

# Design and Analysis of Aircraft Truss Using ANSYS

K. S. ANIL MANIKANTA<sup>1</sup>, B. SRINIVASA RAO<sup>2</sup>

<sup>1</sup>PG Student, Newton's Institute of Science and Technology

<sup>2</sup>Assistant Professor, Newton's Institute of Science and Technology

**Abstract**—This paper deals with the reduction of weight ratio in the wing structure improves the efficiency and performance of an aircraft wing. Amongst all the aircraft parts reduction in the weight of the wing has got higher importance. Generally an aircraft wing structures are design using pure aluminium, but in this project composite material which is a combination of Aluminium LM25 (AL) and Silicon Carbide (SiC) where in aluminium is the base metal and silicon carbide is reinforcement is used to reduce the weight ratio of the wing structure. By varying silicon carbide percentages in aluminium25 four types of specimens are prepared using stir casting process. The young's modulus, Poisson's ratio and density of each specimen are determined experimentally by subjecting the specimen to compression test, hardness test and tensile test. By comparing the material properties obtained experimentally optimum percentage of silicon carbide in aluminium is determined. A suitable wing profile NACA 4412 is selected and modelled in CATIAV5 R20. The generated wing profile is imported to ANSYS WORKBENCH. Static structural analysis is carried out in ANSYS by inputting the properties of the optimum specimen which are obtained experimentally. Similarly by in putting pure AL25 properties. The results obtained from ANSYS for pure AL25 and metal matrix composite (SiC) are compared. By comparing the results it is found that composite material has better material properties and stresses than pure aluminium. **Keywords** - Aircraft wing, Aluminium alloy (LM25), Silicon Carbide(SiC), stir casting, CATIA, ANSYS workbench.

**Indexed Terms**—irfoil, NACA 2412, analysis of airfoil, design of airfoil, 3D analysis of airfoil, four digit airfoil, angle of attacks etc.

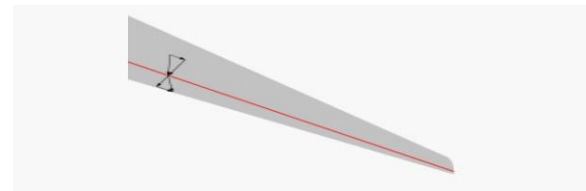
## I. INTRODUCTION

- Early history

Early aircraft adhered to the basic design of square wings at right angles to the body of the machine, but there were experimentalists who explored other geometries to achieve better aerodynamic results. The swept wing geometry appeared before World War I, and was conceived as a means of permitting the design of safe, stable, and tailless flying wings. It imposed

"self-damping" inherent stability upon the flying wing, and, as a result, many flying wing gliders and some powered aircraft appeared in the interwar years. One of the earliest swept wing designs was used by José Weiss to construct a swept-wing tail-less glider in 1908 in England. He followed this up with a version powered by an Anzani engine driving two propellers.

- Subsonic and transonic behaviour

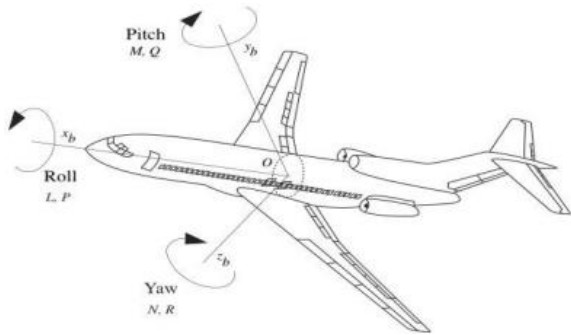


As an aircraft enters the transonic speeds just below the speed of sound, the pressure waves associated with subsonic flight converge and begin to impinge on the aircraft. As the pressure waves converge the air in front of the aircraft begins to compress. This creates a force known as wave drag. This wave drag increases steeply until the whole aircraft is supersonic and then reduces.

- Supersonic behaviour

Airflow at supersonic speeds generates lift through the formation of shock waves, as opposed to the patterns of airflow over and under the wing. These shock waves, as in the transonic case, generate large amounts of drag. One of these shock waves is created by the leading edge of the wing, but contributes little to the lift. In order to minimize the strength of this shock it needs to remain "attached" to the front of the wing, which demands a very sharp leading edge. To better shape the shocks that will contribute to lift, the rest of an ideal supersonic air foil is roughly diamond-shaped in cross-section. For low-speed lift these same air foils are very inefficient, leading to poor handling and very high landing speeds.

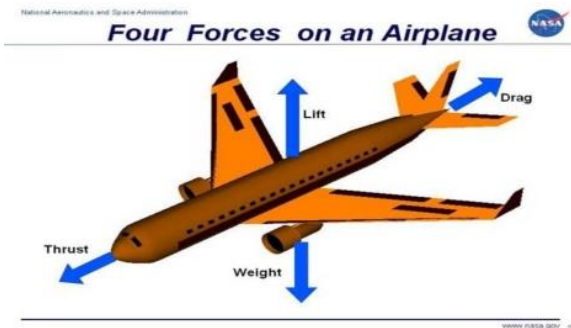
• Angular movements of an aeroplane



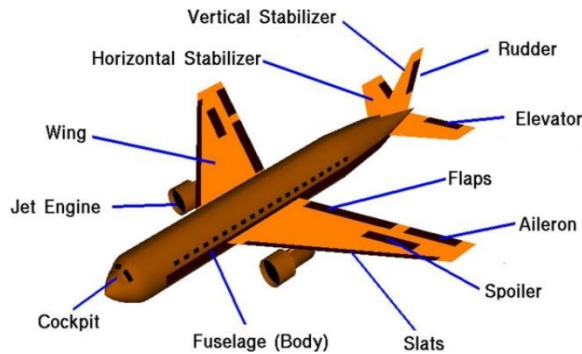
There are three different angular motions that makes an aeroplane to move in different directions.

1. Yaw - This movement is generally managed by the wing at the rear end to guide the plane to move towards left or right.
2. Pitch – This angular motion is generally carried out by elevators, aileron and flaps to make the plane move up and down.
3. Roll – Both the front wings help in making the plane to rotate in a circular path.

• Forces on an Aeroplane



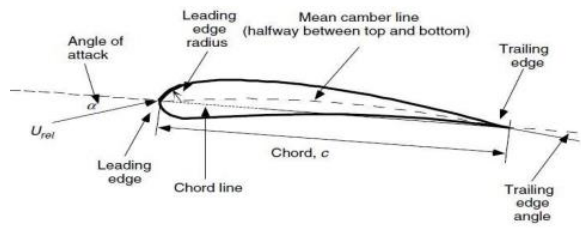
• Parts of an Aeroplane



1	Wing	Generate lift to hold airplane in air.
2	Jet Engine	Generate thrust to overcome the drag and to move in forward direction
3	Cockpit	Pilot sit here to control and command the plane.
4	Fuselage (Body)	Holds all parts together
5	Slats	To increase airplane lift during take-off and landing
6	Spoiler	To reduce plane speed
7	Aileron	Roll the wings side ward direction
8	Flaps	Increase lift and drag of airplane during take-off and landing
9	Elevator	Deflect the tail of the airplane up and down motion
10	Rudder	Deflect the tail direction to the left and right side
11	Vertical Stabilizer	To maintain the balance of the airplane from swinging side ward directions
12	Horizontal Stabilizer	To maintain the balance of the airplane from moving up-and-down

• AirFoil

Airfoils are structures with specific geometric shapes that are used to generate mechanical forces due to the relative motion of the Airfoil and a surrounding fluid. Wind turbine blades use Airfoils to develop mechanical power. The cross-sections of wind turbine blades have the shape of Air foils. The width and length of the blade are functions of the desired aerodynamic Performance, the maximum desired rotor power, the assumed Airfoil properties, and strength considerations.



• Angle of attack

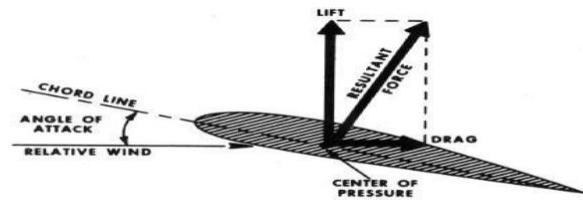


Figure 17-8 Force Vectors on an Airfoil

In fluid dynamics, angle of attack (AOA, or  $\alpha$  Greek letter alpha) is the angle between a reference line on a body (often the chord line of an airfoil) and the vector representing the relative motion between the body and the fluid through which it is moving. Angle of attack is the angle between the body's reference line and the oncoming flow. This article focuses on the most

common application, the angle of attack of a wing or airfoil moving through air.

## II. NACA FOUR DIGIT SERIES

The NACA four-digit wing sections define the profile by:

1. First digit describing maximum camber as percentage of the chord.
2. Second digit describing the distance of maximum camber from the airfoil leading edge in tens of percent of the chord.
3. Last two digits describing maximum thickness of the airfoil as percent of the chord.

NACA 2412 is the airfoil of NACA 4 digit series. From its designation we get the NACA 2412 airfoil has a maximum camber of 2% located 40% (0.4 chords) from the leading edge with a maximum thickness of 12% of the chord. Four-digit series airfoils by default have maximum thickness at 30% of the chord (0.3 chords) from the leading edge. NACA 2412 is slow speed airfoil; this airfoil is used in single engine Cessna 152, 172 and 182 airplanes.

## III. CAD & CAM

- CAD (Computer Aided Design)

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

Its use in designing electronic systems is known as electronic design automation, or EDA. In mechanical design it is known as mechanical design automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software.

CAD software for mechanical design uses either vector-based graphics to depict the objects of

traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

The design of geometric models for object shapes, in particular, is occasionally called computer-aided geometric design (CAGD).

## IV. DESIGN METHODOLOGY

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the CAD/CAM/CAE market with Siemens NX, Pro/E, Autodesk Inventor, and Solid Edge as well as many others.

- SCOPE OF APPLICATION

Ordinarily alluded to as 3D Product Lifecycle Management programming suite, CATIA underpins

numerous phases of item improvement (from conceptualization, plan (CAD), fabricating (CAM), and building (CAE). CATIA encourages community oriented building crosswise over disciplines, including surfacing and shape outline, mechanical designing, gear and frameworks engineering. Commonly alluded to as 3D Product Lifecycle Management programming suite, CATIA bolsters different phases of item advancement (from conceptualization, plan (CAD), fabricating (CAM), and designing (CAE). CATIA encourages community oriented building crosswise over disciplines, including surfacing and shape outline, mechanical designing, gear and frameworks designing.

- Aerospace

The Boeing Company utilized CATIA V3 to create its 777 carrier, and is as of now utilizing CATIA V5 for the 787 arrangement airplane. They have utilized the full scope of Dassault Systems' 3D PLM items — CATIA, DELMIA, and ENOVIALCA — supplemented by Boeing created applications.

The advancement of the Indian Light Combat Aircraft has been utilizing CATIA V5.

Chinese Xian JH-7 An is the principal airplane created by CATIA V5, when the plan was finished on September 26, 2000.

European aviation monster Airbus has been utilizing CATIA since 2001.

Canadian air ship producer Bombardier Aerospace has done the greater part of its airplane outline on CATIA.

- The Brazilian flying machine organization, EMBRAER, utilize Catia V4 and V5 to fabricate all planes.
- Vought Aircraft Industries utilize CATIA V4 and V5 to create its parts.
- The British Helicopter organization, Westland, utilize CATIA V4 and V5 to deliver all their flying machine. Westland is currently part of an Italian organization called Finmeccanica the joined organization calls themselves Agusta Westland.

- Automotive

Numerous automotive organizations utilize CATIA to changing degrees, including BMW, Porsche, Daimler AG, Chrysler, Honda, Audi, Jaguar Land Rover Volkswagen, Bentley Motors Limited, Volvo, Fiat, Benteler AG, PSA Peugeot Citroën, Renault,

Toyota, Ford, Scania, Hyundai, Skoda Auto, Tesla Motors, Valmet Automotive, Proton, Tata engines and Mahindra and Mahindra Limited.

Goodyear utilizes it in making tires for car and aviation and furthermore utilizes a tweaked CATIA for its plan and advancement. Numerous car organizations utilize CATIA for car structures — entryway pillars, IP bolsters, guard bars, rooftop rails, side rails, body parts — in light of the fact that CATIA is great in surface creation and Computer portrayal of surfaces. Bombardier Transportation, Canada is utilizing CATIA programming to outline its whole armada of Train motors, Coaches.

- Ship building

Dassault Systems has started serving shipbuilders with CATIA V5 discharge 8, which incorporates uncommon components valuable to shipbuilders. GD Electric Boat utilized CATIA to plan the most recent quick assault submarine class for the United States Navy, the Virginia class. Northrop Grumman Newport News additionally utilized CATIA to plan the Gerald R. Portage class of super carriers for the US Navy.

## V. ANSYS

ANSYS, Inc. is an American Computer-aided engineering software developer headquartered south of Pittsburgh in Cecil Township, Pennsylvania, United States. ANSYS publishes engineering analysis software across a range of disciplines including finite element analysis, structural analysis, computational fluid dynamics, explicit and implicit methods, and heat transfer.

- Structural Analysis

ANSYS Autodyn

ANSYS Autodyn is computer simulation tool for simulating the response of materials to short duration severe loadings from impact, high pressure or explosions.

- ANSYS Mechanical

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behaviour,

and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled- physics capabilities involving acoustics, piezoelectric, thermal-structural and thermo-electric analysis.

- Fluid Dynamics

ANSYS Fluent, CFD, CFX, FENSAP-ICE

ANSYS Fluent, CFD, CFX, FENSAP-ICE and related software are Computational Fluid Dynamics software tools used by engineers for design and analysis. These tools can simulate fluid flows in a virtual environment — for example, the fluid dynamics of ship hulls; gas turbine engines (including the compressors, combustion chamber, turbines and afterburners); aircraft aerodynamics; pumps, fans, HVAC systems, mixing vessels, hydrocyclones, vacuum cleaners, etc.

- Electronics

ANSYS HFSS

ANSYS HFSS is a Finite Element Analysis tool for simulating full-wave electromagnetic fields. HFSS incorporates finite element, integral equation, and hybrid methods to solve a wide range of microwave, RF and high-speed digital applications.

ANSYS Maxwell

ANSYS Maxwell is a Finite Element Analysis tool for electromagnetic field simulation, primarily for engineers tasked with designing and analysing electromagnetic and electromechanical devices, including motors, actuators, transformers, sensors and coils. ANSYS Maxwell incorporates finite element method solvers to solve static, frequency-domain, and time-varying electromagnetic and electric fields.

ANSYS SIwave

ANSYS SIwave is a specialized design platform for power integrity,

## VI. CONCLUSION

In this project we have designed NACA 2412 swept back wings with 3D CAD model i.e. NX 11. After designing we did analysis with CAE software i.e. ANSYS with the three different material's those are

POLYURETHANE, ALUMINIUM CARBIDE and ALUMINIUM

MAGNESIUM. After analysing we compared all the three material's and we studied that Aluminium carbide having less deformation as well as less equivalent stress as compare to rest of material (i.e. Polyurethane and Aluminium magnesium ) then finally we conclude that the aluminium carbide is better than the rest of the materials for this model.

## REFERENCES

- [1] <http://airfoiltools.com/airfoil/details?airfoil=naca2412-il>.
- [2] <http://adg.stanford.edu/aa241/wingdesign/winggeometry.html>
- [3] <http://www.boldmethod.com/learn-to-fly/aerodynamics/wing-sweep/>
- [4] <http://www.dept.aoe.vt.edu/~lutze/AOE3104/clipboard.pdf>
- [5] Aerodynamics By-J.D.Anderson