# COMPOSITE COMPONENTS IN AIRCRAFT APPLICATIONS

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***Abstract***: *There are more than 50,000 materials available to engineers for the design and manufacturing of products for various applications. These materials range from ordinary materials (e.g., copper, cast iron, brass), which have been available for several hundred years, to the more recently developed, advanced materials (e.g., composites, ceramics, and high-performance steels). Due to the wide choice of materials, today's engineers are posed with a big challenge for the right selection of a material and the right selection of a manufacturing process for an application.*

***Keywords***: *composite, fibres, Aerospace Industry.*

A composite material is made by combining two or more materials to give a unique combination of properties. The above definition is more general and can include metals alloys, plastic co-polymers, minerals, and wood. Fiber-reinforced composite materials differ from the above materials in that the constituent materials are different at the molecular level and are mechanically separable. In bulk form, the constituent materials work together but remain in their original forms.

The final properties of composite materials are better than constituent material properties.

The concept of composites was not invented by human beings; it is found in nature. An example is wood, which is a composite of cellulose fibers in a matrix of natural glue called lignin. The shell of invertebrates, such as snails and oysters, is an example of a composite. Such shells are stronger and tougher than man-made advanced composites.

Scientists have found that the fibers taken from a spider's web are stronger than synthetic fibers. In India, Greece, and other countries, husks or straws mixed with clay have been used to build houses for several hundred years. Mixing husk or sawdust in a clay is an example of a particulate composite and mixing straws in a clay is an example of a shortfiber composite.

These reinforcements are done to improve performance.

The main concept of a composite is that it contains matrix materials. Typically, composite material is formed by reinforcing fibers in a matrix resin. The reinforcements can be fibers, particulates, or whiskers, and the matrix materials can be metals, plastics, or ceramics.

The reinforcements can be made from polymers, ceramics, and metals. The fibers can be continuous, long, or short. Composites made with a polymer matrix have become more common and are widely used in various industries.

The reinforcing fiber or fabric provides strength and stiffness to the composite, whereas the matrix gives rigidity and environmental resistance.

Reinforcing fibers are found in different forms, from long continuous fibers to woven fabric to short chopped fibers and mat. Each configuration results in different properties. The properties strongly depend on the way the fibers are laid in the composites. All of the above combinations or only one form can be used in a composite. The important thing to remember about composites is that the fiber carries the load and its strength is greatest along the axis of the fiber. Long continuous fibers in the direction of the load result in a composite with properties far exceeding the matrix resin itself. The same material chopped into short lengths yields lower properties than continuous fibers. Depending on the type of application (structural or nonstructural) and manufacturing method, the fiber form is selected.

For structural applications, continuous fibers or long fibers are recommended; whereas for nonstructural applications, short fibers are recommended.

Injection and compression molding utilize short fibers, whereas filament winding, pultrusion, and roll wrapping use continuous fibers.

Composites offer good impact properties, as shown in Figures 1 and 2. Figure 1 shows impact properties of aluminum, steel, glass/epoxy, kevlar/epoxy, and carbon/epoxy continuous fiber composites. Glass and Kevlar composites provide higher impact strength than steel and aluminum.

Figure 2 compares impact properties of short and long glass fiber thermoplastic composites with aluminum and magnesium. Among thermoplastic composites, impact properties of long glass fiber nylon 66 composite (NylonLG60) with 60% fiber content, short glass fiber nylon 66 composite (NylonSG40) with 40% fiber content, long glass fiber polypropylene composite (PPLG40) with 40% fiber content, short glass fiber polypropylene composite (PPSG40) with 40% fiber content, long glass fiber PPS composite (PPSLG50) with 50% fiber content, and long glass fiber polyurethane composite (PULG60) with 60% fiber content are described. Long glass fiber provides three to four times improved impact properties than short glass fiber composites.

Noise, vibration, and harshness (NVH) characteristics are better for composite materials than metals.

Composite materials dampen vibrations an order of magnitude better than metals. These characteristics are used in a variety of applications, from the leading edge of an airplane to golf clubs.

By utilizing proper design and manufacturing techniques, cost-effective composite parts can be manufactured. Composites offer design freedom by tailoring material properties to meet performance specifications, thus avoiding the over-design of products.

This is achieved by changing the fiber orientation, fiber type, and/or resin systems.

Glass-reinforced and aramid-reinforced phenolic composites meet FAA (Federal Aviation Administration) requirements for low smoke and toxicity. This feature is required for aircraft interior panels, stowbins, and galley walls.

The cost of tooling required for composites processing is much lower than that for metals processing because of lower pressure and temperature requirements. This offers greater flexibility for design changes in this competitive market where product lifetime is continuously reducing.

The aerospace industry was among the first to realize the benefits of composite materials. Airplanes, rockets, and missiles all fly higher, faster, and farther with the help of composites. Glass, carbon, and Kevlar fiber composites have been routinely designed and manufactured for aerospace parts.

The aerospace industry primarily uses carbon fiber composites because of their high-performance characteristics.

The hand lay-up technique is a common manufacturing method for the fabrication of aerospace parts; RTM (Resin Transfer Molding) and filament winding are also being used. Military aircrafts, such as the F-11, F-14, F-15, and F-16, use composite materials to lower the weight of the structure. The composite components used in the above-mentioned fighter planes are horizontal and vertical stabilizers, wing skins, fin boxes, flaps, and various other structural components as shown in Table 1.

Typical mass reductions achieved for the above components are in the range of 20 to 35%. The mass saving in fighter planes increases the payload capacity as well as the missile range.

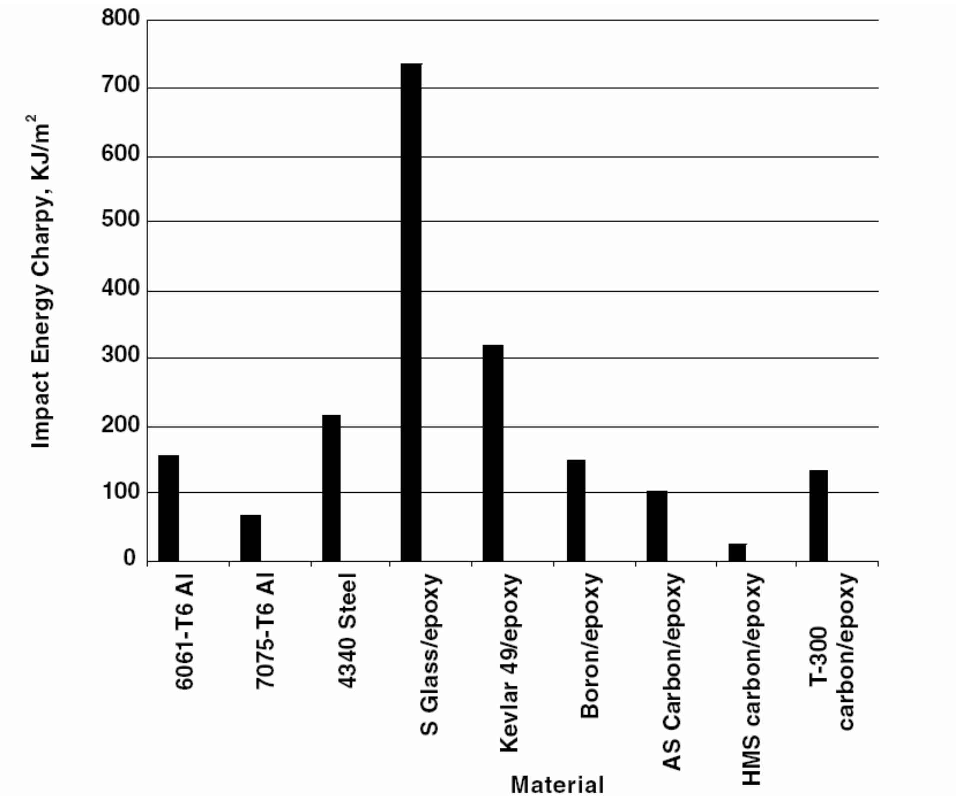


Fig. 1 Impact properties of various engineering materials.
Unidirectional composite materials with about 60% fiber volume fraction are used

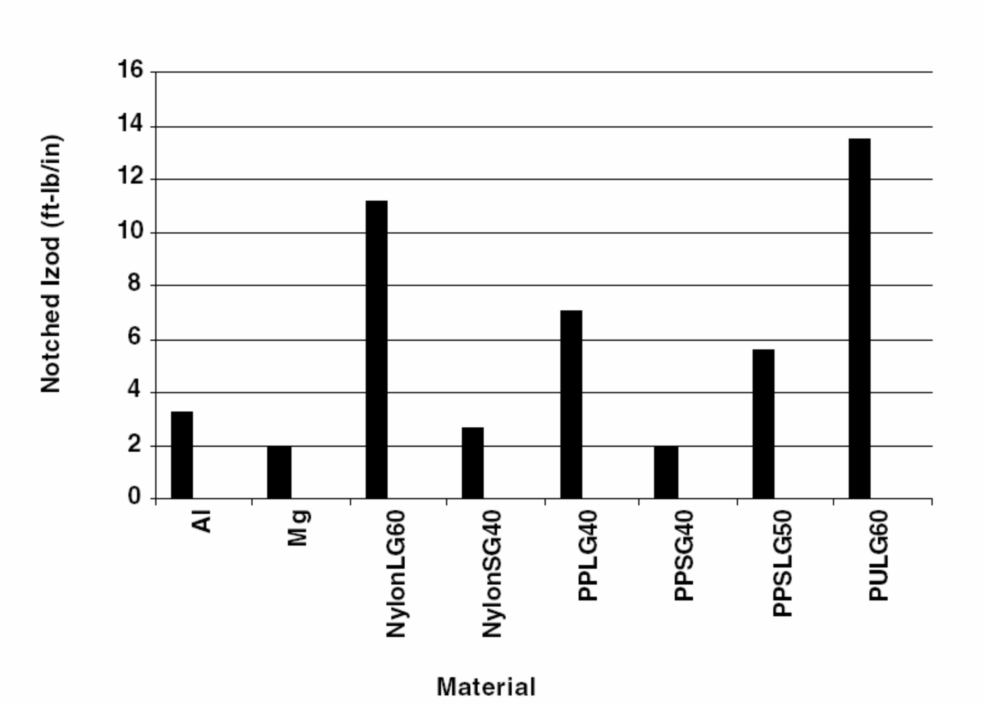


Fig. 2 Impact properties of long glass (LG) and short glass (SG) fibers reinforced thermoplastic composites. Fiber weight percent is written at the end in two digit

Table 1 Composite Components in Aircraft Applications

| | Composite Components |
|---|---|
| F-14 | Doors, horizontal tails, fairings, stabilizer skins |
| F-15 | Fins, rudders, vertical tails, horizontal tails, speed brakes, stabilizer skins |
| F-16 | Vertical and horizontal tails, fin leading edge, skins on vertical fin box |
| B-1 | Doors, vertical and horizontal tails, flaps, slats, inlets |
| AV-8B | Doors, rudders, vertical and horizontal tails, ailerons, flaps, fin box, fairings |
| Boeing 737 | Spoilers, horizontal stabilizers, wings |
| Boeing 757 | Doors, rudders, elevators, ailerons, spoilers, flaps, fairings |
| Boeing 767 | Doors, rudders, elevators, ailerons, spoilers, fairings |

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