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CFD ANALYSIS OF A BLENDED BODY AIRCRAFT

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ABSTRACT

Flying airplanes to high altitudes requires high lift, which can be achieved by better design, increased wingspan and reduced drag. Aircraft with BWB or Blended wing body suit the need to fly at high altitudes and have better stealth properties (avoiding RADAR detection) due to their triangular shape. This study is related to the investigation of a concept airplane by changing the design parameters using CFD software results. The mixed body aircraft CAD model is developed in Creo design software and CFD simulation is performed using ANSYS CFX. The values of aerodynamic force, lift force and pressure are determined for 2 aircraft with different taper ratios and different angles of attack. A low angle of attack angle of attack is found to be 180 and a high bank angle of attack if the angle of attack is found to be 150. Vortex formation was noted at the rear of the aircraft.

i. INTRODUCTION

An airplane is controlled by the forces acting on it. These forces are lift force, braking force, weight and thrust.
The wing profile affects the overall aerodynamics of the aircraft, see landing/takeoff, stall, and cruise speed Fig. 2: Airfoil camber is the curvature of the airfoil. "Mean camber line" is a line equidistant from the top and bottom surfaces. The overall airfoil is the maximum distance of the center deflection from the chord line, expressed as a percentage of the chord. The profile thickness distribution is the distance from the top surface to the bottom surface, measured perpendicular to the camber centerline, and is a function of the distance from the leading edge. "Airfoil Thickness Ratio" (tic) refers to the maximum airfoil thickness divided by its chord.

Lift is generated by the passage of different velocities of air above and below it. The angle of attack of the airfoil causes the wind to flow quickly over it and then under the airfoil. 5 Bernoulli's equation shows that higher speeds produce lower pressures, so the upper airfoil surface tends to be pulled up by lower-than-ambient pressures, while the lower airfoil surface tends to be pushed up by higher-than-ambient pressures. The pressure difference between the top and bottom of the airfoil generates the lifting force. Pressure distribution for the upper and lower surfaces of the airfoil at subsonic speeds.

The entire surface of the wing, both upper and lower, is affected by the air flow. The down force acts throughout the wing, which provides the lift of the wing. The arrows in the diagram show how lift forces might appear on a typical wing in normal level flight

Wing design parameter

Aircraft design includes various design parameters. For this study, our study will focus on the design of the delta wing of our aircraft while maintaining constant parameters of the other bodies of the aircraft.

Giant. 1: Wing design parameters

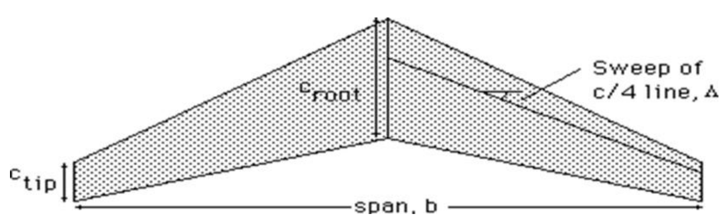


Fig 1: Wing Design Parameter

ii. LITERATURE REVIEW

Adam Kosík [1] presented CFD calculations with the help of ANSA and OpenFOAM. All results presented were generated to simulate fluid flow around a twin-engine turboprop EV-55 Outback. The main objectives were to control the aerodynamic characteristics of the aircraft. Flow simulations are obtained from the OpenFOAM package.

Zoran A. Stefanović [2] used a CFD code that is used for the analysis of new light aircraft in different phases of flight. Different calculations and methods for new light aircraft are developed for different flight phases and compares the results obtained by them to verify the results obtained from the simulations. Comparison of lift/drag forces was done for angle of attack at 0 0 and 300.

S. Rajiv Rao[3] worked on the vertical take-off and landing model of the V-22 Sprey tilt-rotor aircraft using CFD techniques. Studies have been conducted at various angles of attack from 0 to 20 degrees and the lift coefficient and drag coefficient are calculated for each angle of attack. The values of CL & Cd increase with the angle of attack up to 6 0, beyond which these coefficients change abruptly.

Abhishek Patil [4] calculated the 3D turbulent flow field over sharp-edged finials with rhomboidal planforms and a moderate pitch angle. The braking force and lift force were analyzed at different angles of attack of 0,4,8,12 degrees and the aerodynamic properties were predicted, viz. pressure distribution, skin fraction distribution, flow and Cl values of the biconvex delta wing cross section.

Karna S. Patel et al.[5] studied a CFD analysis of the flow over a NACA 0012 airfoil and concluded that no lift is produced at zero degree AOA. The magnitude of the aerodynamic force and the value of the drag coefficient are also increased, but the magnitude of the increment of the aerodynamic force and the drag coefficient is quite lower compared to the lift force.

Toshihiro Ikeda et al. [6], studied experimentally and numerically that the BWB configuration has better flight performance due to a higher lift-to-drag (L/D) ratio and could improve existing conventional aircraft in the areas of noise emissions, fuel consumption and Direct Operating Cost (DOC) per service. However, the BWB configuration must use a new structural system for passenger safety procedures such as passenger boarding/disembarking. The favorable results of the BWB design were that the drag of the parasite was reduced and the body with the span as a whole could generate lift.

Thomas A. Reist and David W. Zinggy et al. [7], numerically studied that an elliptical lift distribution is achieved on the wing, shocks are eliminated and large areas of highly separated flow on the base structure are greatly reduced. These drag reductions are achieved by trimming and stabilizing the basic design.

Luis Ayuso Moreno, Rodolfo Sant Palma and Luis Plágaro Pascual et al. [8], in an experimental and numerical study compared the performance and operational problems of the latest generation of conventional very large aircraft. The results are very encouraging and predict about a 20 percent increase in the efficiency of transportation productivity, without the burden of new or aggravated safety or operational problems.

Kai Lehmkuehler, KC Wong and Dries Verstraete et al. [9], experimentally studied that a design methodology using fast panel methods proved to be viable for an unusual configuration. Wind tunnel tests matched predicted data well and flight tests revealed good handling characteristics in flight. Some take-off and landing problems remain due to the limited stability of the aircraft and the presence of propulsion effects on longitudinal stability. Improved induced drag properties and remaining stability issues.

R. H. Liebeck et al. [10], studied 800-passenger BWB aircraft and conventional configurations were sized and compared for a design range of 7000 n mil. The results showed a remarkable 14 improvement in BWB performance over the conventional baseline, including a 15% reduction in takeoff weight

Harijono Djojodihardjo and Alvin Kek Leong Wei et al. [11], studied and concluded that aerodynamically, the BWB is much better than conventional aircraft as it has at least a 20% higher "lift-to-drag ratio" because a single body produces uniform lift and no other surfaces are attached to the body, reducing skin friction pulls considerably.

Akash Sharma, Tejas Alva et al. [12], numerically analyzed the flow over the surface of a 2-D Blended Wing Body for a given set of boundary conditions, and the obtained results safely meet the theoretical standards.

OUTCOMES FROM LITERATURE REVIEW

Flying airplanes to high altitudes requires high lift, which can be achieved by better design, increased wingspan and reduced drag. Airplanes with BWB or Blended wing body meet the need to fly at high altitudes and have better stealth characteristics (avoiding RADAR detection) due to their triangular shape.

The hypothesis proved to be correct as the drag force continued to increase and eventually the lift force began to decrease to zero. However, research has shown that the critical angle of attack should be about fifteen degrees

In general, the taper causes a reduction in drag (most effective at high speeds) and an increase in lift. There is also a design advantage due to the weight savings of the wing.

CAUSES OF LOW LOFT:

1 Due to the smaller wingspan

2. Reduce engine thrust.

3. Construction and shape of the wing.

4. Air density.

5. Air temperature.

6. Higher payload.

7. Due to poor choice of material.

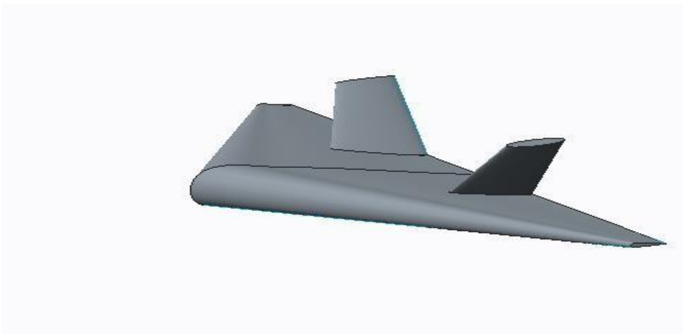
8. Corrosion and fatigue

iii. SCOPE OF PROJECT

This study is related to the research of the concept airplane according to the changing design parameters using CFD software the result
1. Concept aircraft modeling in Creo Software.
2. Aircraft analysis in ANSYS software.
3. Pressure graph using ANSYS software.
4. Determination of the graph of lift vs angle of attack.
5. Determination of the graph of resistance vs angle of attack.
6. Changing taper ratio
7. Study of vorticity

iv. CREO MODEL

We have design a creo model with two different taper ratios 0.125 and 0.4.



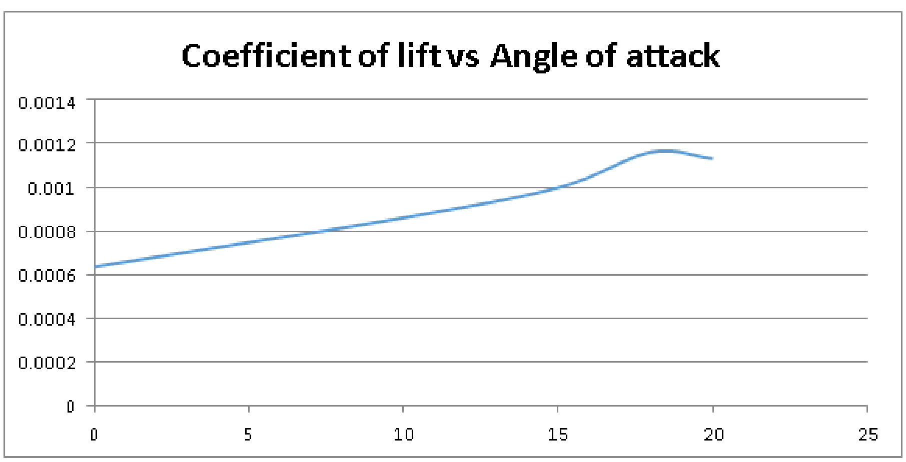
v. RESULT

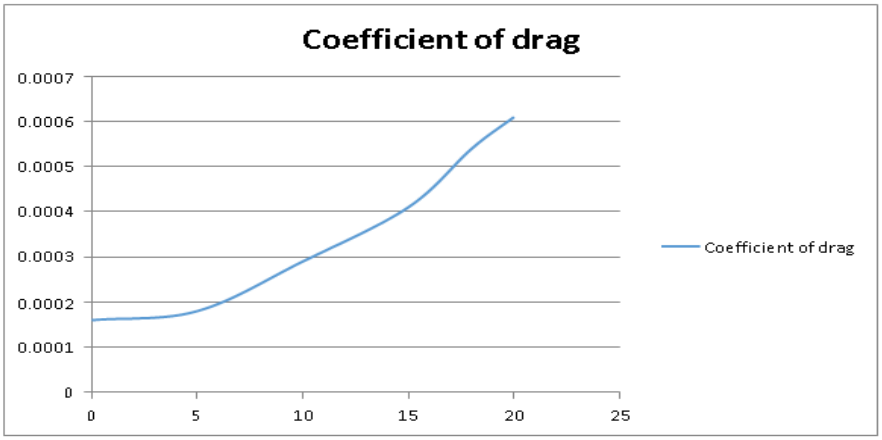
Analysis is performed for different taper ratios and pressure, lift force and drag force is computed. CL vs angle of attack and CD vs angle of attack is computed.

Calculation of CL

CASE 1: Taper ratio= .125

Angle of Attack	Pressure (Pa)	Drag Force (N)	Lift Force (N)	C_L	C_D
0^0	1836	3.932	14.73	.0006354	.00016
5^0	1843	4.37	17.32	.0007471	.00018
10^0	1821	6.73	19.93	.0008597	.00029
15^0	1876	10.47	23.12	.0009974	.00041
18^0	1947	12.73	26.89	.001160	.00054
20^0	1938	14.35	26.29	.0011303	.00061

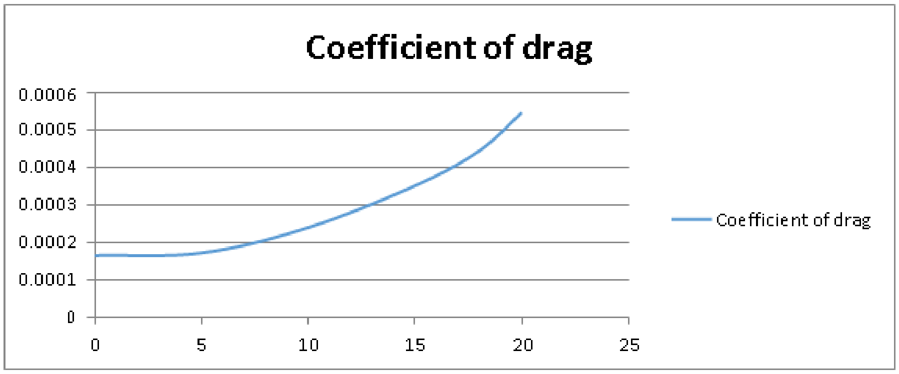


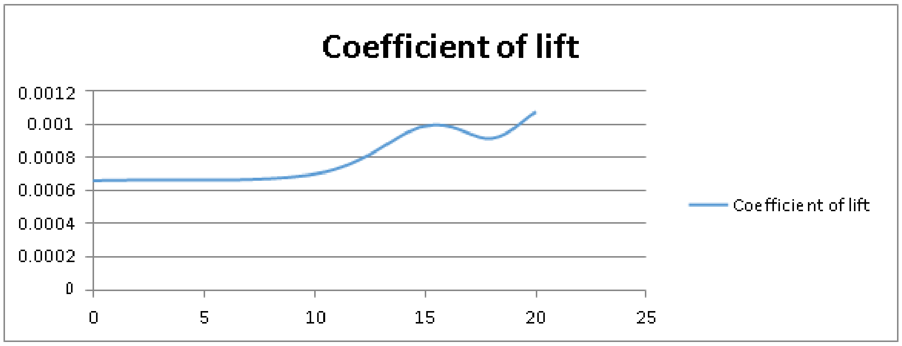


CASE 2: Taper ratio=.4

Wing Area: 15.47 m2

Angle of Attack	Pressure	Drag Force	Lift Force	C_L	C_D
0^0	1849	4.77	19.18	.000660	.000164
5^0	1889	4.97	23.47	.000808	.000171
10^0	1896	6.94	20.31	.000699	.000239
15^0	1919	10.19	28.75	.000990	.000351
18^0	1966	12.90	26.56	.000915	.000444
20^0	2071	15.89	31.17	.001074	.000547





vi. CONCLUSION

1. The computation of flow past a biconvex delta wing cross section with aspect ratio shows physically possible flow field, demonstrated by the surface pressure distribution and particle traces on different planes.
2. Drag force and lift force generated by aircraft is computed with low taper ratio of .125 by increasing angle of attack from 00,50,100,150, 180,200.
3. Drag force and lift force generated by aircraft is computed with high taper ratio of .4 by increasing angle of attack from 00,50,100, 150, 180,200.
4. Coefficient of lift vs angle of attack, coefficient of drag vs angle of attack graph is plotted .
5. Stall angle with low taper ratio is found to be at 180 angle of attack and stall angle with high taper ratio if found to be at 150 angle of attack.
6. Formation of vortex has been noticed at back portion of aircraft is shown by vectorial representation
7. The lift and drag depend on the airfoil shape and it is depending upon the velocity distribution, but also on the wing planform and on the wing area. It is possible to calculate the aerodynamic properties of differently sized airfoils or wings if all forces and moments are normalized
8. Turbulence kinetic energy is found to be maximum at front portion of wing with value of 32.65 m2s-2

vii. REFERENCE

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