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Vibration and CFD Analysis of Hybrid Composite Wing

Beulah Saripalli[1], Ratnakar Pandu[2], Vijay John[3]

[1]PG student, [2]Professor, [3]Asst. Professor, Marri Laxman Reddy Institute of Technology and Management, Dundigal, Hyderabad

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Abstract: **The current trend in aircraft design is to increase the proportion of fibre composites in the structures. Since many primary parts also are constructed using metals, the number of metal-composite structures is increasing. Such structures have traditionally often been avoided as an option because of the lack of methodology to handle the mismatch between the material properties. From the design point of view, it is a challenge to construct a weight optimal hybrid structure with the right material in the right place. With a growing number of hybrid structures, these problems need to be addressed. The purpose of the current research is to assess the strength, durability and thermo mechanical behaviour of a hybrid composite-aluminum wing structure by testing and analysis. The work performed in this paper focuses on the analysis part of the research and is divided into two parts. In the first part, the theoretical framework and the background are outlined. Significant material properties, aircraft specification aspects and the modelling framework are discussed. In the second part the profile is modelled in detail using the software further analyzed using computerized finite element analysis and the result is incorporated.**

Keywords: **Vibration and CFD Analysis of Hybrid Composite Wing, fibre composites in the structures.**

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1. INTRODUCTION

The aerospace market is one of the largest and arguably the most important to the composites industry. Commercial aircraft, military craft, helicopters, business jets, general aviation aircraft and space craft all make substantial use of composites, both inside and outside. Aluminium alloys have, for a long time, been the primary materials used in aircraft structural design. Compared to most other metals, aluminium alloys have a high strength-to-weight ratio, which is essential for the aircraft performance and load-carrying capability. Aluminium alloys are, however, susceptible to fatigue and this poses a problem considering that aircraft structures usually are exposed to a large number of cyclic load repetitions during their operational life. Structural parts that are made of both metal and composite materials and that include such interfaces are referred to as hybrid structures. Such mixed solutions have traditionally often been avoided as an alternative, because of the lack of a proper methodology to handle the mismatch of the material properties. But with a growing number of hybrid structures, this problem needs to be addressed. From a design point of view it is a challenge to construct a weight optimal hybrid structure, where the right material is put into the right place.The wing is a framework made up of spars and ribs and covered with metal. Wing structures carry some of the heavier loads found in the aircraft structure. The particular design of a wing depends on many factors, such as the size, weight, speed, rate of climb, and use of the aircraft. Wing is mainly used as a lift producing component in an aircraft.

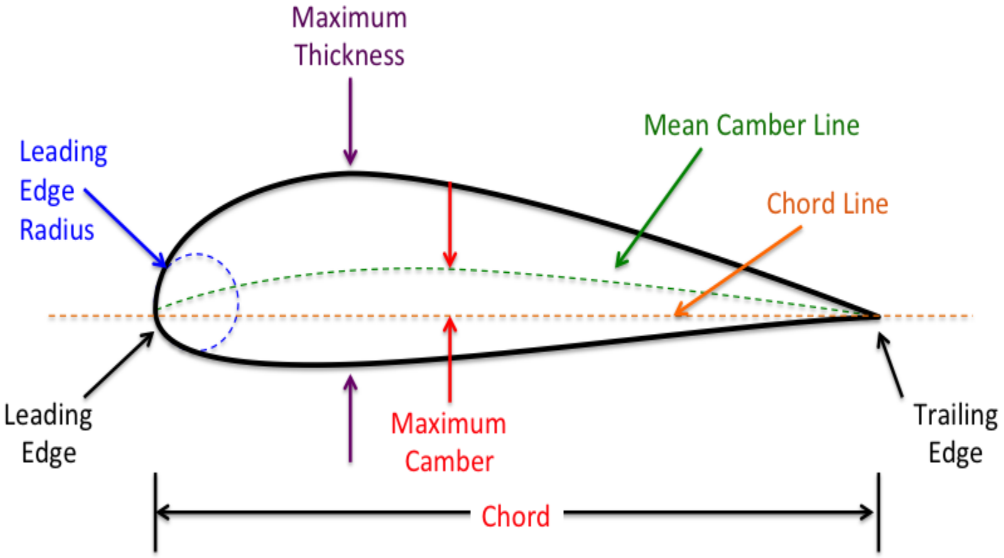

Fig.1. Airfoil geometric parameters

2. LITERATURE SURVEY

Mohamed Hamdan and Nithiya kalyani [1] were designed and analyzed the ribs and spars of a 150 seated regional aircraft for the stresses and displacements due to the applied loads. The optimum design parameters are suitably selected and then the model was designed. The major wing design parameters were explained in detail and the wing configuration has been described. Different types of loads acting on the aircraft and the wing are determined and the moments, displacements, etc., are also determined. Bret K. Stanford and Peter D. Dunning [2] have studied several topology optimization problems conducted within the ribs and spars of a wing box. It is desired to locate the best position of lightening holes, truss/cross-bracing, etc. A variety of aero elastic metrics are isolated for each of these problems: elastic wing compliance under trim loads and taxi loads, stress distribution, and crushing loads. Aileron effectiveness under a constant roll rate is considered as are dynamic metrics natural vibration frequency and flutter. This approach helps uncover the relationship between topology and aero elasticity in subsonic transport wings and can therefore aid in understanding the complex aircraft design process that must eventually consider all these metrics and load cases simultaneously.

W.J. Goodey [3] in his articles on the subject of Two-Spar Wing Stress Analysis, has assumed that flexibility of the ribs has no appreciable effect on the distribution of stress in the wing. Using the method of minimum strain energy, this assumption is equivalent to neglecting the strain energy stored in the ribs. Other writers have, in effect, made this same assumption by neglecting change of shape of cross-sections under load. Pritish Chitte et al., [4**]** studied about preliminary sizing and analysis of a wing box. The main objective is to fix an appropriate structure within the given envelope. Sizing is done by using classical engineering theories and FEA. Skin and web are considers as shell elements. Flange, spar and stringer are considered as beam elements. The analysis is carried out with iterations such as, with different sections like Rectangular sections, Z –sections and L- sections, Panel breakings and varying skin thicknesses. From the analysis structure has been optimally designed which satisfies the strength and stability criteria, which still has a scope for optimization by redesigning components like Ribs and Spars.

P. Murugesan and P. Thirumurugan [5] have mentioned most important aspects in the aircraft design are safety and weight of the structure. Wing is one of the major components of the aircraft. Wing creates the lift required for flight. Spars, ribs and skins are the major structural elements of the wing. Spars are the structural members which run through the wing root at the fuselage to the wing tip. Spars carry the major wing bending loads. Ribs are the structural members which are oriented in the chord wise direction. Ribs carry the shear and compression loads on the wing. Ribs also help the wing to maintain its aerodynamic shape under loaded condition. Current study includes a composite wing configuration consisting of five ribs and two spars. The aerodynamic distributed load on the wing creates shear force, bending moment and torsion moment at wing stations. Static load carrying capability of the wing spar is carried out through a linear static stress analysis. The top skin of the wing box will experience the axial compression during wing bending. The top skin panels between the spar and ribs will be considered for the buckling analysis. These panels will be evaluated for their buckling critical loads through analytical approach.

A. Ramesh Kumar et al., [6] explained Wing structure consists of skin, ribs and spar sections. The spar carries flight loads and the weight of the wings while on the ground. Other structural and forming members such as ribs are attached to the spars, with stressed skin. The wings are the most important lift- producing part of the aircraft. The design of wings may vary according to the type of aircraft and its purpose. Experimental testing of wing structure is more expensive and time consuming process. Then stress analysis of the wing structure is carried out to compute the stresses at wing structure. The stresses are estimated to find out the safety factor of the structure. In a structure like airframe, a fatigue crack may appear at the location of high tensile stress. Life prediction requires a model for fatigue damage accumulation, constant amplitude S-N (stress life) data for various stress ratios and local stress history at the stress concentration. The response of the wing structure will be evaluated. In this study prediction of fatigue life for crack initiation will be carried out at maximum stress location.

Vikas kumar et. al., [7**]** stated for designing of wing box it should be noted that the structure should be strong enough to withstand the load forces and exceptional circumstances in which aircraft has to be operate. Wing is essentially a beam which transmits and gathers all the applied loads to the fuselage. Spar, ribs, stringers and skin are the major essential part of the wing. The primary function of wing is to generate a lift. Wing requires longitudinal member to withstand the bending moments which are greatest during flight and landing of aircrafts. Ribs are structural members which maintain the aerodynamic shape of the wing. In this paper we study a wing box; this wing box is subjected to flight loads. Load distribution on wing is also carried out in this paper.

Cindie Giummarra et. al., [8] discussed two aluminium-lithium alloys for aerospace applications, including the relationship between their alloying elements and thermal-mechanical processing, to the alloy’s properties. The paper also includes selected properties of these alloys in sheet, plate and extrusion forms. Finally, a trade study conducted between Alcoa and Bombardier using these alloys is discussed which highlights the weight and performance benefits to an aircraft when alloys with optimized properties are selected for specific aircraft applications. William E. Frazier et al [9] studied the design requirements of the next generation of advanced aerospace vehicles and propulsion systems necessitate the development of structural materials with properties vastly superior to those which are currently achievable. Recognizing that each class of materials possesses its own unique set of advantages and disadvantages, the designers of tomorrow’s aircraft must choose wisely from the plethora of available alloys. Hashiguchi et al [10] were explained a family of low density - high elastic modulus aluminium-beryllium alloys is under development in order to meet the requirements of advanced aerospace designs. These alloys are aluminium based with 10%-75% beryllium and combine the high specific stiffness of beryllium with the ductility and ease of fabrication of aluminium. Densities ranging from 2.0 to 2.58 g/cc with excellent strength and ductility have been achieved. The family of AlbeMet alloys under development was manufactured by both powder and ingot metallurgy techniques. Property characterization of extruded bar and rolled sheet included tensile, fatigue and fracture mechanics evaluation. The dependence of microstructure and properties upon composition and fabrication method, as well as upon third element additions is required.

Zlatan Kapid [11] mentioned composite and metal properties differ with respect to thermal expansion, failure mechanisms, plasticity, sensitivity to load type, fatigue accumulation and scatter, impact resistance and residual strength, anisotropy, environmental sensitivity, density etc. Based on these differences, the materials are subject to different design and certification requirements. The issues that arise in certification of hybrid structures are: thermally induced loads, multiplicity of failure modes, damage tolerance, buckling and permanent deformations, material property scatter, significant load states etc. The purpose of the current research is to assess the strength, durability and thermo mechanical behavior of a hybrid composite-aluminum wing structure by testing and analysis. The influence of the hybrid structure constitution and requirement profiles on the mass, strength, fatigue durability, stability and thermo-mechanical behavior is considered. Based on the conceptual studies, a hybrid concept to be used in the subsequent structural testing is chosen. The second paper focuses on the virtual testing of the wing structure. In particular, the local behavior of hybrid fastener joints is modeled in detail using the finite element method, and the result is then incorporated into a global model using line elements. Damage accumulation and failure behavior of the composite material are given special attention.

Computations of progressive fastener failure in the experimental setup are performed. The analysis results indicate the critical features of the hybrid wing structure from static, fatigue, damage tolerance and thermo-mechanical points of view.

P. K Mallick [12] stated the fundamental understanding of fiber reinforcement has not changed, but much new advancement has taken place in the materials area, especially after the discovery of carbon nanotubes. There has also been increasing applications of composite materials, which started mainly in the aerospace industry, but now can be seen in many non aerospace industries, including consumer goods, automotive, power transmission, and biomedical. It is now becoming a part of the ‘‘regular’’ materials vocabulary. Deborah D.L Chung [13] mentioned carbon fiber composites, particularly those with polymeric matrices, have become the dominant advanced composite materials for aerospace, automobile, sporting goods, and other applications due to their high strength, high modulus, low density, and reasonable cost. For applications requiring high temperature resistance, as required by spacecraft, carbon fiber carbon-matrix composites have become dominant. As the price of carbon fibers decreases, their applications have even broadened to the construction industry, which uses carbon fibers to reinforce concrete. An objective of this book is to provide up-to-date information on the whole spectrum of carbon fiber composites, including polymer-matrix, metal-matrix, carbon-matrix, ceramic-matrix, and hybrid composites. Such information pertains to the processing, properties, and applications, and is given in a tutorial fashion, so that no prior knowledge of the field is required. At the end of each chapter, a large number of up-to-date references are included, so the reader can look up further information, if desired. Thus, the book is focused on composites with a variety of matrices but carbon fibers alone as the filler. This focus allows detailed consideration of the fiber-matrix interface and the composite processing for a variety of matrices.

Martin Alberto Masuelli [14] has given brief review of FRP has summarized the very broad range of unusual functionalities that these products bring (Polymers, Aramids, Composites, Carbon FRP, and Glass-FRP). While the chemistry plays an important role in defining the scope of applications for which these materials are suited, it is equally important that the final parts are designed to maximize the value of the inherent properties of these materials. Clearly exemplify the constant trade-off between functionality and process ability that is an ongoing challenge with these advanced materials. The functionality that allows these materials to perform under extreme conditions has to be balanced against process ability that allows them to be economically shaped into useful forms. The ability of a polymer material to deform is determined by the mobility of its molecules, characterized by specific molecular motions and relaxation mechanisms, which are accelerated by temperature and stress. Since these relaxation mechanisms are material specific and depend on the molecular structure, they are used here to establish the desired link with the intrinsic deformation behavior.

Maria Mrazova [15] said since Orville and Wilbur Wright first decided to power their Flyer with a purpose built, cast aluminum engine to meet the specific requirements for power to weight ratio, new materials have been necessary to improve and advance aviation. This improvement in material properties has helped us to travel quickly and inexpensively around the world, by improving the performance and operations of modern aircraft. In the first part of this study the author introduces the composites materials with their advantages and disadvantages. Airbus and its innovation in composite materials are introduced in the second part of the thesis. Composite technology continues to advance, and the advent of new types such as nano tube forms is certain to accelerate and extend composite usage. This issue is introduced in the last part of this thesis. A continuing trend in material development is the improvement in processing and production of incumbent materials to either improve physical properties or to allow their application in new areas and roles for further usage in the future.

Nikhil V Nayak [16] stated Fiber- reinforced polymer composite materials are fast gaining ground as preferred materials for construction of aircrafts and spacecrafts. In particular, their use as primary structural materials in recent years in several technology demonstrator front-line aerospace projects world-wide has provided confidence leading to their acceptance as prime materials for aerospace vehicles. Although several applications in the aerospace vector are mentioned, the emphasis of the review is on applications of composites as structural materials where they have seen a significant growth in usage. A brief review of composites usage in aerospace sector is first given. The nature of composite materials behavior and special problems in designing and working with them are then highlighted. The issues discussed relate to the impact damage and damage tolerance in general, environmental degradation and long-term durability.

2.1 Fiber Materials:

Fibres are the principal constituents in a fibre -reinforced composite material. They occupy the largest volume fraction in a composite laminate and share the major portion of the load acting on a composite structure. Proper selection of the fibre type, fibre volume fraction, fibre length, and fibre orientation is very important. To present the potential of carbon fibre reinforced polymer composites, some important properties of a few metallic materials have been compared. The lowest density of carbon fibre reinforced epoxy composite is 1.55 kg/m3 when compared with 7.87 kg/m3 and 2.7 kg/m3 for SAE 1010 and 6061-T6 Al alloy respectively. Modulus is also competitive with 137.8GPa for composite against 207GPa and 68.9GPa for SAE 1010 and 6061-T6 Al alloy respectively. Further, in the case of tensile strength carbon fibre epoxy composites possess 1550MPa against 365GPa for SAE 1010 and against 310GPa for 6061-T6 Al alloy. Aramid fibres are used mainly in applications where they offer a unique combination of properties, such as high specific strength combined with toughness and creep resistance. The outstanding toughness of para-aramids is often the reason they are used over cheaper, stiffer or even stronger fibres. Unlike glass and carbon composites, aramid composites loaded in compression, flexure or shear fail in a non-brittle manner, with significant work being required to fail the composite. Their fatigue resistance is also excellent. Aramid fibres are used in numerous applications. Many of these are not as structural composites.

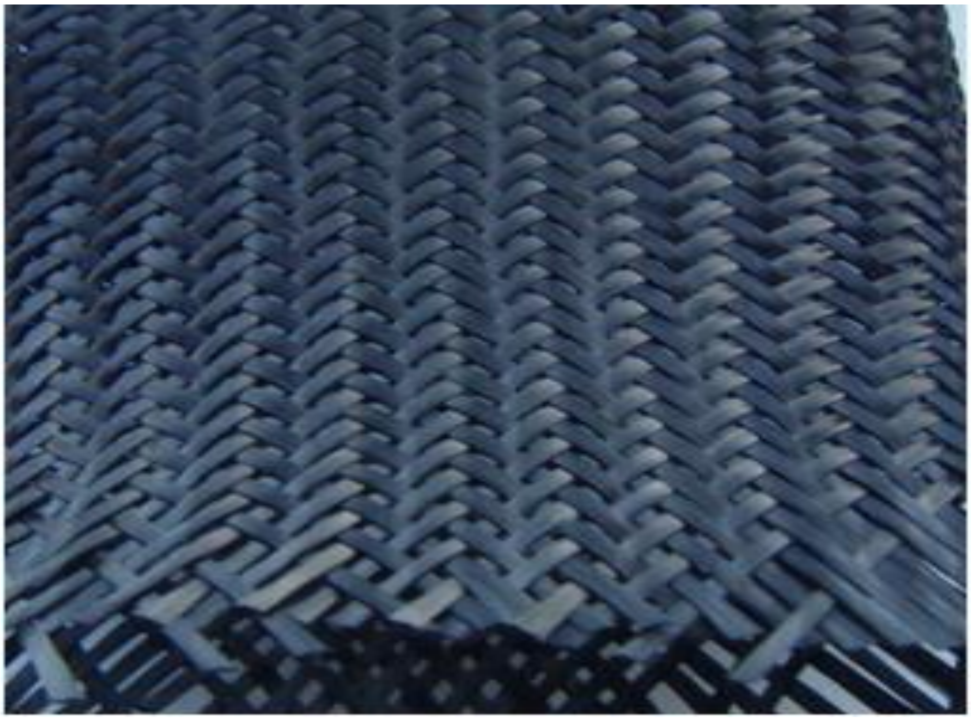

Fig. 1 Aramid fibre

Aramid is short for “aromatic-polymide”. Aramids are a class of polymers, where self-repeating units contain large phenyl rings, linked together by amide groups. As per US based FTC, aramid fibres are manufactured fibres where “the fibre-forming substance is a long-chain synthetic polyamide in which at least 85% of the amide linkages, (-CO-NH-) are attached directly to two aromatic rings”.

3. MODELING AND ANALYSIS OF COMPOSITE WING

Considering the two fibre materials wings, carbon and aramid which are been used for the study are now being analysed. The structural analysis is being done for both the fibres where the deformation, stress and strain values are calculated and the results are tabulated and compared with the help of graphs. Vibration analysis is done for the wings and the modal values at different frequencies are tabulated and the respective results are compared with the help of the graphs. CFD analysis is done at different angles of the wing and values of pressure, velocity, lift and drag are calculated and tabulated.

3.1 Deformation, Strain and Stresses of Aramid fibre wing:

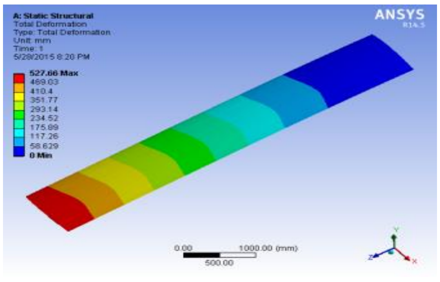

Fig.2 Deformation of Aramid fibre wing

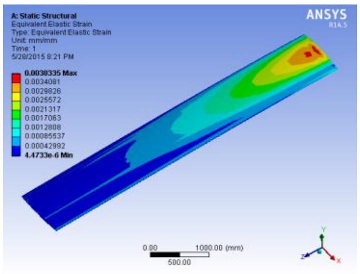

Fig.3 Strain of Aramid fibre wing

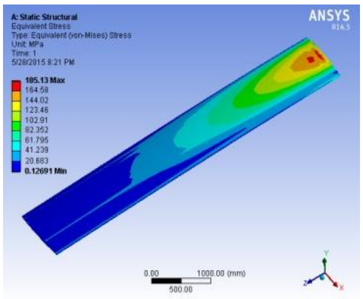

Fig.4 Stress of Aramid fibre wing

The contour plot (Fig.2), wing minimum deformation at one end is 0mm and a uniform gradual increase is noticed to 527.66mm at other end. The contour plot (Fig.3), the minimum change of the length at bottom end of wing is 4.4733e-6 while the maximum change of the length on top of the surface is 0.0038335. The contour plot (Fig.4), the minimum stress at the bottom end of wing is 0.12691N/mm^2 and the maximum stress on top of the surface is 185.13N/mm^2.

4. STRUCTURAL ANALYSIS OF CARBON FIBRE WING

Density : 1.75 g/cc

Young's modulus: 85 GPa

Poisson's ratio : 0.20

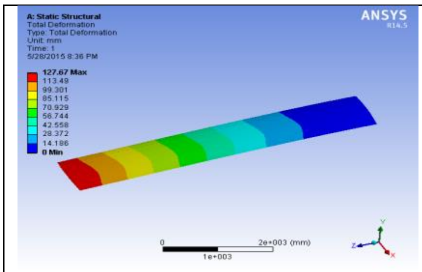

Fig.5 Deformation of carbon fibre wing

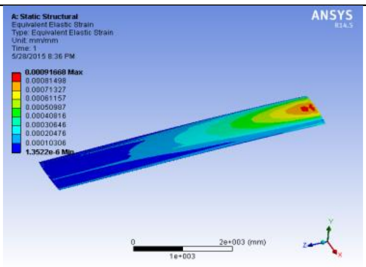

Fig.6 Strain of carbon fibre wing

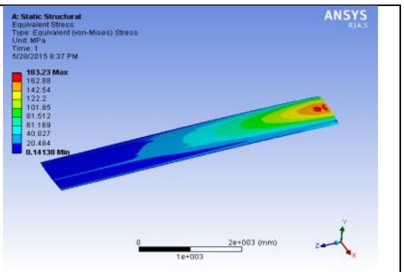

Fig.7 Stress of carbon fibre wing

The contour plot (Fig.5) specifies that the wing minimum deformation initially is 0mm and is increased periodically to 127.67mm at other end. The contour plot (Fig.6), the minimum change of the length at bottom end of wing is 1.3522e-6 while the maximum change of the length on top of the surface is 0.0009168. The contour plot (Fig.7), the minimum stress at the bottom end of wing is 0.14138N/mm^2 and the maximum stress on top of the surface is 183.23 N/mm^2.

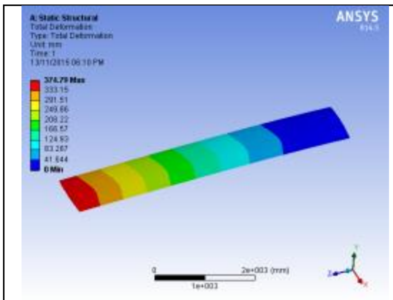

Fig.8 Deformation of a Plain Wing

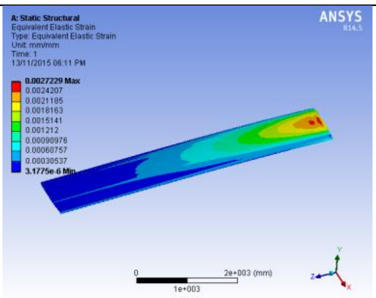

Fig.9 Strain of a Plain Wing

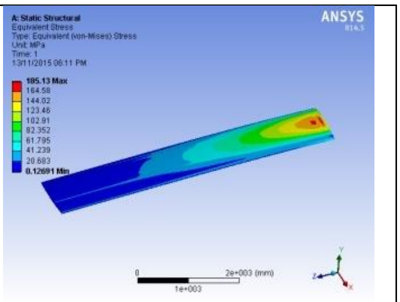

Fig.10 Stress of a Plain Wing

The contour plot (Fig.8), wing minimum deformation at one end is 0mm and gradually increased to 374.79mm at other end. The contour plot (Fig.9), the minimum change of the length at bottom end of wing is 3.1775e-6mm while the maximum change of the length on top of the surface is 0.0027229mm. The contour plot (Fig.10), the minimum stress at the bottom end of wing is 0.12691N/mm^2 and the maximum stress on top of the surface is 185.13 N/mm^2.

	Plain wing	Aramid fibre	Carbon Fibre
Deformation	374.79	527.66	127.67
Strain	0.0027229	0.0038335	0.00091668
Stress	185.13	185.13	183.23

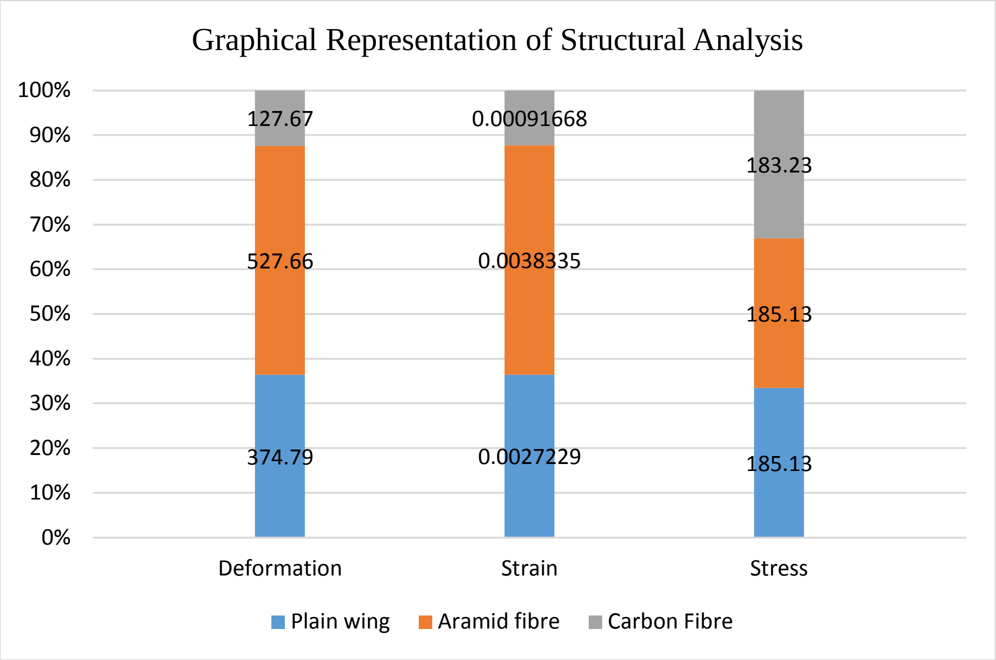

Fig.11 Graphical Representation of Structural Analysis for different wings

Structural analysis of the three different wings i.e. plain or regular wing, carbon fibre wing and aramid fibre wing are calculated in ANSYS and the deformation, strain and stress values are being tabulated and represented graphically.

4.1 Vibration Analysis of Aramid fibre Wing:

Density : 1.52 g/cc

Young's modulus : 4.83Mpa

Poisson's ratio : 0.36

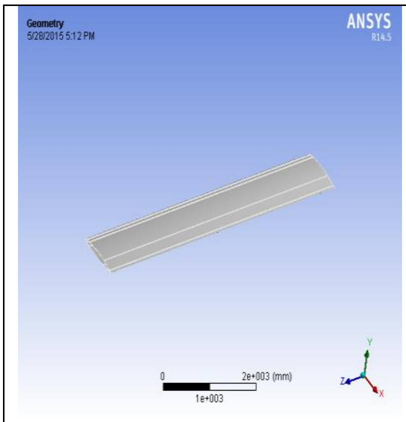

Fig.12 Wing imported from CATIA

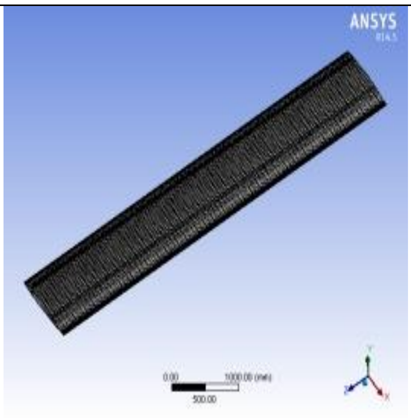

Fig.13 Wing Meshing done in ANSYS

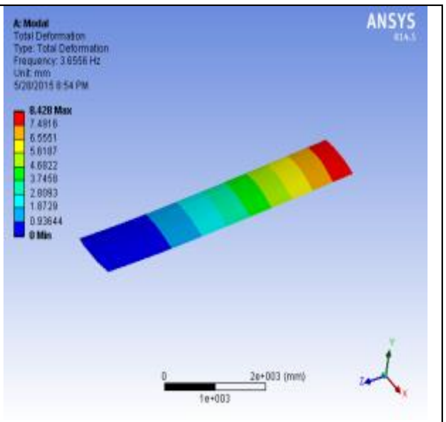

Fig.14 Wing deformation at Modal no.1

4.2 Modal values of Aramid Fibre Wing:

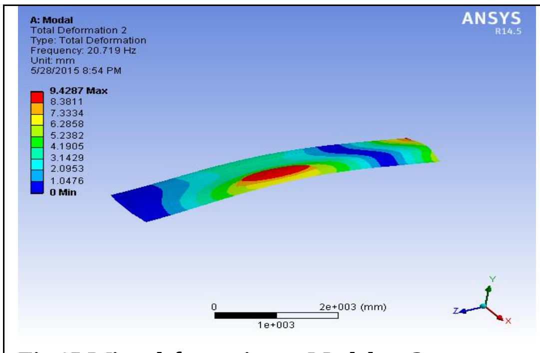

Fig.15 Wing deformation at Modal no.2

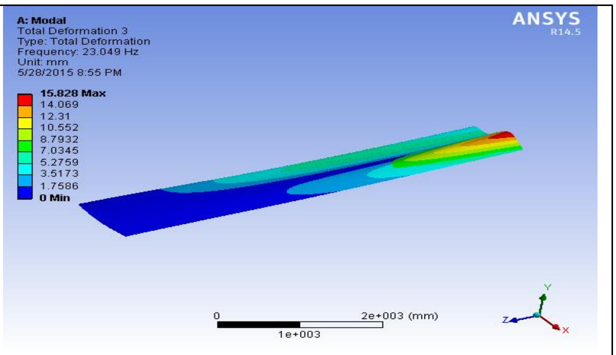

Fig.16 Wing deformation at Modal no.3

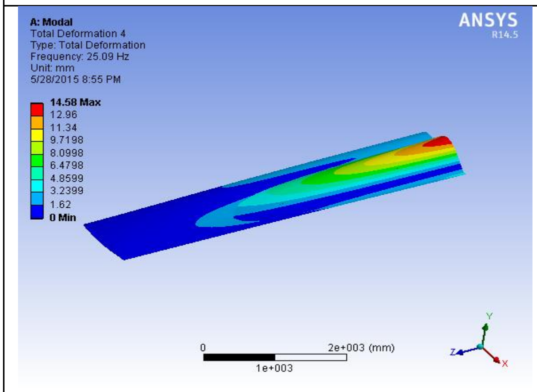

Fig.17 Wing deformation at Modal no.4

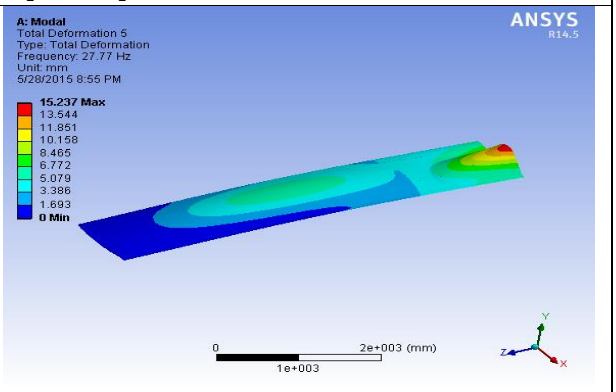

Fig.18 Wing deformation at Modal no.5

The contour plot (Fig 14), wing minimum deformation at one end is 0mm and is gradually increased to 8.428mm which is maximum towards the other end because of frequency (3.6556Hz). The contour plot (Fig 15), wing minimum deformation is towards bottom and 3/4th end on the top surface is 0mm and increases at middle of the wing to 9.4287mm because of frequency (20.719Hz). The contour plot (Fig 16), wing minimum deformation is towards bottom end 0mm and increases to the top end of the wing surface 15.828mm because of frequency (23.049Hz). The contour plot (Fig 17), wing minimum deformation is towards bottom end 0mm and increases to top end of the wing surface 14.58 mm because of frequency (25.09Hz). The contour plot (Fig 18), wing minimum deformation is towards bottom end is 0mm and increases to top end of the wing surface 15.237 mm because of frequency (27.77Hz).

4.3 Vibration Analysis of Carbon Fibre Wing:

Density : 1.75 g/cc

Young’s modulus : 85GPa

Poisson’s ratio : 0.20

4.4 Modal values of Carbon Fibre Wing:

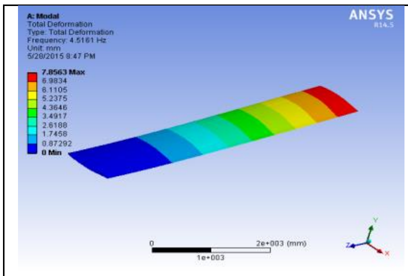

Fig.19 Wing deformation at Modal no.1

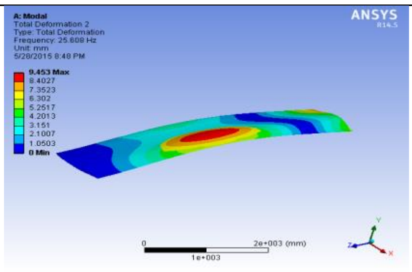

Fig.20 Wing deformation at Modal no.2

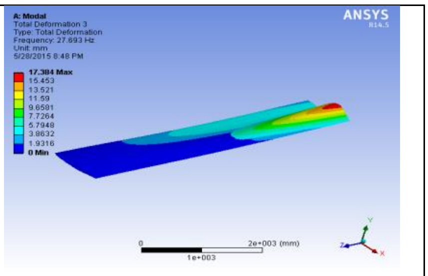

Fig.21 Wing deformation at Modal no.3

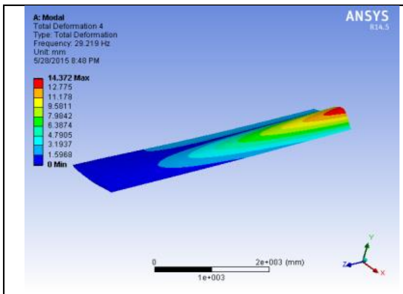

Fig.22 Wing deformation at Modal no.4

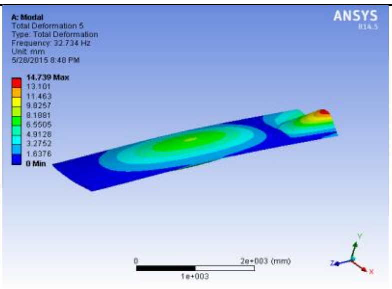

Fig.23 Wing deformation at Modal no.5

The contour plot (Fig 19), wing minimum deformation at one end is 0mm and gradually increased to 7.8563mm which is maximum towards the other end because of frequency (4.5161Hz). The contour plot (Fig 20), wing minimum deformation is towards bottom and 3/4th end on the top surface is 0mm and increases at middle of the wing to 9.453mm because of frequency (25.608Hz). The contour plot (Fig 21), wing minimum deformation is towards bottom end 0mm and increases to the top end of the wing surface 17.384mm because of frequency (27.693Hz). The contour plot (Fig 22), wing minimum deformation is towards bottom end 0mm and increases to top end of the wing surface 14.372 mm because of frequency (29.219Hz). The contour plot (Fig 23), wing minimum deformation is towards bottom end is 0mm and increases to top end of the wing surface 14.739 mm because of frequency (32.734Hz).

5. VIBRATION ANALYSIS OF A PLAIN WING

5.1 Modal values of Plain Fibre Wing:

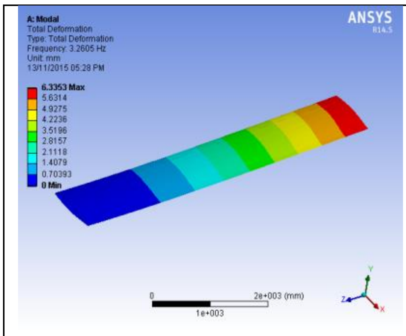

Fig.24 Wing deformation at Modal no.1

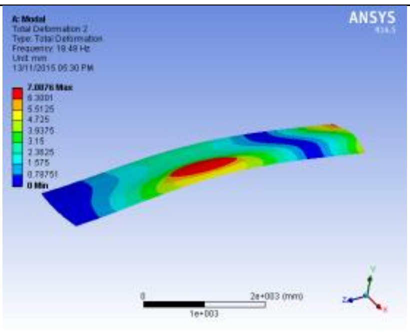

Fig.25 Wing deformation at Modal no.2

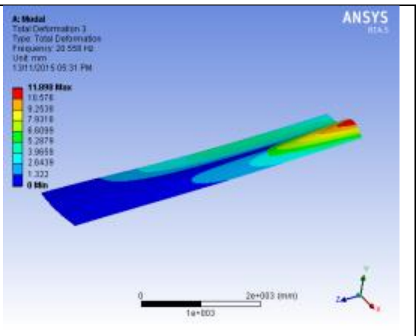

Fig.26 Wing deformation at Modal no.3

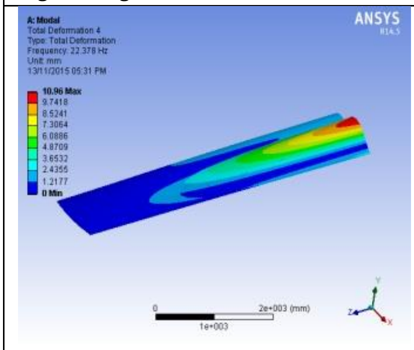

Fig.27 Wing deformation at Modal no.4

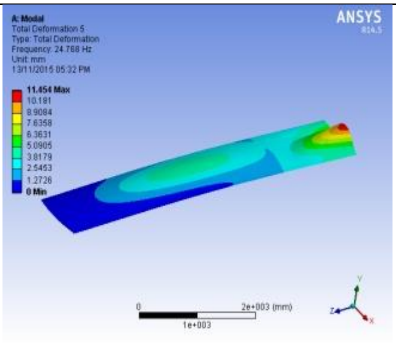

Fig.28 Wing deformation at Modal no.5

The contour plot (Fig 24), wing minimum deformation at one end is 0mm and gradually increased to 6.3353mm which is maximum towards the other end because of frequency (3.2605Hz). The contour plot (Fig 25), wing minimum deformation is towards bottom and 3/4th end on the top surface is 0mm and increases at middle of the wing to 7.0876mm because of frequency (18.48Hz). The contour plot (Fig 26), wing minimum deformation is towards bottom and 3/4th end on the top surface is 0mm and increases at middle of the wing to 11.898mm because of frequency (20.558Hz). The contour plot (Fig 27), wing minimum deformation is towards bottom end 0mm and increases to top end of the wing surface 10.96 mm because of frequency (22.378Hz). The contour plot (Fig 28), wing minimum deformation is towards bottom end is 0mm and increases to top end of the wing surface 11.454 mm because of frequency (24.768Hz).

	Aramid fibre	Carbon fibre	Plain Wing
Model 1	8.428	7.8563	6.3353
Model 2	9.4287	9.453	7.0876
Model 3	15.828	17.384	11.898
Model 4	12.96	14.372	10.96
Model 5	15.237	14.739	11.454

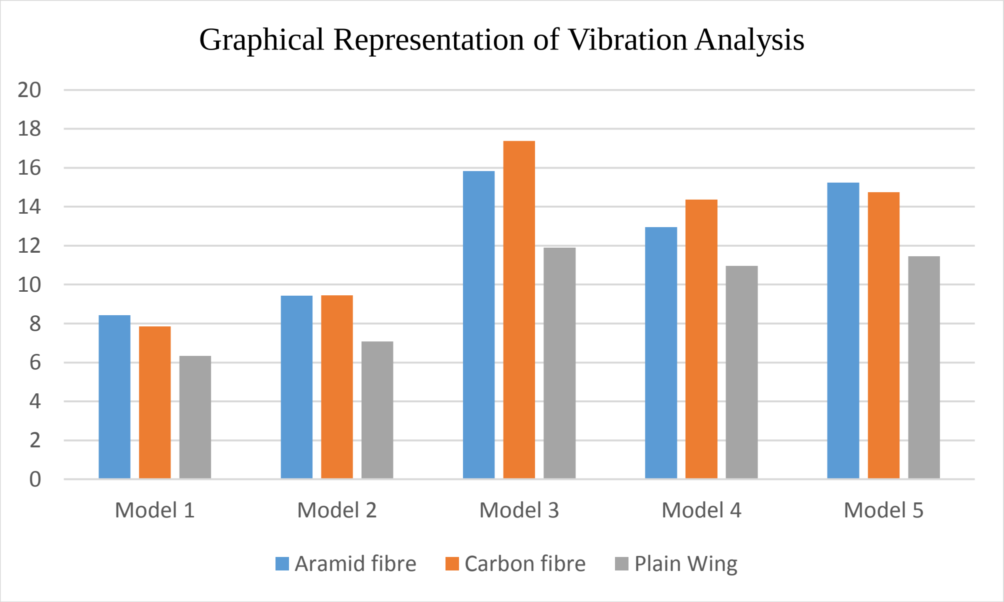

Fig.29 Graphical Representation of Vibration Analysis of different wings.

5.2 CFD Analysis of Flow parameters and Forces at Angle 2:

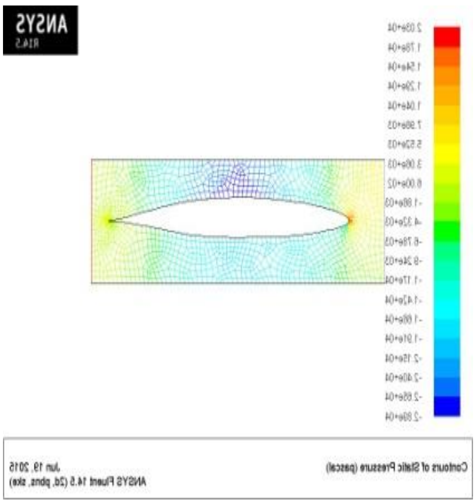

Fig.30 Static Pressure at angle 2

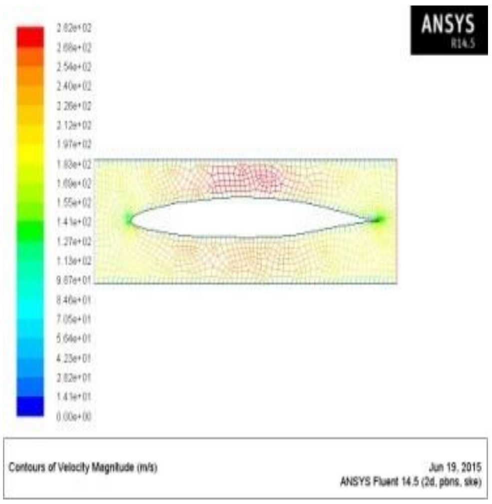

Fig.31 Velocity at angle 2

The contour plot (Fig 30), the pressure will be minimum, middle portion of the wing is -2.89e+04N/mm^2 and pressure will be maximum at both ends 2.03e+04N/mm^2. The contour plot (Fig 31), the Velocity will be maximum, middle portion of the wing is 2.82e+02N/mm^2 and pressure will be maximum at both 1.41e+01N/mm^2

5.3 Flow parameters and Forces at Angle 4:

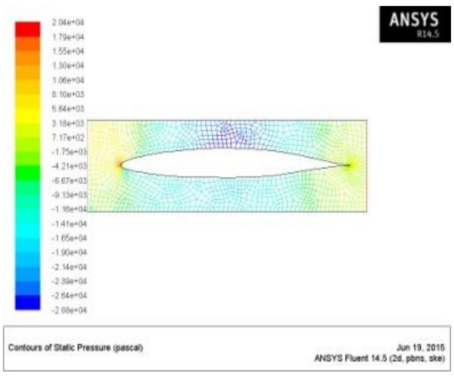

Fig.32 Static Pressure a t angle 4

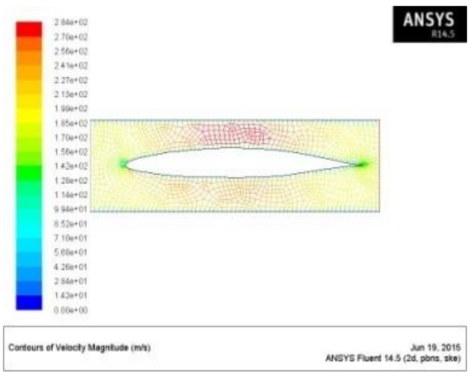

Fig.33 Velocity at angle 4

The counter plot (Fig 32), the pressure will be minimum, middle portion of the wing is -2.88e+04N/mm^2 and pressure will be maximum at both ends 2.04e+04N/mm^2. The counter plot (Fig 33), the Velocity will be maximum, middle portion of the wing is 2.84e+02N/mm^2 and velocity will be maximum at both ends 1.42e+01N/mm^2.

5.4 CFD Analysis of Plain Wing:

	Pressure	**Velocity**	**Lift**	**Drag**
At angle 2	2.03e+04	2.82e+02	128.07404	74.514945
At angle 4	2.04e+04	2.8e+02	244.14127	76.159145

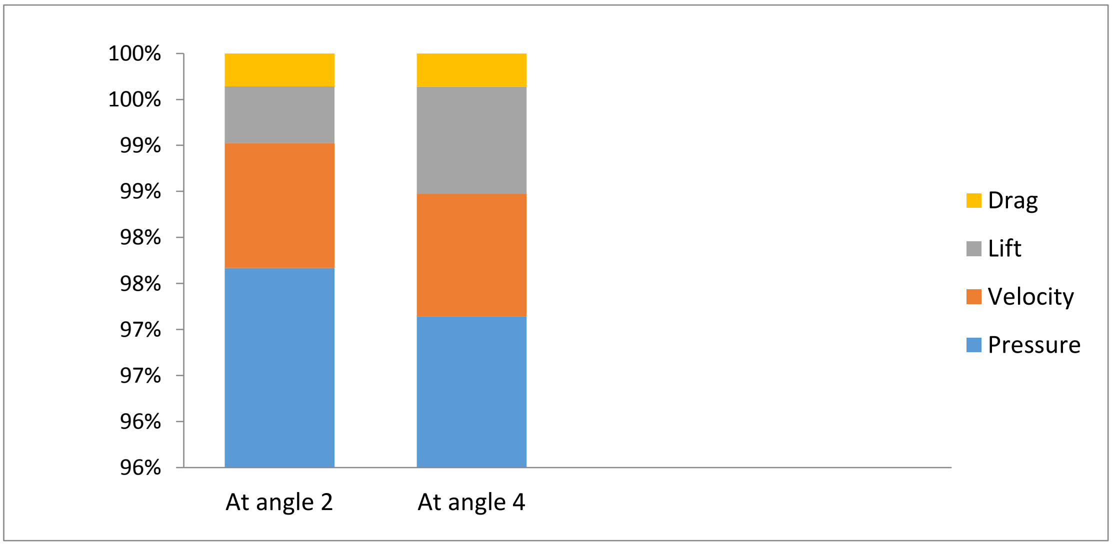

Fig.34 Graphical representation of CFD analysis at different angles of an aerofoil model

6. CONCLUSIONS

In this paper, an aircraft wing is designed and modelled in 3D modelling software. The materials used for aircraft wings are hybrid composite aluminum alloys and specifically the composite materials preferred are Carbon Fibre and Aramid Fibre. Further, Structural analysis is done using analysis software, in which Static analysis is done on the wing by applying air pressure for two materials aluminium - carbon fibre and aluminium - aramid fibre. By observing the analysis results, the deformation and stress are less for Carbon Fibre than Aramid Fibre. Vibration analysis is also done on the aircraft wing for the similar two materials to determine the frequencies. By observing the results, the frequencies are more for Carbon Fibre than Aramid Fibre, so the vibrations are more when Carbon Fibre is used.

CFD analysis is done on the wing to determine the lift and drag forces by changing angle of attacks. The angle of attack taken is 2^0 and 4^0. By observing the results, the drag force is less for 2^0 angle of attack. It is better if the drag force is reduced. So it can be concluded that by decreasing the angle of attack, the drag force is reduced. By observing both the results, the stress produced when Aramid fibre is used are slightly more than that of carbon fibre, but by vibration analysis, Aramid fibre is better.

However considerably the hybrid composite – aluminium wing produce fine results when analysed under pressure and frequencies when compared to a basic aluminium wing which is used today. Considering an example of two unlike natured fibre this is being analysed that where a normal aluminium alloy wing performance would comparably less effective than a hybrid composite wing.

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