

Introduction to Industry 4.0

Assignment 2: Introduction to industry 4.0 Essay

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Supervisor : Jaymie Phillips

Advance Composite Materials in Aircraft Industry

“Future of Lightweight”

Prepared by

Student : Rahul Bhosale
(University of Wales Trinity Saint David)

Email: 2116970@student.uwtsd.ac.uk

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Abstract

Composite material had played a very vital role from very early days to develop new innovation in the industry. Composites have various advantages in which the important one is its resistance, ability to adapt the properties in terms of durability, less in mass and more strong. Use of composite is seen in our day to day life like the products used in construction, medical equipment's, oil / gas. Aerospace, automotive and many more. This essay gives an information about the pros and cons of fiber composite materials, development in the product and manufacturing of composites with manufacturing processes with its classification.

In aviation new materials have been necessary in improving a product in aircraft industry. This updating in material properties has helped us to travel quickly and low cost around the world, by improving the performance and operations of modern aircraft. This method continues developing new type methodology in terms of weight reduction. This different material is introduced at the end part of this document.

1. Introduction

Composite material is used in a wide range in the aircraft industry as per the airliner requirements which insist to get composite material involvement in part design. The aircraft industry trying to get some alternative materials that will help in reducing the weight of the component and improve efficiency without affecting the safety norms,

Advanced composite materials can address all the demands asked for in aerospace materials, and its demand in the aerospace is increasing.

The main purpose of using this material is as they provide good strength if we compare with metal parts and are also less in weight as compare to other material. so this are widely used in aircraft industry which further helps us to increase the efficiency. This essay will investigate and describes outline & justification with industry examples.

- Role of composites a significant milestone for aircraft production.
- Composite structure for Airbus product.
- Composite panels structure in SAFRAN Aerospace industry.
- Pros and cons of composite material for future development projects.
- The Implications for society and our planet.

The essay will begin by basics of composite, its structure, classification, and major monolithic CFRP and thermoplastics applications. Further different types of composite material for future projects.

Controlling the quality of product is very important in aerospace engineering. there are various steps that involves the checking of quality of product which normally starts from material selection, manufacturing process, check whether the part is structural.

What is composite?

Composite are mixture of various material with different properties macroscopically mixed together for getting the desired property which they cannot achieve alone.

These are widely replacing the aluminum traditionally used for aircraft industries specially in seating interiors.

Many aircraft seat manufacturers have initiated producing composite based seats because they are lighter, cheaper and stronger

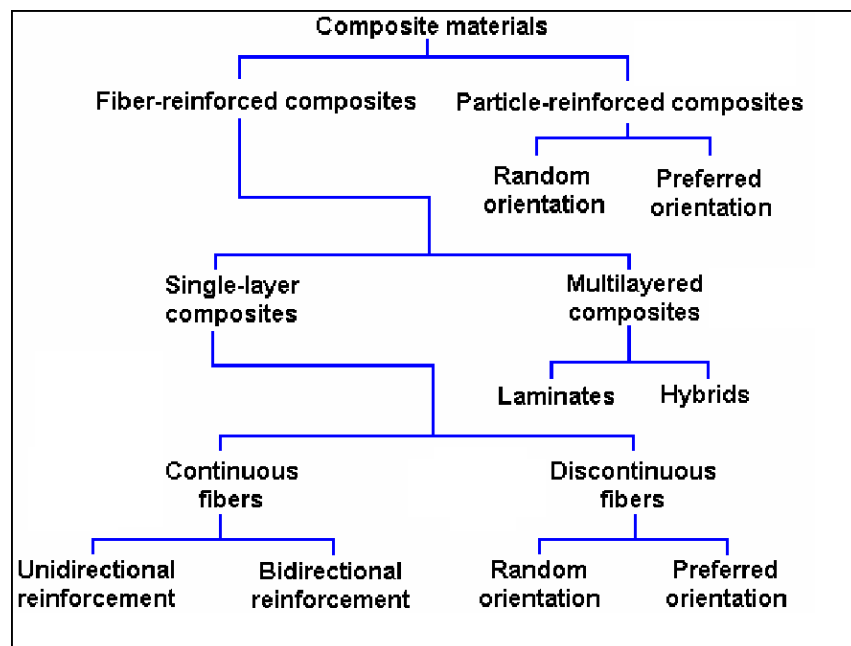
2. Classification of composite

Composite may be a laminated or reinforcement type -

Laminated: Two or more layer of different material bonded physically to each other

Reinforced Composite: These composite have particles or fibre imbedded in matrix
Generally fiber / particle are harder and stronger than matrix. Matrix: Soft metals/
Polymer. Polymer is long chain structure having repetition of a simple chemical unit for a very large number of times.

Fig. 1 Classification of Composites



Composite can be classified as strong & weak materials. such as reinforcement leads to hardness and matrix can lead to a weaker side for nonstructural properties. Mainly stronger material is considered for primary load-taking parts. The

benefit of the matrix is the shape of the structure. A polymer is a long chain structure of a simple chemical unit for a very large number of times. Polymers are recognized by their thermal Properties: E.g. Thermoplastic Polymers and Thermosetting Polymers



Fig. 2 Chemical units of Composites

Thermosetting polymers are polymers that are set when heated. They cannot be reheated and remelted. They having self-life after molding they become hard and strong
E.g. Phenolic resins, epoxy resins, etc

Phenolic resins are usually very brittle, so need reinforcement to increase strength and toughness. A large number of OH groups gives excellent adhesive qualities. Hence widely used as adhesives in Plywood, PCB, Foundry shells and cores, Brake linings and Grinding wheels.

3. Fiber Composite use in Aircraft.

Previously the composite used in military aircraft are widely used in other passenger aircraft. It has been noticed that most of them are fiberglass. Details as explained below.

Fiberglass - is a fiber-reinforced polymer typically from plastic. This is mainly used because of minimum weight as compared to others. Also, it is available financially cheap.

Carbon- fiber-Reinforced polymer- is an extremely strong and light fiber-reinforced polymer that contains carbon fibers. The composite may contain other fibers. For example, Kevlar or glass fibers can be used.

4. Pros and Cons of composites

The application of this material is seen mainly in primary load conditions and used in passenger aircraft, structures in the marine industry, etc.

This material does not corrode like metals – the mixture of corrosion and fatigue cracking is a common issue for aluminum structure commercial fuselage.

The main advantage of composite is saving fuel. one of the articles published shows that composite if widely used in the market excellent growth rate and might reach a high level by the year 2026.

There are some advantages of composite materials:

The main advantage is less weight and helps in saving around 25% to 55%

Safran has adapted the layup technologies with different thicknesses in their product like aircraft seating for developing different parts made with composite.

Survivability with high resistance and damage tolerance.

When corrosion issues in a wet state, It occurs between two different metals that are in contact are avoided. In this case, nonconductive fiberglass plays an important role. There are also some disadvantages in terms of higher recurring/non-recurring / Material costs.

As stated before, These materials are a good example of weight reduction they are compatibility 20 % less in weight than aluminum and are known as the most reliable and traditional metallic material which decreases the maintenance cost. This material is high in strength and helps to reduce the overall cost, The application in the seating system helps to minimize the suite weight.

The research program from Federal Aviation Administration found that there is much saving on every pound of weight saved. Data shows there is a massive saving in the service of an aircraft. The Boeing 787 Dream liner, with its widespread composite use in primary structures, will result in less weight and consumes 20 % less fuel which is very much beneficial. This indicates that the fiber composite material applied in aerospace leads to weight saving and fuel saving which will make the airline industry profitable in the today's world where the rates are drastically increasing.

Fewer weight results in minimum fuel consumption and emissions. The assembly procedure for the plastic structure needs different rivet joints which result in low manufacturing cost & improves efficiencies. Composite materials played a major part in weight reduction. Composites are versatile, and used for both structural applications and components, in the aerospace industry. For example, the types have various mechanical properties and are implicated in different areas of aircraft manufacturing. For example, carbon fiber material has different behavior and is brittle. It was discovered by rolls Royce when the jet engine with carbon fiber compressor blades failed due to bird strikes.

In one of the experiments, Boeing used composite parts around 1500 to replace metal components. To write a small abstract of the above points , composite material had a wide scope in upcoming years. This material will be kept on updating and lots of improvement can be seen. As stated above this shows that this material is highly in demand and used in various companies for product development and weight optimization.

5. Composite manufacturing process

There are different types of manufacturing processes as stated below. which related the knowledge and facts. The below types describe how what and why the process is classified into various techniques.

Hand Layup technique :

In this process, the surface is treated with the solution which helps in releasing the component. It will not get stuck to the surface. the solution is in the form of a gel. Minimum the plastic sheets are placed on the bottom and the top face of the plate so that an excellent surface finish is achieved. Reinforcement-like chopped mats are made as per mould size and placed on the surface of the mould after the sheet. The next step is mixing the resin which is thermoset in liquid form which is further mixed evenly with the required amount of curing agent and poured on the mat surface. During this process check for any small/tiny gaps left, the process is repeated after every layer till the required layers are stacked. After placing the sheet, release gel is sprayed on the inner surface of the top mould plate which is then kept on the stacked layers and the pressure is applied. After curing at normal room temp, the mould is opened and the developed composite part is taken out and further processed.

Spray Layup

This process is a continuation of the hand lay-up method. The resins and the reinforcement are in the form of chopped fibers which are further passed through the spray gun and further chopped with a gun. the materials can be incorporated simultaneously and then the spray on the surface to avoid sticky surface. A roller is rolled over the sprayed material to remove air trapped in the lay-ups. The spray lay-up method is used for lower load-carrying parts like small boats & bathtubs etc.

Pultrusion

Pultrusion is a molding type with automated and closed types. The dies are used from which the material is pulled from it. The unrolled Fiber mats are used and passed through the resin tank. This resin forms a path along the guide and is guided through the hot die the desired shape is produced. Curing of the composite also takes place in this section due to heating. The cured composite profile which is formed in the die is pulled out. with the help and gripper to get the part pulled from the die. Finally, these parts are pulled with the help of a gripper coming from the hot dies.

Resin Transfer Moulding

In this process the reinforcement is already placed in the processes & Resin is added. Resin transfer moulding is a closed moulding process. Resin is transferred over the already-placed reinforcement. It's a closed moulding process normally done in a closed environment,. The release spray is applied on the surface so that the part does not stick. . A release gel is applied on the mould surface for easy removal of the composite. The mould is properly closed and clamped. The resin is pumped into the mould through ports and air is displaced through other vents. After curing, the mould is opened and the composite product is taken out.

Match metal moulding (Compression Moulding)

This process is high-pressure molding in which two matched metal moulds are used to fabricate lightweight products. It is a closed molding process with a high-pressure application. for a definite period of time, the whole assy is kept in between the compression molder. the compression molding will require whole assy Heat and pressure, is applied as per the requirement of composite for a definite period of time. The material placed in between the moulding plates flows due to the application of pressure and heat and acquires the shape of the mould cavity with accuracy. Curing may be carried out at room temperature or at some elevated temperature. In this process production rate is high as the mould cycle time is in a few minutes.

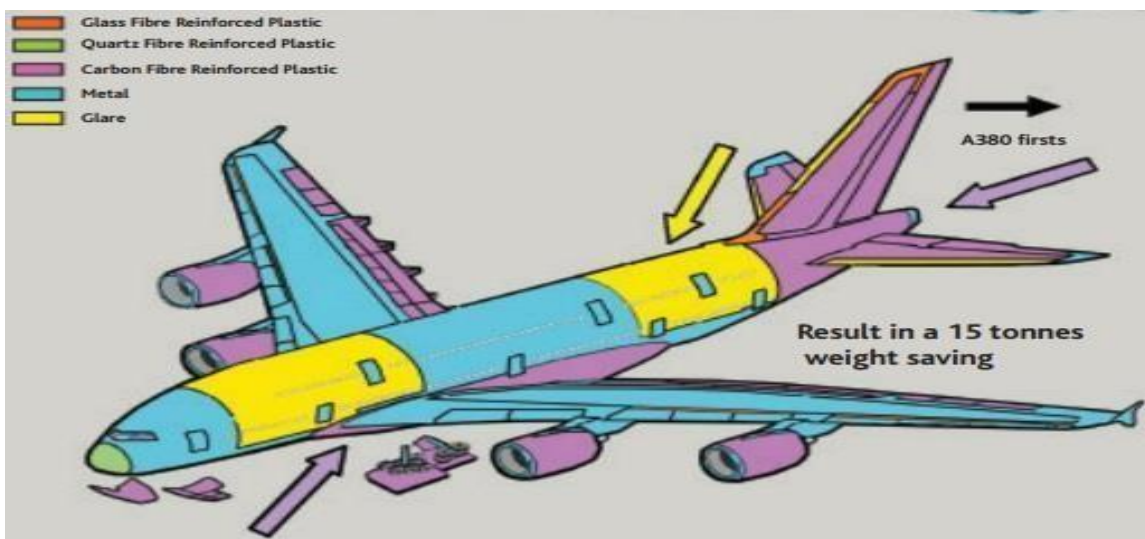


Fig 3 . Airbus material composition

Above fig shows the pictorial idea about the composite used in aircraft .The latest development in the field of aerospace materials depends upon the application. The excessive use of this material enables the A400M to be much lighter, enabling to enhance its performance in all aspect such as play load and range. Below few comparisons of the composite structure studied.

Composite structure of the Airbus A380

The Aircraft Company's goal is to select the most suitable type of material as per their specific requirement which will give them the result of achieving lighter-weight parts. For this weight optimization, composite material is a perfect choice. As per the ref, article A380 is the first aircraft ever that boasts a CFRP (Carbon Fiber Reinforced Plastic) composite central wing box, which represents the massive weight saving that results in fuel consumption and leads to sustainable growth toward society. The upper deck floor beams and the rear pressure bulkhead are made of CFRP.

Composite structure in SAFRAN aerospace.

As mentioned earlier, most of the seat manufacturers are moving to build their seats with a composite structure. SAFRAN has implemented the same and is using honeycomb sandwich panels as a composite for the furniture structure. Composite panels are anisotropic materials. Composite panels used by SAFRAN is a layup, which is a combination of Skin, core, and insert blocks (Metal Blocks). This combination is designed based on the requirements.

SSGB and most of the aero interior manufacturers are using Honeycomb sandwich panels as a composite for the furniture structure...Composite panels are anisotropic materials. Composite panels used by SGB is a layup, which is a combination of Skin, core, and insert blocks (Metal Blocks). This combination is designed based on the requirements. Skin currently used by Safran is Phenolic Pre-impregnated Glass Fibre skin. This skin is also called prepreg.

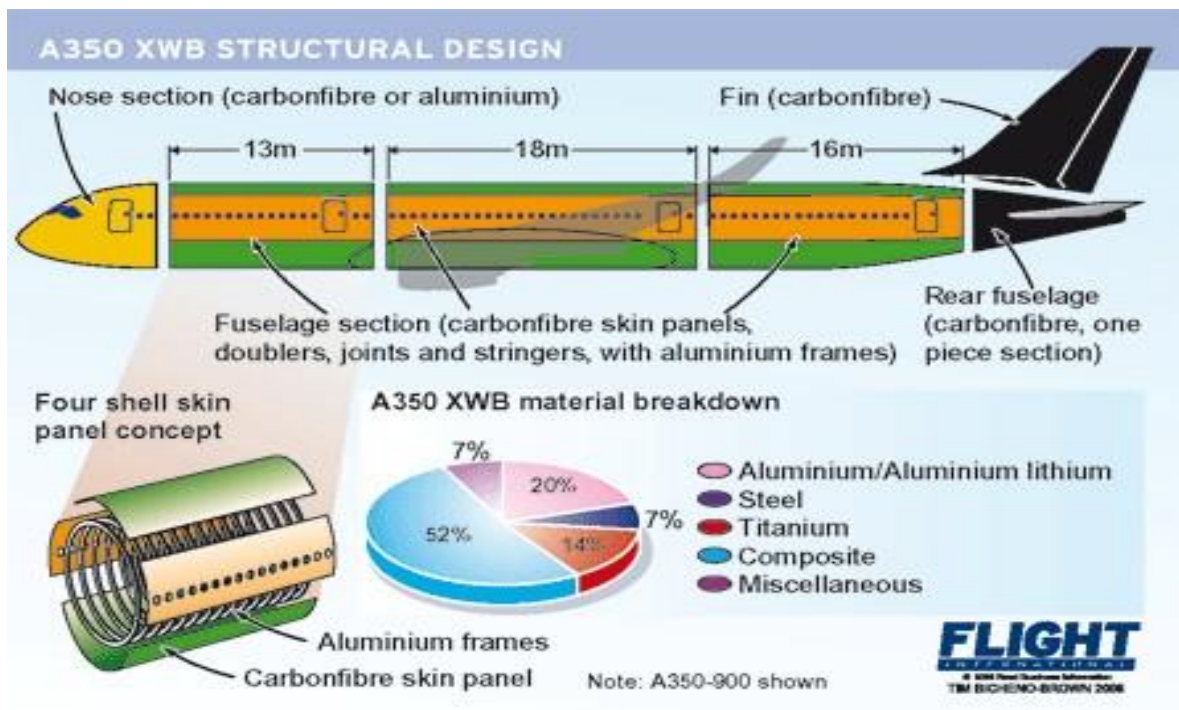


Fig. 4 Composite structure of A350XB

8. The development of new composite materials

The development can be said when as new material which is not been implemented and going to apply in aviation. For example the material practically are: metal matrix composites (MMC) and ceramic matrix composites (CMC) have seen some in-flight testing but have yet to gain wide ranging acceptance by OEMs for various reasons. Following are the list of material.

Ceramic matrix composites (CMCs)

This material as very good thermal properties as well as excellent mechanical properties. This overcomes the limitation if any regarding the monolithic ceramic (i.e. toughness) and shows other benefits. This material is commonly used in aerospace where the temperature is extremely high such as aero engines and turbine disks, linear, and turbine airfoils.

Metal matrix composites (MMCs)

These are mainly aluminum or carbide reinforcement and have various advantages over monolithic materials. But the properties of this material are not so hard and its comparatively costly. Also, they are difficult to machine. These are mainly used in highly loaded surfaces such as floor supports.

Carbon Nanotube technology

This material is one of the new-generation materials and comes under the advanced material category. The main application of this material is the electronic shielding of large-scale aircraft. Carbon nanotube technology has various applications for aerospace electronics mainly in defense systems. It is EMI shielding, for example, aircraft that form the carbon-based composite often get residual current from lightning strikes. To protect the aircraft metal protection is used but the residual current will still remain. This lightweight material is used for EMI shielding for the inside which provides better shielding for the weight of the paint applied and gets it to shield internally mainly in a carbon fiber-based plane. Carbon nanotubes have the property of minimum tensile strength of carbon fiber. This is very flexible. The good thing is that this material's brittleness property doesn't remain the same due to which the failure in terms of strain is different. This can be in the form of fabric and can be incorporated in composite by themselves. For example, the wing's surface is a structural part and it would be deiced on its own and could act as an antenna with a number of multifunction operations that this material can be used.

Core materials

The aerospace composite sandwich structure is made of two skin face sheets placed on the core in between. these sheets are attached by using adhesive. There are many materials involved in the development of the core. The most commonly used core in the aerospace industry is the honeycomb core. Depending on the application and the requirements the part of this core can be metallic or nonmetallic, it totally depends on the design parameter. This honeycomb material is made from different sub materials like fiberglass or Nomex. This panel consist of variety of material and various configurations.

Honeycomb-cored sandwich panels are mainly used because they reduce the part stiffness at very less weight than the monolithic CMP material. This material has high compressive strength in the direction of the cell wall. The adhesive layers play an important role in creating a bond between the panel and prepped skin. These panels are commonly used in the seating system which includes the shroud, plinth, and seat furniture. It has also wide implementation in aircraft galley design.

9. Quality control and testing

The below details are about the quality control in the composite sandwich panels in line with their manufacturing and repair in service. Below is the list of testing methods commonly used which are: Visual, ultrasonic, X-ray . Manufacturing rework and defects usually include delaminating, resin-starved and resin. This section shows the common non destructive testing techniques (NDTs) used to identify such defects in the process of quality control inspection made during the manufacturing and in-service condition of panels.

No destructing testing

The most commonly used nondestructive methods to detect damages in Aircraft sandwich structures are as follows. (Info from Aviation Maintenance Tech Handbook 2012.

Visual inspection: This is the primary method for the inspection of the composite sandwich structure. It is fast and has a large field of view, being suitable for detecting impact damages larger than 0.5 mm and its seen that it cannot detect debonding, and it is not suited estimation of depth and sizing .

Audible sonic testing (coin tapping): This is the most common technique for detecting delaminating or deboning. It is performed by tapping with a round disk or a light hammer and then listening to the sound response. The result is declared by analyzing sound effects, a clear sound will tell us discrepant areas. The automated tap test is similar in this instead of a hammer a solenoid is used. A transducer and recording system is used for signals.

Ultrasonic inspection: This is the method in which the use of sounds wave plays an important role, This technique uses sound waves with frequencies above the audible range. the process is such a way that the Ultrasonic waves are introduced into a material where they travel in a straight line with constant speed until they encounter an interface. The amount of reflected wave is captured and detects the damage. Information from this test is presented in three formats: A-scan as time function, B-scan displays a cross-section of a part and C-scan displays discontinuities.

Radiography: Radiography is the process where the X-rays is passed through the composite part and the image is taken on the other side of the composite. the result is captured with varying degrees of density and absorption and exhibits different behavior in terms of absorbed radiation. The application involves identifying voids, water, and crack-damaged cores.

Thermography: The process is to capture the thermal response & thermal conductivity is done, The principle of thermograph is to send a heat flow on the surface of an inspected sandwich part during a certain time and then to capture the resulting thermal response. Thermal conductivity analysis is done to detect the defected areas.

Moisture detector: It is the method where the moisture / water contained in the sandwich structure is detected.

10. Composites excellence aerospace companies

GE Aviation,

This company is the leader in producing jet engines and has employees about 450 in the factory situated in the north west of Mississippi. In this factory, the major work on the fan for engine work is carried out. The specific type used here which is known as Polymer Matrix Composites. These fans are made up of polymer resin and are manufactured with advanced manufacturing processes and equipment.

Hexcel – a leading advanced composites company

This company is well known for its carbon fiber and composite materials which are mainly used in commercial helicopters, engines, and defense aircraft. This multinational company has around 40 years of expertise in lighter / lightweight parts composite which includes the core part of engineering. The component produced by Hexcel company are very beneficial to the aircraft design and improvement in a performance like fatigue with the reinforced carbon fiber prepreg is also a major benefit.

The example shown in this report about the Boeing company used 50 % as carbon fiber. This organization is the major supplier of material for both the Boeing and Airbus programs and has also been awarded a contract to support this company with the required material for prepreg.

Blackhawk Composites

Advanced composites are important in today's aviation industry and play a very vital role while designing any components for weight optimization. Many components are developed with new material properties and even aftermarket has provided their solution. Blackhawk Composites has expertise in making prototypes and building components in composite with a wide range of reinforcement and resin matrices which are required in advanced aerospace applications. The usage of TORAY carbon is authorized to use by this organization. This is an epoxy composite material mainly used in a commercial jetliners and it has been recently approved for Cessna. This is the basic information about the organization which is composite and works for a sustainable environment.

11. Composite Laminate Panels

In aircraft interiors the use of bonded laminates has extensive usage. This bonded laminate is mainly seen in the seating, galley units, lavatories, and rest area of crew. A wide range of advanced materials and different shapes and their finishes are developed based on the requirements created by implementing various processes like heating and pressure molding of sheet materials. Laminating carbon, glass and organic fibers with thermoplastics is a significant benefit. The most common areas where Composite Laminate Materials are used are listed as below.

- Seating system
- Cabin system and lining.
- Bag Storage units.
- Galley and bar units with kitchen.
- Spaces provided for crew.
- Lighting system.
- Tables, desks and work surfaces
- Decorative laminated and its surround.
-

Laminate plastic film is generally categorized into these five categories: Standard, Low-temperature, Heat set (or heat-assisted), Pressure-sensitive, and Liquid laminate.

Conclusions

Composites material are now the most demanding material in the aerospace industry and are used in various parts of aircraft for producing lighter weight and improving the sustainability of the environment. With reference to the current study the material glass fiber composites are one of the most famous due to its availability which is cheap and easy while manufacturing. This will remain in the market in both the factor one is valued and the other is the volume in the forecast future.

In aerospace structures, composite materials are becoming more important. New generation large aircraft are designed with all composite fuselage and wing structures and the repair of these advanced composite materials requires in-depth tooling knowledge and structure, and material.

The carbon nanotube technology itself is the greatest challenge for being able to drive scale to volume and minimum cost. For example it is great to have a cable that's 69% lighter weight, but you have to be able to produce this in a format and at a cost that can be broadly used by aircraft engineers. So the future is driving up the output, decreasing cost, and eventually getting broadly used across the entire industry. The future of the composite industry looks for great development and continuous improvement with expansion in the industry. It seems to be for long-term growth, new innovative expansion, and applications always on the horizon.

This material plays a vital part in saving fuel saving and less carbon emission which also leads to environmental safety.

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