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Sandwich Composite for UAV Wing Design and Fabrication

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***Abstract*: The aerospace applications are bonded to the low weight and high structural strength necessity, this lead to the more research work in the field of composites. The composites hold the more strength to weight ratio compared to the other conventional materials. Their strength mainly depends on the orientation of the reinforcement material and volume fraction of matrix and reinforcement. The sandwich composites are extensively used in the aerospace applications where a conventional material's strength is increased by adding the layers of composite material by prescribed orientations. The different fabrication techniques and the selection factor for aero foil is discussed in the paper.**

***Keywords*: sandwich composite, composites, aerospace, manufacturing of composites.**

1. Introduction

Composite materials are made of various layers of various materials. They are light weight and high in quality. Composite materials incorporate a blend of materials that are solidified to accomplish specific fundamental properties. The individual materials don't separate or join totally in the composite, yet they act together as one. A pushed composite material is made of a stringy material presented in a gum matrix, by and large overlaid with strands organized in substituting headings to give the material quality and immovability. Stringy materials are not new; wood is the most extensively seen strong assistant material known to man.

Matrix: A homogeneous base material that structures the majority of a composite material layer.

Fibers: Fortified or inserted fortifying filaments that are normally in charge of the anisotropy of the composite.

Lamina: A composite material in sheet shape normally alluded to as a layer or employ. The material properties of a layer are generally decided through an equal homogenization (spreading) process.

Laminate: A heap of lamina combined in subjective ways, alluded to as a composite lay-up or stacking-succession. The utilization of composites in aircraft is expanding quickly, particularly in military aircraft, where the result is the best. In business aircraft, the acknowledgment of composites as essential structures have been slower, yet is presently expanding quickly. The composite parts utilized as a part of the aircraft are fundamentally, horizontal and vertical stabilizers, wing skins, fin boxes, flaps, and different other basic segments. In shuttle, where the weight is of the best significance, the composites are acknowledged as essential materials.

A. *Properties of sandwich structures*

Sandwich development has high bowing stiffness at insignificant weight in contrast with aluminum and composite cover development. Most honeycombs are anisotropic; that is, properties are directional. Focal points of utilizing a honeycomb development. Expanding the core thickness incredibly builds the stiffness of the honeycomb development, while the weight increment is insignificant. Because of the high stiffness of a honeycomb development, it isn't important to utilize outer stiffeners, for example, stringers and frames.

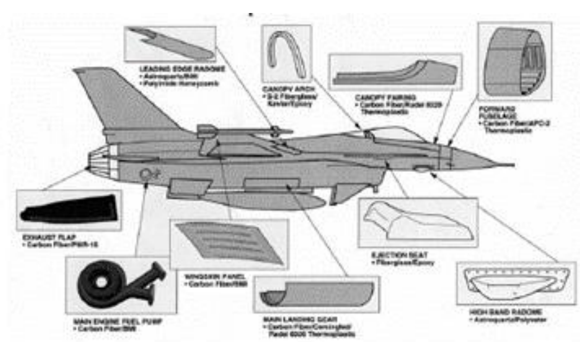


Fig. 1. Composite components used in an engine application Sandwich structures.

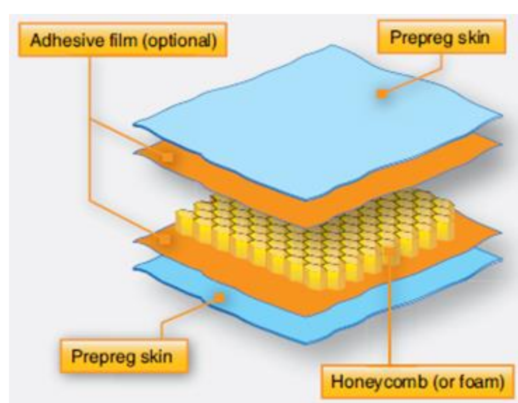


Fig. 2. Sandwich structure.

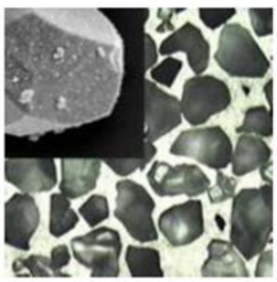
	Solid Material	Core Thickness t	Core Thickness 3t
	t	2t	4t
Thickness	1.0	7.0	37.0
Flexural Strength	1.0	3.5	9.2
Weight	1.0	1.03	1.06

Fig. 3. Strength and stiffness of Honeycomb Sandwich material compared to a solid laminate

2. Classification of composites based on reinforcement

Composite Materials can be classified by the type of reinforcements used for the matrix material.

- Particle Reinforced Composites
- Fiber Reinforced Composites
- Short Fiber Reinforced
- Long Fiber Reinforced



Ceramic - Aluminum

Fig. 4. Typical ceramic- aluminum

1) Particle reinforced composites

Molecule strengthened composites comprise of particles of one material scattered in a framework of a second material. Particles may have any shape or size, however are by and large round, ellipsoidal, polyhedral, or sporadic fit as a fiddle

2) Fibre Reinforced Composites

Molecule strengthened composites comprise of particles of one material scattered l. Particles may have any shape or size, however are by and large round, ellipsoidal, polyhedral, or sporadic fit as a fiddle.

B. Types of Fibers

1) Fiberglass

Fiberglass is consistently used for discretionary structure on flying machine, for instance, fairings, randomness, and wing tips. Fiberglass is moreover used for helicopter rotor sharp edges. There are a couple of sorts of fiberglass used as a piece of the flight business. Electrical glass, or E-glass, is recognized in that limit with respect to electrical applications. It has high protection from current stream. E-glass is created utilizing borosilicate glass. S-glass and S2-glass perceive essential fiberglass that have a higher quality than E-glass. S-glass is conveyed from magnesia-alumina-silicate. Central purposes of fiberglass are cut down expense than other composite materials, blend or galvanic utilization opposition, and electrical properties (fiberglass does not immediate power). Fiberglass has a white shading and is open as a dry fiber surface or prepreg material.

2) Carbon/Graphite

One of the principle refinements to be had among strands is the effect among carbon and graphite fibers, despite how the terms are as frequently as possible utilized correspondingly. Carbon and graphite fibers depend upon grapheme (hexagonal) layer structures show up in carbon. In the event that the graphene layers, or planes, are stacked with three dimensional interest, the material is depicted as graphite. This material is depicted as carbon. Carbon strands are firm and solid, 3 to 10 times stiffer than glass fibers. Carbon fiber is utilized for basic flying machine applications, for example, floor segments, stabilizers, flight controls, and fundamental fuselage and wing structure. Motivations behind interest combine its high caliber and breaking down restriction. Deficiencies combine cut down conductivity than aluminium in this way, a lightning security work or covering is basic for flying machine parts that are inclined to lightning strikes. Another snag of carbon fiber is its stunning expense. Carbon fiber is reduce or diminish in shading and is accessible as dry surface and prepreg material. Carbon strands have a high potential for causing galvanic usage when utilized with metallic bolts and structures.

3. Manufacturing methods

There are two general techniques for assembling composites. Open embellishment depicts forms with materials being presented to the environment amid the assembling procedure while shut trim procedures utilize two-sided shape sets or vacuum sacks.

1) Open Molding

- Hand Lay-Up
- Spray-up
- Filament Winding

2) Closed Molding

- Vacuum Bag Molding
- Vacuum Infusion Processing
- Compression molding
- Pultrusion
- Resin Transfer Molding (RTM)
- Centrifugal Casting
- Continuous Lamination

4. Air foil selection

Substantial plane organizations like Boeing and Airbus may design their own particular airfoils. In any case, amid the fundamental design organize, the typical handy is to pick the airfoil from the huge number of airfoils whose geometric and streamlined attributes are accessible in the aeronautical writing. To empower such a determination it is useful to know the streamlined and geometrical attributes of airfoils and their classification. These themes are canvassed in the following three subsections.

A. Presentation of aerodynamic characteristics of airfoils

Ordinary exploratory attributes of an aero foil are appeared in underneath figure. The highlights of the three plots in this figure can be quickly portrayed as takes after.

- Lift coefficient (l C) versus angle of attack (α). The bend has four imperative highlights viz. (an) angle of zero lift (0l α), (b) incline of the lift bend signified by d l C/dα or a0 or lα C , (c) most extreme lift coefficient (lmax C) and (d) angle of attack (αstall) relating to lmax C .
- Drag coefficient (Cd) versus l C. The bend has two critical highlights viz. (a) base drag coefficient (Cdmin) and (b) lift coefficient (lopt C) comparing to Cdmin. In a few airfoils, called laminar stream airfoils or low-drag airfoils, the base drag coefficient reaches out finished a scope of lift coefficients. This component is called 'Drag pail'. The degree of the drag container and the lift coefficient at the center of this district are additionally trademark highlights of the airfoil. It might be included that the camber chooses lopt C and thickness proportion chooses the degree of the drag basin.
- Pitching minute coefficient about quarter-harmony Cmc/4 versus α. This bend. Once in a while this bend is likewise plotted as Cmc/4 versus l C. From this bend, the area of the streamlined focus (a.c.) and the minute about it (Cmac) can be worked out. It might be reviewed that a.c. is the point on the harmony about which the minute coefficient is free of l C.

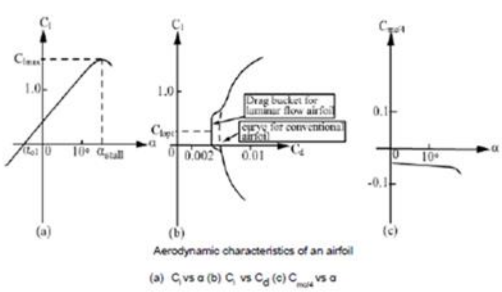


Fig. 5. Aerodynamic characteristics of an airfoil

- Slow pattern: Variation of the lift coefficient with angle of attack close to the slowdown means that the slowdown example. A progressive example as appeared in Fig. 5, is an alluring component. A few airfoils show unexpected reduction in l C after slow down. This conduct is unfortunate as pilot does not get satisfactory cautioning in regards to approaching loss of lift. Airfoils with thickness proportion (t/c) between 6 – 10% for the most part show unexpected slow down while those with t/c over 14% show a progressive slow down. It might be included that the slowdown examples the wing and on the airfoil are specifically related just for high angle proportion (A > 6) unswept wings. For low perspective proportion very cleared wings three-dimensional impacts may command.

5. Fabrication of the wing

In this section, the detailed manufacturing process of the sandwich composite wing is explained. Fabrication of wing involves following steps:

- Making of core i.e. foam with NACA profile.
- Cutting of the woven glass fiber as per wing size.
- Application of epoxy resin and layup on the wing.

A. Making of core (foam) with NACA profile.

As shown in the wing drawings, the wing is designed with NACA 0015 profile. For this, foam models of the wing have been cut by utilizing the numerically controlled foam cutting machine which is shown in below Figure. Foam cutting machine is a practical CNC machine used for cutting polystyrene foams easily and accurately. The cutting action is done by a hot cutting wire which is numerically controlled from the two ends via feeds. The driving mechanisms of both feeds are controlled by the software installed on the PC. The software also controls the current and the voltage in the cutting wire, as well as the speed and x-y location of each of the feeds.

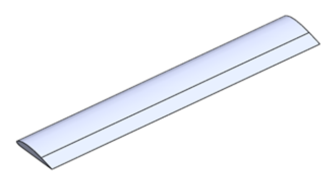


Fig. 6. 3D model of a wing

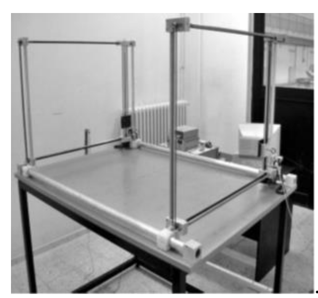


Fig. 7. Numerically controlled foam cutting machine

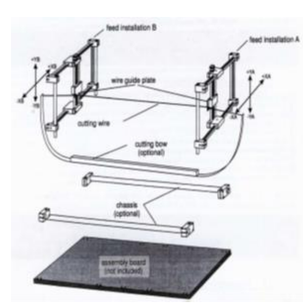


Fig. 8. Schematic setup of the foam cutting machine

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The airfoil tip and root segments of the wing are stacked to the PC. At that point, with legitimate feed speed and wire temperature the model is cut from the froth square. It is critical that, while cutting the froth, the square ought not to move. Thus, the froth square is reasonably settled to the gathering leading body of the cutting machine.

B. Cutting of the woven glass fiber as per wing size.

Once we get the finished part from foam cutting machine it is further polished for superior surface finish using sandpaper.

C. Glass fibre layup

A layer of glass fibre is laid up over the foam wing with the application of epoxy resin to the wing.

Fig. 9. Image showing foam core wing and cross section of the wing with NACA 0015 aerofoil

Fig. 10. Image showing glass fibre and wing section before layup and application of resin.

The woven fiber is laid on the wing with adequate dissemination of epoxy pitch and weight is connected for the adequate holding with fiber layers .The hand lay-up get together is left to remedy for one day. After the restoring of the get together, the upper surface of the wing is at first treated by sandpaper and a layer of polyester glue is connected over the wing surface. The objective of spreading a layer of polyester over the wing is to fill in the pores of the composite texture. Along these lines, a smooth wing surface is accomplished. After the use of the polyester glue, the wing structure is dealt with by various review sandpapers. At first, the wing surface is dealt with in dry conditions. The last sandpaper treatment is performed with a higher review sandpaper wetted with water so as to accomplish an extremely smooth wing surface. After every one of the medicines of the wing surface is finished.

Fig. 11. Prototype model of wing with foam as core and skin as composite woven material

6. Conclusion

The sandwich composite material is prepared by using the foam as the core part and the finely woven glass fiber as the reinforcement with epoxy as the matrix material. The different manufacturing methods are discussed in the present paper. The process of airfoil selection and the profile cutting of the aero foil on the core material is discussed and the hand layup method is implemented for the present model.

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