerospace Industry because they provide structural strength at lower weights comparable to other materials. This leads to less usage of fuel and thereby improved fuel efficiency and performance from an aircraft.

*G. The Role of Composites in Aerospace Industry*

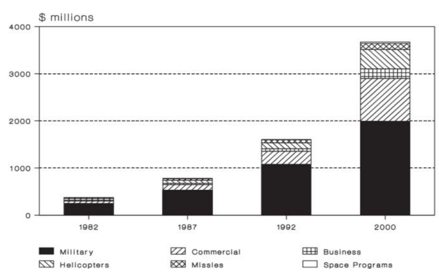


Figure1The Role of Composites in Aerospace industry

*H.  Commercial Aircraft*

Boeing 787 Dream liner
The Boeing 757 and 767 employ about 3000 pounds each of composites for doors and control surfaces. Boeing’s 787 Dream liners

is the first commercial aircraft in which the major structural elements are made of composites materials.

*I. Airbus*

A380 uses composite materials in its wings as a structural material which is a load carrying structure and helps to enable a 17% lower fuel use per passenger than other comparable aircraft.A highly mechanized production process was established to determine if high material cost could be compensated by increased manufacturing efficiency. Although material costs were 35% greater than a comparable aluminum structure, total manufacturing costs were lowered around 70 to 85%. Robotic assemblies were developed to handle and process materials in an optimal and repeatable fashion.

## II. MILITARY

*A. Advanced Tactical Fighter (ATF)*

Advanced composites meets improved performance requirements such as reduced drag, low radar observbility and increased resistance to temperatures generated at high speeds in ATF. The ATF is made up of 50% of composites by weight.

*B. Advanced Technology Bomber (B-2)*

The important quality of B-2 is its stealth qualities from the material properties of composites. Each B-2 contains an estimated 40,000 to 50,000 pounds of advanced composite materials.

## III. HELICOPTERS

*A. Rotors*

Composite materials have been used as structural materials for helicopter such as rotors for some time and now have gained virtually 100% acceptance as the material of choice for Helicopters. The use of fibrous composites offers improvements in helicopter rotors due to improved aerodynamic shape, improved aerodynamic maneuvers, good damage tolerance and potentially at low cost.

*B. Composite Components Used on Helicopter*

| Helicopter type | Component made of composite material |
|---|---|
| MBB BK117 | Main rotor blades, Tail rotor blades, Horizontal Stabilizer, Vertical Stabilizer |
| BELL 206L | Vertical Stabilizer |
| BELL 402 | Main rotor blades |
| Dauphin | Main rotor blades, Vertical Stabilizer |
| McDonnell Douglas, MD 520N | Main rotor blades, Tail boom |
| McDonnell Douglas, MD 900 | Main rotor blades, fuselage mid section, Tail boom, canopy frame, internal fuselage, Horizontal Stabilizer, Vertical Stabilizer |

*C. Space*

Th high specific modulus and strength, and dimensional stability during large variations in temperature in space make composites the material of choice in space applications. An example of usage of composite materials in space is the graphite/epoxy-honeycomb payload in the space shuttle.Graphite /epoxy was chosen as primary for weight savings and for small mechanical and thermal deflections.

## IV. ROCKET AND MISSILES

The parts like Rocket motor cases and liners are made using composites of carbon, aramid and glass. Phenolics and polyimide

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materials are also being used as composites in Rocket and Missiles components. Carbon – carbon composites are used for re-entry nose tips and heat shields.

*A. Advantages*

1) *Light Weight:* Composites are light in weight, compared to most other materials such as woods and metals. Their lightness is important in all applications like automobiles and aircraft, for example, where less weight leads to better fuel efficiency (more miles to the gallon). The important factor in designing of airplanes is to reduce weight, since reducing a aircraft's weight it reduces the amount of fuel it needs and leads to increase the speeds it can reach. Some modern airplanes are built with more composites than metal including the new Boeing 787, Dream liner, Airbus A380 etc, has a positive effect on costs and the environment. All benefits are combined together and that leads to significantly a long term reduction in cost.
2) *High Strength:* Composites have more strength than aluminum or steel at lower weights. Metals are also equally strong in all directions. But composites can be engineered and designed to be strong in a specific direction.
3) *Strength to Weight Ratio:* Strength-to-weight ratio is a material's strength relative to how much it weighs. Some materials are very strong and heavy, such as steel. Other materials can be strong and light, such as bamboo. Composite materials can be made to be both strong and light. This property makes the composites used to build airplanes-which need a very high strength material at very low possible weight. Composite materials are very strong at lower weights and there by it has high strength-to-weight ratios in structures today.
4) *Corrosion Resistance :* Composites are highly resistance to corrosion and also provides resistance to damage from the weather and from heavy chemicals which has ability to eat away at other materials. Composite materials are best choices where chemicals are used or stored.
5) *High-Impact Strength:* Composites have tendency to withstand the impacts, the sudden force, for some time, or the blast from an explosion. Because of this high impact strength tendency, composites an be used as bulletproof materials such as vests and panels, and as a shield to airplanes, buildings, and military vehicles from explosions.
6) *Design Flexibility:* Since composites are flexible, it can be molded into complex shapes more easily than most other materials. This allows designers to create almost any shape or form. For example, are built from fiberglass composites because these materials can easily be molded into complex shapes, which improve boat design while lowering costs.

*B. Disadvantage*

Composites are more brittle than wrought metals and thus are more easily damaged
Cost of the material s high.
Repair are different and introduces new problem than those to meet structures
Non – visible impact damage may occur

1) *The Future of Composites in Aerospace Industry: Ceramic Matrix Composites (CMC):* Efforts have been made to develop light weight, high temperature composite material at national aeronautics and space administration for use in Aircraft parts. Temperature rises as high as 1650$^o$c for turbine inlets of a conceptual engine and also for many parts in the engine. In order for materials to withstand such temperatures, the use of ceramic matrix composites (CMC) has been recommended. The uses of CMC's in advanced engines withstand an increase in the temperature at which the engine can be operated, leading to increased yield.
2) *Spider Silks Fibers:* Spider silk is another material which can be used as composite material. Because, Spider silk exhibits high ductility, allowing stitching of a fiber up to 140% of its normal length. Spider silk also withstand its strength at temperatures as low as -40$^o$c. These properties allows spider silks as a ideal use as a fiber material in production of ductile composite materials that will retain their strength even at abnormal temperatures.
3) *Hybrid Composites Steel Sheets:* Another promising material can be stainless steel constructed from composites and Nano tech fibers and plywood. This material is made into sheets and these sheets of steel are able to handle easily at elevated temperatures and tool exactly the same way as conventional steel. But in some percent it is lighter for the same strength. This is especially valuable for automobile manufacturing.

## V. CONCLUSION

Due to their higher strength–to-weight ratios, high stiffness, composite materials have an advantage over other conventional metallic

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materials like metals, ceramics, and glass fibres. But, currently it is expensive to fabricate composites and the availability is also less. Until new technologies are introduced to reduce initial implementation costs and should provide possible solutions for the issue of non-biodegradability of current composites, this makes composite material not be able to completely replace traditional metallic alloys.

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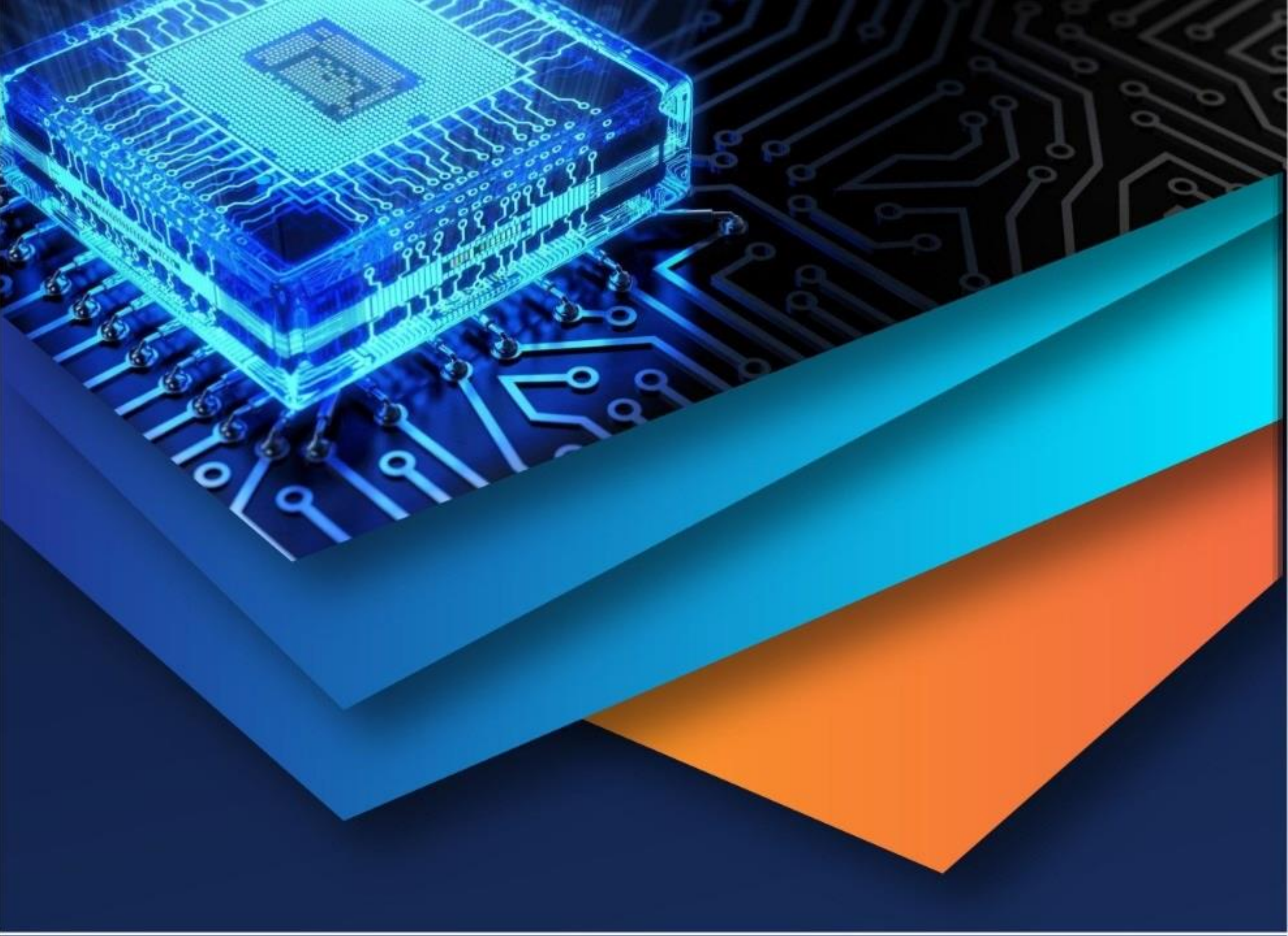


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