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Design and Aero Dynamic Analysis of Military Aircraft Wing Using Different Materials

Gyangi Hyder Basha[1], Shaik Abzal Basha[2] ,M.Venkataramudu[3]
[1] P.G. Scholar, [2] Assistnat Professor, [3]Head of the Department M.Tech
Branch :Mechanical , Machine Design
Geethanjali College Of Engineering & Technology (Gcet), Cheeryala(V)
Keesara(M), Rangareddy Dist.
Telangana,
Email :- [1]hyderbasha88@gmail.com, [2]shaikabzalbasha777@gmail.com

Abstract:

The wings of a military aircraft are long, tight airfoils with a high angle proportion, a shape that limits haul from tip vortices . They by and large contain a level of washout that diminishes the lift created at the tips, where the wind stream is fastest and vortex generation. Wing blades are made out of different materials, including aluminum, composite structure, and steel or titanium, with scraped area shields along the main edge. he primary aircraft wing is for the most part influenced by the wind stream for development of wing blade and the impact of aerodynamic power and radiating power applying to blade has been completely considered. The dynamic attributes examination of rotor blade is chiefly engaged with the vibration control.

The goal is to ascertain the common recurrence of wing blade is regulating those frequencies and keeping away from reverberation at rotational speed, in this manner the vibrations of helicopter may diminish. In this undertaking, the three-measurement model of military aircraft wing is demonstrated in NX-CAD and imported into ANSYS programming to break down quality and dynamic attributes of rotor blade has been produced. The static quality and the dynamic attributes about aircraft wing have been broke down with ANSYS programming for various materials (aluminum combination and composite E-GLASS/EPOXY AND KEVLAR/EPOXY). Amid the investigation of dynamic trademark, the impact of aerodynamic power and outward power applying to wing has been completely considered

Keywords:- Aero Dynamics, CAD/ CAM/CAE, Static Analysis, Modal Analysis.

INTRODUCTION

1.1 MILITARY AIR CRAFT

Naval aircraft are worked to meet certain predefined necessities. These prerequisites must be chosen so they can be incorporated with one aircraft. It isn't workable for one aircraft to have all qualities; similarly as it isn't feasible for an aircraft to have the solace of a traveler transport and the mobility of a contender. The sort and class of the aircraft decide how solid it must be fabricated. A Navy warrior must be quick, flexibility, and prepared for assault and protection. To meet these necessities, the aircraft is exceptionally controlled and has an extremely solid structure. The airframe of a settled wing aircraft comprises of the following five major units:

1. Fuselage

2. Wings
3. Stabilizers
4. Flight controls surfaces
5. Landing gear

MILITARY AIR CRAFT WING

Wings build up the major segment of the lift of a heavier-than-air aircraft. Wing structures convey a portion of the heavier burdens found in the aircraft structure. The specific plan of a wing relies upon numerous variables, for example, the size, weight, speed, rate of ascension, and utilization of the aircraft. The wing must be built so it holds its aerodynamics shape under the outrageous worries of battle moves or wing stacking. Wing development is comparative in most present day aircraft. In its most straightforward shape, the wing is a system made up of competes and ribs and secured with metal. The development of an aircraft wing is appeared in figure 4-8. Fights are the primary auxiliary individuals from the wing. They reach out from the fuselage to the tip of the wing. All the heap conveyed by the wing is taken up by the competes. The fights are intended to have incredible bowing quality. Ribs give the wing area its shape, and they transmit the air stack from the wing covering to the competes. Ribs reach out from the main edge to the trailing edge of the wing. Notwithstanding the primary competes, a few wings have a false fight to help the ailerons and folds. Most aircraft wings have a removable tip, which streamlines the external end of the wing.

Most Navy aircraft are structured with a wing alluded to as a wet wing. This term portrays the wing that is developed so it very well may be utilized as an energy unit. The wet wing is fixed with a fuel-safe compound as it is constructed. The wing holds fuel without the standard elastic cells or tanks. The wings of most naval aircraft are of all metal, full cantilever development. Frequently, they might be collapsed for bearer utilize. A full cantilever wing structure is extremely solid. The wing can be secured to the fuselage without the utilization of outer propping, for example, wires or swaggers. An entire wing get together comprises of the surface giving lift to the help of the aircraft. It additionally gives the essential flight control surfaces.

PROBLEM DEFINE AND METHODOLOGY

The aircraft wing predominantly influenced by the wind current for development of aircraft and the impact of aerodynamic power and radiating power applying to wing has been completely considered. The dynamic attributes examination of aircraft wing is for the most part associated with the vibration control. The goal is to figure the characteristic recurrence and working recurrence of aircraft wing is tweaking those frequencies and keeping away from reverberation at rotational speed, along these lines the vibrations of helicopter may decrease. The static quality and the dynamic attributes about aircraft wing have been examined with ANSYS programming for various materials (aluminum combination and composite materials).

The procedure followed in my task is as per the following:

- Create a 3D model of the military aircraft wing utilizing NX-CAD programming.
- Perform Static analysis utilizing ANSYS programming and get the avoidances and von mises stresses for aluminum material.
- Perform modal analysis of military aircraft wing for common recurrence and mode shapes.
- Perform static analysis utilizing ANSYS programming and get the avoidances and stresses for composite materials like Kevlar/epoxy material.

- Perform modal analysis of military aircraft wing for common recurrence and mode shapes.
- Perform static analysis utilizing ANSYS programming and get the avoidances and stresses for composite materials like Kevlar/epoxy material.
- Perform modal analysis of military aircraft wing for normal recurrence and mode shapes.
- From analysis results, best material was proposed.

DESIGNING OF MILITARY AIRCRAFT WING

COMPUTER AIDED DESIGN (CAD):

Computer aided design is an imperative mechanical workmanship broadly utilized in numerous applications, including car, shipbuilding, and aviation ventures, modern and building structure, prosthetics, and some more. Computer aided design is additionally generally used to deliver PC activity for embellishments in motion pictures, promoting and specialized manuals. The cutting edge pervasiveness and intensity of PCs implies that even scent jugs and cleanser gadgets are structured utilizing systems incomprehensible by specialists of the 1960s. On account of its gigantic financial significance, CAD has been a major main thrust for research in computational geometry, PC designs (both equipment and programming), and discrete differential geometry.

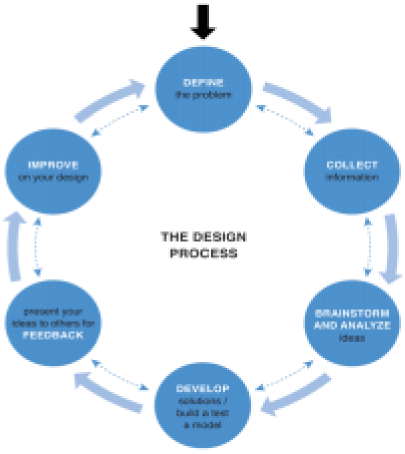


Fig Shows Design Process Of Product

UNIGRAPHICS INTRODUCTION:

NX, otherwise called NX unigraphics or normally just u-g, is a propelled CAD/CAM/CAE programming bundle created by Siemens PLM programming.

It is utilized, among different assignments, for:

- Design (parametric and coordinate strong/surface demonstrating)
- Engineering analysis (static, dynamic, electro-attractive, warm, utilizing the limited component technique, and liquid utilizing the limited volume strategy).
- Manufacturing completed plan by utilizing included machining modules

First arrival of the new "individuals to come" adjustment of unigraphics and I-deas, called NX. this will over the long haul bring the helpfulness and limits of both unigraphics and I-deas together into a lone joined thing.

Growing multifaceted nature of things, enhancement methodology and setup bunches is trying associations to find new devices and techniques to pass on more conspicuous improvement and higher quality at lower cost. driving edge advancement from Siemens PLM programming passes on more critical power for the present arrangement test. from inventive synchronous advancement that joins parametric and sans history illustrating, to NX dynamic mockup for multi-knave get together structure, NX passes on accomplishment development that sets new measures for speed, execution, and ease of use.

NX mechanizes and unravels setup by using the thing and process data that associations gain in actuality and from industry best practices. it consolidates instruments that fashioners can use to get data to robotized repetitive errands. the result is diminished cost and process term and improved quality

.Overview of Solid Modeling:

The Unigraphics NX Modeling application gives a strong demonstrating framework to empower quick reasonable design. Engineers can fuse their necessities and design confinements by characterizing scientific connections between various parts of the design.

Design engineers can rapidly perform reasonable and nitty gritty designs utilizing the Modeling highlight and limitation based strong modeler. They can make and alter perplexing, sensible, strong models intelligently, and with far less exertion than more conventional wire edge and strong based frameworks. Highlight Based strong demonstrating and altering abilities enable designers to change and refresh strong bodies by specifically altering the measurements of a strong element as well as by utilizing other geometric altering and development strategies.

Advantages of Solid Modeling:

Strong Modeling raises the level of articulation with the goal that designs can be characterized as far as building highlights, as opposed to bring down level CAD geometry. Highlights are parametrically characterized for measurement driven altering dependent on size and position.

Highlights:

- Powerful inherent building focused frame highlights spaces, openings, cushions, managers, pockets-catch design aim and increment profitability
- Patterns of highlight cases rectangular and round clusters with relocation of individual highlights; all highlights in the example are related with the ace component.

Blending and Chamfering:

- zero radius
- Ability to chamfer any edge
- Cliff-edge blends for designs that cannot accommodate complete blend radius but still require blends

Advanced Modeling Operations:

- Profiles can be cleared, expelled or spun to shape solids
- Extremely ground-breaking empty body direction transforms solids into thin-walled designs in a moment or two; inward divider topology will vary from the external divider, if vital
- Fixed and variable span mixes may cover encompassing appearances and reach out to a Tapering for displaying fabricated close net shape parts
- User-characterized highlights for basic design components (Unigraphics NX/User-Defined Features is required to characterize them ahead of time

DESIGN OF MILTARY AIRCRAFT WING

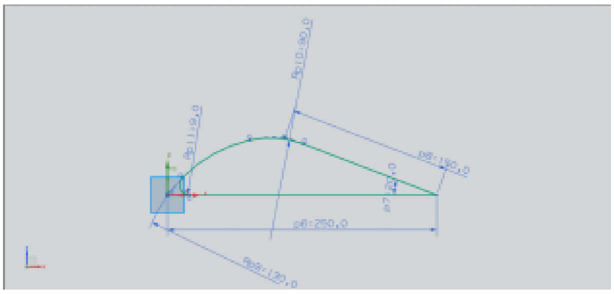


Fig.4.1 2D sketch of aircraft wing

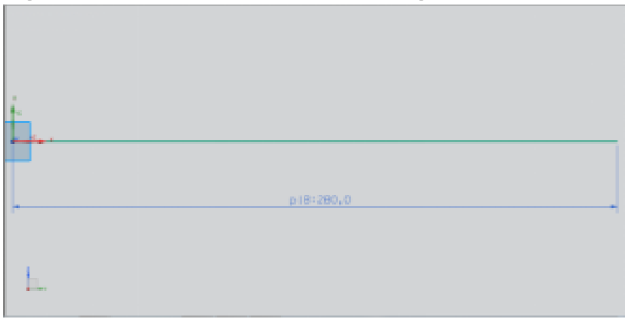


Fig.4.2 Profile path of 2D sketch of aircraft wing

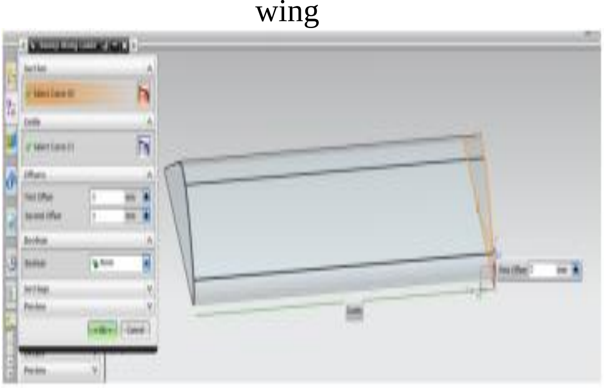


Fig.4.3 Sweep along Profile path of 2D sketch of aircraft wing

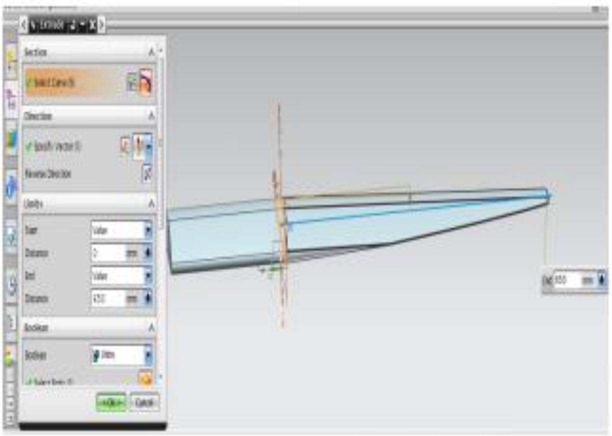


Fig.4.4 Extrude option to front region of 2D sketch of aircraft wing

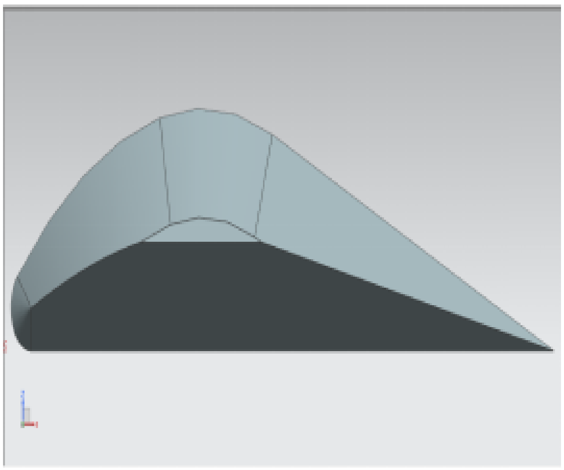


Fig.4.5 Front view of aircraft wing

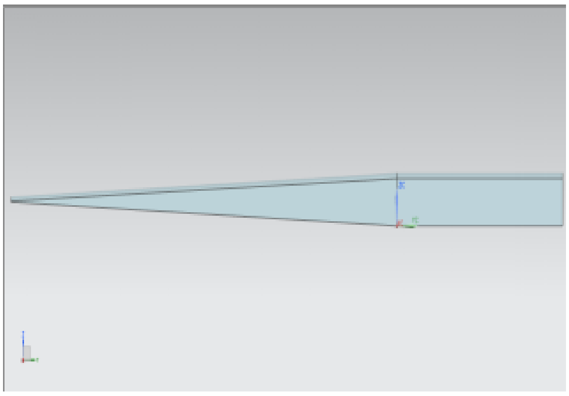
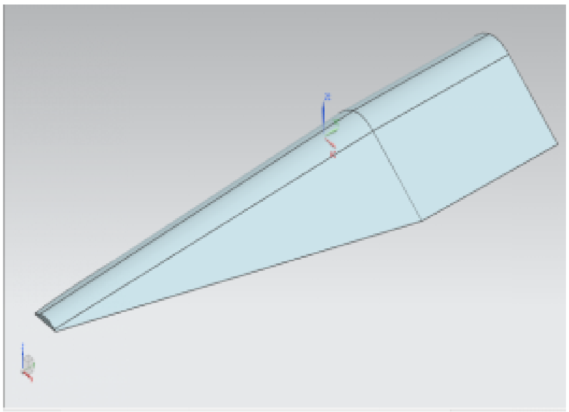


Fig.4.6 Side view of aircraft wing



STATIC AND VIBRATION (DYNAMIC) ANALYSIS OF MILITARY AIRCRAFT WING USING Aluminum ALLOY 2024

5.1 Introduction about CAE (COMPUTER AIDED ENGINEERING)

In traditional methodology conceptional thoughts are changed over into representations or building drawing. With the assistance of this drawings the models i.e. item which looks same as that of conclusive item are made. It is propelled in the market subsequent to testing of model which gives adequate outcomes. The thing is, item is propelled in the wake of doing numerous down to earth testing and numerous experimentation techniques which expends additional time and cost as well. Figure 1 delineates the stream procedure received for regular design approach.

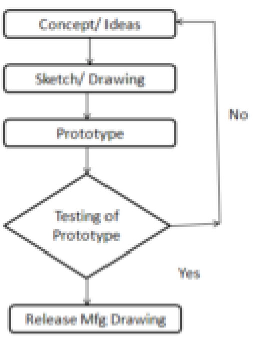


Fig.5.1 Conventional approach

In CAE approach a few stages are same as that of ordinary strategy. Here likewise thoughts, ideas are changed over into designing drawing, yet it is then demonstrated on PC. Geometric model of item is made by the utilization of strong work programming like CAD which empowers better representation of basic and also complex models. These models at that point additionally utilized for automated analysis by utilizing diverse CAE devices (FEA/CFD software's) contingent on the application before the model is been made to check whether the parts will work as per its planned capacity. After that once proper outcomes are acquired the last commonsense testing is done.

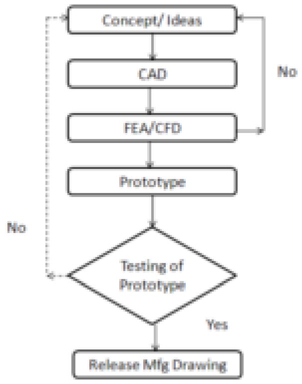


Figure 5.2 show the CAE approach for design a machine component.

When the arrangement has been figured, we can utilize the ANSYS postprocessor to survey the outcomes. Two postprocessors are accessible: POST1 and POST 26. We utilize POST 1, the general postprocessor to audit the outcomes at one sub venture over the whole model or chose part of the model. We can acquire form shows, distort shapes and unthinkable postings to survey and decipher the consequences of the analysis. POST 1 offers numerous different capacities, including blunder estimation, stack case mix, computation among results information and way activities.

We utilize POST 26, the time history post processor, to survey results at particular focuses in the model over unsurpassed advances. We can acquire chart plots of results, information versus time and unthinkable postings. Other POST 26 capacities incorporate number juggling figurings and complex variable based math.

In the arrangement of the analysis the PC assumes control and unravels the synchronous arrangement of conditions that the limited component strategy produces, the consequences of the arrangement are

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- Nodal level of opportunity esteems, which shape the primary arrangement
- Derived esteems which shape the component arrangement

Static analysis

A static examination learns the effects of study stacking conditions on a structure, while slighting dormancy and damping impacts, for instance, those caused by time moving weights. A static examination can in any case consolidate persisting idleness loads and time varying burdens that can be approximated as static indistinguishable weights. Static examination is used to choose the movements, stresses, strains and powers in structures or portions caused by burdens that don't incite imperative dormancy and damping impacts. Reliable stacking and response conditions are acknowledged, i.e. the piles and the structure's responses are required to move bit by bit concerning time. The sorts of stacking that can be associated in static examination consolidate:

- Externally connected powers and weights.
- Steady state inertial powers
- Imposed uprooting
- Temperatures
- Fluencies (for atomic swelling).

Modal analysis

A measured examination chooses the vibration traits (basic frequencies and mode shapes) of a structure or a machine section. It can in like manner fill in as a starting stage for another, more positive, remarkable examination, for instance, a transient ground-breaking examination, a consonant examination, or a range examination. The regular frequencies and mode shapes are basic parameters in the diagram of a structure for dynamic stacking conditions. Presently can in like manner play out a secluded examination on a pre-concentrated on structure, for instance, a turning turbine sharp edge.

Static analysis of military aircraft wing

Material properties:

2024 aluminum combination's piece generally incorporates 4.3-4.5% copper, 0.5-0.6% manganese,
1.3-1.5% magnesium and not as much as an a large portion of a percent of silicon, zinc, nickel, chromium, lead and bismuth.

Thickness: 2.79g/cc
Young's modulus: 72.4 GPa
Poisson Ratio : 0.33
Ultimate tensile strength: 427MPa

Limit condition:

Aerodynamic lift drive (5KN) is follow up on surface of wing when aircraft move to upward. Also, side surface is dashing with aircraft body.

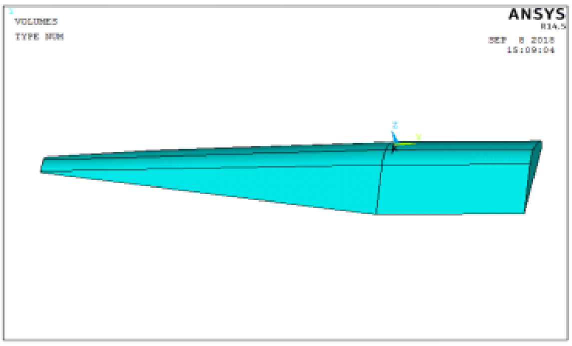

Fig. Imported military aircraft wing in Ansys

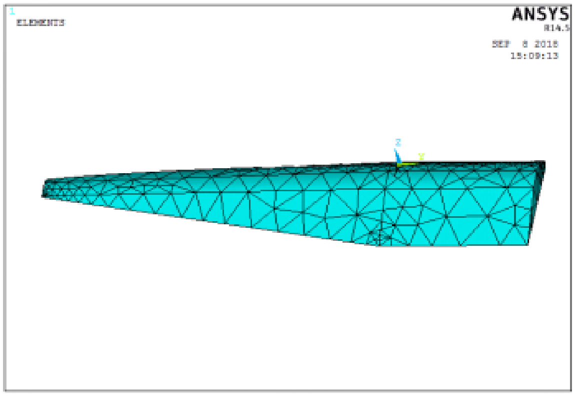

Fig.5.5 Created mesh on military aircraft wing in Ansys

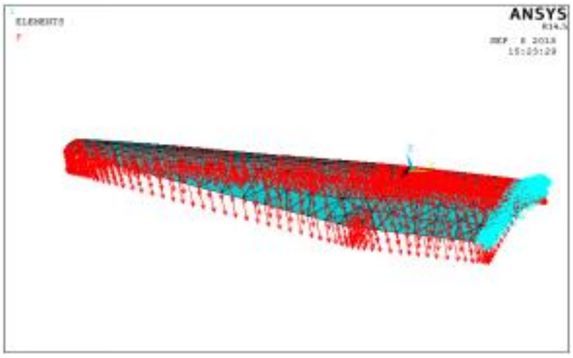

Fig.5.6 Applied loads on military aircraft wing

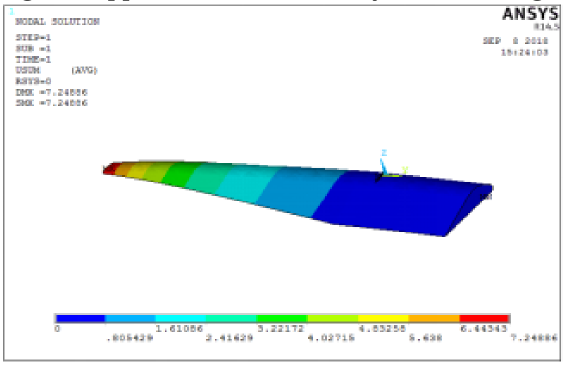

Fig.5.7 Deformation results on military aircraft wing

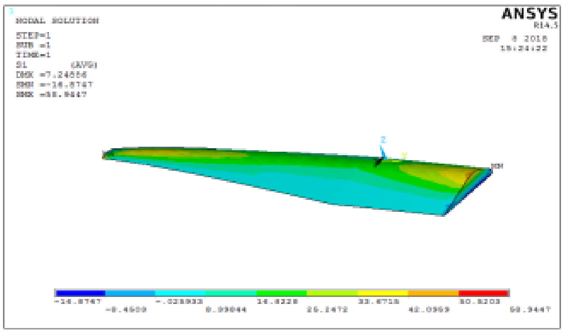

Fig.5.8 1st Principle stress results on military aircraft wing

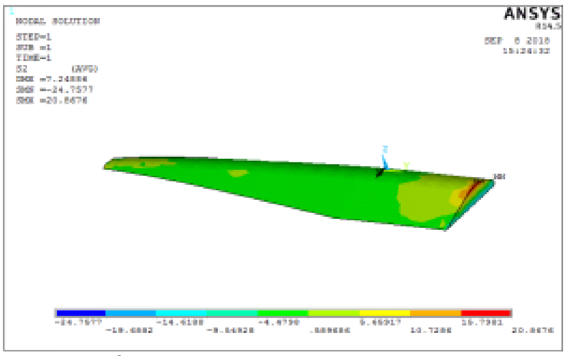

Fig.5.9 2nd Principle stress results on military aircraft wing

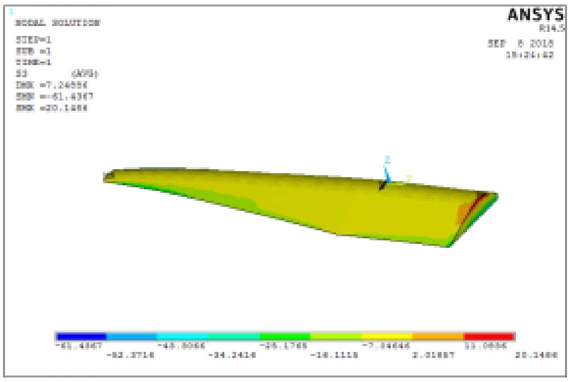

Fig.5.10 3rd Principle stress results on military aircraft wing

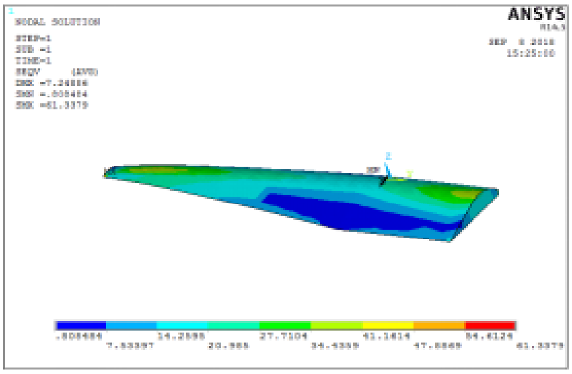

Fig.5.11 Von misses stress results on military aircraft wing

Modal analysis of military aircraft wing

Boundary condition:

Side surface is bolting with aircraft body.

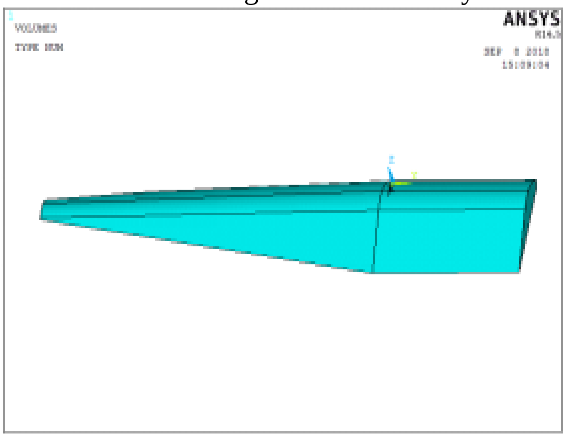

Fig.5.12 Imported military aircraft wing in Ansys

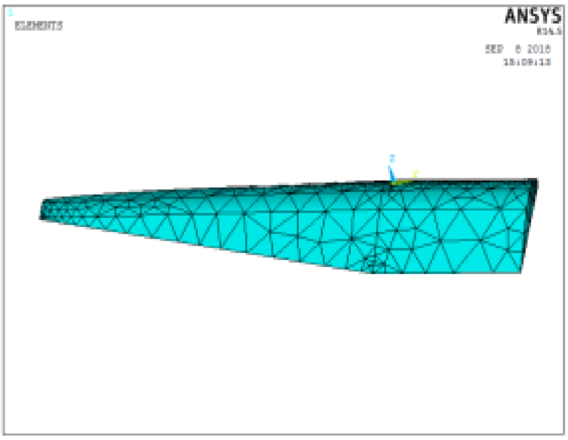

Fig.5.13 Created mesh on military aircraft wing in Ansys

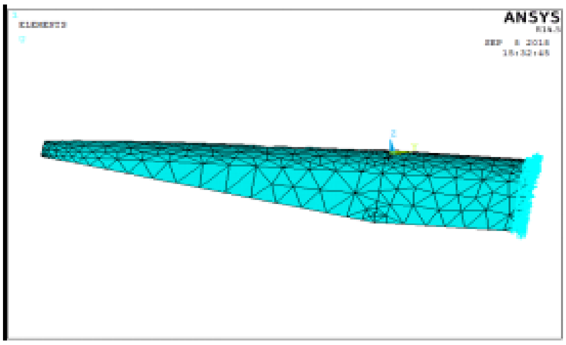

Fig.5.14 Applied fixed condition on military aircraft wing

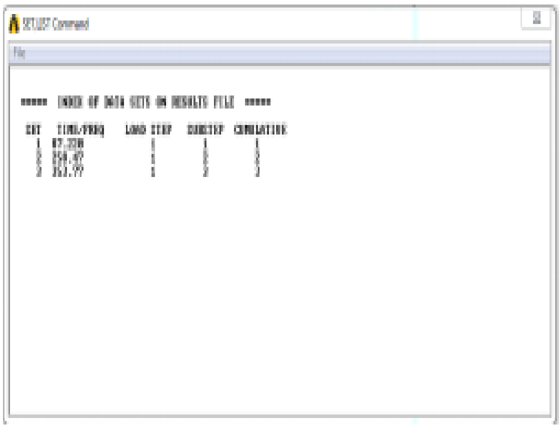

Fig.5.15 Natural frequency results of military aircraft wing

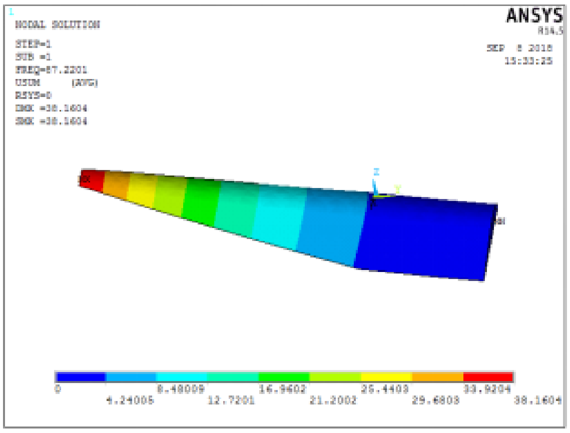

Fig.5.16 Mode shape 1 results of military aircraft wing(Displacement at 1st frequency)

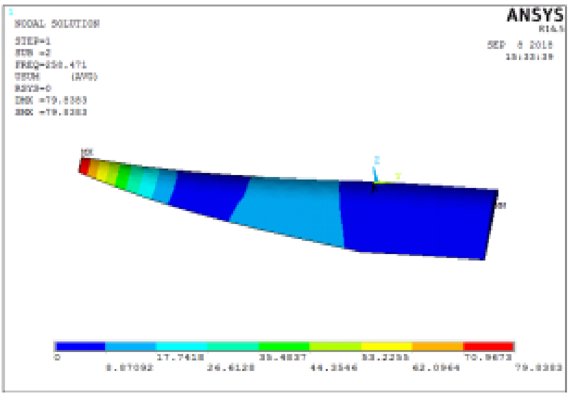

Fig.5.17 Mode shape 2 results of military aircraft wing (Displacement at 2nd frequency)

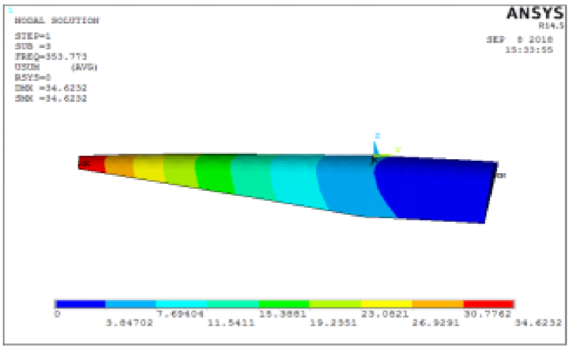

Fig.5.18 Mode shape 3 results of military aircraft wing (Displacement at 3rd frequency)

STATIC AND VIBRATION (DYNAMIC) ANALYSIS OF MILITARY AIRCRAFT WING USING E-GLASS/EPOXY

Static analysis of military aircraft wing

Longitudinal Modulus (E_X): **50 GPa**
Transverse Modulus (E_Y): **12 GPa**
Shear modulus (G_{xy}): **5 .6GPa**
Shear modulus (G_{yz}): **5.6 GPa**
Shear modulus (G_{xz}): **5.6 GPa**
Poisson's Ratio: **0.33**
Density: **2000 Kg/m3**

Limit condition:

Aerodynamic lift compel (5KN) is follow up on surface of wing when aircraft move to upward. What's more, side surface is darting with aircraft body.

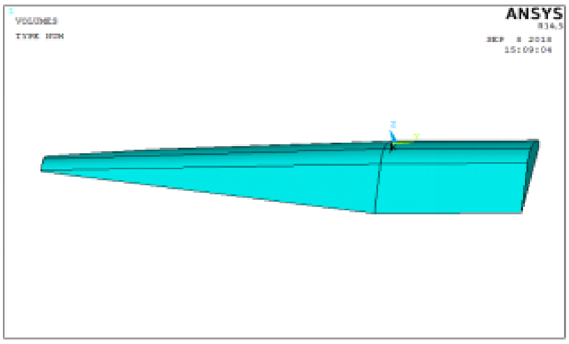

Fig.6.1 Imported military aircraft wing in Ansys

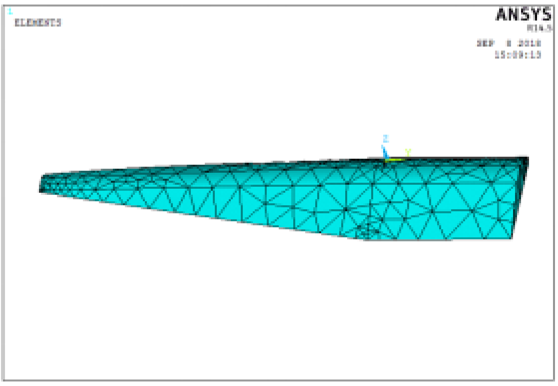

Fig.6.2 Created mesh on military aircraft wing in Ansys

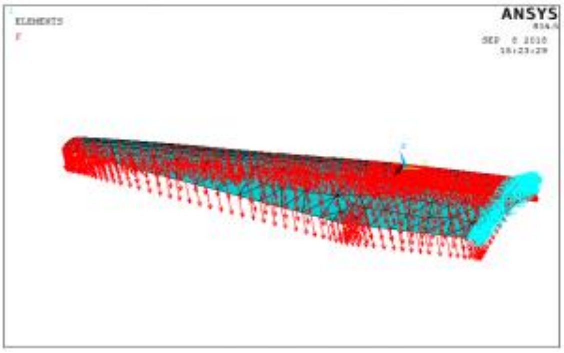

Fig.6.3 Applied loads on military aircraft wing

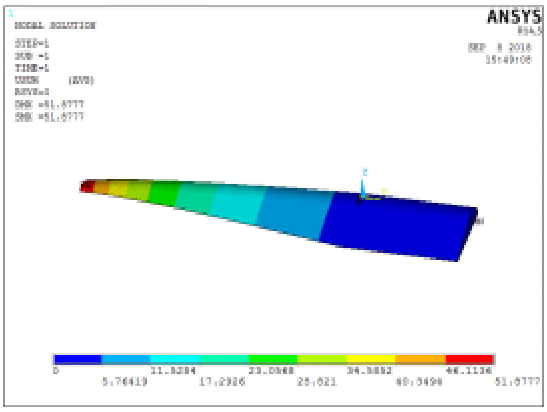

Fig.6.4 Deformation results on military aircraft wing

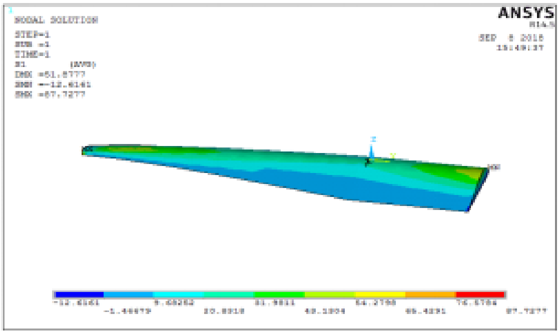

Fig.6.5 1st Principle stress results of military aircraft wing

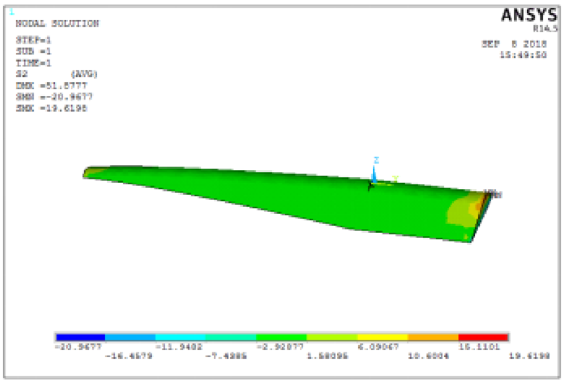

Fig.5.16 Mode shape 1 results of military aircraft wing (Displacement at 1stfrequency)

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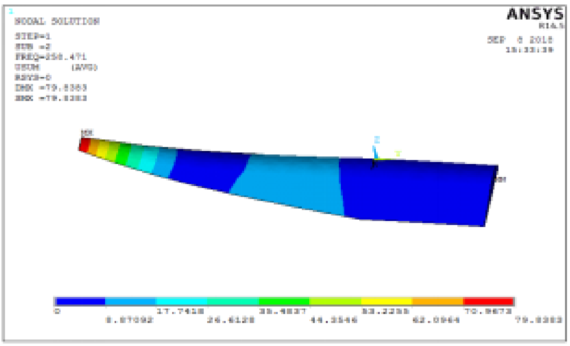

Fig.5.17 Mode shape 2 results of military aircraft wing (Displacement at 2nd frequency)

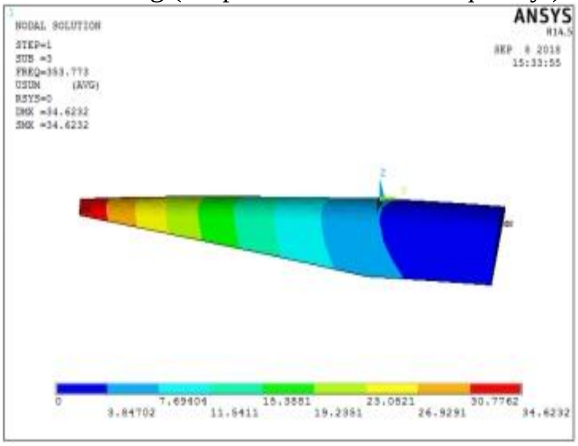

Fig.5.18 Mode shape 3 results of military aircraft wing (Displacement at 3rd frequency)

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Density: **2000 Kg/m3**

Limit condition:

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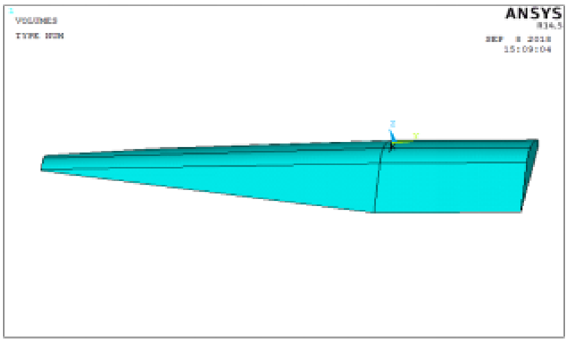

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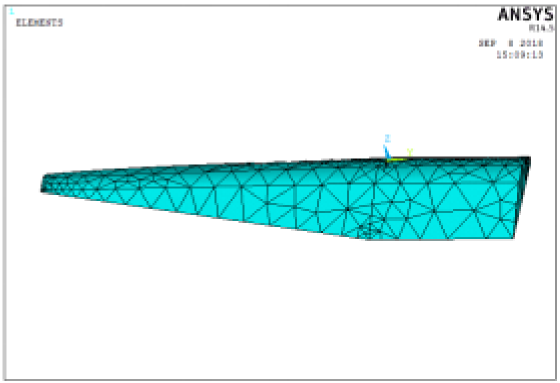

Fig.6.2 Created mesh on military aircraft wing in Ansys

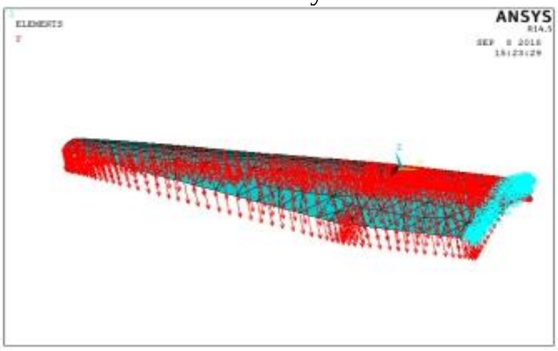

Fig.6.3 Applied loads on military aircraft wing

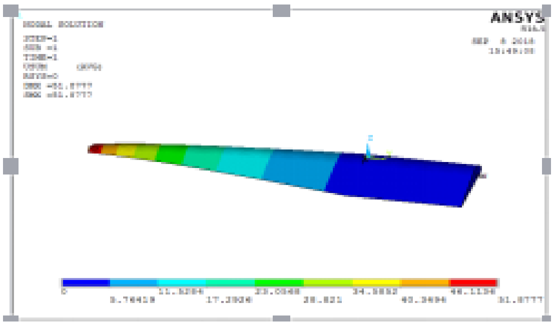

Fig.6.4 Deformation results on military aircraft wing

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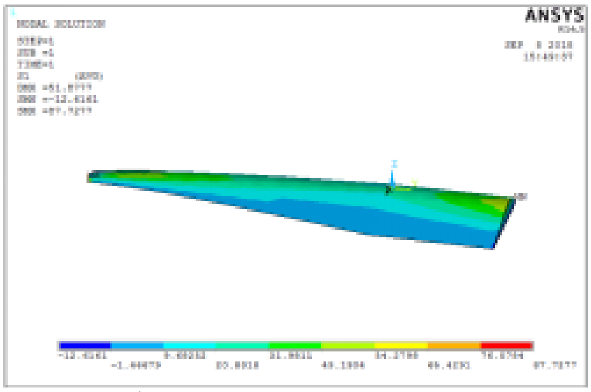

Fig.6.5 1st Principle stress results of military aircraft wing

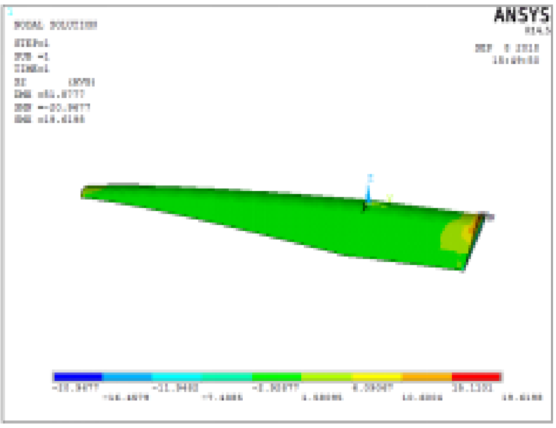

Fig.6.6 2nd Principle stress results of military aircraft wing

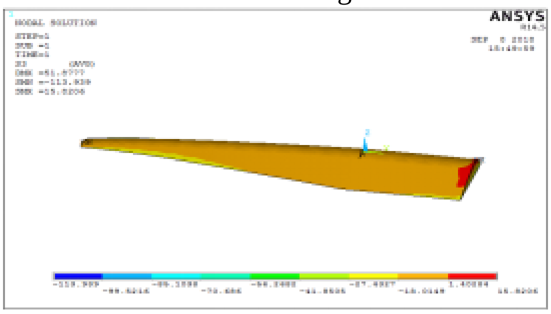

Fig.6.7 3rd Principle stress results of military aircraft wing

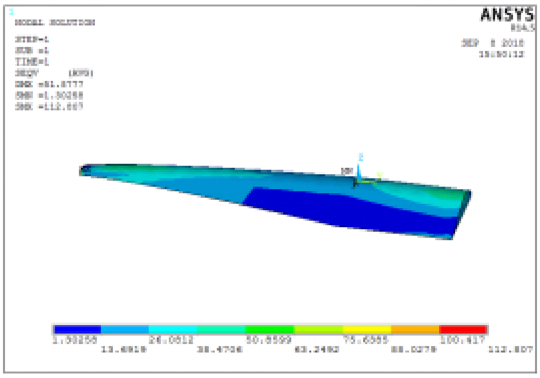

Fig.6.8 Von misses stress results of military aircraft wing

6.2 Modal examination of military airplane wing

Limit condition:

Side surface is darting with airplane body

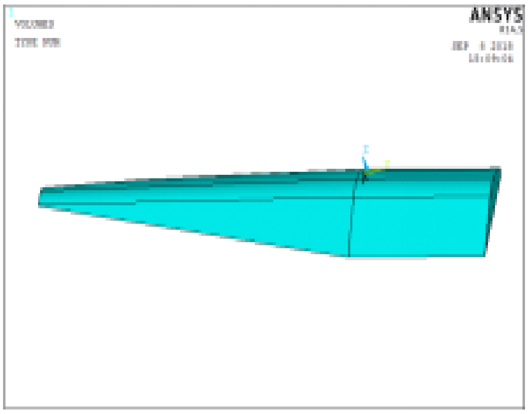

Fig.6.9 Imported military aircraft wing in Ansys

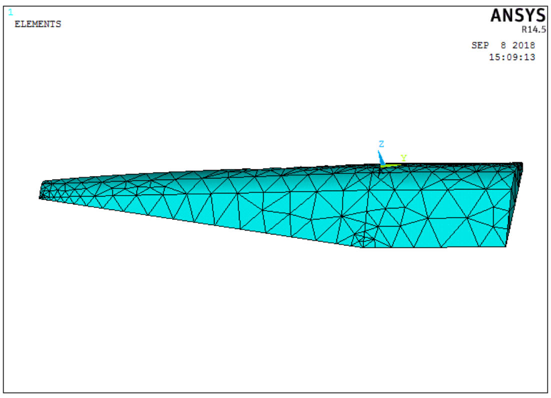

Fig.6.10 Created mesh on military aircraft wing in Ansys

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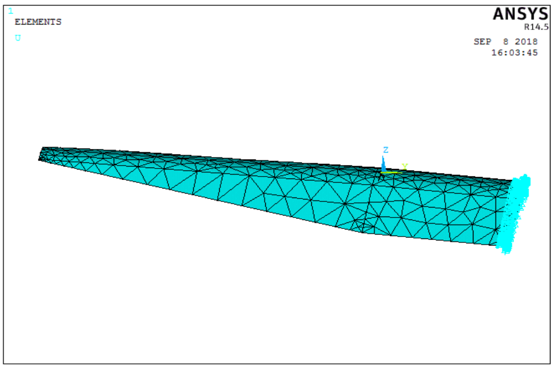

Fig.6.11 Applied fixed condition on military aircraft wing in Ansys

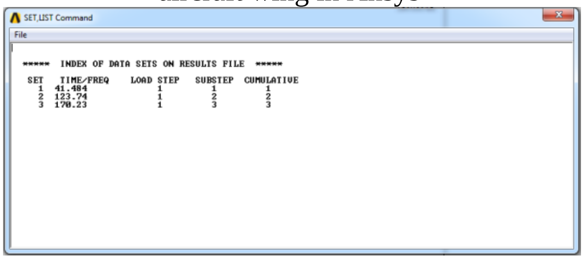
SET_LIST Command

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Fig.6.12 Natural frequency results of military aircraft wing in Ansys

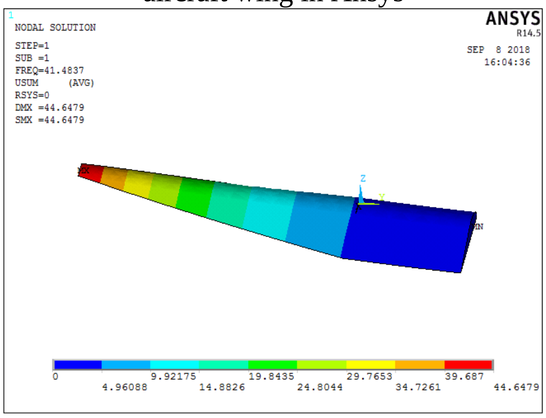

Fig.6.13 Mode shape 1 results of military aircraft wing (Displacement at 1st frequency)

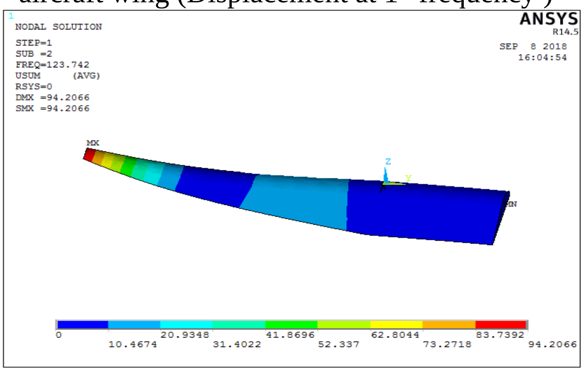

Fig.6.14 Mode shape 2 results of military aircraft wing (Displacement at 2nd frequency)

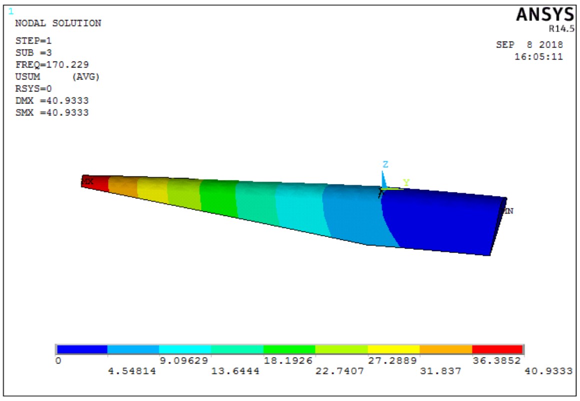

Fig.6.15 Mode shape 3 results of military aircraft wing (Displacement at 3rd frequency)

STATIC AND VIBRATION (DYNAMIC) ANALYSIS OF MILITARY AIRCRAFT WING USING KEVLAR/EPOXY

Static investigation of military air ship wing
Longitudinal Modulus (Ex): 79.2 GPa
Transverse Modulus (EY): 7.25 GPa
Shear modulus (Gxy): 4.25 GPa
Shear modulus (Gyz): 4.25 GPa
Shear modulus (Gxz): 4.25 GPa
Poisson's Ratio: 0.34
Density: 1384 Kg/m3
Limit condition:
Streamlined lift constrain (5KN) is follow up on surface of wing when flying machine move to upward. What's more, side surface is darting with airplane body.

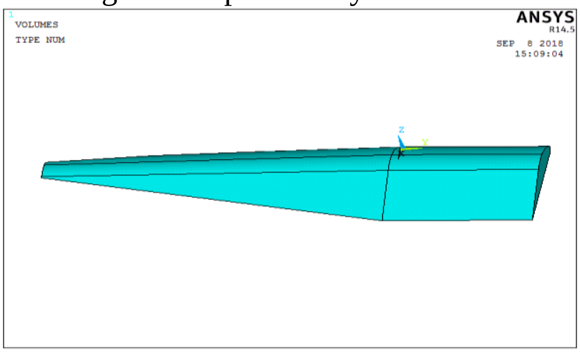

Fig.7.1 Imported military aircraft wing in Ansys

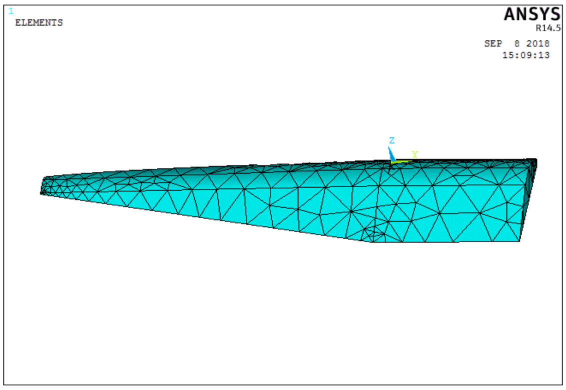

Fig.7.2 Created mesh on military aircraft wing in Ansys

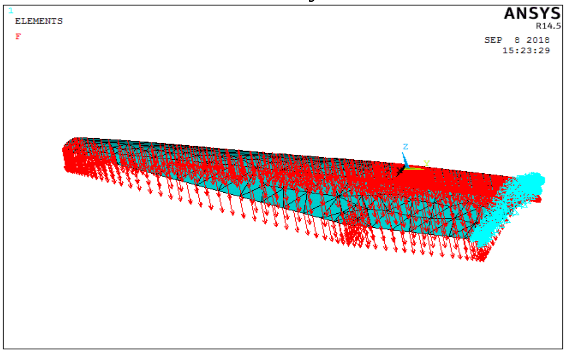

Fig.7.3 Applied loads on military aircraft wing

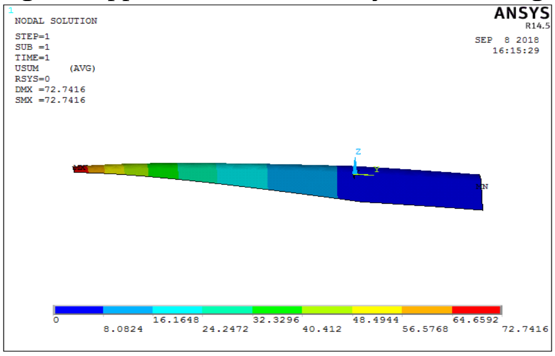

Fig.7.4 Deformation results of military aircraft wing

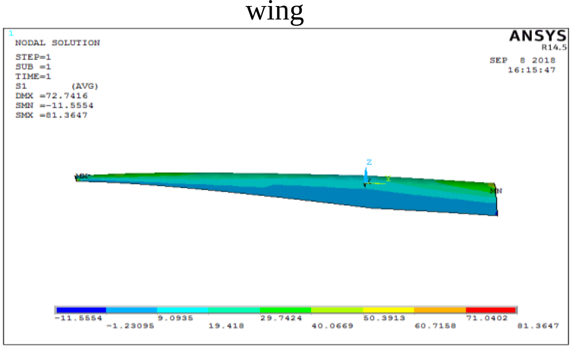

Fig.7.7 1st Principle stress results of military aircraft wing

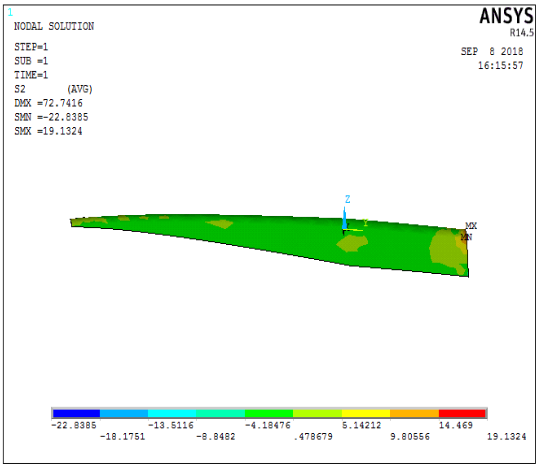

Fig.7.8 2nd Principle stress results of military aircraft wing

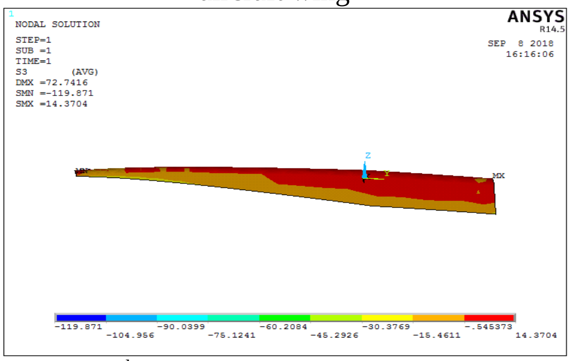

Fig.7.9 3rd Principle stress results of military aircraft wing

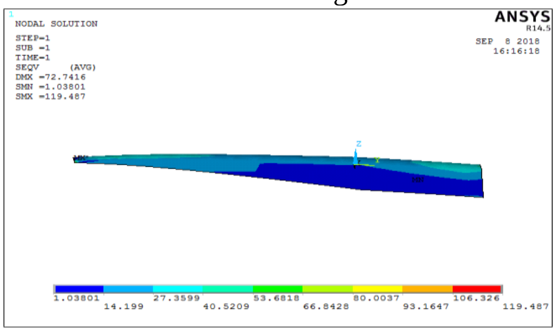

Fig.7.10 Von misses stress results of military aircraft wing

Modal analysis of military aircraft wing

Boundary condition:

Side surface is bolting with aircraft body.

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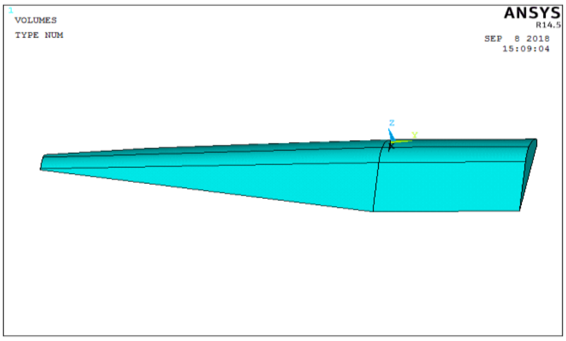

Fig.7.11 Imported military aircraft wing in Ansys

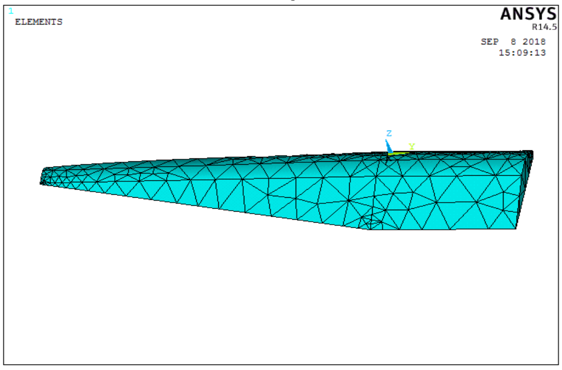

Fig.7.12 Created mesh on military aircraft wing in Ansys

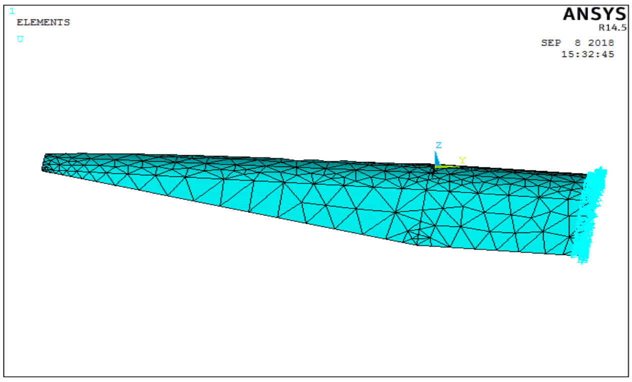

Fig.7.13 Applied fixed condition on military aircraft wing

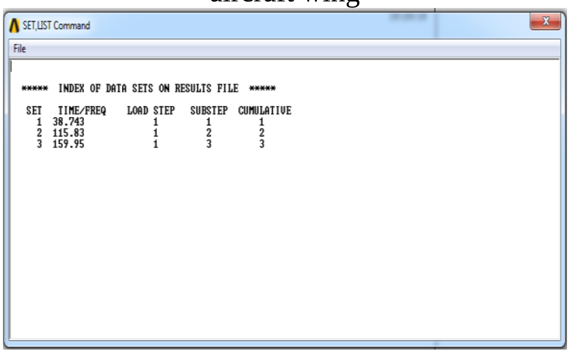

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Fig.7.14 Natural frequency results of military aircraft wing in Ansys

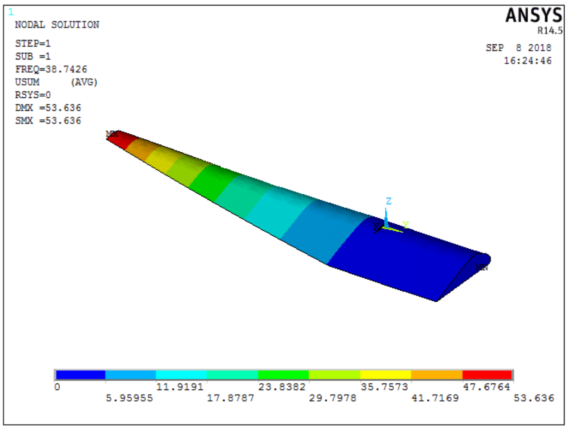

Fig.7.15 Mode shape 1 results of military aircraft wing (Displacement at 1st frequency)

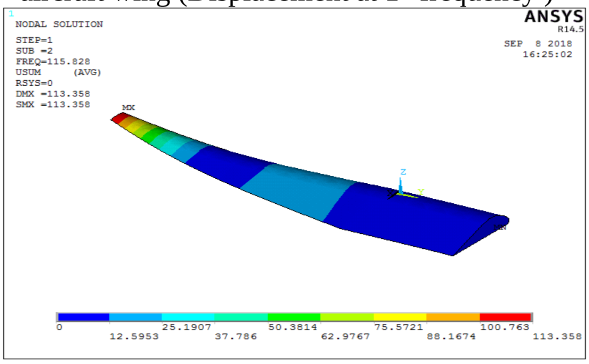

Fig.7.16 Mode shape2 results of military aircraft wing (Displacement at 2nd frequency)

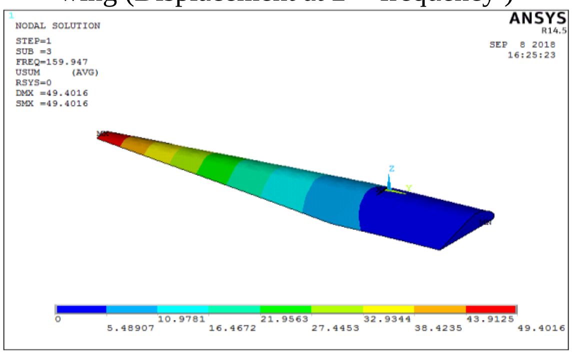

Fig.7.17 Mode shape3 results of military aircraft wing (Displacement at 3rd frequency)

RESULTS AND CONCLUSION

In this undertaking, light weight military aircraft wing is produced with composite materials. Likewise characteristic frequency results (free vibrations) of military aircraft wing are computed. Exact plan of military aircraft wing is finished utilizing Unigraphics programming and auxiliary static and Modal examination of military aircraft wing is finished by Ansys FEA programming. Both static and modular investigation of aircraft wing is finished with various composite materials. Also, results are given below

Result's Type	Using Aluminium alloy 2024	Using Composite E-Glass/ Epoxy	Using Composite Kevlar/Epoxy
Deformation (mm)	7.24	51.87	72.74
Von misses Stress (MPa)	61.33	112.8	119.48
Yield strength (MPa)	427	800	900
Safe condition	Safe	Safe	Safe
Frequency range (Hz)	87 - 353	41 - 178	38 - 159

Conclusion

Comparing analysis results of military aircraft wing using mentioned materials, All materials should become safe condition at mentioned aerodynamic loading condition because of formed von misses stress results are less that those yield strength results. But military aircraft wing using Kevlar/ Epoxy material form less noise at working condition because less frequency range found in modal analysis. So Kevlar/Epoxy material is a best one for manufacturing of aircraft wing.

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