Review: Composites Used In Aircrafts

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Abstract. Since the first aircrafts were produced one of the main objectives of the aircrafts manufacturers was to keep the wight of the aircraft down without compromising the structural integrity and strength of the aircraft. This led to the utilization of fabrics for the skin of the aircrafts in the years of infancy of aircraft building, with the improvement in technologies the materials used in the construction varied but also added wight to the aircraft. In order to reduce the wight of aircrafts various innovative solution were used. In the recent years composites have take the spot light due to their versatility, and currently the order of the day is to use green composites or hybrid composites in the manufacturing of components for aircrafts.

Keywords: Hybrid Composite, Glass fiber, Bamboo fiber.

1 Introduction

The dictionary defines an aircraft as a vehicle used for travelling through air [1] which is a very simple definition of an aircraft. A more concise or a more in-depth definition of an aircraft or an aeroplane or plane is, any type of a fixed-wing vehicle, which is heavier than air and is propelled forward by a propeller or a jet and is supported by the dynamic reactions of air against the wings [2].

Wilbur and Orville Wright since 1899 were experimenting with the concepts of flight and on December 17th 1903 Orville Wright achieved the first controlled, powered and sustained flight which lasted for around 120 feet and by the end of the day the brothers had achieved flight for about 59 seconds travelling 852 feet in this time [3]. The Wright flyer was constructed with wood and steel, it had a fabric wing wrapping and a lightweight aluminium engine. It was thought in the beginning by aircraft experts that only lightweight materials like wood, struts, tension wires and could be used to produce an aircraft which could achieve flight, but Hugo Junkers believed that heavier materials like metals could be used to produce aircrafts, which would be capable of carrying goods and passengers, and 12 years later in 1915, Hugo Junkers (1859-1935) built the Junkers J1 a full-metal aircraft was built and flown. The innovator Howard Huges and innovators in the aviation sector found that, making aircrafts with Aluminium and its alloys made the aircraft lighter, fuel efficient and was also able to withstand higher stresses and pressures. Henry Ford in 1925 produced the "Tin

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Goose" an aircraft based on the design principle proposed by Hugo Junkers and in the 1930s the Eastern Air Transport a domestic airline started flying these aircrafts due to their inherent advantages. This led to the development of full-metal aircrafts for the civilian and military uses. During World War 2 rubber and high-grade plastics were used in place of some aluminium parts, which led to the decrease in weight and an increase in the performance of the aircrafts. In the 1960's the space programmes pushed innovators to make use of new materials, which could withstand the greater stresses required for flight outside the Earth's atmosphere along with carrying a huge quantity of fuel and protecting the crew. For this purpose, the scientists at NASA used Kevlar and Nylon in the production of the space crafts, and now these fibers have become the staple fibers in the aerospace industry. The usage of plastics in the industry has only increased over time, and in 2009 the first aircraft with carbon-fiber wings and fuselage, the Boeing 787-8 Dreamliner took to the skies for the time. These plastics have been used since they offer high resistance impact along with their ability to withstand corrosive environments. The plastics also offer the military with a unique property of being able to absorb Radar waves, and thus these materials have also found their way into the military aviation along with the civil aviation sector [4].

With the decline in the conventional energy sources, it is paramount to look into the use of renewable sources not just in the energy sector, but also in the various fields where conventional materials are being utilised. The developments that have taken place in replacing the conventional materials has led to the development of composite materials, which would replace the conventional materials [5].

Composite can be defined as the of two or more materials combined macroscopically combined, with the essential components being a fiber material and a matrix [6]. With the advancements in the field of composites taking place at break neck speeds, composites are being replaced by hybrid composites [5], a hybrid composite can be defined as a composite material which has one or more matrix materials with one fiber material or one or more fiber materials with one matrix material [7].

With the advancements taking place, it can be seen that natural fibers can be used as filler or fiber materials in composite materials and these natural fibers can be obtained from plants, animals and minerals [8]. When a hybrid composite is combined with natural fibers, it gives rise to a novel and new kind of composites known as Green Hybrid Composites [5]. Natural fibers hold an advantage over the synthetic fibers that they are eco-friendly, easily available, very cheap, bio-degradable, low greenhouse emissions, reduced wear and enhanced energy recovery [9].

The various process used in the manufacturing of natural polymer composites and the analysis of the structures and various approaches of characterisation have been reviewed by Sanjay et al [10]. A study done by Senthilkumar et al [11] has discussed the effect of the sisal fibers on the mechanical properties of its polymer composites. The investigation of the mechanical characteristics of Glass-vinyl Ester composites and Glass-Epoxy composites were carried out by Singh et al [12], where fatigue studies were carried out and the it was concluded that the flaws and fractures occur at higher frequencies leading to the decline in the stress levels in the test specimens. Along with these studies a statistical study was carried out to find out if a relation exists between the physical and mechanical attributes. A study conducted by Sanjay et al [13] reviewed the various manufacturing processes in the production of composites from natural fibers along with the reviewing the research work done in analysing the structures.

The aviation industry demands materials with a high strength to weight ratio. The Green hybrid composites provide a range of properties like light weight, high tensile strength, high specific mass, high modulus, low cost, light weight, good strength and many more properties that a very suitable for the aviation industry [14]. Numerous researchers have worked on the mechanical properties of green hybrid composites as can be seen in the various papers listed here [15-20]. The hybridisation of glass fibers with natural fibers has elicited comparably lesser attention over the years. Here we would talk of the hybridisation of glass fibers bamboo fibers, polyester can be used here as the resin matrix.

The following are the properties possessed by the composites and hybrid materials:

- Electrical conductivity
- Thermal conductivity
- Magnetic properties
- Resistance to corrosion
- Mechanical properties
- Optical property [5]

2 Glass Fibers:

The preeminent material used in the reinforcement of composite materials are synthetic fibers and glass fiber is classified as synthetic fiber. Glass fibers are used as reinforcement material due to their high strength, flexibility, good chemical resistivity and high stiffness [21]. Glass fiber manufacturing is comparatively easy since they are manufactured by the process of moulding. A variety of glass fibers are available like:

- C-Glass
- A-Glass
- E-Glass
- D-Glass
- R-Glass
- S-Glass
- S2-Glass
- AR-Glass

Various mechanical properties of E-Glass, S-Glass and R-Glass are given below in Tables 1:

Table 1. Mechanical and Physical Properties

Fibers	Density(g/cm^3)	Tensile Strength (GPa)	Young's Modulus (GPa)	Elongation (%)	Poisson's ratio	Refractive index
E-Glass	2.58	3.445	72.3	4.8	0.2	1.558
S-Glass	2.68	4.4-4.6	88-91	-	-	-
R-Glass	2.54	4.135	85.5	4.8	-	1.546

Due to the inexpensive nature of the raw materials used in the production coupled with low fiberizing temperatures S-Glass and E-Glass are extensively used in the production of composite materials. E-glass is used the production of equipments with a relatively low cost and do not take into consideration strength, when strength is taken into consideration S-Glass is utilised. S-Glass is used in the production of components for vehicles, hulls of ships and tails wings of aircrafts. In the production of the composites, the matrix used can be of either thermoplastic or thermoset in nature [5].

3 Natural Fibers

Plants, minerals and animals are the main sources of natural fibers. The main constituent of fibers derived from plants is cellulose and fibers obtained from animals contain proteins. In the automotive industry and the aviation industry fibers derived mainly from plants are utilised. This is due to the fact that these fibers renewable while taking into consideration the global sustainability issue. The natural fibers can be used in place of conventional materials in the role of reinforcing materials, the main advantage of using natural fibers is that they are non-toxic in nature, wide availability inexpensive and biodegradable in nature [22].

4 Bamboo Fiber

Scientifically bamboo fibers are known as Phyllostachys pubescens and bamboo belongs to the family Bambusoidae. Composites produced with bamboo fiber reinforcements can be produced easily by the hand lay-up method [23]. The mechanical properties of bamboo fibers are as follows:

- Density: 1.2 to 1.5 (g/cm^3)
- Elongation: 1.9 to 3.2 (%)
- Young's Modulus: 27.0 to 40.0 (GPa)
- Tensile Strength: 500 to 575 (MPa)
- Specific Gravity: 0.4 to0.8
- Specific Modulus: 67.9 to 50 (GPa)

The chemical composition of bamboo fibers are as follows:

- Cellulose (%): 48.2 to 73.8
- Hemicellulose (%): 12.5 to 73.3

- Lignin (%): 10.2 to 21.4
- Pectin (%): 0.37
- Wax (%): -
- Ash (%): 2.3
- Moisture (%): 11.7

Bamboo fiber reinforced composites are used in applications which are focused on increasing the strength of the structure produced. Bamboo fibers can be extracted either mechanically or by using chemicals via the alkali hydrolysis process. Due to the low weight, eco-friendly nature, biodegradability and high growth rate, bamboo is used in a variety of industrial applications.

5 Hybrid Composites

Some of the process utilised in the manufacture of hybrid composites are Cold Press Method, Hand-Layup Method, Compression Molding Method, Hydraulic Process etc.

The properties of hybrid composites can be varied by varying the structure of the fibers, fiber content, length of the fibers used, orientation of the fibers used, fabric-matrix bonding and the arrangement of fibers.

Hybridisation of composites can be done in two ways either by depositing different layers of lamina one above the other or by reinforcing the matrix using various fibers. When natural fibers are hybridised along with synthetic fiber the mechanical properties of the composite obtained have superior mechanical properties when compared to the composites made from the hybridisation of only natural fibers or even or only the synthetic fibers [5]. The content of cellulose, structure of fibers, cross section of fibers and the angle of fibrils play an important role in determining the physical properties of green hybrid composites.

6 Conclusion

Various methods types of composites have been brought forward to be used in the manufacturing of parts for the aircrafts. With the eternal requirement of improvement along with the requirement of using green or hybrid composites coming into the spot light over the recent years. Composites are being produced which have good strength characteristics, as well as being light wight in order to tackle the issues of eco-friendliness and fuel efficiency. The path to utilizing hybrid composites has shown light on the fact that composites can be produced mixing both natural and synthetic fibers, the natural fibers being the green part of the hybrid composite and the synthetic fibers acting as reinforcements which lend the required strength to the composite in order to meet the requirements of being green, strong and light. In the coming years the development of the hybrid composites will grow exponentially as shown by the fact, when the utilization of composites burst onto the scene the research and development progressed in this direction at an exponential rate.

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