Design And Analysis of Aircraft Wing

[1]Prabhat Dixit, [2]Vivek Rathod, [3]Chetan Deshmukh, [4]Piyush Patil

[1,2,3,4]Department of Aerospace Engineering, Sandip University, Nashik, Maharashtra, India

Abstract- This research develops and analyses a general aviation plane. A preliminary representation of the eventual product is used to start the design process for an airplane. Based on a drawing, a design mission profile is utilized to determine the weight. A more advanced approach is used to estimate weight, which employs calculated performance criteria to produce a more exact weight estimate. The wing design has been demonstrated to be a feasible alternative for a similar general aviation aircraft. When traveling through air or other fluids, a wing is a type of fin that provides lift. Airfoils may be observed on the wings, which have a streamlined cross-section, as a result of this. The lift created by a wing is compared to the drag generated by it to determine its aerodynamic efficiency. At any given speed and attack angle, an airplane's lift-to-drag ratio can be up to two orders of magnitude greater than its overall drag. To fly at a high lift level, wings with a high lift-to-drag ratio require less power.

Keywords: Airfoil, Aerodynamics, Aircraft Design, Structural analysis.

I. Introduction

Performance and operational considerations, flying characteristics and handling, structural design, and general layout design aspects are all basic requirements for wing design.

The best wing loading conditions for long-range aircraft are calculated and compared to low-speed performance requirements, available tank volume, and buffet tolerances for high-speed aircraft. The knowledge on stall handling requirements, airfoil section stall characteristics, and stall advancement can help all conventional wing designs. Low-speed and high-subsonic aircraft have significantly different planform shapes and airfoil section designs. To achieve a certain high-speed Mach number, wing sweep and thickness ratio combinations must be identified using an approximation approach based on key Mach number specifications. Aircraft with sweeping wings are better suited to deal with low-speed difficulties. After a review of high-lift technologies, recommendations are made for ailerons and spoilers, as well as wing/fuselage incidence and structural design difficulties.

II. Design and Construction

The airfoils of an airplane's wings produce lift when they move through the air at high speeds. These items can come in a variety of shapes and sizes. The wing design can be changed to obtain certain flying characteristics. The lift generated, as well as balance and stability, are totally within the control of the operator at various operating speeds. The wings of an aircraft are designed to lift it into the air. A glider's design is based on a number of factors, including the plane's size, weight, intended function, desired flying and landing speeds, and desired rate of ascension. The plane's left and right wings correspond to the operator's left and right sides while seated.

The wings of a plane can be attached to the fuselage in three places: at the top, in the centre, or at the bottom. They might run parallel to the fuselage's horizontal plane, or somewhat above or below it. It changes shape when the wing changes. The leading and trailing edges of a wing might be straight or curved, or a straight leading edge and a curved following edge. One or both of the wing's edges can be tapered, depending on the arrangement, to minimize the total width at the root. The wingtip might be square, round, or even pointed in shape. Figure 1 shows a range of conventional wingtip leading and trailing edge morphologies.

Wings are most commonly composed of aluminum, although they can also be built of wood and covered in fabric, or even of a magnesium alloy. In addition, modern airplanes' airframes and wing structures are made of lighter and stronger materials. Wings can be built of carbon fiber or other composite materials, as well as a combination of materials, for maximum strength to weight performance.

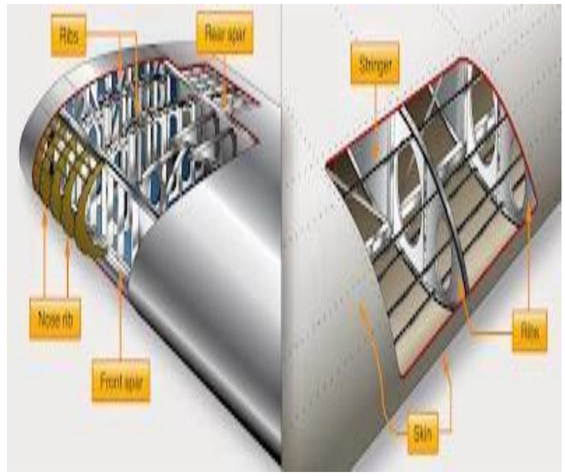
III. Structure of Wings

The wings of an aircraft are designed to lift it into the air. Their particular design for any given aircraft depends on a number of factors, such as size, weight, use of the aircraft, desired speed in flight and at landing, and desired rate of climb. The wings of aircraft are designated left and right, corresponding to the left and right sides of the operator when seated in the cockpit.

Often wings are of full cantilever design. This means they are built so that no external bracing is needed. They are supported internally by structural members assisted by the skin of the aircraft. Other aircraft wings use external struts or wires to assist in supporting the wing and carrying the aerodynamic and landing loads. Wing support cables and struts are generally made from steel. Many struts and their attach fittings have fairings to reduce drag. Short, nearly vertical supports called jury struts are found on struts that attach to the wings a great distance from the fuselage. This serves to subdues movement and oscillation caused by the air flowing around the strut in flight. Figure 4 shows samples of wings using external bracing, also known as semi cantilever wings. Cantilever wings built with no external bracing are also shown.

The internal structures of most wings are made up of spars and stringers running spanwise and ribs and formers or bulkheads running Chord wing (leading edge to trailing edge).

They support all distributed loads, as well as concentrated weights such as the fuselage, landing gear, and engines. The skin, which is attached to the wing structure, carries part of the loads imposed during flight. It also transfers the stresses to the wing ribs. The ribs, in turn, transfer the loads to the wing spars



IV. Wings Component

An aircraft's wings are critical to flight through the production of lift, but they have many parts of the wing to control this lift amount and direction.

- **Ailerons**

  Ailerons are one of the three primary control surfaces that control a plane (along with the Elevator and Rudder) and are located on the trailing edge of the wing to help control the roll of a plane. When a pilot turns to the left in the cockpit, the left aileron goes up, reducing lift on that side, and the right aileron goes down, increasing lift causing that side to rise. This causes the plane to roll to the left and begin a turn.

- **Flaps**

  Flaps, like ailerons, are located on the trailing edge of the wing. Unlike ailerons, the flaps move symmetrically on each side and create more lift and drag. Flaps are typically used during takeoff and landing, when aircraft speeds are lower, to create additional lift and reduce stall speeds.

- **Winglet**

The tip of an airplane's wing is curled upward. What you're looking at is a winglet. Winglets were created to reduce induced drag.' Slats Slats, which are similar to flaps but are affixed to the leading edge of the wing, change the shape of the wing to enhance lift temporarily.

Spoilers are deployed as the plane descends and the lift component of an airfoil is diminished. The plane may now fall and lose height without stalling instead of increasing speed.

- **Slats**

Slats are similar to flaps, only located at the front of the wing (a leading-edge device) and change a wing's shape temporarily to increase lift.

- **Spoilers**

Spoilers are used to help the aircraft descend and reduces the lift component of an airfoil. This allows the plane to descend and lose altitude without gaining airspeed.

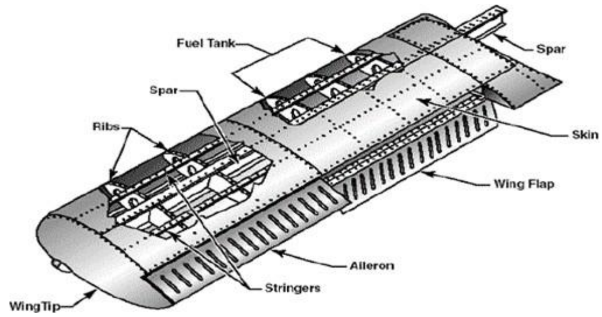
- **Ribs**

The ribs are structural crosspieces that join the spars and stringers to form the wing's structure. They are frequent from the leading edge of the wing to the rear spar or the trailing edge of the wing. The ribs give wings their cambered look due to their cambered shape and act as load-transmitters.

STRIDER LONGITUDINAL In a longitudinal direction, a stringer runs the length of an airplane's fuselage or the span of a wing. Several components are required to transmit loads and stresses from the aircraft's exterior skin to the formers.

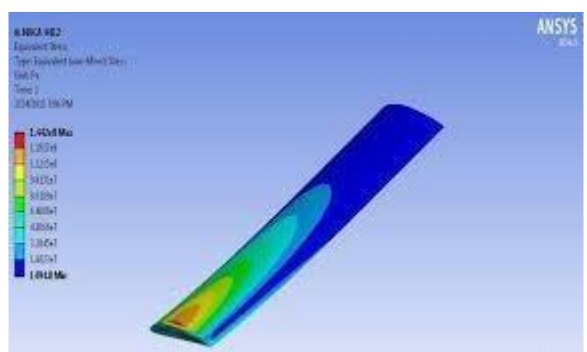
- **Stringers**

Stringers, sometimes confused with, or referred to interchangeably as longerons, **run lengthwise (longitudinally) along an airplane's fuselage or span wise of a wing**. Their purpose is to serve as structural components that transfer loads

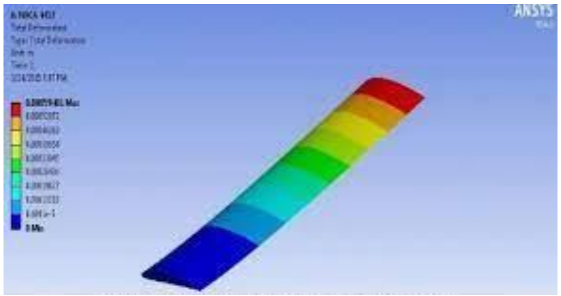


V. STURTURAL ANALYSIS OF WINGS

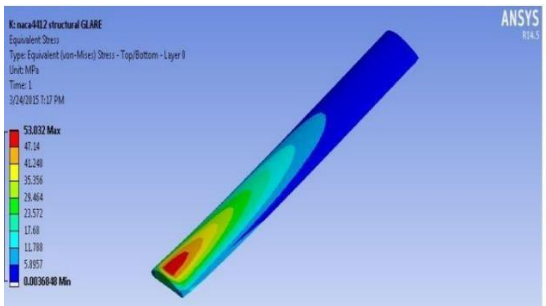
Structural analysis of Aircraft wing AA 7075: A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads. A static analysis can, however. Include steady inertia loads (such as gravity and rotational velocity), and time varying loads that can be approximated as static equivalent loads. Static analysis determines the displacements, stresses, strains and forces in structures and components caused by loads that do not induce significant inertia and damping effect. Steady loading and response conditions are assumed; that is, the loads and structures response are assumed to vary slowly with respect to time



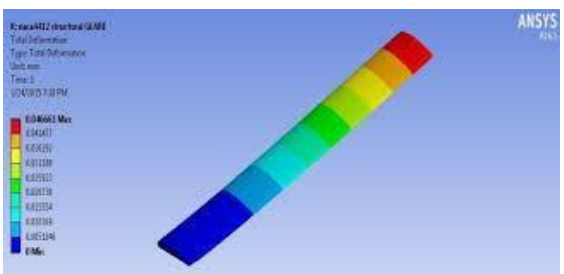
Von-mises stress of AA7075



Structural analysis of composite aircraft wing



von-mises stress of composite aircraft wing



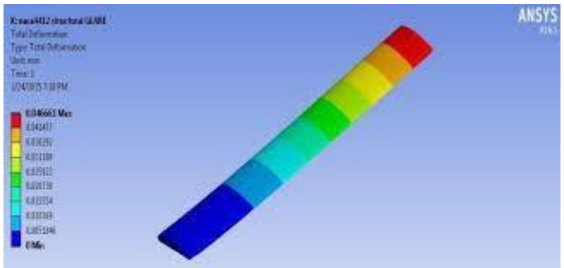
Total deformation of composite aircraft wing

VI. MODAL ANALYSIS OF AIRCRAFT WING

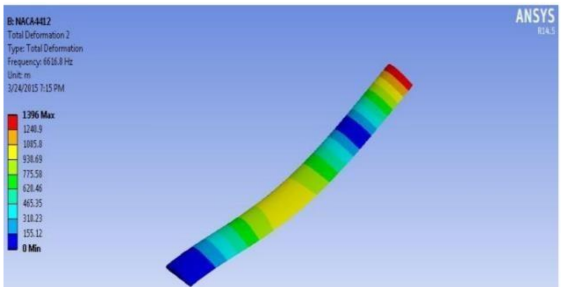
The structural integrity of the AA 7075 aeroplane wing was investigated. Static studies can only describe the effects of constant loading since they disregard inertia and damping effects, such as those caused by time-varying loads. A static analysis, on the other hand, is possible. Time-varying loads that may be approximated as a static equivalent load (such as gravity and rotational velocity) should be included in the calculations. Static analysis, which evaluates displacements, stresses, strains, and forces in structures and components, may be used to loads that do not generate significant inertia or damping effect. Expected stable loading and response conditions, in which loads and structures' reactions are expected to change little over time.

With AA7075, we achieved 0.59mm and just 0.046mm with the composite material. Because of the usage of the composite material GLARE, the deflection of an airplane wing was minimized. The dynamic pressure on the leading edge diminishes as the angle of attack rises, according to fluent analysis. Static pressure on the bottom surface increases as the angle of attack increases, according to the fluency study. We may conclude that as the angle of attack is increased, static pressure rises as well. Dynamic pressure on the lower surface reduces as the angle of attack increases, whereas static pressure on the lower surface increases. As a consequence, we've concluded that increasing the attack angle increases dynamic pressure. The dynamic pressure is at its maximum peak, and the static pressure is at its lowest point in this posture. The airfoil's stagnation point is likewise at the leading edge of the airfoil, as we've discovered. Stagnation points have moved farther from the trend's leading edge. When a result, as the attack angle rises, the stagnation point on the bottom surface of the airfoil moves further away from the leading edge. The fluency examination of the NACA 4412 airfoil reveals that the upper surface of the NACA 4412 airfoil has a negative pressure coefficient of 0. When the angle of attack is increased, the pressure on the top surface decreases while the pressure on the bottom surface increases, reaching a maximum at 8 degrees.

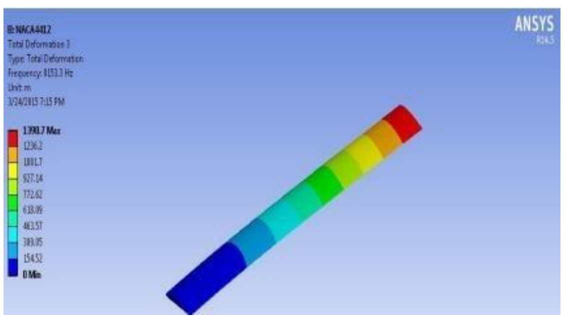
Results



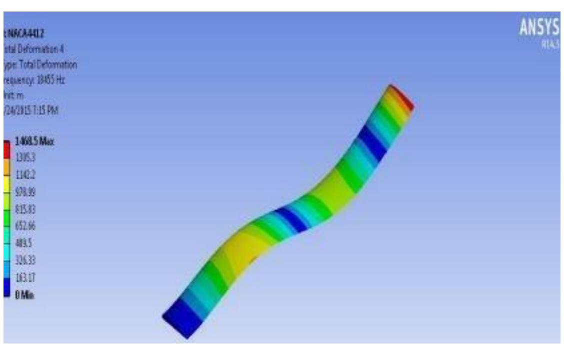
1st Mode



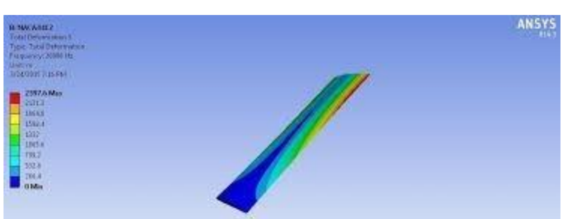
2nd Mode



3rd Mode



4th Mode



5th Mode

VII. CONCLUSION

The computational design and analysis of a wing-box structure were carried out to establish its level of strength as well as its resistance to resonance. In this section, we will discuss the findings and draw a conclusion based on those findings. The model of the aircraft wing is simulated with the help of a CFD tool as part of the modal analysis system. Both the meshing and the boundary conditions of the model are correct. The result of using a technique known as the theoretical approach technique and numerical modal analysis on a cantilever beam. According to this research, the natural frequencies obtained from the numerical method are virtually the same, which validates the FE model of the cantilever beam used for modal analysis. The outcomes of the valid modal analysis performed on the cantilever beam indicate that the methodology utilized for the numerical modal analysis performed on the aircraft wing in accordance with theliterature was appropriate.

REFERENCES

[1]. Nilesh K. Kharate, Dr. Sharad S. Chaudhari "Investigation of Natural Frequency and Modal Analysis of Brake Rotor Using Fea and Ema" ISSN: 2319-8753 Vol. 3, Issue 10 (October 2014)

[2]. J. A de Bruyn, A.S. Jonker "Modal Analysis of a Complete 18m-class Sailplane" (Jan-2013)

[3]. Pavol Lengvarsky, Jozef Bocko, Martin Hagara "Modal Analysis of Titan Cantilever Beam Using ANSYS and SolidWorks" American Journal of Mechanical Engineering, Vol. 1, No. 7, 271- 275(Nov-2013)

[4]. A. Ramesh Kumar, S. R. Balakrishnan, S. Balaji "Design of an Aircraft Wing Structure for Static Analysis and Fatigue Life Prediction" ISSN: 2278-0181 Vol. 2 Issue 5, (May -2013)

[5]. Dr. R. Rajappan, V. Pugazhenthi "Finite Element Analysis of Aircraft Wing Using Composite Structure" ISSN: 2319 – 1813 ISBN: 2319 – 1805 (Feb-2013)

[6]. G. R. Nikhade "Modal Analysis of Body in White" ISSN (Online) 2347-3207 (june-2014)

[7]. Zoran Vulovic "Modal Parameters of Light Aircraft Wing" AIAC-11 Eleventh Australian International Aerospace Congress

[8]. Pritish Chitte, P. K. Jadhav, S. S. Bansode "Statistic and Dynamic Analysis of Typical Wing Structure of Aircraft using Nastran" ISSN 2319 - 4847 Volume 2, Issue 7, (Jul-2013)

[9]. Imran Ahmad Khan, G. K. Awari "The Analysis of Vibrational Response of Structures with Uncertain Parameters" ISSN: 2231 – 6604
Volume 6, Issue 1 (Aug-2013)