Drag Reduction In Supersonic Profiles

V. Madhanraj[1], U.Hemanth[2], N.Sasi kala[3], S.Keerthana[4], I. Preetham[5]
Hindustan Institute of Technology and Science, Padur, Chennai.

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Abstract :- Drag reduction for aerial vehicle has a wide range of positive benefits when the aircraft speed is higher than speed of sound, performance of aircraft will change due to air conditions that are different from the lower speed. In this project, the primary aim is to learn and analyse the performance of drag on supersonic airfoil and various types of drag and drag reduction techniques .the objective of this study is to develop a supersonic airfoil for different types of flows with different parameter using ansys .The parameter which gives more efficiently by reducing drag is used for drag is used for drag reduction.

Keywords:-coefficient of drag, Angle of Attack, Dynamic pressure.

I. Introduction to Drag reduction:

An airfoil is said to be an supersonic when it having an mach number of above 1.A supersonic airfoil is designed in order to generate lift efficiently in supersonic speeds. Supersonic airfoils have very sharp leading and trailing edges with a thin section formed of either angled planes or opposed arcs. These are also called double wedge airfoils and biconvex airfoils. When the airfoil as itself moves through the air sharp edges prevent the formation of a detached bow shock. in front of the airfoil. The simplest and most important component of drag formed in the supersonic regime is the wave drag. The distribution of drag in an optimized aircraft is nearly skin friction drag up to 60% , and 20% of induced drag, and less than 20% of drag is wave drag, so drag due to lift is less than 30% of the drag. As the main topic is to learn and analyze the drag reduction we will go through this topic in detail. Mainly drag is formed in supersonic airfoil due to shearing and due to the thickness ,and due to lift ,or due to the zero lift wave drag. The drag formed due to shearing is called Skin friction drag. The drag formed due to the thickness is called wave drag. Wave drag is also formed due to the zero lift wave drag.

The expression for description of drag coefficient on a supersonic airfoil is

$$C_D = C_{D,thickness}+C_{D,friction}+C_{D,lift}$$

It can also be written as

$$C_D= C_{D,O}+KC_L{}^{\wedge 2}$$

Where K is the function of the Mach number and C (D,O is the sum of C (D, friction) and C(D, thickness).

Reducing a 1% drag in the supersonic designs translates to a 5 -10 % increase in payload.
The wave drag is independent of viscous effects, and with increase in critical Mach number there will be a dramatic increase in drag which leads to the sound barrier.

The aerodynamic design features such as wing sweep, fuselage shape, and anti shock bodies can be used to reduce the wave drag.

Mathematical formula

For flat plate airfoil
$C_d(w) = 4*(\propto \text{^}2/\sqrt{}(M\text{^}2-1))$

For double- wedged airfoil
$C_d(w)= 4*(\propto\text{^}2 +(t/c)\text{^}2/\sqrt{}(M\text{^}2-1)$

There are many new techniques introduced to reduce the wave drag. Many of the techniques are introduced during and just after the World War II. These techniques mainly were able to reduce the wave drag magnitude, and so by this the fighter aircraft could reach the supersonic speeds in early 1950s.

Swept wing:

- The most common solution to reduce the wave drag is to use a swept wing. This technique has been introduced before the starting of a World War II. Using of a swept wing makes the wing longer and thinner in the direction of flow. The curvature and the thickness are more important in reduction of a drag.
- When we are built to build a thin wing then there is no need sweep the wing. This solution is used in the first man made aircraft to fly at the speed of sound i.e,Bell X-1.
- By using of a swept wing, start of a supersonic flow can be delayed. This happens due to the reduction of acceleration over the wing.

Shaping of Fuselage:

- There is more impact in the drag based on the geometry of airfoil .For an flat shaped airfoil there will be the highest drag and where as for an streamlined flow the drag is low.
- Shaping of an fuselage is changed with the introduction of Area rule. This Area rule is also known as White comb Area rule. This rule is to reduce the drag at transonic and supersonic speeds. Fuselage has to be made narrower so that it joins the wings to reduce the drag and cross sectional area matches the sears-hack body.

In supersonic flow

$P_{o,2}/P_2 = (1+\gamma-1/2(M_2\^2))^{\gamma/\gamma-1}$

$M_2\^2 = [(1+(\gamma-1)/2)M_1\^2]/[\gamma M_1\^2-(\gamma-1)/2]$

II. Methodology:

We have taken a software programmer called Ansys and CFD for the modeling and meshing. The Ansys software programmer is used to stimulate the computer structures or models. This helps to learn and analyze the components or parameters of the fluid or air flow etc.,.It was founded in 1970 by John swason.
CFD:
It is the process of modeling and dynamic simulation of how the gases and liquids will perform. CFD was developed in 1990's and was used to solve linear potential equations. Navier stokes equations are fundamental equations involved in CFD.These technique are used in architecture, chemical& engineering process, electronics ,turbo machinery etc.,.

CFD modelling and meshing

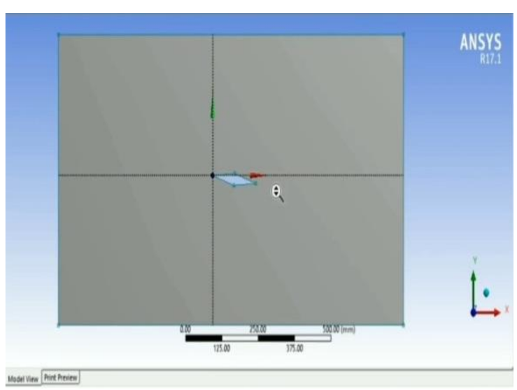

Fig 1 Airfoil design

After the design of airfoil the file is imported to the Ansys fluent the domain is created

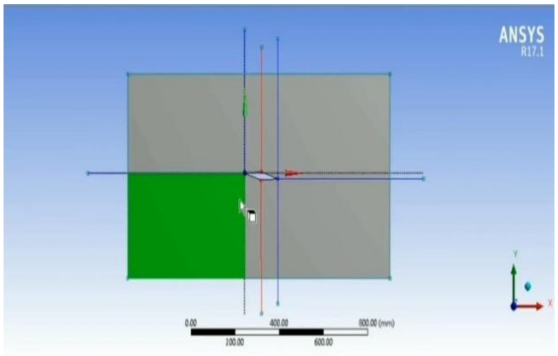

Fig 2 Created line to separate domain to make mesh

We created line to separate the domain which make meshing easer and now select structural mesh and open face split using this we can separate domain and mesh.

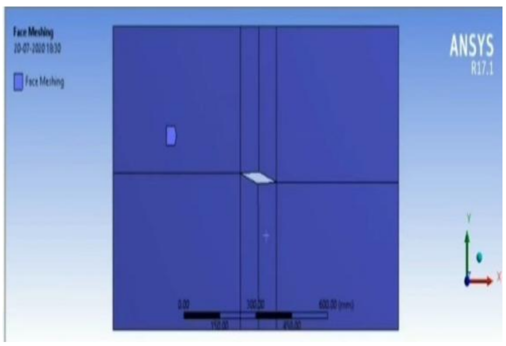

Fig 3 create multiple geometry with split domian

Take lines to create multiple geometry so that we can split our domain in multiple faces and now generate mesh.

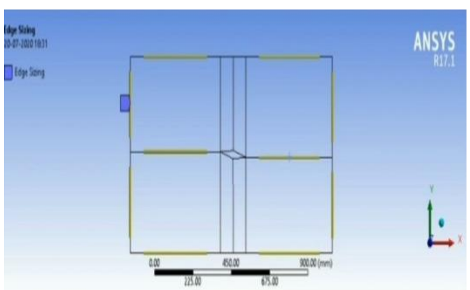

Fig 4 Sizing function and division to proper mesh

Go to sizing function select relevance centre and then to median and fix maximum face size to (5mm) and then generate mesh.
Select the number of divisions up to 40 and change behaviour to hard and do the same as above so that we will get number of divisions and a proper mesh.
Select the top and bottom line and set name as surrounding walls and change the front line as inlet pressure and back line as outlet pressure.

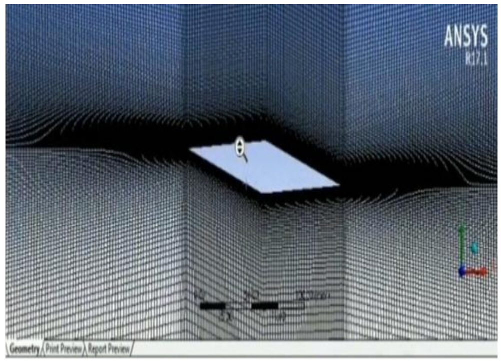

Fig 5 Generated mesh

This is the generated mesh now the mesh is being undertaken into the energy equation and then to the viscous and change to laminar. Now the mesh is taken to the k-ε then changes the realizable fluid to ideal gas then set Mach number 2.0.

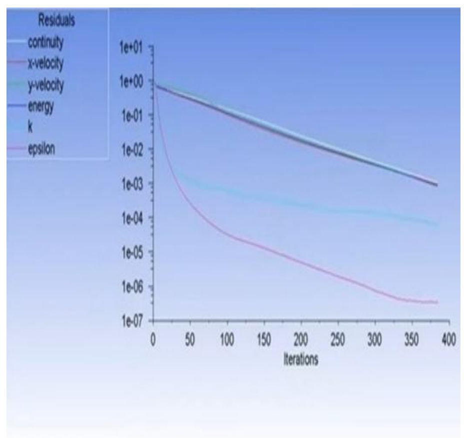

Fig 6 No of Iteration

Mach Number	2.0
Guage pressure	69000
Temperture	254K
Pressure	0p

Table 1

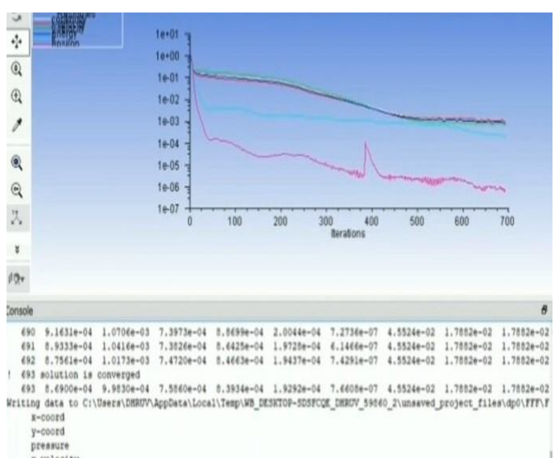

Fig 7 No of Iteration

The mesh has been undergone 2000 Iterations and the results are as above.

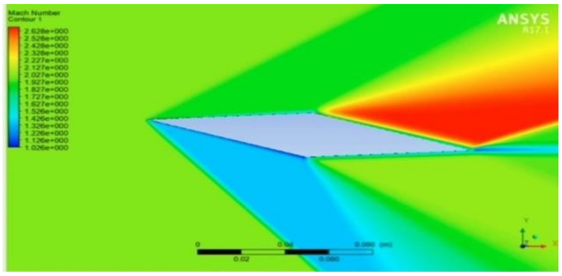

Fig 8 Mach Number

Generally Mach number ranges between 1.8 to 2.8 for an Diamond airfoil. We have taken the mach number of 2 and changed the gauge pressure and so the result of mach number we got is 2.6.

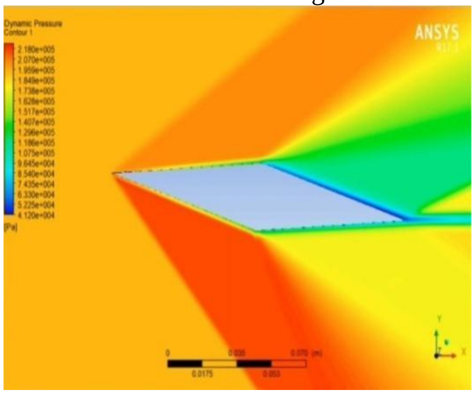

Fig 9 Dynamic pressure

Pressure is inversely proportional to velocity.

Flow separation has been done on leading edge. The resultant dynamic pressure of the airfoil **is** 2.18*10^5(2.180e+005).

III. Boundary conditions:

To find the result we have to give some input parameters to meshed files and by input the flow will start and flow over airfoil and from output area and the top and bottom area are surrounding walls A physics continuum is a set of physics models, such as flow solver forms, materials type1, time models (steady, unsteady), turbulence types, and so on. The following boundary requirements have been investigated for Airfoil designs:

Domain	Boundary conduction
Inlet	Pressure Far field on inlet
Outlet	Pressure far field on outlet
Airfoil	No slip wall on airfoil

Table 2

IV. Conclusion:

The drag reduction in supersonic airfoil is carried out through Solid-works, Ansys and CFD. In this work, a supersonic airfoil is modified from the basic supersonic airfoil i.e., Diamond shaped airfoil of Mach number ranging from 1.8 to 2.8 reduce the drag. This is done by changing the co-ordinates of a Diamond airfoil and creating a mesh to the airfoil in the CFD.A Diamond airfoil is taken as a reference to reduce the drag in the existed supersonic airfoil. The number of Iterations done to the airfoil is at most of 2000. The simulation of an airfoil is carried out in the CFD for the mesh generated airfoil and the results obtained are:

- Change in Temperature
- Difference in Dynamic pressure

- Mach Number
- Turbulence
- Velocity
- Pressure

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