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Implementation Of Aircraft Wardrobe Using Honeycomb Composite Over Aluminium. A Review

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Abstract

The use of aluminum alloys in the aerospace industries has increased over the past four decade. At the time when extensive alloying capability and extensive reserves makes it first choice material. It does carry its own limitations. An important design feature for aerospace applications is the resistance of aluminum alloy to environmentally induced intergranular cracking or stress corrosion cracking. Aluminum honeycomb sandwich panels are used to reduce weight whilst improving the compressive strength of the structure with the aerospace industry being the prime candidate for structural application. The cost of producing all welded honeycomb structure has been the key factor for not using this technology on mass production rate as well as susceptibility of stress corrosion cracking of the alloys. Alternative to the aluminum honeycomb sandwich panels is the aluminum metallic foam, used as core material, sandwich panel, which exhibit non-linear mechanical deformation behavior and they have the potential for use at elevated temperatures up to 200^{o}C.[1]

The honeycomb sandwich construction is one of the most valued structural engineering innovations developed by the composites industry. Used extensively in aerospace and many other industries, the honeycomb sandwich provides the following key benefits over conventional materials Very low weight , High stiffness ,Durability ,Production cost savings, Hexcel began developing honeycomb over 40 years ago, and now supplies a range of high performance honeycombs, film adhesives - all ideally suited to the manufacture of honeycomb sandwich constructions. Hexcel is also the leading supplier of lightweight honeycomb sandwich panels. This guide explains how to design and manufacture honeycomb sandwich panels, from materials selection and analysis of mechanical properties, through to production methods, and includes basic sample calculations for simple constructions. This paper describes the technology developments created by composite materials. [2]

Key words: - Aluminium material, Sand witch Panel, Honey Comb core.

Introduction:

Background information.

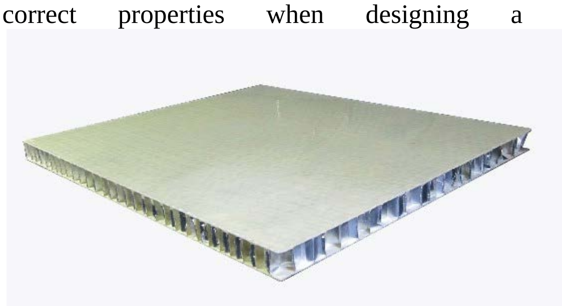
The history of aviation is long. Over time, the aviation market has evolved to be highly responsive to customer needs and hairline profits controlled by oil prices among many other factors. However, be it commercial or VIP business jets, all of those jets must have interior structures made from light weight honeycomb panel materials. These are composite materials, really light weight yet very strong. They are fire resistant, long lasting, and resistant to fatigue. They must go through rigorous structural analysis and certification procedures before they are allowed to be installed on any aircraft and flown.

There is a revolution underway in commercial aircraft manufacturing today and it can be summed up in one word: composites. There are many good reasons for aircraft manufacturers to use composites and for airlines to want composites to be used in their fleets. Many composite materials achieve relatively greater strength characteristics compared with traditional metallic materials, reducing aircraft weight and thus reducing fuel cost per passenger carried. Composites are more resistant than metal to fatigue from repeated take off/landing cycles, resulting in fewer costly inspections over the aircraft's lifespan and more time spent in the air making money. [3]

This paper includes implementation of aircraft wardrobe using honeycomb composite. In this, existing design of wardrobe used in aircraft will be taken for analysis. Comparison may be done between aluminium and honeycomb composite.

1) Aluminium Honeycomb -

Honeycomb is used extensively in composite panels to add bending stiffness with very little mass penalty. The panel face sheets carry tensile and compressive loads, and the honeycomb carries transverse stresses. In a highly loaded panel, the transverse stresses may approach the strength of the honeycomb. Thus, it is important to use the correct properties when designing a panel.



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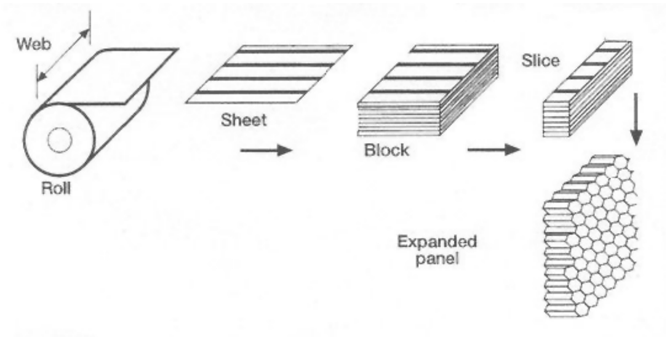
2) How Honeycomb Is Manufactured:

Honeycomb is made primarily by the expansion method .The corrugated process is most common for high density honeycomb materials.

i) Expansion Process:

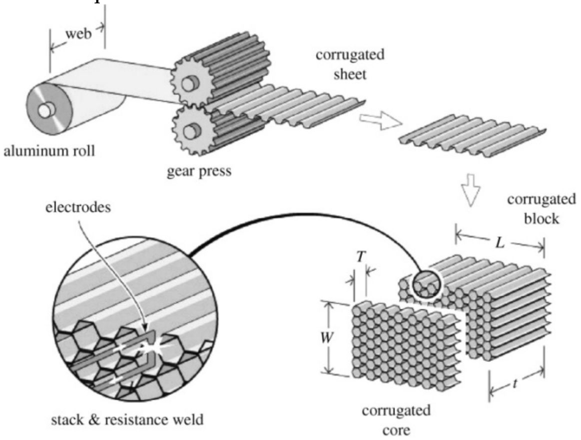
The honeycomb fabrication process by the expansion method begins with the stacking of sheets of the substrate material on which adhesive node lines have been printed. The adhesive lines are then cured to form a HOBE.(Honeycomb Before Expansion) block. The HOBE block it may be expanded after curing to give an expanded block. Slices of the expanded block may then be cut to the desired T dimension. Alternately, HOBE slices can be cut from the HOBE block to the appropriate T dimension and subsequently expanded. Slices can be expanded to regular hexagons, under expanded to 6-sided diamonds, and over expanded to nearly rectangular cells. The expanded sheets are trimmed to the desired L dimension (ribbon direction) and W dimension (transverse to the ribbon).



Expansion Process of Honeycomb Manufacture

ii) Corrugated Process:

The corrugated process of honeycomb manufacture is normally used to produce products in the higher density range. In this process adhesive is applied to the corrugated nodes, the corrugated sheets are stacked into blocks, the node adhesive cured, and sheets are cut from these blocks to the required core thickness.

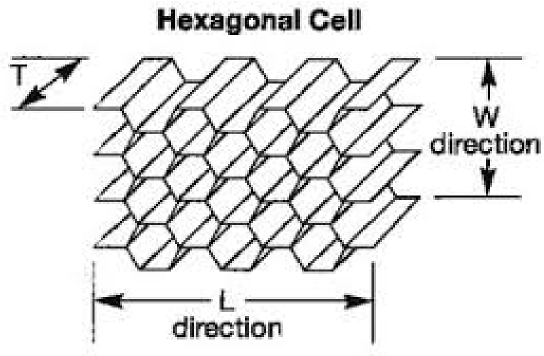


Corrugated Process of Honeycomb Manufacture

3) Honeycomb Cell Configurations:

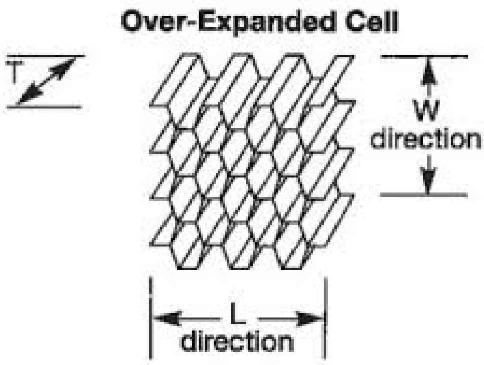
i) **Hexagonal Core**

The standard hexagonal honeycomb is the basic and most common cellular honeycomb Configuration, and is currently available in all metallic and nonmetallic materials.



ii) OX-Core™

The OX configuration is a hexagonal honeycomb that has been over expanded in the W direction, providing a rectangular cell configuration that facilitates curving or forming in the L direction. The OX process increases W shear properties and decreases L shear Properties when compared to hexagonal honeycomb.



iii) Flex-Core®

The Flex-Core cell configuration provides for exceptional formability in compound curvatures with reduced anticlastic curvature and without buckling the cell walls. Curvatures of very tight radii are easily formed. When formed into tight radii, Flex-Core provides higher shear strengths than comparable hexagonal core of equivalent

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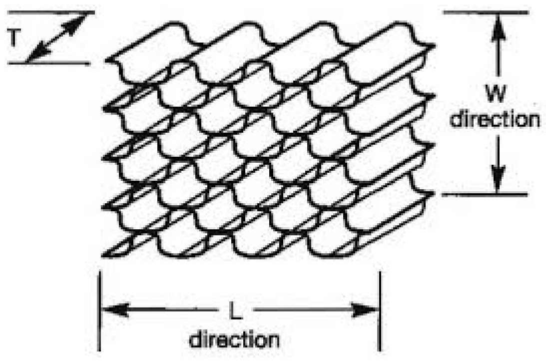
density. Flex-Core is manufactured from aluminum, Nomex, and fiberglass substrates.



4) Honeycomb Materials: Aluminum Honeycomb
Hexcel aluminum honeycombs are designated as follows:

Material – Cell Size – Alloy – Foil Thickness – Density
Example: CR III – 1/4 – 5052 – .002N – 4.3

Where:
CR III® – signifies the honeycomb is treated with a corrosion-resistant coating.
1/4 **–** is the cell size in fractions of an inch.
5052 **–** is the aluminum alloy used.
.002 – is the nominal reference foil thickness in inches.
N **–** Indicates the cell walls are non perforated (P indicates perforated).
4.3 **–** is the density in pounds per cubic foot.

i) Corrosion-Resistant Coatings:

Corrosion-resistant coatings consist of a base layer underlying a primer layer. Aluminum honeycomb is available with two different corrosion-resistant coating options. These are CR III chromate-based and CR-PAA™ phosphoric acid anodized. The corrosion resistant coating is applied to the foil before the node adhesive is placed on the foil, thereby ensuring corrosion protection over the full foil surface.

ii) CR III:
CR III corrosion-resistant coating consists of a chromate-based protective layer and an organo-metallic polymer. CR III corrosion-resistant coating has been specified by the U.S. military for almost 30 years.

iii) CR-PAA™:
CR-PAA phosphoric acid anodized coating provides superior performance in certain instances. CR-PAA is superior with regards to:
• Bond strength to aluminum facings in sandwich panel applications
• Salt spray environments
• Resistance to crack propagation
• hot/wet environments.
Aluminum honeycomb is available in four different alloys, aerospace grades 5052 and 5056, and commercial grades 3104 and 3003.

iv) 5052 Alloy:
Specification grade honeycomb in the 5052 H39 aluminum alloy is available for general purpose applications, in a very wide range of cell size/density combinations in the hexagonal and Flex-Core configurations. OX-Core and under expanded cell configuration can also be provided.

v) 5056 Alloy:
Specification grade honeycomb in the 5056 H39 aluminum alloy offers superior strength over 5052 alloy honeycomb. It is also available in a broad range of cell size/density combinations in the hexagonal and Flex-Core configurations. The strength properties of 5056 alloy honeycomb are approximately 20% greater that the comparable properties of 5052 alloy honeycomb of similar cell size, foil gauge, and density.

5) Specification of honeycomb:
When honeycomb is specified, the following information needs to be provided.

• Material
• Cell configuration (hexagonal, OX-Core, Flex-Core, etc.)
• Cell size
• Alloy and foil gauge (aluminum honeycomb only)
• Density
Cell sizes range from 1/16" to 1", with 1/8", 3/16", 1/4", and 3/8" being the most common. Honeycomb densities range from 1.0 lb/ft3 to 55 lb/ft3.

6) Guide to Determining Which Type of Honeycomb to Specify:
Determining which type of honeycomb to specify requires that the relevant possible attributes be defined for the application. The attributes that help determine the most appropriate honeycomb type can include the following:
• Cost vs. value/performance
• Piece size
• Density
• Strength
– Compressive
– Impact
– Shear
– Fatigue
– Flat wise tensile
• Cell wall thickness
• Moisture
• Color
• Ultraviolet light exposure
• Environmental chemicals

• Processing and operating temperature range
• Flammability/fire retardance
• Thermal conductivity/insulation/heat transfer
• Electrical conductivity
• Wall surface smoothness
• Abrasion resistance
• Cushioning
• Machinability/Formability
• Facings
– Material
– Bonding process, adhesive, conditions
– Thickness

7) Most Important Attributes of Each Honeycomb Material:

Each of the honeycomb materials profiled above has specific benefits that are key to its specification. In general terms, some of the most beneficial properties of each honeycomb material are as follows:

i) Aluminum Honeycomb

• Relatively low cost
• Best for energy absorption
• Greatest strength/weight
• Thinnest cell walls
• Smooth cell walls
• Conductive heat transfer
• Electrical shielding
• mach inability

ii) Aramid Fiber Honeycomb

• Flammability/fire retardance
• Large selection of cell sizes, densities, and strengths
• Formability and parts-making experience
• Insulative
• Low dielectric properties

iii) Fiberglass

• Multidimensional strength of a woven structure
• Heat formability
• Insulative
• Low dielectric properties

iv) Carbon

• Dimensional stability and retention
• Strength retention and performance at high Temperatures
• Very low coefficient of thermal expansion
• tailor able thermal conductivity
• Relatively high shear modulus

v) Polyurethane

• cushioning
• Unaffected by moisture
• Energy redirection [4]

Problem formulation:

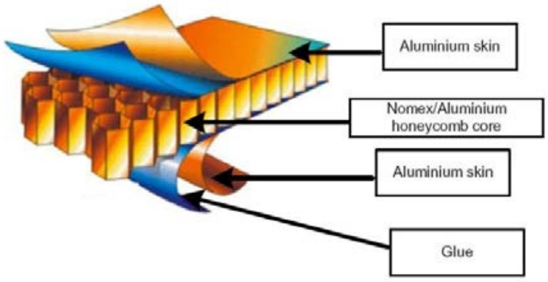
Main problem facing in this project is payload carrying capacity of the interior article which is maximum. It can be measured in term of weight to avoid this problem we can use aluminium honeycomb composite.

The history of aviation is long. Over time, the aviation market has evolved to be highly responsive to customer needs and hairline profits controlled by oil prices among many other factors. However, be it commercial or VIP business jets, all of those jets must have interior structures made from light weight honeycomb panel materials. These are composite materials, really light weight yet very strong. The basic idea was to use the Honeycomb as a shear web between two skins. At this stage the Adhesive Technology was not yet sufficiently developed to bond skins directly on to Honeycomb. The engineers, seeing the benefits of a lightweight expanded core with integral skins, carried on with the development of using end grain balsa as a core, bonded to plywood skins. This particular sandwich or bonded structure was used extensively on the Mosquito and Vampire Aircraft. The development of Epoxy Resin made possible the bonding of aluminum skins to Aluminum Honeycomb.

Literature Survey:

NEED OF HONEYCOMB STRUCTURES

Honeycomb is used extensively in composite panels to add bending stiffness with very little mass penalty. The panel face sheets carry tensile and compressive loads, and the honeycomb carries transverse stresses. In a highly loaded panel, the transverse stresses may approach the strength of the honeycomb. Thus, it is important to use the correct properties when designing a panel. There are some important properties aluminum honeycomb panel are like extremely low weight, excellent strength, High resistance to corrosion, excellent thermal conductivity, Noncombustible. Innovations in aircraft design, motor vehicle technology and light-weight construction have formed the basis for the development of honeycomb structured panels. Their decisive advantage is low weight, combined with great structural strength. Because of their anti-shock properties, honeycomb structures are today used as shock-absorbent layers both in automobile construction and in sports gear and sport shoe production. They are ideally suited for design and architectural applications as a result of their optimal ratio of weight to load-bearing capacity and bending strength. In addition this composite material, which generally consists of a honeycomb core and external facing, can be adapted to individual requirements with regard to strength and choice of materials. And not least, the aesthetic properties of these materials are being increasingly valued. From transparent to translucent, catching the eye and directing the gaze, this versatile material can be tailor-made for a variety of design purposes.



1) Mechanical properties of aluminium honeycomb:

i) Strength:
Honeycomb cores and some facing materials are directional with regard to mechanical properties and care must be taken to ensure that the materials are orientated in the panel to take the best advantage of this attribute.

ii) Stiffness:
Sandwich structures are frequently used to maximize stiffness at very low weights. Because of the relatively low shear modulus of most core materials, however, the deflection calculations must allow for shear deflection of the structure in addition to the bending deflections usually considered.

iii) Adhesive Performance:
The adhesive must rigidly attach the facings to the core material in order for loads to be transmitted from one facing to the other. Suitable adhesives include high modulus, high strength materials available as liquids, pastes or dry films. As a general rule, a low peel-strength, or relatively brittle adhesive should never be used with very light sandwich structures which may be subjected to abuse or damage in storage, handling or service.

iv) Economic Considerations:
Composite sandwich panels can provide a cost effective solution. Value analysis should include assessment of production and assembly costs; and installation costs including supporting structure.

2) Environmental Considerations:

i) Temperature:
As in any materials system the thermal environment will play an important role in the selection of materials. All systems are basically operational at Room Temperature and materials are readily available to give performance up from -55°C to 170°C. Material selection should also take account of available manufacturing facilities, especially cure temperature capability.

ii) Flammability:
Materials used in bonded sandwich construction are usually classified into three categories:

1) Non-burning - which means that the product will not burn.

2) Self-extinguishing - which means that the material will burn while held in a flame but will extinguish when the flame is removed.

3) Flammable- Flammable materials are sometimes further defined by determining the flame spread rate under specified conditions.

iii) Heat Transfer:
The transfer of heat through a sandwich panel is dependent upon the basic principles of convection, conduction and radiation. Metallic cores with metallic facings maximize heat flow characteristics.[2]

iv) Moisture/Humidity:
Some core and facing materials offer excellent resistance to degradation due to moisture and humidity.

4) Benefits of aluminium honeycomb:

i) Weight reduction – savings in the range 20% - 50% are often quoted.

ii) Mechanical properties can be tailored by 'lay-up' design, with tapering thicknesses of reinforcing cloth and cloth orientation.

iii) 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.

iv) High damage tolerance improves accident survivability.

v) 'Galvanic' - electrical – corrosion problems which would occur when two dissimilar metals are in contact (particularly in humid marine environments) are avoided. Here non-conductive fibreglass plays a roll.

Conclusion:

In this paper, existing design of wardrobe used in aircraft will be taken for analysis. Comparison may be done between aluminium and honeycomb composite. Bending test is conducted theoretically on aluminum honeycomb sandwich panel and uniform aluminum rod and it is observed that aluminum honeycomb sandwich panel has more strength to weight ratio compared to uniform aluminum rod.

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