Paper Engineering Report

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Carbon Fiber in an Aviation Industry

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Credit Authorship Contribution Statement

Raksmey Watt: Research and writing on Carbon Fiber aircrafts’ effect on environment in terms of noise and air pollution.

Rishab Humagai: Research and writing on Introduction, Motivation, Formatting the report, summary of the report and future study recommendations.

Tinbit Betre: Research and writing on carbon Fiber Drop test.

Yaman Pandey: Research and writing on History of aircrafts and current trend of aircraft manufacturing involving carbon Fiber.

A Cover Letter Summarizing Your Engineering Report and Findings

The purpose of this paper was to study about the material called as Carbon Fiber and its future in the aviation industry. Aircrafts have been producing harmful gases more than ever. The production of carbon dioxide and other greenhouse gases is tremendous. The proper study and choosing of best material is very important when building the aircraft to lower the weight, to provide more cabin space, to cut off the noise production and to minimize the production of harmful gases. We have come up with the conclusion that Carbon Fiber could fully replace Aluminum and help us solve all the problems mentioned above because of its great properties like higher modulus of elasticity, higher tensile strength, higher specific stiffness and very lower density. The use of Carbon fiber also could improve a lot in the lifecycle cost of the aircraft because it is more reliable.

Table of Contents

Introduction

Carbon fibers are the polymers of graphite, a pure form of carbon where the atoms are bonded together to form a long chain. It is often made of the material called precursor. About 90% of the carbon Fiber produced are from polyacrylonitrile and 10% from rayon or petroleum pitch, involving the process that is partly chemical and partly mechanical. It starts by drawing long strands of fibers and then heating them to a very high temperature without allowing contact to oxygen to prevent the fibers from burning. Then, the process called carbonization takes place where the atoms inside the fibers vibrates leaving the non-carbon atoms out and then the remaining carbon atoms bonds tightly forming carbon crystals aligning them parallel to the long axis of the carbon fiber. Then it involves the process called surface treatment where it oxidized the smooth surface left from carbonization to increase the roughness which will increase the surface area on the fiber surface which will later increase the adhesion with various matrices and improves the effectiveness of the carbon fiber. Lastly, they coat the fibers to prevent damage once oxidation is achieved by the materials like polyester, nylon, etc, and is known as sizing.

Carbon Fiber is extremely strong, stiff, and light in weight, so it is used to make composite parts. Its properties are close to that of steel but the wight is close to that of plastic i.e. its strength to weight ratio is very high. carbon fiber can be considered as an important material which could lower down the lifecycle cost and enhance better performance where structure design plays a major role. For instance, in Aviation Industry.

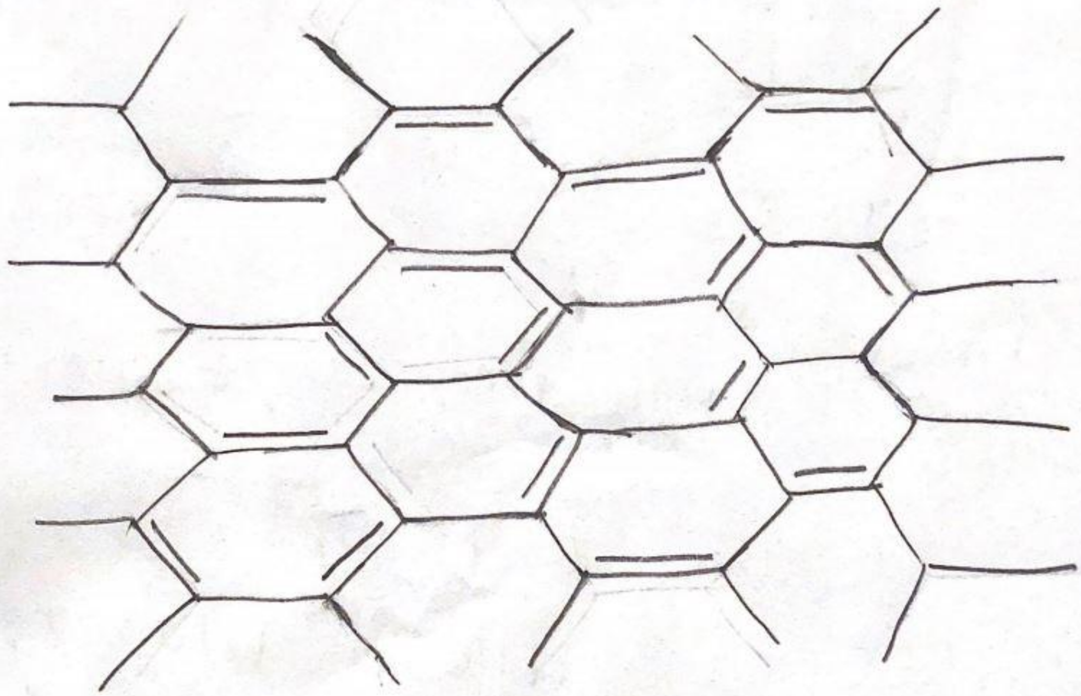


Fig: a section of a sheet of grahite

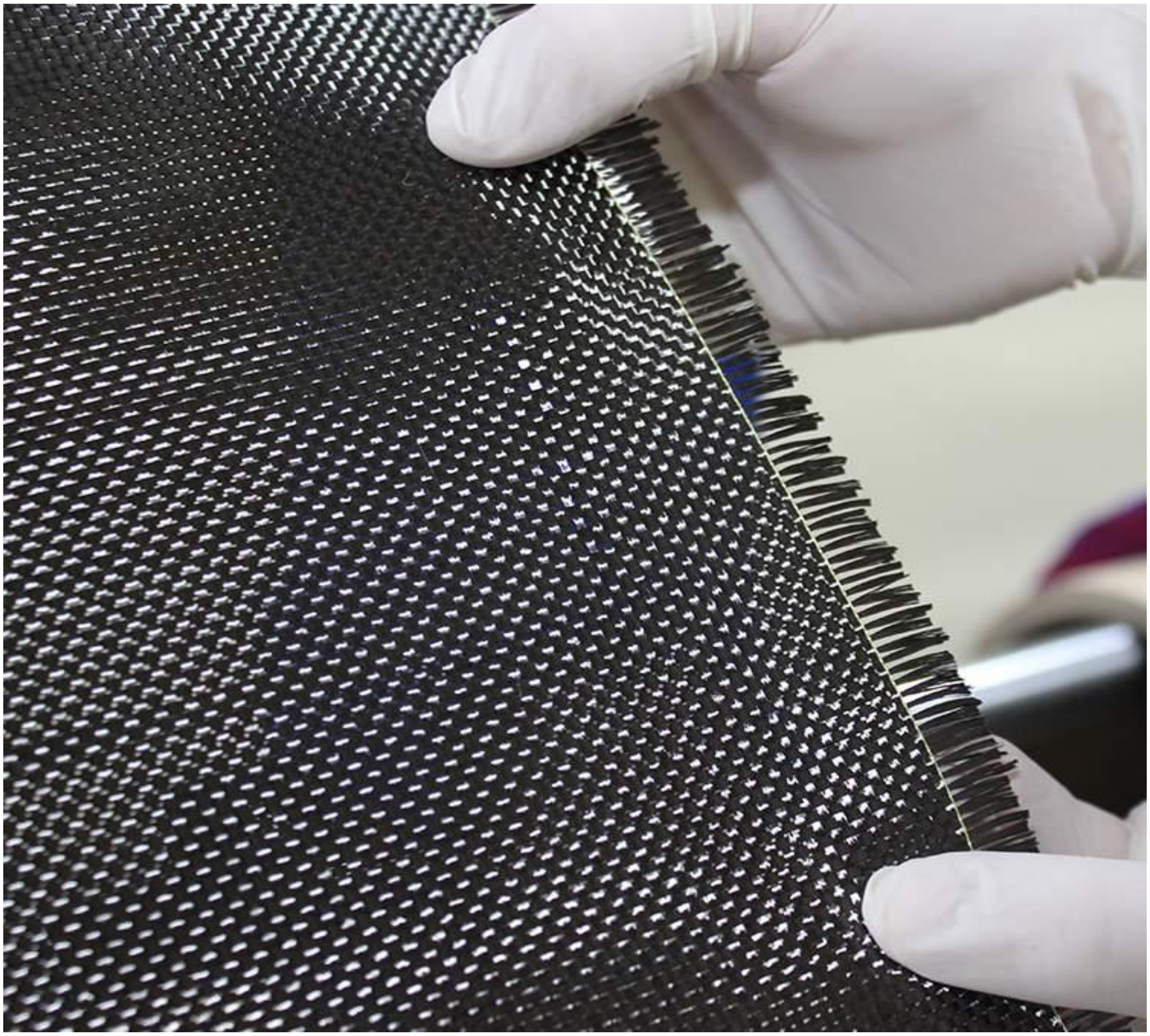


Fig: Plain weave Carbon Fiber Fabric

Fig: Building Carbon Fiber wings with aluminum ribs

Physical properties of Carbon Fiber

Grade	Supplier	Item	Tensile Strength	Tensile Modulus	Elongation	Density
			Mpa	Gpa	%	g / cm3
24T	Toho	HTA	3920	235	1.7	1.76
	Tairyfil	TC35	4000	240	1.6	1.80
	Tenax	STS	4000	240	1.7	1.75
24T	Toray	T700	4900	230	2.1	1.80
	Mrc	TR50	4900	240	2.0	1.82
	Toho	UT500	5000	240	2.1	1.80
	Tairyfil	TC36	4680	250	1.9	1.81
30T	Toray	T800	5490	294	1.9	1.73
	Mrc	MR60	5800	295	1.9	1.81
	Toho	IM600	5790	285	2.0	1.80
	Tairyfil	TC42	4890	290	1.7	1.80
40T	Toray	M40JB	4400	377	1.2	1.77
	Mrc	HR40	4610	390	1.2	1.82
	Toho	UM40	4900	382	1.3	1.79
46T	Mrc	HS40	4610	455	1.0	1.85

MOTIVATION

When it comes to Faster, safer and reliable transportation, we choose it to be through aircraft. Since 1903, we have been familiar with the word called aircraft or airplane. Right now, aviation industry is flourishing more than ever, and the air traffic is increasing heavily which means the Aircrafts are producing the huge amount of green house gas which will eventually lead into global warming anytime soon in the future. Scientists has predicted that by 2050, 43 metric gigatons of carbon dioxide emissions will be generated from the aviation industry. This is a huge amount of harmful gas and so to minimize the production of such harmful gases and for sustainable use of natural resources like fuel of the aircraft, the use of carbon fiber plays a significant role in the aircraft as it decreases the weight of the aircraft causing engine to burn less fuel and producing less emission.

OUR FINDINGS

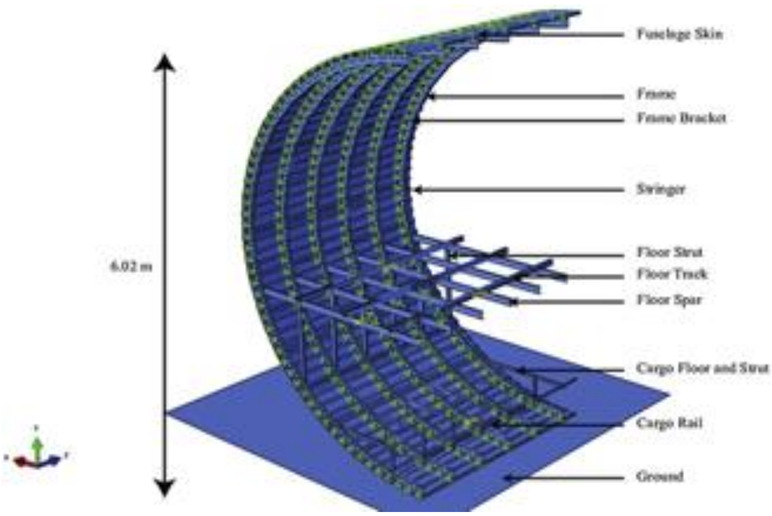
Since Wright brothers flew their first ever aircraft on December 17th, 1903, aircrafts industry has evolved a lot. And has undergone a lot of changes in terms of Shapes, sizes and materials used on it. After the aircraft took its first commercial flight on January 1st, 1914, engineers are concerned more about safety and the ways to minimize manufacturing cost. Choice of proper material plays a vital role on this. Due to the lightweight nature of Aluminum, Wright brothers used Aluminum for some part of the aircraft. But, in those days aluminum was not easily found so they used Sitka Spruce and Bamboo to make the aircraft. During World War I, wooden aircrafts were replaced with Aluminums. Since then, many alloys of Aluminum are used which gives the proper strength to the aircraft and makes it light. In modern days, from Twin Otter to commercial Jets, Aluminum and its alloy are widely used.

The lower weight of aircraft makes it more fuel efficient. Also, the use of strong material to make an aircraft makes it safer. Material scientists and Engineers have been investigating other materials which could replace Aluminum in aircrafts. Carbon fiber has been the best replacement for Aluminum till date. The history of Carbon fiber can be traced to 1879, when Thomas Edison used it in his light bulbs. At that time, Carbon fiber lacked tensile strength. After the late 1950s, high tensile strength carbon fibers were discovered which drew engineer's attention. From the 1970s, civil airlines started adding Carbon fiber in their airframes. Now, commercial aircrafts have started to use carbon fiber due to its highly efficient properties like modulus of elasticity, tensile strength, specific stiffness, and specific tensile strength being more than that of aluminum. Moreover, the density of carbon fiber is much lesser than that of aluminum which will improve fuel efficiency of the aircraft. Airbus and Boeing companies have successfully started producing aircraft with more percentage of Carbon fiber consecutively.

Carbon Fiber has helped revolutionize aircraft manufacturing. Since carbon fiber composites are incredibly strong and stiff for their weight and can be made to withstand everything from hailstorms to extreme winds, it makes sense that aircraft manufacturers are leaning more and more in that direction. Using carbon fiber composites to build an airplane reduces its weight by up to 20%, versus the weight of a traditional aluminum plane, also it is five times stronger than steel and half the weight. It is no secret that in the airline industry, the lighter the aircraft, the more increase in fuel efficiency, which significantly reduces carbon dioxide emissions. In addition to decreasing weight, another important contributor for the fuel efficiency is aerodynamics. The sleeker the design, the more fuel-efficient the plane becomes. Because carbon fiber composite fabrication processes can produce very smooth yet complex geometries, aircraft designers can more easily optimize the aerodynamics of a carbon fiber aircraft. Additionally, the stiffness of carbon fiber facilitates the use of swept wing designs in commercial aircraft, which cuts fuel consumption by up to 5%, by reducing aerodynamic drag. Using carbon fiber to build aircraft, instead of traditional metals, offers aircraft designers more flexibility when it comes to manipulating aerodynamic efficiency and saving fuel. This flexibility allows the opportunity to change up traditional plane designs as well. Commercial aircraft could include designs where the fuselage and wings blends being one like some military aircrafts today. This type of design greatly improves a plane's lift-to-drag ratio, making the plane more aerodynamically efficient while still reducing weight. A recent Airbus concept plane introduced a plane with a fatter, curved fuselage, designed to improve airflow and provide more cabin space for passengers. Longer, thinner wings would reduce drag and improve fuel efficiency. A U-shaped tail acts as a shield to reduce engine noise. Carbon fiber also makes other design features possible. With traditional materials, making an aircraft window any bigger than it already is would require a lot of extra reinforcement under the skin for structural integrity. And that adds weight because carbon fiber is much stronger, the airplane's windows can be made much bigger without the weight penalty. It is carbon fiber that allows all these concepts to even be conceived. Since flight generates huge amount of the global carbon dioxide emissions these days, air travel and transport have an important role to play in reducing greenhouse gas emissions, and by using Carbon fiber to manufacture aircrafts, it will help reduce the weight of the aircraft, and increase fuel efficiency as well as will reduce the production of harmful gases and protects the environment from the threat of Global warming and scarcity of natural resources.

However, we looked over a paper that dealt about the Drop test of the carbon fiber composite fuselages in a survivable crash to exactly know how strong the material is when it comes to crash and the survivability of the passengers. Carbon fiber is used due to its lighter weight than metals. This makes them have higher strength to weight ratio. They can be modeled as laminate or quasi-isotropic.

Six-frame drop test was performed by elevating a sample fuselage at a certain height and dropping it. Six frame aircraft section was modeled as six passenger rows in an aircraft. Gransden's simulation model was used, the six-frame model for composite material is shown below.



"A half model of a six-frame fuselage section of an Airbus A350-like aircraft"

Unlike metals, Composite structures are harder to model because of the layers of their composition. The model above is shown simplified and considered to have more brittle fracture characteristics than metals.

From Gransden's research we found that the risk of injury and damage is higher in fuselage made of carbon fiber composite materials. The damage in composites is not always visible. They simply become weaker, losing their strength rapidly. In order to reduce the risk, it was suggested that if foam or frangible sinusoidal composite walls are put in the bottom of the fuselage, it will serve as a primary structure to get damaged before damaging the frame and dissipating lesser energy to the passengers.

There is an improved drop testing including forward velocity carried out by NASA Langley Landing and Impact Research Faculty. This test would make the drop test like a crash landing and will be able to show a fuller picture of the true case. One incident mentioned in the paper by Django Mathijsen is the Formula One racing in 1981. The brittle carbon fiber car crashed spraying parts over the track. The driver walked out without an injury. This showed the relative safety of carbon fiber material to other materials.

There is not much accurate information for concluding carbon fiber composite fuselages are more reliable than aluminum materials in terms of crash resistance. Therefore, more research and detailed composite modeling is needed as stated by Gransden, assistant professor, Delft University of technology.

Connection with Course Study

Materials science knowledge has come very handy when working in this research paper. We carefully analyzed the property of Carbon Fiber over other metals like Aluminum, starting from the project memo to so far down here utilizing the topics learned on our class like stiffness of materials, thermal expansion, stress-strain, etc to select the proper material which will give the positive impact on the society and help solve the problem of greenhouse gas emission and noise pollution.

Summary and Future Study Recommendations

To conclude, Carbon fiber has been the boon to the aviation industry. The giant companies has already started producing the aircrafts using the Carbon fiber and the engineers and scientists has realized its worth. There are currently 975 Boeing 787Dreamliner and 379 Airbus A350XWB in the sky and hundreds of orders pending to be delivered which uses Carbon Fiber. The use of carbon fiber will reduce the approx. weight of the current aircraft by around 20% providing more fuel efficiency, making it more aerodynamic. We also did a thorough material investigation of Carbon Fiber over other materials and put forward the cost-effective solution to the aviation industry which can also maximize the profit creating more cabin space side by side. The great properties of Carbon Fiber over other materials makes it stand out.

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