Aircraft Cabin Composites

As resource efficiency becomes an increasingly important factor in the aviation industry, there is an ongoing search for more innovative solutions to the problem of aircraft weight. Rising fuel costs accounts for over one-third of fleet operating costs, making the need for reliable lightweight materials all the more pressing.

One potential solution is composite materials for aircraft cabins and seating. While they offer a lighter option, in some applications they currently lack feasibility for widespread use. Some of the pitfalls include reliability, implementation and operational obstacles, and cost.

Potential Innovative Composites Solutions for Cabins and Seating

For the European Commission, the goal is to reduce aircraft emissions 75% by 2050.[i] With that ambitious objective, the onus is on researchers and manufactures to produce workable solutions within a relatively short timeframe, and many have developed unique ideas.

Aviation industry giant Airbus is currently working on aircraft that can sustain prolonged use while utilizing lighter composite materials. They are the leading company involved in the European Union's CleanSky 2 initiative, which is designed to drive aeronautical innovation as a way to drive environmental safety.

One phase of the program is titled "Innovative Physical Integration Cabin-System-Structure," and is focused on concepts for future cabin architectures. This will include component demonstrations and test programs.[ii]

Meanwhile, researchers at

the Sichuan Hongya Zhuyuan Science and Technology Corporation in China are breaking new ground by creating a bamboo fiber composite. This material has only half the compressive strength as steel, but is equally as flexible and only one-sixth of the total weight. Although it is still early in the development stage, scientists believe it can soon replace wood and glass fiber materials currently in place.[iii]

In a research project known as "Fiber Force," the German Aerospace Center and the Technical University of Darmstadt are working in collaboration with Lufthansa Technik to develop methods for load transmission into carbon fiber composites structures for VIP customer aircraft. They are searching for innovative ways to provide ways to install specific cabin components within an aircraft, while reinforcing the materials in such a way that the additional load can be introduced and distributed safely.

They have had some success, as it is now possible to define the maximal load on the floor panels and to develop highly efficient connects that can be individually fitted to the cabin floor. This allows for greater flexibility when designing special cabin fittings such as cupboards, tables and partition walls. These changes are already being implemented in VIP aircraft, as forty of the newly developed floor panel joints are currently being installed in a Boeing 747-8.[iv]

Lufthansa Technik is building off of this success to investigate ways to compensate for sudden drop of pressure in the cabin as well as possibilities for load introduction in the side and upper cabin.

Problems with Using Composites for Aircraft Design

Unfortunately, the rush toward progress, combined with increasingly stringent regulations, has come with several unintended consequences. One of the major issues facing the move toward composite materials is the threat of fire. According to the Federal Aviation Association, thermoset composites account for nearly ninety percent of interior furnishings in commercial aircraft. These are typically made of fiberglass-reinforced resin skins on Nomex honeycomb core which are surfaced with an adhesively-bonded vinyl fluoride decorative film or painted to provide color and texture. Until 1986, these structures were required only to be self-extinguishing in a vertical 60-second Bunsen burner test. Recent regulations have changed these standards however. [v]

The FAA continues to posit that stringent regulations that required material upgrades over a short period of time have resulted in flawed design solutions in many areas, with design costs passed onto the consumer. Therefore, they maintain that the aircraft manufacturing industry should play an active role in the current research programs.

The European Commission group CORDIS held a colloquium on aircraft fire safety titled "AircraftFire Colloquium on the flammability threat of composites on aeronautical fire safety," which brought together researchers, manufacturers and industry leaders in an effort to find workable solutions to the fire issue. According to CORDIS:

> For 20 years, the fire threat in aeronautics has been drastically reduced. But in new generation aircrafts the massive use of flammable composites, substituting metallic structural elements, changes the understanding of fire risk, and influences the fire safety approach for passenger and crew safety and survivability during fire incidents. As recent contribution the FP7 project AircraftFire (AcF) is aimed at the characterisation of the flammability and burning properties of aeronautical composites for fuselage, wings, structures, fuel tanks, cabin materials and their influences on the mechanical behaviour and at the investigation of the effects on inflight fire growth in the cabin and on passenger evacuation during post-crash fire.[vi]

The colloquium is a three-day event that is designed to find solutions to these types of issues. Although fire hazards remain a very real obstacle in the search for better composite materials, a larger roadblock also stands in the way: cost. At present, there is no feasible way to redesign cabin structures with new materials without enduring significant loss.

Looking Ahead: The Future of Composites in Aircraft Cabins and Seating

At the recent SAMPE Conference in Europe, Christian Ruckert of Airbus said that Airbus has the desire to improve performance with new technology, but only if it comes without excessive costs. Changes in materials and structures have to pay off and must be developed in a short period of time, otherwise they will be abandoned.

He admitted that this will be difficult because of modifications in work flow, tools, and new manufacturing processes. Therefore, the cost to develop and implement new composite technology on aircraft will have to be much lower than what they have experienced on recent models. Airbus research and development is now production-driven, so projects must succeed as part of a specific company goal or be shelved. For this reason, engineering development will focus on existing aircraft, and major changes will be made only if specific critical factors are met.[vii]

As with many technological advances, the beginning is typically met with resistance along the lines of feasibility and cost. There is not at present a streamlined approach to redesigning cabins with composite materials, as more research and development must be completed before moving forward.

However, as Axel Krein, senior vice president of research and technology at Airbus, said during the William Littlewood Memorial Lecture, these problems can be solved if people within the industry work together to solve them. Airbus will be leading the way, but they need help. The current A350, which is 50% composite, is in the last stages of test flight and should soon be ready for commercial use.[viii] With a 7 billion people estimated to fly annually by 2032, Krein stresses that changes must be made, and soon.

There have already been impressive breakthroughs in research and design, and innovators are now beginning to look for realistic solutions that can be immediately implemented. Specifically, they are looking for ways to make aircraft safer, more efficient, and more comfortable for passengers.

Companies continue to search for the answer that will solve multiple complex issues facing the airline industry. They are continually turning to composites as a way to lighten the overall aircraft load while maintaining a cabin that meets regulation safety requirements. Increasingly, it has become evident that aircraft seating could be the key factor that propels the industry into a brighter future.

Composites in Aircraft Cabin Seating

One area of particular concern is aircraft seating. Aircraft seating has a major impact on consumer perception and airline cost. As the aviation industry looks for ways to reduce aircraft weight and emissions while also increasing revenue, they are turning to seating as a possible solution. There are currently many different innovations being designed, but each comes with its own drawbacks. Many believe that improvements in this area can successfully solve many of the challenges faced by the airline industry. Fortunately, designs are already underway.

Design Strategies for Composites in Aircraft Seating

Expliseat of Paris has released the Titanium Seat, which is set to enter the market as the world's lightest aircraft seat (roughly 4kg per passenger).[ix] The seat is created mainly of titanium and lightweight composite materials, a design that they boast will save airlines millions of dollars per year in fuel costs. It is planned to be used in the economy sections of narrow-body jets, and consists of a connected three-passenger row of seats that reduces weight and also simplifies seat design by reducing the number of components and parts needed for assembly.[x]

While previous designs required as many as 500 parts, their design requires only 30, which will make maintenance simpler and therefore the probability of component failure less likely. At less than 5kg per passenger, the new seats cut nearly 50% from traditional models. They estimate that this will potentially save airlines 3-5%, or nearly $500,000, on annual fuel costs for each jet.[xi]

The seat has already received EASA ETSO approval certifying that it meets European Union safety standards. After passing several hundred simulations and tests, it has been approved for flight on board European and international airline companies. This makes it the first EASA approved seat under 5kg.[xii]

Similarly, BE Aerospace is working on Pinnacle, which features a lightweight, ergonomic design that is already in use on several Boeing models. They are continuing to research new ways to improve their design, which they have called one of the most successful seating breakthroughs in the industry.[xiii]

Composite manufacture TenCate has been working in collaboration with both seating design firms, pairing their technology with advanced research to produce new solutions for the future of aircraft seating. TenCate is also focused on improving the cabin in other ways, including reducing the weight of necessary areas such as the cabin kitchen.

As they explain, "The materials for kitchens and other interior applications must satisfy very strict fire safety requirements. Interior materials from TenCate also score well on their self-extinguishing capability and requirements relating to fire smoke toxicity. This, moreover, also makes them suitable for ships and trains, which have longer evacuation times."[xiv]

Not to be outdone, Zodiac Aerospace, a world leader in aircraft seating, teamed with Hexcel, a world leader in aerospace carbon fiber composite materials, to develop their own seat, which they are calling L3. This seat design is made for medium to short haul flights, and boasts a good living space to passengers while also offering airlines higher density and lighter weight. Their seat design comes in at under 4kg per passenger. [xv]

The all-composite seat is designed using Hexcel's HexPly® carbon fiber prepregs, providing lightweight mechanical resistance while remaining aesthetically pleasing. The armrests and tray tables are designed using Hexcel's HexMC® compression molding process. They are currently taking these seats through the certification process.[xvi]

Potential Pitfalls for Using Composites in Aircraft Seating

Although successful work has been done in the area of composite seating, there are still some dangers to switching materials. CAE Associates, an engineering consulting firm that also performs composite analysis, lists a few weaknesses in composite use:

> Unlike conventional materials, composites have a large number of potential failure modes, including: failure within a layer (damage or complete failure in fibers and/or matrix material); failure between layers (delamination) induced by transverse shears and tension; fiber debonding (separation of fiber and matrix); and cracking. All must be addressed before a design can be approved.[xvii]

Still, the firm is quick to point out that advances have been made, and as the technology improves and testing because more advanced, composites will have an increasing large role in such industries as defense, energy, automotive, as well as aerospace engineering.[xviii] Better technology will also help to bring costs down, which is at present another potential hurdle.

Technology firm Polygraph notes that graphene could potentially play a role in airline cabin seating, although at present there are still obstacles to overcome – namely cost and production time. There are not yet in place any suitable techniques for industrial-scale production of graphene-reinforced polymers. If there were, then graphene could become important as it has been shown to significantly improve the stiffness, toughness and conductivity

of thermosetting polymer resins, and all while reducing aircraft weight and fuel costs.[xix]

Meanwhile, SAE International recently released its own study of magnesium use, and they are trying to successfully argue for the removal of the magnesium allow restriction in aircraft seat construction. Their tests have concluded that the use of specific types of magnesium alloys in aircraft seat construction does not increase the hazard level potential in the passenger cabin in a post-crash fire scenario. Additionally, the FAA has created a lab scale test method as a certification test to allow acceptable use of magnesium.[xx]

Another problem with composite seating is ergonomics and seating comfort. E-A-R, a specialist in composite seat design, presents the challenge as really a matter of competing interests. On one hand, designers want to make a seat that provides stability and comfort for a wide range of passengers. However, these seats must also fulfill industry regulations with regards to safety, specifically impact absorption. The safest seat designs are not necessarily the most comfortable, and compromises must be made.

They have suggested using COMFOR foam, which was first designed to assist NASA protects its astronauts in-flight. The foam is rate-responsive, meaning it has the ability to react differently depending on the situation. As it is slowly engaged (as when someone is sitting down), the material appears soft and pliable. However, rapid response (as during impact) produces a much different result; the foam becomes firmer and denser, allowing for greater protection.[xxi]

Another added benefit of CONFOR foam is that it is responsive to different temperatures. When placed against a warm body, the foam molds around the body and allows for equal weight distribution. This is effective in eliminating pressure points, which by design reduces vascular restriction and improves comfort over long-term use.[xxii]

E-A-R- designers and researchers are confident that these benefits will provide a single solution to the complexities of the composite seat problem. By creating a safer and more comfortable seating option, they believe their design should be considered for use in all commercial aircrafts.

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Moving Forward with Composites in Aircraft Design

There continue to be opportunities for innovative teams to develop seats that change the industry. At the 4th Annual Innovative Seating Conference in Germany, companies and inventors were asked to submit their best ideas for composite seats that would both reduce weight and cost to the airlines.[xxiii]

Faculty members from the Department of Aerospace Engineering at the Universiti Putra Malaysia have recently released a conceptual design for a vertical aircraft seat. In their presentation, they explain that the competition between airlines today is based mainly on the affordability of air travel. Therefore, the company that can offer the lowest fare often secures the greatest number of passengers.[xxiv]

Theoretically, by designing upright seating arrangements, airlines could hold more passengers in a single flight, thereby allowing for a lower fare – and thus they could become leaders in the marketplace. The design would make airplanes closer in nature to buses and trains in which many passengers stand during the duration of the flight.[xxv] This would work essentially for short flights, as cross-country or even international flights would be impractical for standing room only aircrafts.

Whether the plans are feasible or not, there are still many teams out there developing new seat designs that can accomplish the pressing goals of the airline industry: specifically, how to serve the greatest amount of passengers for the lowest cost.

There is reason for innovators and manufacturers to be optimistic in light of recent industry breakthroughs. As this technology becomes more common and multiple seat designs pass certification and reach the market, the costs for airline companies should be reduced. These costs should be more than covered by the net savings they will experience by reducing their weight load and by extension their fuel costs.

In 2014, the fuel bill for the airline industry will reach an estimated $212 billion, or roughly one-third of their total operating costs.[xxvi] By reducing their weight while making aircraft seating more comfortable, safer, and more reliable, they will significantly reduce their operating costs while upgrading their fleet. Presumably, they will then be able to pass these savings onto the consumer, who could find air travel not only better but more cost-effective in the coming years.

Consumers will continue to monitor the situation closely. As Airbus senior vice president of research and technology Axel Krein noted in a recent address, the number of airline consumers doubles every fifteen years, which he forecasts as 7 billion flyers by 2032.[xxvii]

This presents a number of unique challenges, with technology at the forefront. However, he is confident that within the next few years the innovations in the industry will begin to affect commercial flights, and that by working together with manufacturers, designers, and government agencies, they will be able to comprehensively solve the most pressing problems in the industry.

Maryruth Belsey Priebe

Maryruth can't help but seek out the keys to environmental sustainability - it's the fire that gets her leaping out of bed every day. With green writing interests that range from sustainable business practices to net-zero building designs, environmental health to cleantech, and green lifestyle choices to social entrepreneurism, Maryruth has been exploring and writing about earth-matters and ethics for over a decade. You can learn more about Maryruth's work on JadeCreative.com.

Image Sources

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