



USE OF COMPOSITE STRUCTURES IN AIRCRAFT CONSTRUCTION

STRENGTH AND DURABILITY COMBINED WITH MAINTAINABILITY

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Overview

Composites are hardly new in aviation – in the truest sense, all aircraft rely on composite techniques to provide safety, strength, light weight and durability. The first airplanes incorporated wood, fabric, and resins in their construction. Today's high tech aircraft combine fibers such as carbon and Kevlar with high temperature curing epoxy resins.

Background

The appeal of higher strength, stiffness and lower density, combined with great resistance to fatigue and corrosion led to the use of metals...but weight has also always been a consideration. These factors and its durability have propelled carbon fiber/epoxy to widespread use in aerospace and a variety of high performance applications. NASA utilized composites in civil airframe trials in the 1970s, carbon fiber and Kevlar control surfaces were introduced on Boeing's 757s and 767s in the '80s and complete tail structures are in current airline service on Airbus 310 and Boeing 777 models. The military has made extensive use of all-composite construction on the F-117, V-22, B-2 and F-22. The Beech Starship was the first all-carbon fiber airplane to receive FAA certification.

Composite rotor blades are also in widespread use on military and civilian helicopters and have brought about significant improvements in reliability and safety due to their exceptional resistance to fatigue cracking.

Benefits

Carbon fiber construction offers exceptional strength and stiffness at a lower density than traditional metal materials. The high temperature epoxy resins with which the fibers are cured are highly resistant to water, fuel, anti-freeze, and solvents which might cause wear or deterioration, and they can be protected from ultraviolet radiation using the same paint finishes used on metal airplane components. With this type of finish HBC composite parts are qualified for use in weather and climates found anywhere in the world and at all certified altitudes.

Quality Assurance

Hawker Beechcraft Corporation (HBC) carbon fiber composite materials are used in construction on the fuselage, horizontal stabilizers, vertical stabilizer, flaps, ailerons, and spoilers of the Premier I and Hawker 4000 business jets. The fuselages are the major components manufactured using a very precise carbon fiber honeycomb process. A specially-designed machine places every strip of prepreg (meaning pre-impregnated

with resin) carbon fiber in the exact position as designed to achieve maximum strength with minimum weight. The machine builds up carbon fiber plies (layers) for the inner and outer face sheets, and a ¾-inch Nomex (Aramid) honeycomb core is placed in between the two sheets. The final ply on the outer surface is a hybrid fabric woven of carbon fiber and fine metal wires to provide lightning strike protection.

Much like bones, this “sandwich construction” gives very high resistance to bending, since the strength is in the shell itself. When each fuselage section is finished on the machine, it is transferred to a different tool to be cured (baked under high temperature and pressure). In the case of the forward fuselage, this means a pressure cabin formed in one piece with integral frames with few joints, rivets or leak paths. It’s also considerably lighter than conventional, metal jet structures. Every composite part is tested before acceptance for assembly using a proprietary sonic technique. This process ensures no voids are present, that the fiber placement is correctly oriented, and that the resins have properly bonded to the fibers, creating an incredibly strong and light finished material.

Ease of Repair

While the engineering and materials behind aircraft composite technology are exotic, the actual repairs to composite structures are relatively simple.

Composite damage identification does differ significantly from aluminum in that it typically does not dent and appears normal. A simple tap test of the suspected damage area can reveal if underlying damage exists. Undamaged composites have a crisp metallic ring that will transition to a dull thud when a damaged area is encountered. Typically, very simple tools can be used to examine suspected damage: a tap hammer or even the edge of a coin; thus further minimizing costs associated with operating expenses.

The materials used in the composite repair will preserve or increase the strength, weight, aerodynamic characteristics, and the electrical properties of the original structure. The standard composite repair is a wet lay-up, meaning that readily available fibers, or sheets of fibers and resins, can be applied wherever the aircraft is located. Tooling is simple, and may consist of a vacuum bag and possibly a heat source, such as a lamp. The wet lay-up repair results in a very smooth repair and often does not require mechanical rivets or fasteners. The lay-up consists of several layers of composite fabric and foil mesh, each slightly larger than the preceding layer. By sealing the repair area with a vacuum bag and breather plies, air bubbles trapped in the resin mix will be drawn out and excess resin will be removed resulting in a very low profile repair. Curing the resins by controlled elevated temperatures makes the repair stronger and greatly reduces cure time. For instance, the cure time for the resin at room temperature at 77 degrees is 5 days; elevating the temperature up to 100 to 130 degrees shortens the cure time to just a few hours. Once the repair is completed, the structure is returned to an airworthy condition and, unlike metal, it does not bear the obvious signs of being patched or reinforced.