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Implementation of Honeycomb Structure in An X-48b Supersonic Aircraft with Blended Wing Aircraft Configuration

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***Abstract*—.Aircraft structures must withstand all anticipated mission loads. It will be designed to have optimal structural weight with the required safety margins. The structural stress, deflection, strain, and margins of safety distributions are to be visualized and the design is to be improved. The elasticity, stiffness, strength and stress distribution is more in the nodes of the structure. The present application focus on the blended-wing-body vehicle structure and advanced composite material are also to be discussed.A sandwich construction, which consists of two thin facing layers separated by a thick core, offers various advantages for design of weight critical structure. Depending on the specific mission requirements of the structures, aluminium alloys, high tensile steels, titanium or composites are used as the material of facings skins. Several core shapes and material may be utilized in the construction of sandwich among them; it has been known that the aluminium honeycomb core has excellent properties with regard to weight savings and fabrication costs. The blended wing aircraft NASA X-48B will be implemented by honeycomb structure in order to achieve the highly specified advanced aircraft.**

***Index Terms*—morphed, fabric wing, optimization, loads, stress, lift force.**

I. INTRODUCTION

In this project we are going to do the static structural analysis of the blended wing aircraft wing without any spar and ribs by using of the honeycomb structure. The structure used reduce the weight and increase the strength. The wing of x-48 B NASA aircraft has modified as sandwich wing with core of hexagonal honeycomb structure the honeycomb structure used for load carrying purpose, and reduction of material used for the wing construction. By using the sandwich construction the stress will be reduced, because if will spread over the nodes and the stress will reduced. The blended wing body have less connection so that, the implementation honeycomb structure is easy in the wing construction. The blended wing shear leads and, air load, are less because of the design of the BWB Aircraft the honeycomb structure which is made for the stress with stand capacity. The structure had honeycomb structure, over the wing and it has less weight to increase the efficiency. So the passenger load and efficiency may be increased. Economically it is useful for the subsonic passenger aircraft. The boeing 797 is one of the BWB passenger, aircraft, the weight will reduced about 25% because of the reduce of material usage.

A. **Blended wing body** (BWB or Hybrid Wing Body, HWB) craft have no clear dividing line between the wings and the main body of the craft. The body form is composed of distinct and separate wing structures, though the wings are smoothly blended into the body, unlike a flying wing which has no distinct fuselage. Many BWB craft have a flattened and airfoil shaped body, which produces most of the lift, the wings contributing the balance.

The purported advantages of the BWB approach are efficient high-lift wings and a wide airfoil-shaped body. This enables the entire craft to contribute to lift generation with the result of potentially increased fuel efficiency and range. A blended wing body can have lift-to-drag ratio 50% greater than a conventional craft.

B. **NASA BWB Research** NASA is studying the flying characteristics of the BWB. Because it is a configuration that has only been used in military missions, there are a number of critical questions that researchers must address before a BWB can be commercially certified. The primary goals of the research are to study the flight and handling characteristics of the BWB design, match the vehicle's performance with engineering predictions based on computer and wind tunnel studies, develop and evaluate digital flight controls, and assess the integration of the propulsion system to the airframe Over the past several years, wind tunnel and free flight model tests have been conducted to study particular aerodynamic characteristics of the BWB design. At the NASA Langley Research Center in Hampton, Virginia, researchers tested five wind tunnel models of three versions of the BWB to evaluate the concept's aerodynamic, noise, stability and control, and spin and tumble characteristics. Data obtained during these tests were used to develop computer performance models and flight control laws. The researchers will incorporate all wind tunnel (and later flight) data into simulations of a full-scale BWB to evaluate the flying characteristics.

C. HONEYCOMB STRUCTURE:

Natural honeycomb structures include beehives, honeycomb weathering in rocks, tripe, and bone. Man-made honeycomb structures include sandwich-structured composites with honeycomb cores. Man-made honeycomb structures are manufactured by using a variety of different materials, depending on the intended application and required characteristics, from paper or thermoplastics, used for low strength and stiffness for low load applications, to high strength and stiffness for high performance applications, from aluminium or fibre reinforced plastics.

The strength of laminated or sandwich panels depends on the size of the panel, facing material used and the number or density of the honeycomb cells within it. Honeycomb composites are used widely in many industries, from aerospace industries, automotive and furniture to packaging and logistics. The material takes its name from its visual resemblance to a bee's honeycomb – a hexagonal sheet structure.

Honeycomb structures are natural or man-made structures that have the geometry of a honeycomb to allow the minimization of the amount of used material to reach minimal weight and minimal material cost. The geometry of honeycomb structures can vary widely but the common feature of all such structures is an array of hollow cells formed between thin vertical walls.

D. SANDWICH HONEYCOMB STRUCTURE:

The facing skins of a sandwich panel can be compared to the flanges of an I-beam, as they carry the bending stresses to which the beam is subjected. With one facing skin in compression, the other is in tension. Similarly the honeycomb core corresponds to the web of the I-beam.

The core resists the shear loads, increases the stiffness of the structure by holding the facing skins apart, and improving on the I-beam, it gives continuous support to the flanges or facing skins to produce a uniformly stiffened panel. The core-to-skin adhesive rigidly joins the sandwich components and allows them to act as one unit with a high torsional and bending rigidity.The honeycomb is structurally effective and ensures that the fire-resistant material is not only lighter but has both greater durability and load-bearing strength than conventional glass. Standard tile size: 600 x 600 mm. Surfaces can be either sandblasted or made non-slip using clear anti-slip strips or plastic bubbles.

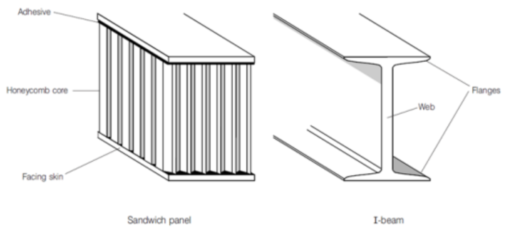

Figure 1.1 *Sandwich Panel constructions*

E. *SANDWICH MATERIALS PROPERTIES*:

- High load bearing capacity at low weight.
- Surface finished faceplates provide good resistance against aggressive environments.
- Excellent thermal insulation.
- Long life at low maintenance cost.
- Good water and vapor barrier.
- Excellent acoustic damping properties.
- Creep under sustained load with rigid foam cores
- Low thermal capacity
- Poor fire resistance with rigid plastic foam cores.
- Deformation when one side of faceplate is exposed to intense heat

F. TITANIUM ALLOY:

Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures). They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. However, the high cost of both raw materials and processing limit their use to military applications, aircraft, spacecraft, medical devices, highly stressed components such as connecting rods on expensive sports cars and some premium sports equipment and consumer electronics.

Although "commercially pure" titanium has acceptable mechanical properties and has been used for orthopedic and dental implants, for most applications titanium is alloyed with small amounts of aluminium and vanadium, typically 6% and 4% respectively, by weight. This mixture has a solid solubility which varies dramatically with temperature, allowing it to undergo precipitation strengthening. This heat treatment process is carried out after the alloy has been worked into its final shape but before it is put to use, allowing much easier fabrication of a high-strength product.

The crystal structure of titanium at ambient temperature and pressure is close-packed hexagonal α phase with a c/a ratio of 1.587. At about 890°C, the titanium undergoes an *allotropic transformation to a body-centred cubic β phase which remains stable to the melting temperature.*

II. Carbon Fiber Reinforced Polymer

The Carbon-fiber-reinforced polymer, carbon-fiber reinforced plastic or carbon-fiber reinforced thermoplastic (CFRP, CRP, CFRTP or often simply carbon fiber, or even carbon), is an extremely strong and light fiber reinforced polymer which contains carbon fibers. The binding polymer is often a thermoset resin such as epoxy, but other thermoset or thermoplastic polymers, such as polyester, vinyl ester or nylon, are sometimes used. The composite may contain other fibers, such as aramid e.g. Kevlar, Twaron, aluminium, or glass fibers, as well as carbon fiber. The properties of the final CFRP product can also be affected by the type of additives introduced to the binding matrix (the resin) [4]. The most frequent additive is silica, but other additives such as rubber and carbon nanotubes can be used. CFRPs are commonly used in the transportation industry; normally in cars, boats and trains, and in sporting goods industry for manufacture of bicycles, bicycle components, golfing equipment and fishing rods. Although carbon fiber can be relatively expensive, it has many applications in aerospace and automotive fields, such as Formula One racing[5]. The compound is also used in sailboats, rowing shells, modern bicycles, and motorcycles because of its high strength-to-weight ratio and very good rigidity. Improved manufacturing techniques are reducing the costs and time to manufacture, making it increasingly common in small consumer goods as well, such as certain Think Pads since the 600 series, tripods, fishing rods, hockey sticks, paintball equipment, archery equipment, tent poles, racquet frames, stringed instrument bodies, drum shells, golf clubs, helmets used as a paragliding accessory and pool/billiards/snooker cues [6]. The material is also referred to as graphite-reinforced polymer or graphite fiber-reinforced polymer (GFRP is less common, as it clashes with glass-(fiber) - reinforced polymer). In product advertisements, it is sometimes referred to simply as graphite fiber for short.

III. Composite Wing Spars

Composite wing spars for large aircraft are, for all intents and purposes, new technology, having been used only twice in the past in notable but limited aircraft programs. The first instance was on Howard Hughes' plywood-airframe H-4 Hercules Flying Boat, better known as the Spruce Goose (a composite of thin wood layers and plastic resin), which was prototyped for the U.S. military during WWII, flown once, but never placed into production. The other was the B2 Spirit stealth bomber, of which only 21 were built and placed into service for the U.S. Air Force beginning in 1993. GKN Aerospace (Cowes, Isle of Wight, U.K.) recently joined this select group as it completed the design and built the first composite components for the ~18.3m/60-ft main wing spars on Toulouse, France-based aircraft manufacturer Airbus Industries' A400M military transport aircraft [7]. The A400M was conceived as a larger-sized replacement for aging C- 130 Hercules and C-160 Transail military transport fleets maintained in Europe. Airbus has, thus far, fielded 192 orders for the airlifter, which is scheduled for first flight in mid-2007, with entry into service in 2009. "Softfield" capable, the A400M is designed to take off and land on short (<1,150m/3,773 ft), unpaved runways powered by four of the Western world's most powerful turboprop engines. Each of the A400M spars must carry all the normal flight loads for the aircraft and highly concentrated loads from the two flaps, ailerons and four spoilers [8]. The front spars, however must carry the engine loads like major design driver in wing spar development. The engines drive the aircraft through the propellers by means of torque, which is reacted at the attachment points on the front spar. Each engine produces over 7,500 kW or 10,000 shp (shaft horsepower) to drive eight composite propellers per engine through a speed reduction gearbox. Each of the four sets of eight propellers, made by Ratier-Figeac (Figeac, France), weighs about 250 kg/550 lb 1 metric ton per aircraft. The propellers, rotating at 850 rpm at take-off power, develop over 8,700 Nm (6,500 lb-ft) of torque. This torque is taken through the fittings bolted to the front spars. In general, spar web thicknesses are about 5 mm to 6 mm (about 0.2 inches) near the engine attachment points, but at the point of attachment of the engine mounting structure, the thickness of both the web and the caps is doubled to about 10 mm/0.4 inch. Similar increases in thickness occur in the vicinity of the root end where the spar is attached to the wing box. These local changes in thickness created a significant design challenge for both the structural and manufacturing engineers on the A400M program.

IV. Application Of Carbon Epoxy In Aerospace Engineering

The Airbus A350 is built of 53% CFRP including wing and fuselage components, the Boeing 787 Dreamliner, 50%. Specialist aircraft designer and manufacturer Scaled Composites have made extensive use of CFRP throughout their design range including the first private spacecraft Spaceship One. CFRP is widely used in micro air vehicles (MAVs) because of its high strength to weight ratio. In the MAVSTAR Project, CFRP reduces the weight of the MAV significantly and the high stiffness of the CFRP blades overcomes the problem of collision between blades under strong wind. Concrete is the most common artificial composite material of all and typically consists of loose stones (aggregate) held with a matrix of cement.

Concrete is a very robust material, much more robust than cement, and will not compress or shatter even under quite a large compressive force. However, concrete cannot survive tensile loading (i.e. if stretched it will quickly break apart). Therefore to give concrete the ability to resist being stretched, steel bars, which can resist high stretching forces, are often added to concrete to form reinforced concrete.

Fibre-reinforced polymers or FRPs include carbon-fibre reinforced plastic or CFRP, and glass-reinforced plastic or GRP. If classified by matrix then there are thermoplastic composites, short fibre thermoplastics, long fibre thermoplastics or long fibre-reinforced thermoplastics. There are numerous thermoset composites, but advanced systems usually incorporate aramid fibre and carbon fibre in an epoxy resin matrix.

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Shape memory polymer composites are high-performance composites, formulated using fibre or fabric reinforcement and shape memory polymer resin as the matrix. Since a shape memory polymer resin is used as the matrix, these composites have the ability to be easily manipulated into various configurations when they are heated above their activation temperatures and will exhibit high strength and stiffness at lower temperatures. They can also be reheated and
reshaped repeatedly without losing their material properties. These composites are ideal for applications such as lightweight, rigid, deployable structures; rapid manufacturing; and dynamic reinforcement [9]. Composites can also use metal fibres reinforcing other metals, as in metal matrix composite (MMC) or ceramic matrix (CMC), which includes bone (hydroxyapatite reinforced with collagen fibres), cermet (ceramic and metal) and concrete. Ceramic matrix composites are built primarily for fracture toughness, not for strength. Organic matrix/ceramic aggregate composites include asphalt concrete, mastic asphalt, mastic roller hybrid, dental composite, syntactic foam and mother of pearl.

Chobham armour is a special type of composite armour used in military applications. Additionally, thermoplastic composite materials can be formulated with specific metal powders resulting in materials with a density range from 2 g/cm³ to 11 g/cm³ (same density as lead). The most common name for this type of material is "high gravity compound" (HGC), although "lead replacement" is also used. These materials can be used in place of traditional materials such as aluminium, stainless steel, brass, bronze, copper, lead, and even tungsten in weighting, balancing (for example, modifying the centre of gravity of a tennis racquet), vibration damping, and radiation shielding applications. High density composites are an economically viable option when certain materials are deemed hazardous and are banned (such as lead) or when secondary operations cost (such as machining, finishing, or coating) are a factor.

VI. Resins

Typically, most common polymer-based composite materials, including fiberglass, carbon fiber, and Kevlar, include at least two parts, the substrate and the resin.

Polyester resin tends to have yellowish tint, and is suitable for most backyard projects. Its weaknesses are that it is UV sensitive and can tend to degrade over time, and thus generally is also coated to help preserve it [10]. It is often used in the making of surfboards and for marine applications. Its hardener is peroxide, often MEKP (methyl ethyl ketone peroxide). When the peroxide is mixed with the resin, it decomposes to generate free radicals, which initiate the curing reaction. Hardeners in these systems are commonly called catalysts, but since they do not re-appear unchanged at the end of the reaction, they do not fit the strictest chemical definition of a catalyst.

Vinyl ester resin tends to have a purplish to bluish to greenish tint. This resin has lower viscosity than polyester resin, and is more transparent. This resin is often billed as being fuel resistant, but will melt in contact with gasoline. This resin tends to be more resistant over time to degradation than polyester resin, and is more flexible. It uses the same hardeners as polyester resin (at a similar mix ratio) and the cost is approximately the same. Epoxy resin is almost totally transparent when cured. In the aerospace industry, epoxy is used as a structural matrix material or as structural glue [11].

Shape memory polymer (SMP) resins have varying visual characteristics depending on their formulation. These resins may be epoxy-based, which can be used for auto body and outdoor equipment repairs; cyanate-ester-based, which are used in space applications; and acrylate-based, which can be used in very cold temperature applications, such as for sensors that indicate whether perishable goods have warmed above a certain maximum temperature. These resins are unique in that their shape can be repeatedly changed by heating above their glass transition temperature (Tg). When heated, they become flexible and elastic, allowing for easy configuration. Once they are cooled, they will maintain their new shape. The resins will return to their original shapes when they are reheated above their Tg. The advantage of shape memory polymer resins is that they can be shaped and reshaped repeatedly without losing their material properties. These resins can be used in fabricating shape memory composites.

Epoxy is the cured end product of epoxy resins, as well as a colloquial name for the epoxide functional group [12]. Epoxy resins, also known as polyepoxides are a class of reactive prepolymers and polymers which contain epoxide groups.

VII. Modeling of the Wing

Blended wing body (BWB) business jet is a new concept of business jet aircraft which give an alternative solution to solve the fuel efficiency problem of long range of an aircraft, it means aircraft must have higher velocity to cut the time deficiency, and it means more fuel to burn up and more cost to pay and design with honey comb structure to increase the structural strength with reducing the weight of the aircraft

The sandwich panel has drawn over than surface of the wing structure, by the CATIA profile drawn with in the surface, the profile in the shape of hexagon and its extrude upto 2mm, and the hexagonal honeycomb structure covered by the surface.

The surface has modified into part body because the surface body cannot taken into the ANSYS workbench. This is the whole blended wing aircraft’s wing for the analysis.

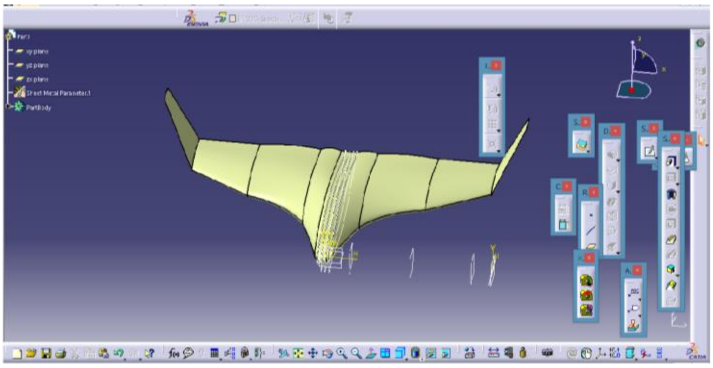

FIGURE 7.1 WING STRUCTURE

For the modeling purpose and in order to get the accurate results when importing to the analysis part, the structural part of wing is divided into solid and surface sections [10]. Modeling of the wing normally is done using CAD packages which can be easily ported to the analysis packages.

VIII. *ANALYSIS OF THE WING BOX*

The software used for the analysis of wing structure of transport class aircraft with spar and ribs is ANSYS V12.The ANSYS program is capable of analyzing problems in a wide range of engineering disciplines. However, this project focuses only on the following disciplines of analysis.

Static Structural Analysis **TABLE 1** Material Properties Of titanium Alloy

Tensile Strength, Ultimate	950 MPa	138000 psi
Tensile Strength, Yield	880 MPa	128000 psi
Elongation at Break		
Reduction of Area	36 %	36 %
Modulus of Elasticity	113.8 GPa	16500 ksi
Compressive Yield Strength		
Notched Tensile Strength	1450 MPa	210000 psi
Ultimate Bearing Strength	1860 MPa	270000 psi

A. Meshing and applying Boundary Conditions

V. The wing small section which is going to use for the analysis in workbench the closed wing has developed with in the part body then it over with surface body, the honeycomb hexagonal structure used for withstand the maximum stress.

In the FEM analysis of high pressure turbine rotor blade meshing is the initial step that is to be followed after the model is being imported for the purpose of analysis. Meshing is the process that divides the model into finite number of elements for the analysis .In general, a large number of elements provide a better approximation of the solution. However, in some cases, an excessive number of elements may increase the round-off error. Therefore, it is important that the mesh is adequately fine or coarse in the appropriate regions. An analysis with an initial mesh is performed first and then reanalyzed by using twice as many elements. The two solutions are compared. If the results are close to each other, the initial mesh configuration is considered to be adequate.If there are substantial differences between the two, the analysis should continue with a more-refined mesh and a subsequent comparison until convergence is established.

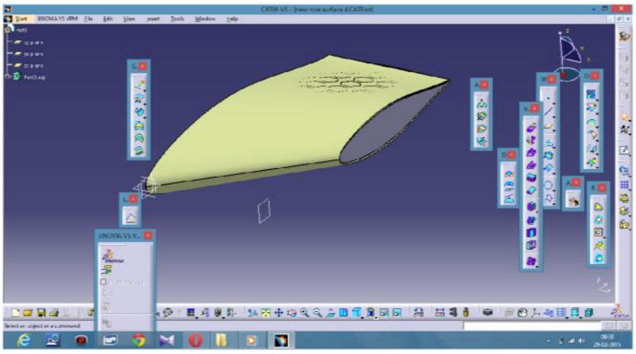

FIGURE 8.1 MESHED MODEL OF WING STRUCTURE

After meshing the structural part of the wing, the wing is fixed at one end and other end is free. The force is applied on the top layer of the wing as shown in the Fig IV.

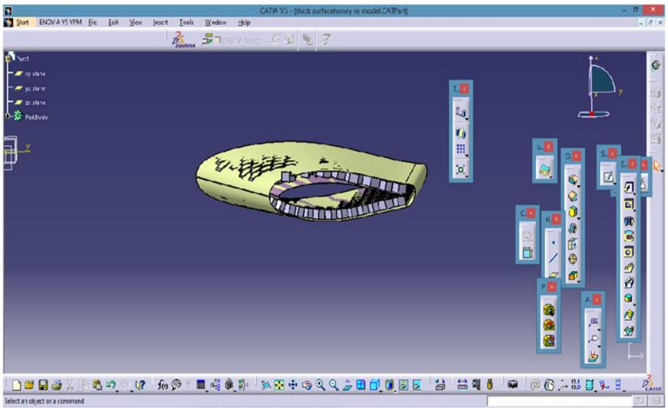

FIGURE 8.2 SUPPORT AND LOADING CONDITIONS

The wing box is now allowed to analysis process in ANSYS 12 and the data is to be present as a result with the difference of Aluminium alloy and Carbon Epoxy. Further the strength of the wing box is to be identified. Because the material property of both material are different.

IX. *RESULTS AND DISCUSSION*

A. titanium alloy

The three solutions for the aircraft wing section. In which each analysis should be carrying the three loads. The name of the three analysis are given below

- Equivalent Stress (Von Misses Stress)
- Total Deformation

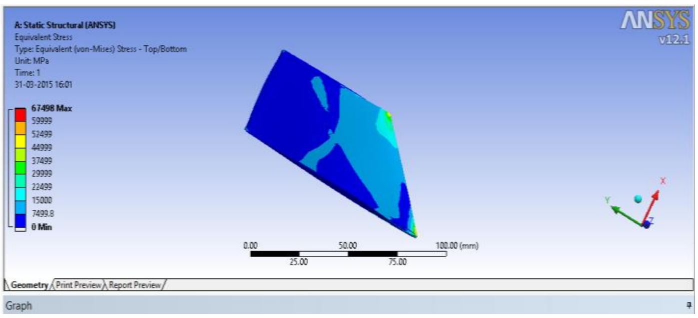

FIGURE 9.1 EQUIVALENT STRESS OF THE WING BOX

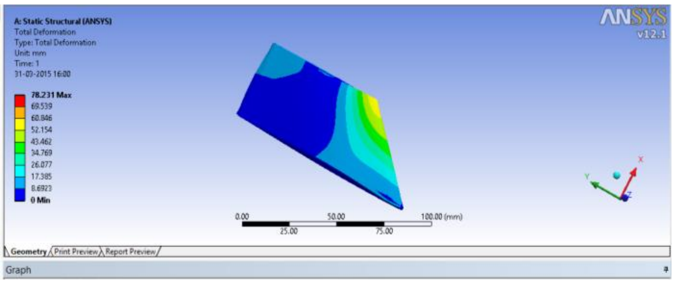

FIGURE 9.2 TOTAL DEFORMATION OF THE WING BOX

B. Carbon Epoxy

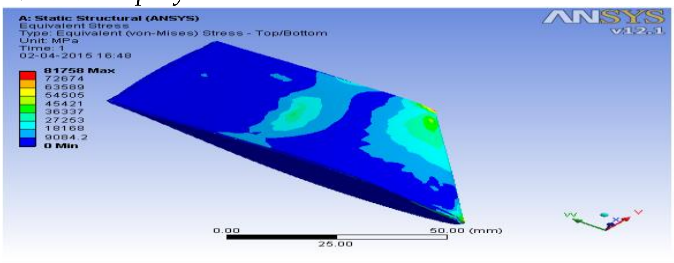

FIGURE **9.3** TOTAL DEFORMATION OF THE WING BOX

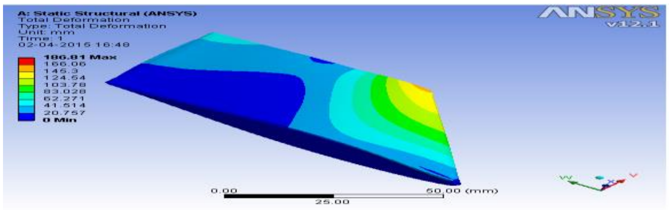

FIGURE 9.4 EQUIVALENT STRESS OF THE WING BOX

C. ALUMINIM ALLOY

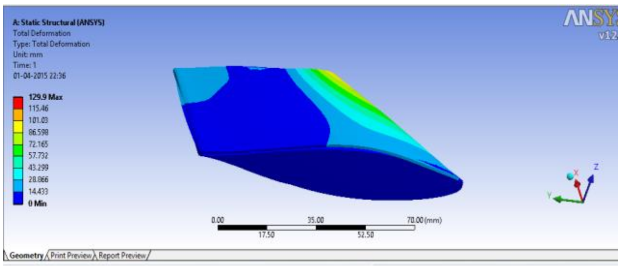

Figure 9.5 Deformation of the Of The Wing Box

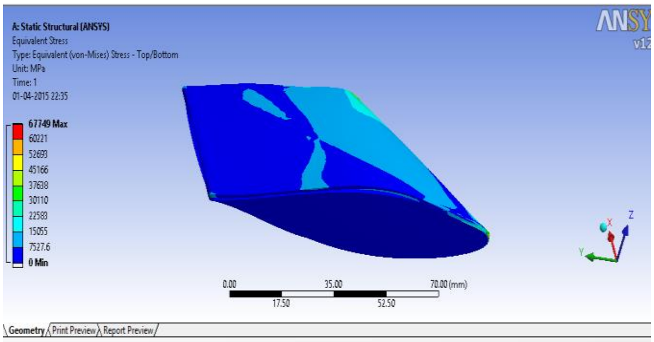

FIGURE 9.6 EQUIVALENT STRESS OF THE WING BOX

TABLE 2: Table of Comparison

Titanium alloy		
Minimum	0. mm	0. MPa
Maximum	78.231 mm	67498 MPa
Minimum Occurs On	Part 1	Part 2
Density	4.67e-006 kg mm^-3	

Aluminium alloy		
Minimum	0. mm	0. MPa
Maximum	146.65 mm	76488 MPa
Minimum Occurs On	Part 1	Part 2
Density	2.77e-006 kg mm^-3	

Carbon fibre		
Minimum	0. mm	0. MPa
Maximum	186.81 mm	81758 MPa
Minimum Occurs On	Part 1	Part 2

From this analysis we proved that the Composite material can carry more load as compare to the Aluminium Alloy.

X. CONCLUSION

In the structural analysis of the wing we can conclude that the titanium alloy has maximum stress withstand capacity and it will reduce the deformation of the wing for the blended wing aircraft with honey comb structure titanium alloy is the best one

XI. FUTURE WORK

In this paper we have implement Sandwich panel with core of honeycomb structure in the blended wing aircraft which is used to reduced the total aircraft weight so the passenger weight can be increase. The research has been doing by NASA to make 1000 passengers high speed aircraft with lowest economical level.

- In the future instead of honeycomb structure using the CELPACT technology for reducing material usage.

- By using the CELPACT technology the structural performance, strength to weight ratio, fatigue resistance, damage tolerance and crash worthiness to be improved.
- CELPACT will develop new manufacturing techniques for both composite hybrid and metal cellular materials and structures.
- New advanced manufacturing process will be developed and refined for cellular metal structures using selected laser melting technology, and for continuous fabrication of folded hybrid composite core structures.

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