COMPARISON OF NACA 23024 AEROFOIL WITH AND WITHOUT VORTEX GENERATORS USING CFD

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ABSTRACT
The following report is about the CFD analysis of NACA 23024 aerofoil. In this report the results obtained are drag and lift forces for aerofoil using computation fluid dynamics which can also be determined through wind tunnel testing, as the process is quite heavy and costs more than computation fluid dynamics. Thus as have gone through numerical method, compared and listed the results for NACA 23024 aerofoil with and without vortex generator. The analysis of the two dimensional flow over a NACA 23024 aerofoil at various angles of attack operating at Reynolds number of 1 million is presented.

Key words: CFD, NACA 23024, AOA


1. INTRODUCTION
Aerofoil is structure with curved surface design to most favourable ratio of lift to drag in flight, used as basic forms of wings. A fluid flowing over the surface body acts force on it and lift is a type force which acts perpendicular to the flow direction. It is also come with drag force which acts parallel to the flow direction, if fluid is air it is aerodynamic, if it is water then it hydrodynamic. Aerofoil vortex is a extra surface over the aerofoil. Lift and drag involves in the action and reaction over the surface of aerofoil causes pressure differences their causes increase in velocity. The lift on the aerofoil is caused by the resultant change in angle of attack and aerofoil shape. When the angle is changed the aerofoil faces the oncoming air creates air downward force by the air in the direction opposite to the deflection causes rise of aerofoil wing. And practically aerofoil used in Boeing FA/18 super hornets and rear wings of the Bugatti Veyron
NOMENCLATURE OF AEROFOIL

The geometric terms related to aerofoil is described below:

- **Trailing edge** – the rear edge of wing is termed as Trailing edge
- **Leading edge** – The front edge of wing is termed as leading edge
- **Chord** - the distance along the chord line from leading to trailing edge
- **The chord line** – connection line between leading and trailing edges of the aerofoil.
- **Angle of Attack** - The angle between relative direction of air and chord line called angle of attack

Types of forces acting Aerofoil

- **Drag** - drage force oppose thrust force, which is act parallel to the direction flow of an aerofoil is known as Drag force
- **Lift** - oppose the downward force of weight and it is act perpendicular to the direction to of an aerofoil is known as lift force
- **Weight** - the combined load of aircraft itself, the crew, the fuel, and the cargo and which is acts in downward direction
- **Thrust** - the forward produced by the power plant/propeller or rotor and it overcomes force of drag.
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2. PROCEDURE
1. Consider coordinates of NACA 23024 aerofoil as per NACA specification to get vortex over the aerofoil coordinates are set to get better lift and drag (for Vortex Generator)
2. Those coordinates are imported in solid works software then aerofoil profile is generated.
3. Above geometry file is converted into IGS format and this geometry file is imported into Ansys fluent software. For change in angle of attack a new plane is created and aerofoil is imported on that particular plane.
4. An Exact semi-circular cross sectional area is generated around aerofoil wing
5. After generation of these cross sectional area, triangular mesh is generated for cross sectional area and edge sizing mesh is done for the aerofoil wing.
6. Results are produced as per boundary condition at inlet of 14.25m/s.
7. Initialize the values before running calculation to get better results than run the calculations.
8. Get the results and graphs for lift, drag, velocity and pressure.

3. BOUNDARY CONDITION

<table>
<thead>
<tr>
<th>SR NO</th>
<th>INPUT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>velocity</td>
<td>14.207m/s</td>
</tr>
<tr>
<td>2</td>
<td>Operating Temperature</td>
<td>27°C</td>
</tr>
<tr>
<td>3</td>
<td>Angle Of Attack</td>
<td>0°, 6° and 12° degree</td>
</tr>
<tr>
<td>4</td>
<td>Reynolds Number</td>
<td>10^6</td>
</tr>
<tr>
<td>5</td>
<td>Length</td>
<td>1m</td>
</tr>
<tr>
<td>6</td>
<td>Model</td>
<td>Transition</td>
</tr>
<tr>
<td>7</td>
<td>Density</td>
<td>1.225Kg/m^3</td>
</tr>
<tr>
<td>8</td>
<td>Fluid</td>
<td>Air</td>
</tr>
<tr>
<td>9</td>
<td>Dynamic Viscosity</td>
<td>1.7899*10^-5Kg/m-s</td>
</tr>
<tr>
<td>10</td>
<td>Operating Pressure</td>
<td>101.325 Kpa</td>
</tr>
</tbody>
</table>

4. ANALYSIS
This CFD Analysis has been done using Ansys fluent software. In these CFD simulation desired outputs have obtained through a series of steps. The series of steps are as follows:
1. First import the modelled geometry. If there are any adjustments like surfaces not good, edges not prepared well etc., then the geometry tools of the simulation CFD lets us know. Later create an external volume around the model. This volume acts as a wind tunnel since project is to perform an external fluid flow analysis.
2. Now materials are assigned to corresponding components. For the wind tunnel assign “Air” as a medium i.e., the whole external volume will comprise of air particles. Then assign “Aluminium” as a material to the aerofoil wing model.
3. Now apply the boundary conditions. At the front surface of the external geometry then give the velocity as 14.205m/s. At the back surface of the volume give a pressure of 0 Pa. In the same way a pressure 101325 Pa is applied to the front surface.
4. Now the meshing is set to auto size. The software itself sets the mesh size for different components.
5. After successful meshing of Geometry, boundary conditions are applied and the numerical problem is solved.
   After solving the software takes us to the results section there gets the required results. Now consider 3 angle s of attacks like 0°, 6°, 12°.
5. RESULTS AND CONCLUSION

AOA-0° (PRESSURE)

The above figure represents high pressure at leading edge at angle attack at ZERO degree for Without VG

AOA-0° (VELOCITY)

The Above Figure Represents Velocity contour at angle of ZERO angle for Normal Without VG
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(AOA-0° VELOCITY WITH VG)
The Above Figure Represents Velocity contour at angle of zero degree angle With VG

(AOA-0° PRESSURE WITH VG)
The Above Figure Represents pressure contour at angle of zero degree angle With VG
The Above Figure Represents Velocity contour at angle of six degree angle Without VG

(AOA-6° VELOCITY WITHOUT VG)

The Above Figure Represents Pressure contour at angle of six degree angle Without VG

(AOA-6° PRESSURE WITHOUT VG)
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(AOA-6° VELOCITY WITH VG)
The Above Figure Represents Velocity contour at angle of six degree angle With VG

(AOA-6° PRESSURE WITH VG)
The Above Figure Represents pressure contour at angle of six degree angle With VG
The Above Figure Represents Velocity contour at angle of twelve degree angle Without VG

The Above Figure Represents Pressure contour at angle of twelve degree angle Without VG

The Above Figure Represents Velocity contour at angle of twelve degree angle With VG
Comparison of NACA 23024 Aerofoil with and Without Vortex Generators Using CFD

(AOA-12° PRESSURE WITH VG)

The Above Figure Represents pressure contour at angle of twelve degree angle With VG

<table>
<thead>
<tr>
<th>AOA</th>
<th>C_L</th>
<th>C_D</th>
<th>AOA</th>
<th>C_L</th>
<th>C_D</th>
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<tr>
<td>0°</td>
<td>0.1034</td>
<td>0.0268</td>
<td>0°</td>
<td>0.310</td>
<td>0.139</td>
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<tr>
<td>6°</td>
<td>0.634</td>
<td>0.059</td>
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<td>12°</td>
<td>0.922</td>
<td>0.0652</td>
<td>12°</td>
<td>1.235</td>
<td>0.194</td>
</tr>
</tbody>
</table>

**GRAPHS**

The Variation in coefficient drag for different angles attacks which shown above in above graph
The variation in coefficient lift for different angle attacks which shown above graph

The Variation in velocity for different angle attacks which shown in above graph

6. CONCLUSION
Comparison of NACA 23024 aerofoil with and without vortex generator has been studied. By performing computational fluid dynamic analysis in Ansys fluent. The aerofoil with vortex generator shows improved drag and lift coefficient for variation angles of attack. When compare to aerofoil without vortex generator.
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