OPTIMIZATION OF A BLENDED WING BODY AIRCRAFT MATERIAL USING ANSYS

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Abstract - *The main aim of this project work is to improve the efficiency and performance of a blended wing body aircraft model. Generally aircraft wing structures are designed by pure aluminum and other suitable composites such as Carbon fiber reinforced polymer (CRFP), Glass fiber reinforced polymer (GRFP) etc, but in this project a new hybrid composite is developed by introducing a natural fiber such as SISAL. The wing is designed in solid modeling software CATIA V5 and analysis is done using finite element method by using ANSYS. Static and Structural analysis of the wing is done to find out the max stress, max strain and max deformation rate acting on the aircraft model with each combination of materials. Optimum design is found by tabulating the graph obtained for each case. By comparing the results it is found that the combination of carbon fiber with natural composite offers more flexural strength and mechanical properties.*

Key Words: Finite element analysis, Aircraft wing, CFRP, GFRP, SISAL

1. INTRODUCTION

The design of an aircraft wing requires attention to several unique structural demands. High strength and light weight are the two primary functional requirements to be considered in selecting materials for the construction of aircraft wing. Traditionally aero planes have been made out of metal like alloys of aluminum. Now a days the composites have been replaced the traditional metals, to make an aircraft lighter with added benefits of less maintenance, super fatigue resistance and high fuel efficiency. Composite materials offer higher strength to weight ratio and stiffness-to-weight ratio than metals. In order to study the structural behavior of a wing the linear static analysis is carried out on an aircraft wing and the stresses, strain and total deformation rate are analyzed. In order to improve the t properties of these fiber reinforced components, a method was proposed to mix with another natural fiber called sisal to develop a hybrid composite.

1.1 NACA Nomenclature

Most of the NACA airfoils are classified as : the four-digit, the five-digit, and the series 6 sections. The meanings of these designations are illustrated by the examples below.

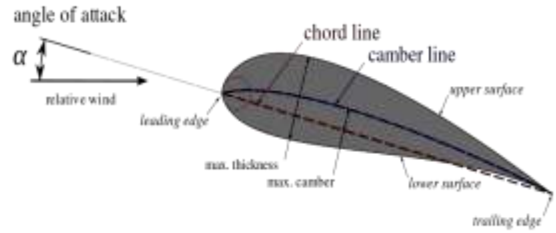

Fig 1.1: Air craft wing

1.2 Wings

A wing is a type of fin that produces aerodynamic force for flight or propulsion through the atmosphere, or through another gaseous or liquid fluid. BWB is a different form of aircraft design consist of no clear dividing line between the wings and the main body of the aircraft. BWB is known as Blended Wing Body or Hybrid wing body aircraft. The main advantages of the BWB approach are efficient high-lift wings and a wide airfoil-shaped body. This enables the entire craft to generate lift, potentially reducing the size and drag of the wings. A BWB can have a lift-to-drag ratio significantly greater than a conventional craft. Offering improved fuel economy.

Wing Construction & Mathematics

- Aspect Ratio: It is the ratio of the wing's length to its chord line.
- Camber: The name given to the curvature of the upper or lower surfaces of the wing.
- Chord Line: The theoretical line running from the leading edge of the wing to the trailing edge.
- Leading Edge: It is the front edge of an aircraft's wing.
- Trailing Edge: It is the rear edge of an aircraft's wing.

1.3 Materials used in the design of aircraft

While designing an aircraft it has to meet specific requirements which influence the complexity of its structure and the materials used in its construction. Combination of materials can be used in the design of the aircraft to achieve properties such as strength elasticity, specific weight and corrosion resistance. Variety of materials can be used in the design of specific parts of the aircraft, as a function of the initial requirements of the strength-to-weight ratio and the preferential directions of the applied loads.

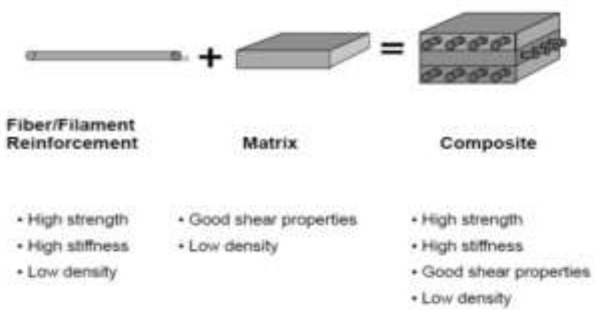

Fig 1.2 : Composite

CFRP

CFRP is known as Carbon-fiber-reinforced plastic composite. Basically composite consists of two parts: a matrix phase and a reinforcement phase. In CFRP, the reinforcement phase is carbon fiber, which provides the strength to the structure. The matrix phase is a polymer resin, such as epoxy etc, to bind the reinforcements together. It is highly strong and also known as light fiber-reinforced plastic. A super strong material that's also extremely lightweight. It's five times stronger than steel, Two times stiffer, and about Two-Third times less in weight.

GFRP

GFRP is known as Glass-fiber-reinforced plastic composite. GFRP composite material made of a polymer reinforced with fibers. Consists of thermo setting resins and glass fiber.High Strength, Lightweight, Design flexibility, Low maintenance, Durability. GFRP is a composite material made of a polymer reinforced with fibers. The fibers are usually glass, carbon, aramid although other fibers such as paper or wood have been sometimes used. These composites are mainly used in the aerospace, automotive, marine, and construction industries.

SISAL

Sisal is a natural fiber obtained from the outer leaf skin, by removing the inner pulp. The main properties of this fiber are Anti static, it does not attract or trap dust particles and does not absorb moisture or water easily. Sisal fibers are obtained from the outer leaf skin by removing the inner pulp. It exhibits good sound and impact absorbing properties. Exceptionally durable with low maintenance. It is recyclable. It exhibits good sound and impact absorbing properties. Sisal Fiber is highly durable with a low maintenance with minimal wear and tear. While treating the leaves of sisal with natural borax to attain fire resistance properties.

2. LITERATURE REVIEW

Optimization of aircraft wing with composite material

The main objective of this paper is to create an accurate model for optimal design through design the structure of wing that combine the composite (Skins) and isotropic materials. And then compare this with the same wing made by changing the orientation of composite ply orientation in skin. The best design for each wing with different ply orientation can be obtained by comparing stress and displacement. The best design is found by tabulating stress and displacement for each ply combination.

Finite element analysis of aircraft wing using CFRP and GFRP composite

The objective of this paper is to analyze the wing of an aircraft which consists of Carbon fiber reinforced polymer (CRFP), Glass fiber reinforced polymer (GRFP) and compare with Al alloy to find suitable material for wing. The wing is designed in solid modeling software CATIA V5 R20 and analysis is done using finite element method by using ANSYS. Static structural analysis of the wing is done to find deformation, stress, and strain induced in the wing structure. Model analysis is done to find the natural frequency of the wing to reduce the noise and avoid vibration. Then fatigue life analysis is carried out to find out the damage, life and factor of safety of the wing due to applied pressure loads. In this study, the trainer aircraft wing structure with skin, 2 spars and 15 ribs is considered for the analysis. The ribs consist of running from leading edge to trailing edge and 2 spars running longitudinally along the length of wing.

3. PROBLEM DESCRIPTION

From the above journals the research problem has been identified and we must want to think about the solution to overcome this problem. While designing of an aircraft wing. The design engineer has a prominent role during each design stages. In earlier the aircraft body is made by metals such as Aluminum, Steel, and Titanium. Now the modern aircraft structure is basically made by CFRP and GFRP composites. But carbon fibers can cause corrosion when CFRP parts are attached to Aluminum. And CFRP cause environmental degradation such as moisture absorption, exposure etc. To overcome this problem CFRP are mixed with another suitable natural composite.

The methodology followed in this project

1. Design the structure of wing that combines the composite materials like GFRP, CFRP and other suitable materials.
2. Structural modeling is completed with the help of CATIA, each component modeled separately and assembled using Assembly workbench of CATIA
3. This assembly is then converted to IGS file. Finite element modeling is completed using the IGS file as geometry, the

element type used for meshing is 2D shell elements with QUAD4 element topology and different parts are connected

4. Static and flow analysis will be carried out using ANSYS software.
5. With the ANSYS identify the best materials for aircraft wing and further it is simulated to identify the best geometrical design for aircraft wing.
6. Compare this with the same wing with existing materials. The optimum design for each wing with different design changes can be obtained by comparing stress and displacement.

4. INTRODUCTION TO CAD/CAE:

CAD is technology used with the help of computer for the process of design and design-documentation. CAD is called computer aided design and CAE is called computer aided engineering.

FINITE ELEMENT METHOD

FEM is known as Finite Element Method. While it is used for analyzing a particular component hence it is also called as Finite Element Analysis (FEA). Finite Element Method is a basic analysis technique for resolving and substituting complicated problems by simpler ones, obtaining approximate solutions Finite element method being a flexible tool is used in various situations to solve several practical engineering problems. Finite element method is feasible to generate the relative results with appropriate conclusions.

5. MODELING OF THE WING

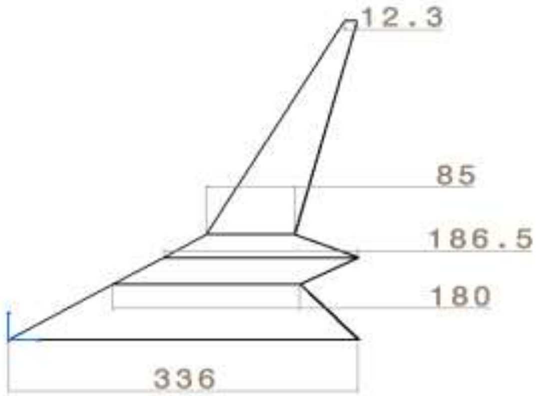

Fig 5.1 : 2d model of wing

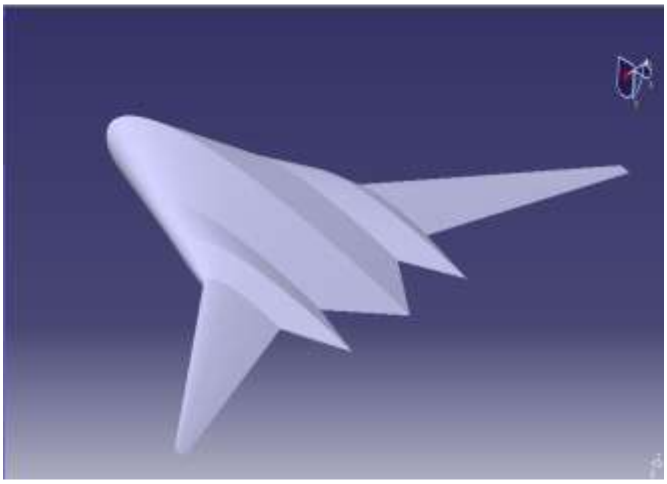

Fig 5.2 : Full model

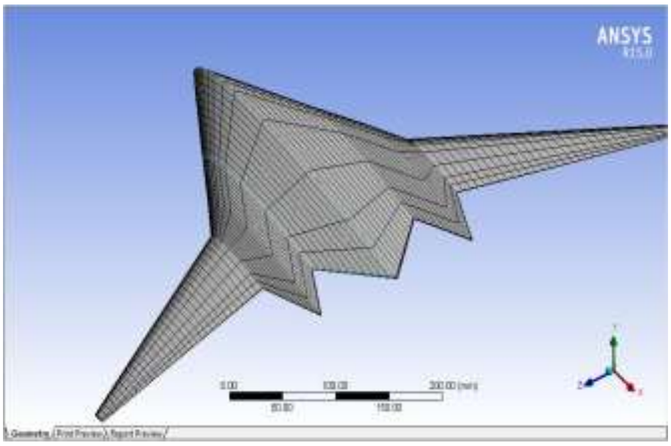

Fig 5.3 : Meshed model

6. RESULTS AND DISCUSSIONS:

- Models of aircraft wing using ribs and spars done in CATIA V5.
- Open work bench in ANSYS 14.5
- Click static structural > select geometry > import IGES model > OK
- Click on model > select EDIT > apply materials to all the objects (different materials also)
- Mesh > generate mesh > ok

6.1 CFRP

Stress

Insert > stress > equivalent (von misses) > right click on equivalent > select evaluate all results. Speed – 400km/hr, In CFRP the maximum stress is obtained as 3.2735 Mpa

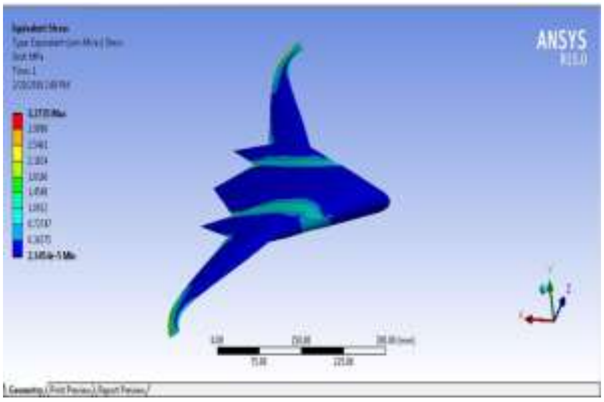

Fig 6.1.1 : Stress on CFRP

Strain

Firstly insert > strain > equivalent (von misses) > right click on equivalent > select evaluate all results. Speed – 400km/hr, In CFRP the maximum strain is obtained as 2.6668e-5 mm/mm

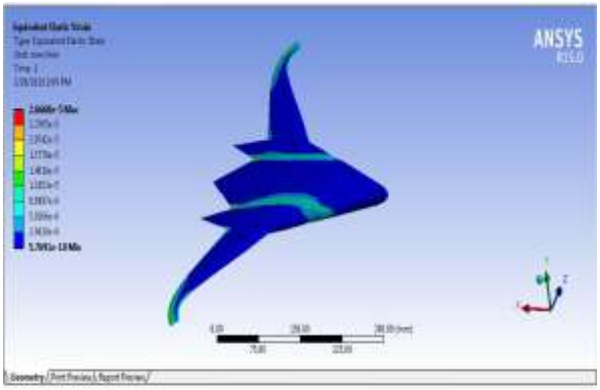

Fig 6.1.2 Strain on CFRP

Total deformation

Speed – 400km/hr

In CFRP the maximum deformation rate is 0.0025525 mm

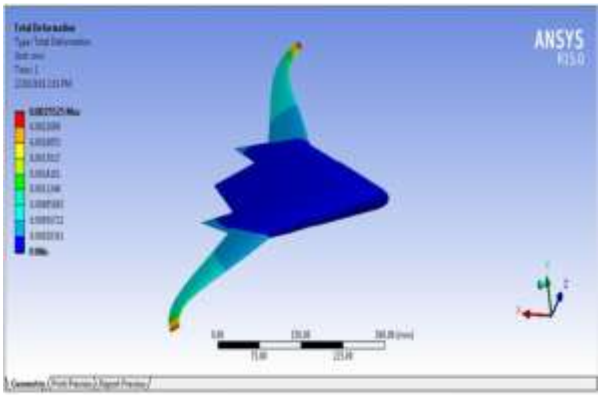

Fig 6.1.3 : Total deformation on CFRP

6.2 GFRP

Speed – 400km/hr

In GFRP the maximum stress is obtained as 3.8021 Mpa

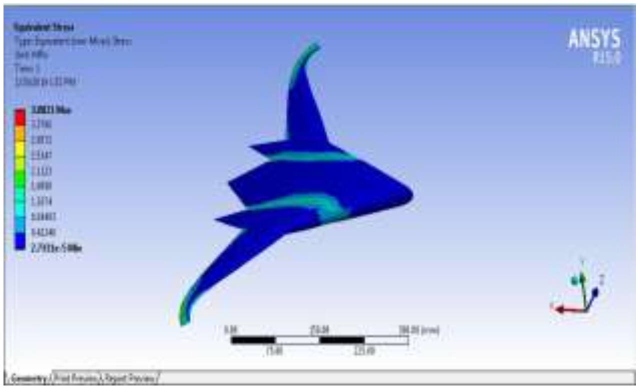

Fig 6.2.1 : Stress on GFRP

Speed- 400km/hr

In GFRP the maximum strain is obtained as 0.00030504 mm/mm

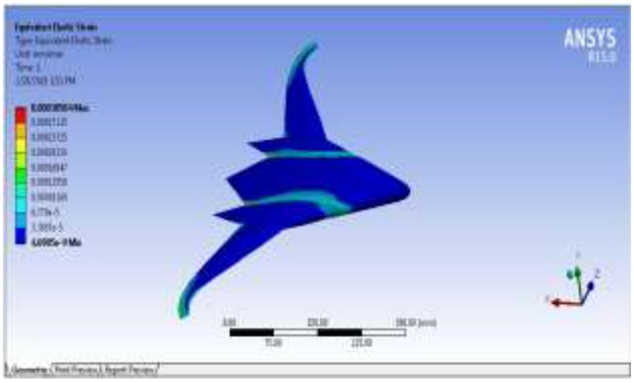

Fig 6.2.2: Strain on GFRP

Speed- 400km/hr

In GFRP the maximum deformation rate is 0.026143 mm

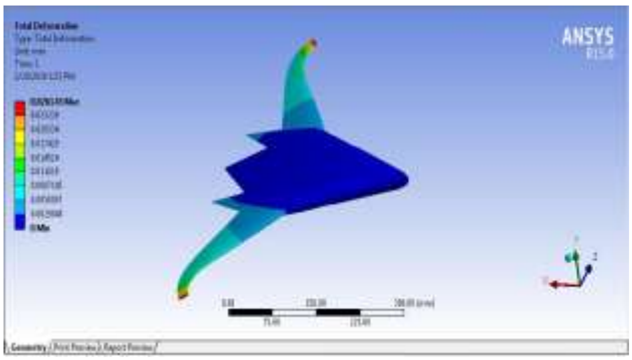

Fig 6.2.3 : Total deformation on GFRP

6.3 GFRP+CFRP

Speed – 400km/hr

In GFRP+CFRP the maximum stress is obtained as 3.539 Mpa

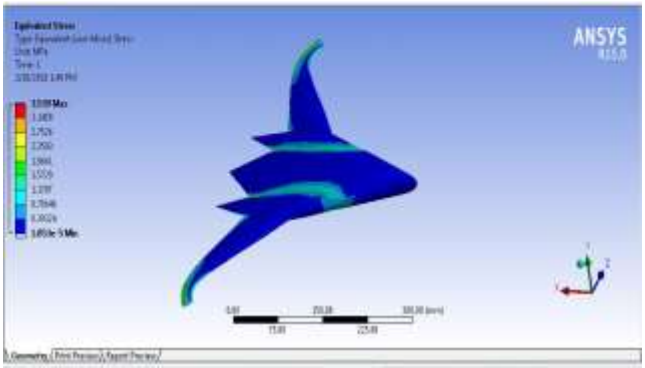

Fig 6.3.1 : Stress on GFRP+CFRP

Speed – 400km/hr

In GFRP+CFRP the maximum strain is obtained as 5.1972e-5 mm/mm

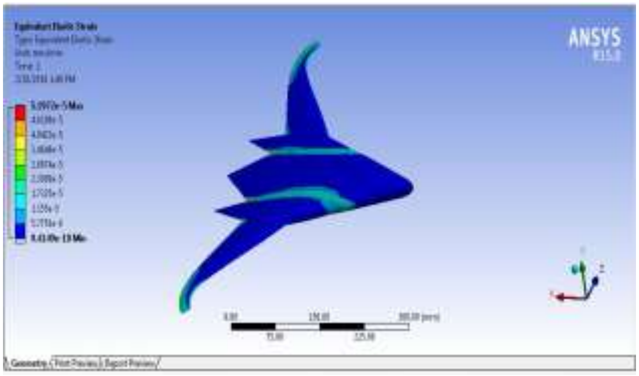

Fig 6.3.2 : Strain on GFRP+CFRP

Speed – 400km/hr

In CFRP+GFRP the maximum deformation rate is 0.0046963 mm

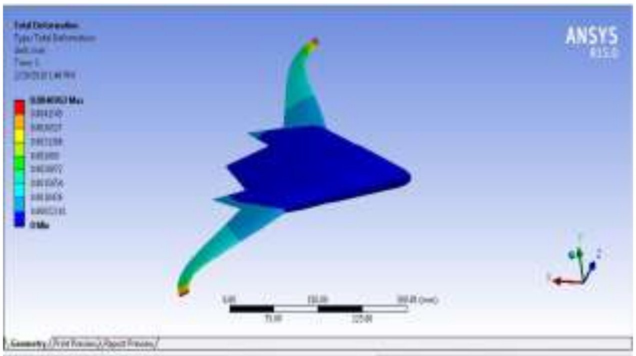

Fig 6.3.3 : Total deformation on GFRP+CFRP

6.4 GFRP+SISAL

Speed – 400km/hr

In GFRP+SISAL the maximum stress is obtained as 2.5789 Mpa

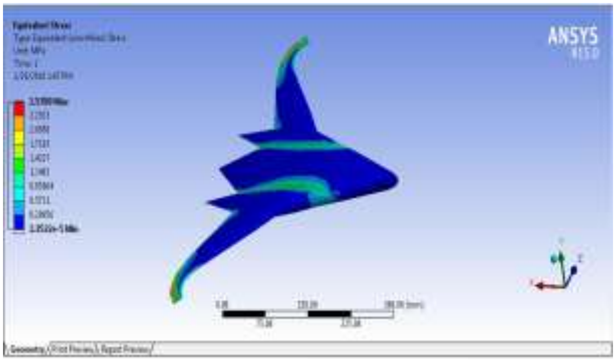

Fig 6.4.1 : Stress on GFRP + Sisal

Speed – 400km/hr

In GFRP+SISAL the maximum strain is obtained as 0.00032584 mm/mm

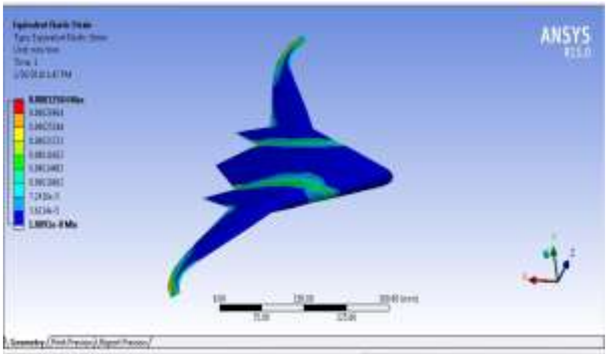

Fig 6.4.2: Strain on GFRP + Sisal

Speed – 400km/hr

In GFRP+SISAL the maximum deformation rate is 0.043151 mm

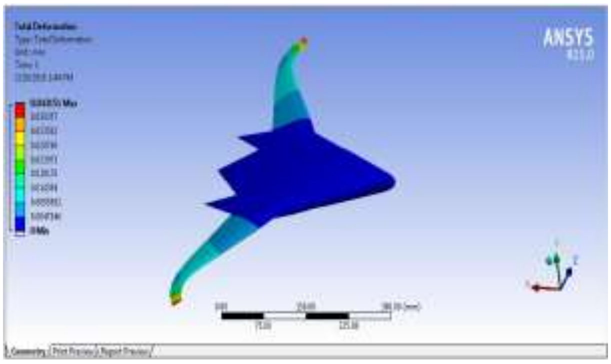

Fig 6.4.3: Total deformation on GFRP + Sisal

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6.5 CFRP+SISAL

Speed – 400km/hr

In CFRP+SISAL the maximum stress is obtained as 2.3789 Mpa

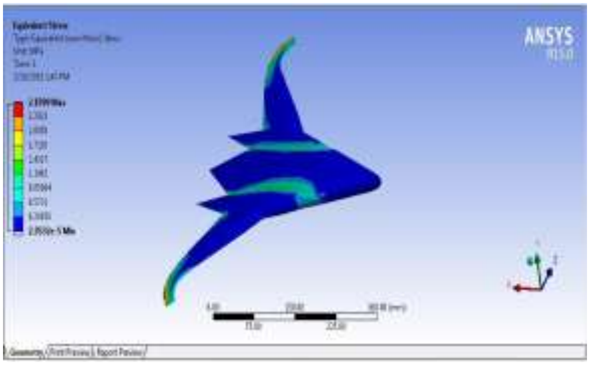

Fig 6.5.1: Stress on CFRP + Sisal

Speed – 400km/hr

In CFRP+SISAL the maximum strain is obtained as 0.00052584 mm/mm

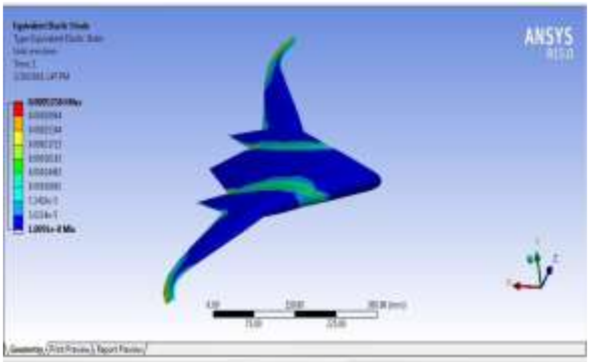

Fig 6.5.2: Strain on CFRP + Sisal

Speed – 400km/hr

In CFRP+SISAL the maximum deformation rate is 0.033151 mm

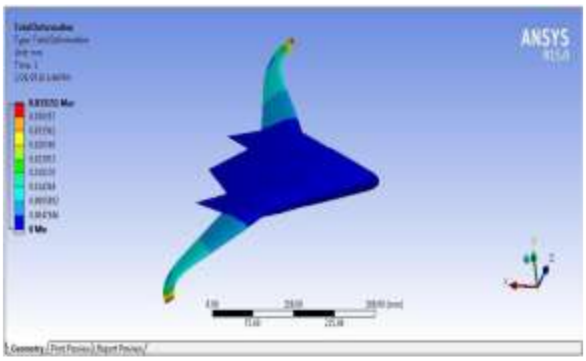

Fig 6.5.3 : Total deformation on CFRP + Sisal

7. RESULT COMPARISON

Fig 7.1: Stress comparison

From figure 7.1 we can see that there is a minimum stress in the combination of CFRP+SISAL which is preferable.

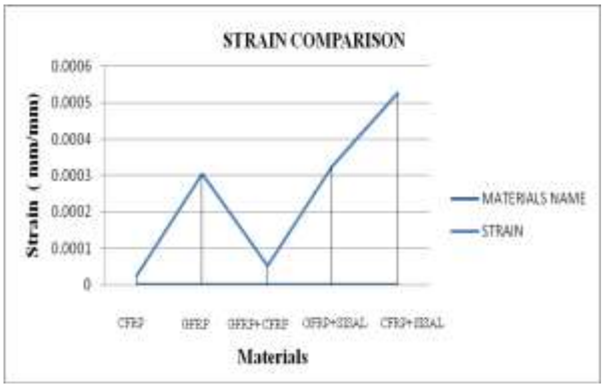

Fig 7.2: Strain comparison

From figure 7.2 there is a maximum strain in the combination of CFRP+SISAL

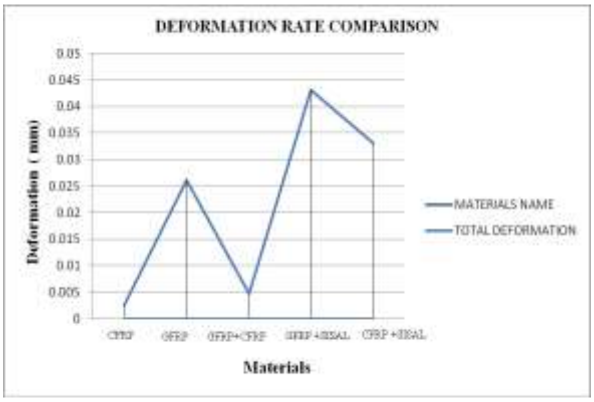

Fig 7.3: Deformation rate comparison

From fig 7.3 we can see that there is a minimum deformation rate in CFRP. But to overcome the limitations of CFRP composite although the combination of CFRP+SISAL is Preferable

8. CONCLUSIONS

- By comparing the Stress graphs we can see that there is a minimum stress in the combination of CFRP+SISAL which is preferable.
- By comparing the strain graphs there is a maximum strain in the combination of CFRP+SISAL.
- By comparing the Total deformation graphs we can see that there is a minimum deformation rate in CFRP. But to overcome the limitations of CFRP composite although the combination of CFRP+SISAL is Preferable

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BIOGRAPHIES

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