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AERODYNAMIC CHARACTERISTICS CALCULATION OF RECTANGULAR, TAPERED AND SWEPT WING USING CATIA AND ANSYS

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ABSTRACT
In this paper, 3 different wing designs with same airfoil, span, and mean aerodynamic chord are analyzed. Various Aerodynamics characteristics like lift and drag are to be examined and compared for these three different wings. The three wings are rectangular, tapered and swept created in CATIA V5 and its analysis is done in Ansys Fluent.

General terms
Ansys, Catia, Lift, Drag, Pressure, Airflow

Keywords
Rectangular, Tapered, Swept, Elliptical, NACA, M.A.C, Sweep angle

1. INTRODUCTION
As we know Lift on the wing is due to the Bernoulli Effect. Air on the upper surface of wing accelerates to generate lift as according to Bernoulli Effect. While flying near the speed of sound Mach .8, the air flowing over the wing could speed up to Mach 1. Now you have supersonic flow. Your critical Mach number is the speed where air flowing over the wing first reaches Mach 1. The airflow on the upper surface speeds up, exceeds Mach, and then slows back down to a subsonic speed. However, when the air slows down below Mach 1, it creates a shock wave. As the air flows along the wing, it sends out pressure waves - which move at the speed of sound. That means that the pressure waves can't move forward through the supersonic air flow. Instead, they build up into a massive pressure, or shock wave.That shock wave generates lots of drag. The air flowing over the wing crosses a massive pressure boundary, which sucks energy out of the airflow causing drag. Plus, the air can lose so much energy that it separates from the wing, causing more drag. This drag is called wave drag. The faster you fly, the more supersonic air travels over the wing. Sweeping the wings delays the onset of supersonic airflow over the wing which delays wave drag. On a rectangular wing airplane, all of the airflow over the wing travels parallel to the aircraft's chord line. But, on a swept wing, only some of the air flows parallel to the chord line. The other part flows perpendicular to the chord - this is called spanwiseflow. Only the component of airflow flowing parallel to the chord line accelerates. So, by reducing the amount of airflow flowing parallel to the chord line, you've reduced the amount of acceleration - and delayed your critical Mach number. Now you can fly at a higher Mach number before you start to create wave drag.When you reduce the amount of air flowing parallel to the chord line, you reduce the amount of lift the wing creates. At high speed, this isn't a problem your high airspeed requires a small angle of attack to create lift. While talking about tapered wing, it is a modification of the rectangular wing where the chord is varied across the span to approximate the elliptical lift distribution (elliptical wing has highest efficiency) but has less induced drag as compared to rectangular wing.

The airfoil we are using is NACA 4-Digit 2412. We generated airfoil cross sections by importing the coordinates of NACA 2412 from airfoiltools.com to CATIA. We generated three different design of wing using the cross section.

- Rectangular wing
- Tapered wing
- Swept back wing

As for tapered and swept wing the chord length doesn't remain constant along the span so instead of using the term chord length we will use the term Mean Aerodynamic Chord. Span and Mean Aerodynamic Chord of all three wings are same. Span of all the wing is 30m and mean aerodynamic mean chord is 7m.The generated wings are analyzed for lift and drag in ansys software at 0 degree angle of attack. We compared the lift and drag characteristics of three wings and verified it with the suggested theory.

2. PROCEDURE
2.1 Rectangular Wing
First we generated a rectangular wing. For it we imported coordinates of airfoil for chord length 7m from airtools.com. Then using GSD_PointSplineLoftFromExcel

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technique to plot all the points and spline (joining all the points) in CATIA. After that using the extrude command to create 60m span.

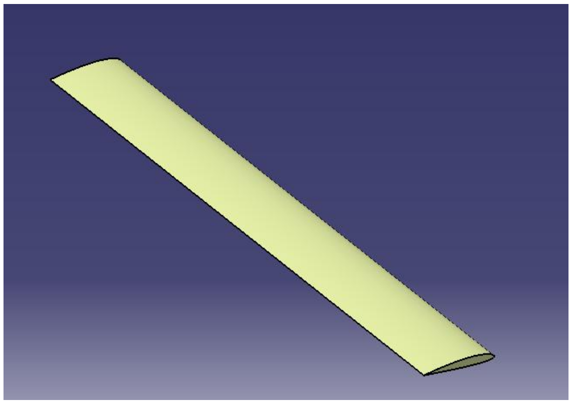

Fig 2.1 Rectangular Wing

2.2 Tapered Wing

Now for generating tapered wing with M.A.C 7m we used a formula M.A.C. = 2/3 (Croot + Ctip - CrootCtip / (Croot+Ctip)).

WhereCroot=chord length near the fuselage

Ctip= chord length at the end of the wing.

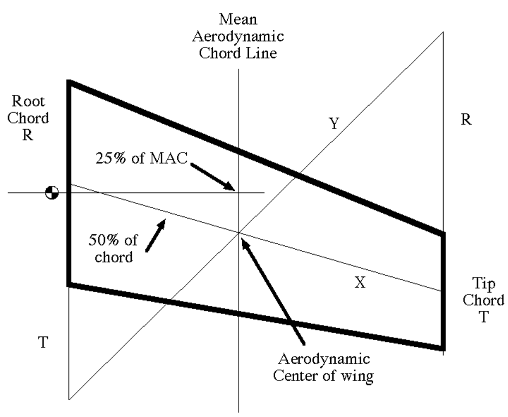

Fig 2.2 Formulae of M.A.C

Assuming Croot = 9m,

Ctip comes out to be 4.5m.

We imported coordinates of airfoils for chord lengths 9m and 4.5m. These airfoils are 30m apart from each other. Then using multi section and symmetry command to generate a wing of span 60 m.

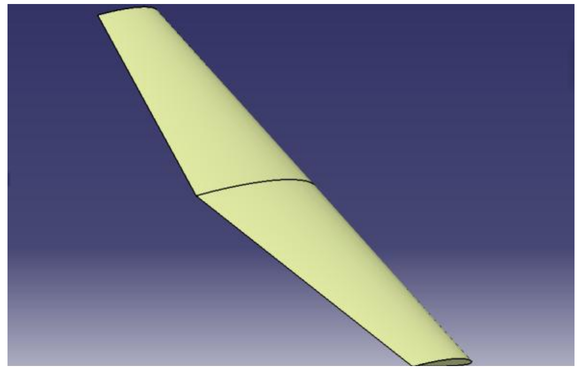

Fig 2.3 Tapered Wing

2.3 Swept Wing

For generating swept wing repeat the same procedureof tapered wing .Just one thingwhile generating the coordinates of airfoil for 4.5m chord length in airfoiltools.com, change the origin %. This will lead to sideways displacement of one airfoil with respect to other and impart sweep angle to the wing.In this the sweep angle is 31 degree.

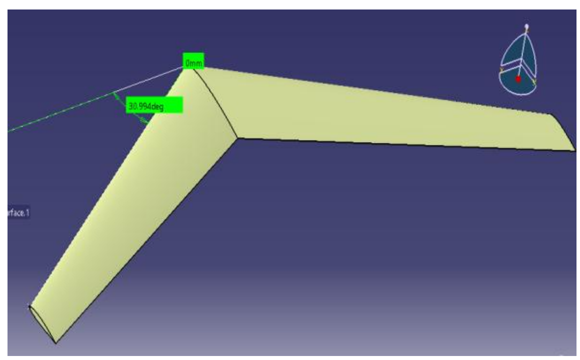

Fig 2.4 Swept Wing

3. RESULTS

The analysis was done with 150 iterations and boundary conditions like temperature and pressure are same as standard sea level conditions.

Velocity=110 m/s

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3.1 Rectangular wing

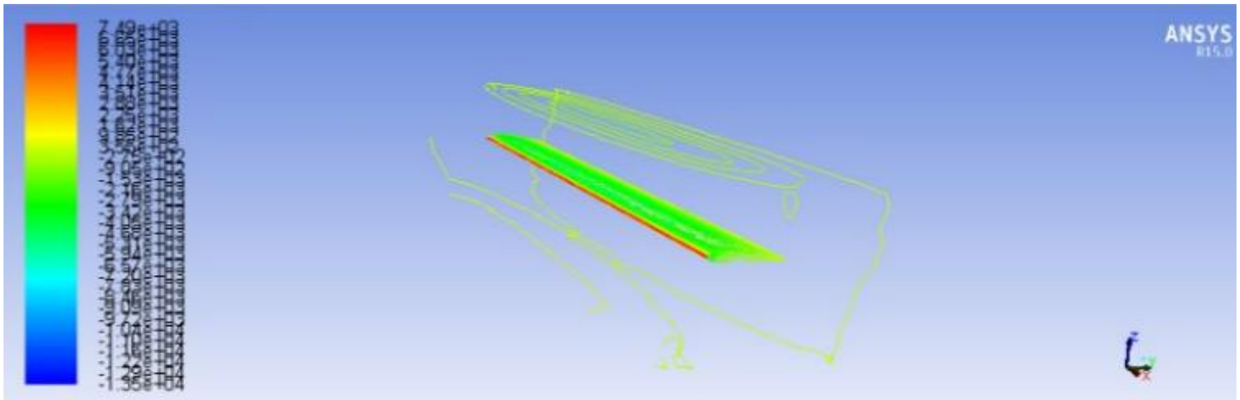

Fig 3.1 Analysis of Rectangular Wing

Lift=83615.672N

Drag=20416.361N

3.2 Tapered wing

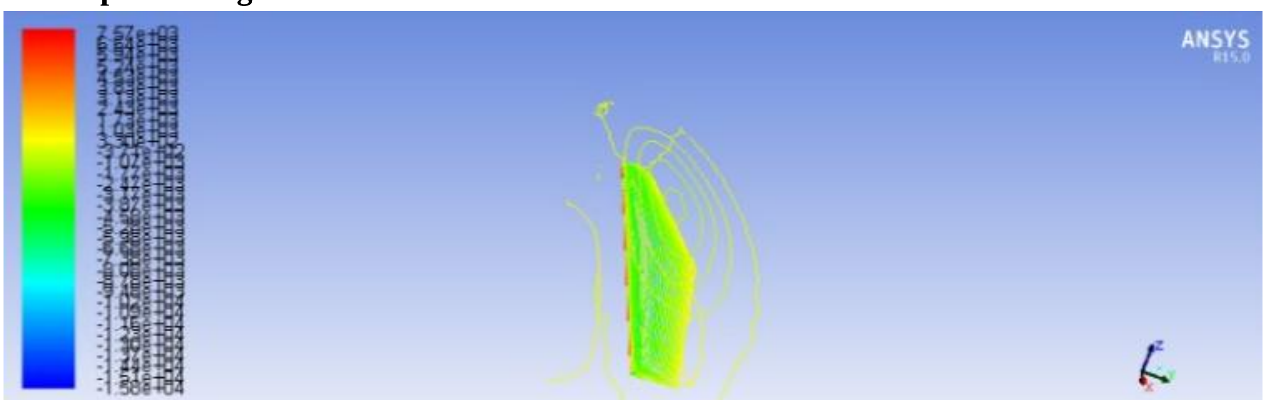

Fig3.2 Analysis of Tapered Wing

Lift=55313.297N

Drag=19343.874N

3.3 Swept wing

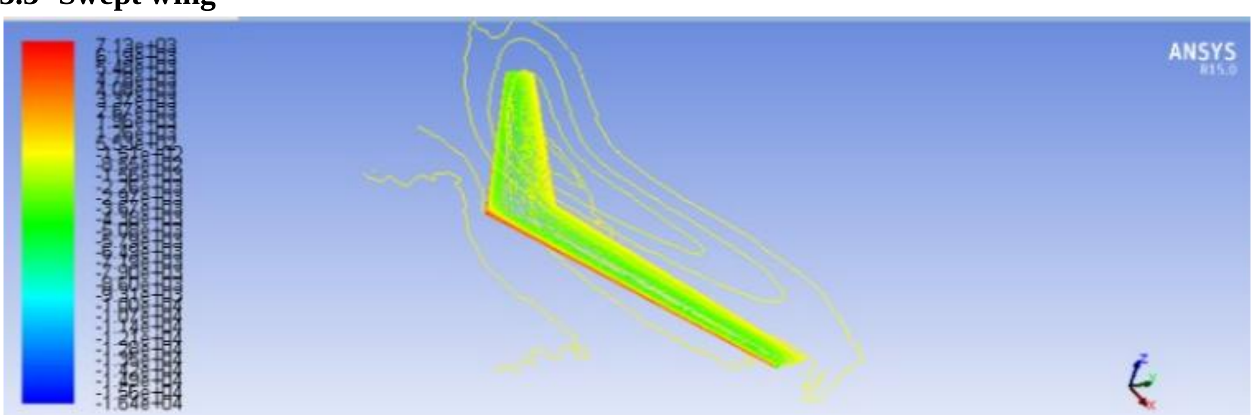

Fig3.3 Analysis of Swept Wing

Lift=19424.25N

Drag=16911.846N

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4. CONCLUSION

From the results we got we concluded that lift and drag are highest for the rectangular wing, least for swept wing and intermediate for the tapered wing. The results are according

WING	**LIFT(N)**	**DRAG(N)**
Rectangular	83615.672	20416.361
Tapered	55313.297	19343.874
Swept	19424.25	16911.846

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