COMPOSITES AND PLASTIC MATERIALS IN THE AVIATION

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The main objective of this article is to describe the composite materials, their use in the aerospace industry, the economic aspects of the use, the main advantages and future composites. In the second part of the article deals with plastics and their use in the aerospace industry, the main advantages of plastics and their application in the 787th Boeing.

K e y w o r d s: composite, composite material, composites in aerospace, plastic, plastics material, advantages of composite, advantages of plastics

1 INTRODUCTION

A composite material is a material that, consist of strong carry-load materials which are embedded in a somewhat weaker material. The stronger material is commonly referred to as reinforcement and the weaker material is commonly referred to as the matrix. The reinforcement provides the strength and rigidity that is needed 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.

Plastics are used on a daily basis throughout the world. The word plastic is a common term that is used for many materials of a synthetic or semi-synthetic nature. The term was derived from the Greek “plastikos” which means “fit for molding.” Plastics are a wide variety of combinations of properties when viewed as a whole. They are used for shellac, cellulose, rubber, and asphalt. We also synthetically manufacture items such as clothing, packaging, automobiles, electronics, aircrafts, medical supplies, and recreational items.

The list could go on and on and it is obvious that much of what we have today would not be possible without plastics.

2 COMPOSITES IN THE AEROSPACE INDUSTRY

Composites

Weight is everything when it comes to heavier-than-air machines, and designers have striven continuously to improve lift to weight ratios since man first took to the air.

Composite materials have played a major part in weight reduction, and today there are three main types in use: carbon fiber-, glass- and aramid- reinforced epoxy.; there are others, such as boron-reinforced (itself a composite formed on a tungsten core).

Since 1987, the use of composites in aerospace has doubled every five years, and new composites regularly appear.

Use of composites in aerospace

Composites are versatile, used for both structural applications and components, in all aircraft and spacecraft, from hot air balloon gondolas and gliders, to passenger airliners, fighter planes and the Space Shuttle. Applications range from complete airplanes such as the Beech Starship, to wing assemblies, helicopter rotor blades, propellers, seats and instrument enclosures.

The types have different mechanical properties and are used in different areas of aircraft construction. Carbon fiber for example, has unique fatigue behavior and is brittle, as Rolls Royce discovered in the 1960's when the innovative RB211 jet engine with carbon fiber compressor blades failed catastrophically due to birdstrikes.

Whereas an aluminium wing has a known metal fatigue lifetime, carbon fiber is much less predictable (but dramatically improving everyday), but boron works well (such as in the wing of the Advanced Tactical Fighter). Aramid fibers ('Kevlar' is a well-known proprietary brand owned by DuPont) are widely used in honeycomb sheet form to construct very stiff, very light bulkhead, fuel tanks and floors. They are also used in leading- and trailing-edge wing components.

In an experimental program, Boeing successfully used 1,500 composite parts to replace 11,000 metal components in a helicopter. The use of composite-based components in place of metal as part of maintenance cycles is growing rapidly in commercial and leisure aviation.

Overall, carbon fiber is the most widely used composite fiber in aerospace applications.

Advantages of composites

Composites are the benefits:

- Weight reduction - savings in the range 20%-50% are often quoted.
- It is easy to assemble complex components using automated layup machinery and rotational molding processes.
- Monocoque ('single-shell') molded structures deliver higher strength at much lower weight.
- Mechanical properties can be tailored by 'lay-up' design, with tapering thicknesses of reinforcing cloth and cloth orientation.
- Thermal stability of composites means they don't expand/contract excessively with change in temperature (for example a 90°F runway to -67°F at 35,000 feet in a matter of minutes).
- High impact resistance - Kevlar (aramid) armor shields planes, too - for example, reducing accidental damage to the engine pylons which carry engine controls and fuel lines.

- High damage tolerance improves accident survivability.
- 'Galvanic' - electrical - corrosion problems which would occur when two dissimilar metals are in contact (particularly in humid marine environments) are avoided. (Here non-conductive fiberglass plays a roll.)
- Combination fatigue/corrosion problems are virtually eliminated.

Future of composites in aerospace

With ever increasing fuel costs and environmental lobbying, commercial flying is under sustained pressure to improve performance, and weight reduction is a key factor in the equation.

Beyond the day-to-day operating costs, the aircraft maintenance programs can be simplified by component count reduction and corrosion reduction. The competitive nature of the aircraft construction business ensures that any opportunity to reduce operating costs is explored and exploited wherever possible.

Competition exists in the military too, with continuous pressure to increase payload and range, flight performance characteristics and 'survivability', not only of airplanes, but of missiles, too.

Composite technology continues to advance, and the advent of new types such as basalt and carbon nanotube forms is certain to accelerate and extend composite usage. When it comes to aerospace, composite materials are here to stay.

3 PLASTIC IN THE AEROSPACE

Plastics and Aviation

World War II accelerated the entry of plastics into aerospace as it did to all modes of transportation. More traditional materials were scarce and almost always more expensive, heavier, and harder to design and manufacture, and even more important, the possible applications of plastics were already envisioned. Vinyl materials became a major substitute for scarce rubber in airplane fuel-tank linings and fliers' boots. Virtually transparent to electromagnetic waves, the plastic used in radomes covering radar installations maximized transmission such that the material later was acknowledged as having significantly advanced the nascent radar technology.

Plastic materials can be flexible enough to withstand helicopter vibration but rigid enough to ensure safety. They can be transparent for easy observation, shatter resistant, and even offer ballistic protection. Their inherent ability to be simultaneously lightweight and strong was compelling in the 1970s, when the oil crisis compelled aerospace companies to create more fuel-efficient aircraft. The need for more efficient engines, improved aerodynamics, and less weight brought plastics to the forefront, and their usage has continued to grow. The heavier the vehicle – plane, car, truck, or spacecraft – the more fuel it needs to travel a given distance. The weight-to-fuel impact for jetliners is extreme. A one-pound weight reduction will mean tens and even hundreds of thousands of dollars in lifetime fuel savings, and plastic composites in the Boeing 787 reduced the total plane weight by about 20 percent, or thousands of pounds.

Plastics also save fuel and money because their smooth contours improve aerodynamics. And owing to their oft-referenced "combination of properties," plastics can be less expensive to manufacture, more resistant to wear, need less upkeep, and be easier to repair than other heavier materials.

New uses continue to be found for plastic materials in aerospace, and new plastic materials continue to be created that further expand the range of possibilities.

Advantages of plastics

Every extra pound a plane weights costs energy to move it and thus money.

The use of modern polymer materials and reinforcing fibres makes it possible to achieve lightweight constructions and hence fuel savings:

- Plastic components can normally be fabricated
- economically
- Plastics are approx. 50% lighter than aluminium
- Compared to metals, plastics do not corrode
- Plastics provide a high degree of freedom in design
- Plastics with modified sliding properties are best suited for use in dry operation under extreme conditions
- Transparent plastics serve as lighter and more impact resistant alternatives to glass

Application of plastics in Boeing 787

Using plastics in the Boeing 787 does more than save weight Boeing used plastics extensively in its 787 Dreamliner not only for its performance but also for sound business reasons – many of them.

Even the Boeing 787's windows set new performance standards Windows in the 787 darken from transparent to black at the touch of a button, and they are significantly larger than in any previous commercial aircraft. Passengers in the middle seats can see out, which reduces possible air sickness.

The dream of flying would quickly become a thing of the past without today's plastics. This is easily substantiated by a casual glance at the inside of a modern aeroplane. The use of plastics makes planes lighter, safer and more economical. This is by no means the case for just the interior, however, but also for sophisticated technical parts, structural elements and propulsion components, for example. More recently, the significance of technical plastics and composites in aviation and aerospace applications has grown rapidly.

Plastics have become a staple product in the world; the only real concern is how they will affect the environment.

4 CONCLUSSION

Composite and plastic materials are indispensable in reducing the economic costs of aviation.

Emerging metallic materials, processing, and manufacturing technologies offer an important opportunity to meet current aircraft-airframe and jet-engine affordability goals, due to their inherent low material costs and excellent producibility characteristics. But to successfully meet systems goals within this new affordability-driven scenario, a consolidation of industry and military-agency development resources and technology-implementation activities is necessary to positively impact the military-aircraft production and sustainment infrastructure. To address this need, a consortium of aircraft and engine manufacturers and key material- and component-supplier companies has been formed to identify critical affordable metal technologies, develop a strategic roadmap for accelerated development and insertion of these technologies, and oversee execution of development activities by integrated industry teams.

The goal of the Metals Affordability Initiative is to reduce the cost of metallic components by 50 percent while accelerating the implementation time for these components.

Metallic materials and processing technologies are critical in meeting the near-term affordability objectives of military and commercial aircraft systems. Until recently, system-performance objectives related to range, acceleration, velocity, maneuverability, and low observability were the primary objectives during system-concept development stages of aircraft programs. Achieving these performance goals was often accomplished at the expense of life-cycle cost economy.

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