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# Aerodynamic Investigation of Double Wedge Supersonic Airfoil

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***Abstract*— This is a aerodynamic design study and flow dynamics of a Double wedge supersonic airfoil. An aerodynamic design methodology was refined by understanding the design which has been developed in Catia V5 and flow simulation performed in ANSYS fluent. A complete aerodynamic study was performed with Computational Fluid Dynamic analysis which gives the performance characteristics like velocity contours, attached shockwave and detached shockwave and it also evaluates the aerodynamic plots. The velocity contours of the supersonic airfoil are found and the selection of appropriate airfoils from a literature review made are also discussed. Finally, the results of the aerodynamic design procedure are presented and appropriate conclusions are drawn.**

***Keywords*— Catia, Ansys, Fluent, Airfoils, design and analysis, performance characteristics.***

## I. INTRODUCTION

An airfoil or aerofoil is the state of a wing wherein fixed-wing aircraft wings, stabilizers are worked with airfoil formed cross-areas. An airfoil-moulded body traveled through a fluid delivers a streamlined power. The part of this power is opposite to the bearing of movement that is called as lift. Supersonic airfoils are substantially more precise fit as a fiddle and can have a sharp driving edge, which is very sensitive to angle of attack [1]. As indicated by Prandtl Meyer, a supercritical airfoil has its most extreme thickness near the main edge to gradually stun the supersonic stream back to subsonic velocities. For the most part, such transonic airfoils and likewise the supersonic airfoils have a low camber to lessen drag difference. Present day aircraft wings may have diverse airfoil segments along the wing length, every one enhanced for the conditions in each area of the wing. A trailing edge fold acts correspondingly to an aileron. Anyway instead of an aileron, can be withdrawn mostly into the wing if not utilized. Supersonic vehicles are presently being examined as future civil transports. The investigation of these vehicles requires the utilization of precise computational fluid dynamics (CFD) models to catch the profoundly nonlinear stream [2]. Additionally, clamor guidelines for trip over land require aeroacoustic investigation of the whole vehicle shape. The models associated with the computational investigations are the top expensive.

## II. METHODOLOGY

### *A. Ideology*

Supersonic airfoils for the most part have a geometry as appeared in the assume that has been observed to be exceptionally compelling at limiting the negative impacts of shock waves at the wing surfaces close to the edges. The meager airfoil shape, looking like a diamond shape, joined with sharp leading and trailing edges is extremely compelling at coordinating the progression of shock waves and lessening their solidarity to decrease their effect on lift age [3]. So the model is planned in catia and then utilized for investigation. A reference supersonic airfoil is shown below in figure 1.

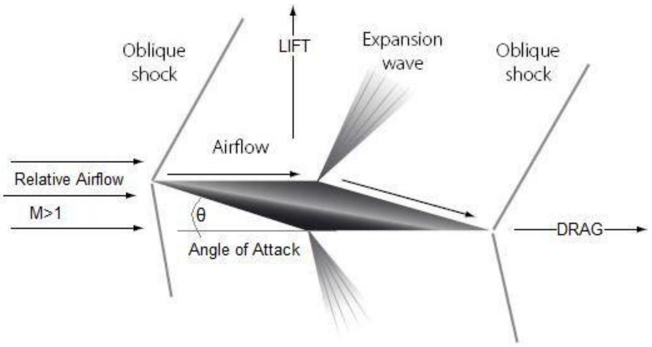


Figure 1 Supersonic Airfoil

### *B. Types of airfoils*

The procedure of airfoil configuration continues from an knowledge of the boundary layer properties and the connection among geometry and pressure dissemination. The objective of an airfoil configuration shifts. A few airfoils are intended to deliver low drag and some may not be required to create lift by any stretch of the imagination. Some of the airfoils are shown below.

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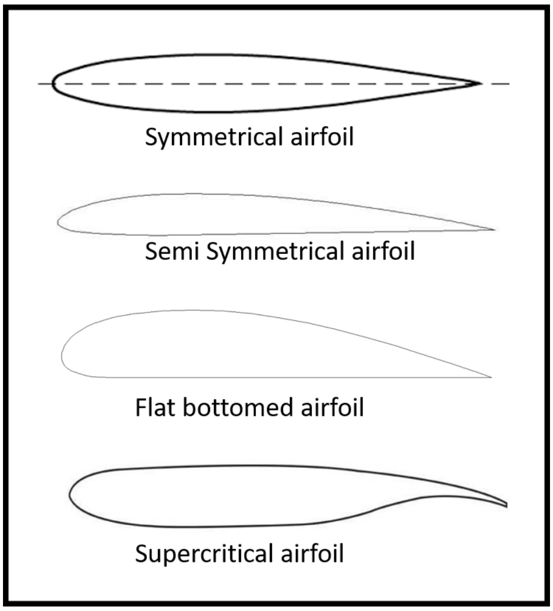


Figure 2 Types of Airfoils

## III. PERFORMANCE VARIABLES

The thin leading edge makes a connected or Oblique shock wave rather than the detached shock waves bow shock wave that would happen if an adjusted airfoil leading edge would be utilized. Bow shocks commonly make more drag than oblique shock waves [4]. There are a few factors, for example, turbulence intensity, oblique shock wave, expansion waves and vorticity

At last, oblique shock wave is slanted as for the occurrence upstream flow bearing.

### *A. Oblique shock wave*

Like a typical shock, the oblique shock wave comprises of a slim locale crosswise over which thermodynamic properties happen. While the upstream and downstream flow bearings are unaltered over an ordinary shock, they are diverse for flow over an oblique shock wave. Solid arrangements are required when flow needs to coordinate downstream high weight condition. Irregular changes additionally happen in weight, thickness and temperature.

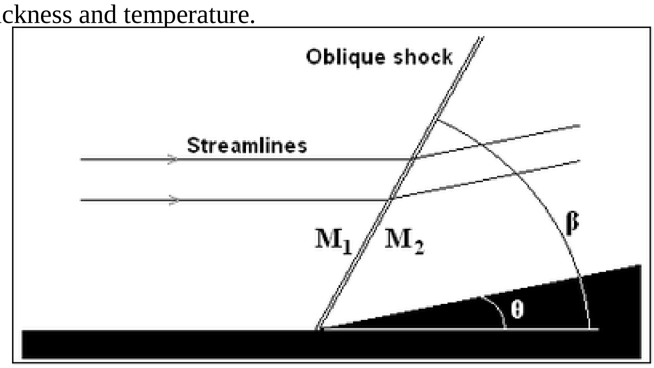


Figure 3 Oblique Shockwave

### *B. Expansion waves*

Expansion waves are from numerous points of view as given:

- These waves emerge when a supersonic flow is left away from a certain distance from itself
- An expansion locale is developed of a boundless number of powerless mach waves.
- Over an expansion surface we get an expansion in flow of mach number, decline in weight, decline in thickness and rise in temperature [5].
- The Prandtl-Meyer capacity can be utilized to get the downstream flow mach number after an expansion locality gives the mach number of upstream flow and edge of deflection.

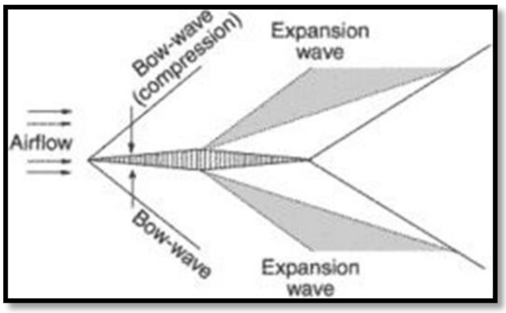


Figure 4 Expansion Wave

### *C. Vorticity*

The vorticity is a pseudovector field that portrays the nearby turning movement of a continuum close to some point as would be seen by an onlooker situated by then and it could likewise be dictated by making portions of a continuum in a little neighborhood of a point and viewing their relative relocations as they move along the stream [6]. The vortex panel method models the stream past an airfoil as the summation of a uniform stream and a progression of vortex 'panels' organized to frame a shut polygon with a shape that approximates, as almost as could be expected under the circumstances. The term panel is somewhat deceptive since it invokes a psychological picture of a strong plate, through which the stream can't pass. This isn't the situation as is represented in figures 2 and 3. This is unequivocally what is finished by the Vortex Panel Method.

### *D. Turbulence Intensity*

When defining limit conditions for a CFD reproduction it is regularly important to gauge the turbulence intensity on the bays. To do this precisely it is a great idea to have some type of estimations or past experience to put together the gauge with respect to. Here are a couple of instances of normal estimations of the approaching turbulence intensity:

- **High-turbulence case**: High-speed flow inside complicated frameworks like warmth exchangers and flow inside pivoting apparatus (turbines and blowers). Commonly the turbulence intensity is somewhere in the range of 5% and 20%.
- **Medium-turbulence case**: Flow in not really complex gadgets like enormous channels, ventilation flows and so on or low speed flows. Regularly the turbulence intensity is somewhere in the range of 1% and 5%.
- **Low-turbulence case**: Flow starting from a liquid that stops, similar to outer flow crosswise over autos, submarines and air ships. High-quality wind-tunnels can likewise achieve truly low turbulence levels. Regularly the turbulence intensity is low, well underneath 1% [7].

## IV. ANALSYIS PROCESS

Just for the idealization of the double wedge supersonic airfoil, it has been designed in Catia v5.

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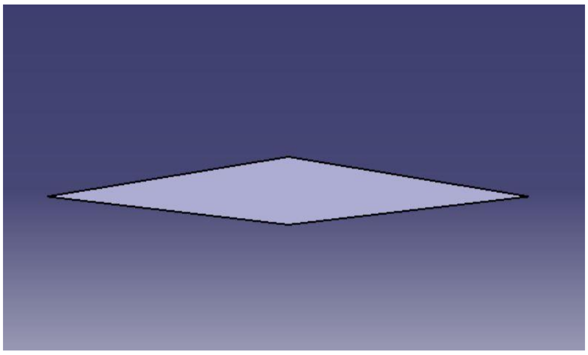
Figure 5 Catia Design

Then we go for the next step as follows.

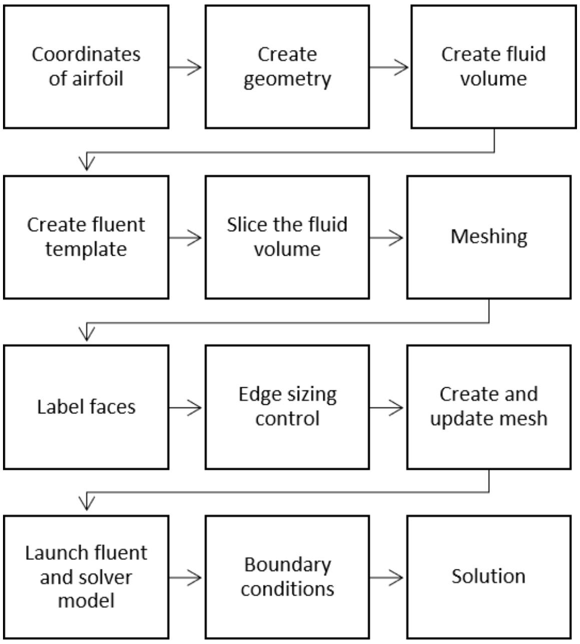

Figure 6 Analysis Process

## RESULTS

The double wedge supersonic airfoil designed is analyzed , the following results are discussed below:

1. Velocity contour over 15° half wedge angle at mach 1.6 is shown:

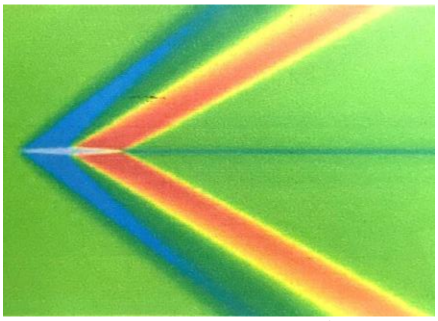
Figure 7 Velocity contour over 15° half wedge angle

2. Detached shockwave is shown below:

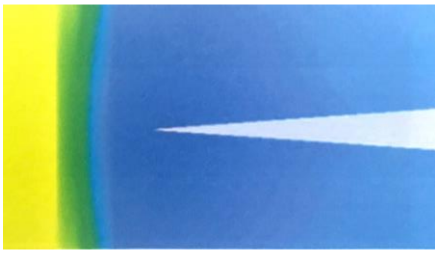
Figure 8 Detached shockwave

3. Attached shockwave at mach 1.6 is shown below:

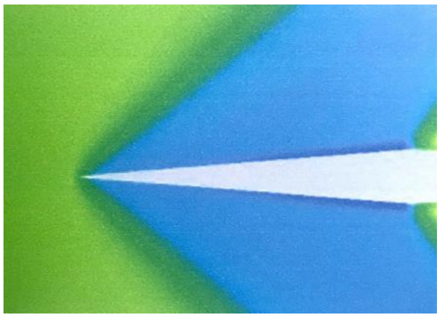
Figure 9 Attached shockwave

4. Velocity contour at 0° Angle of attack at mach 2 free stream velocity is shown:

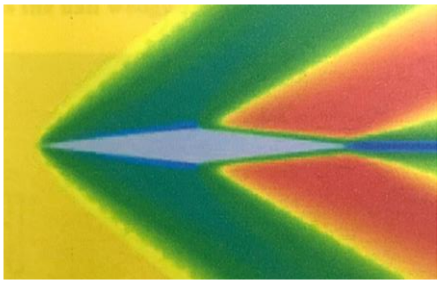
Figure 10 Velocity contour at 0° Angle of attack

5. Velocity contour at 5° angle of attack at mach 2 is shown:

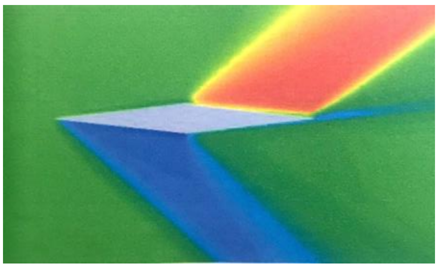
Figure 11 Velocity contour at 5° angle of attack

6. Expansion wave observed at top leading edge when angle of attack exceeds the half wedge angle is shown:

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Figure 12 Expansion wave observed at top leading edge

7. The graph plotted between the coefficient of lift and Mach number (M) as follows:

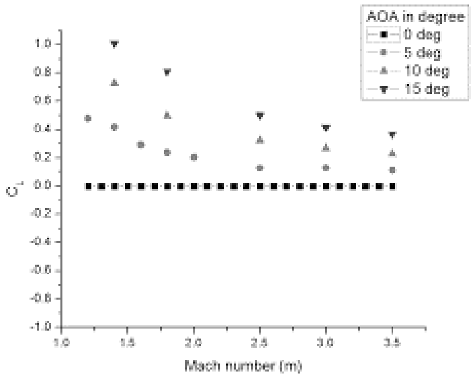


Figure 13 Cl vs M

8. The graph plotted between the coefficient of drag and Mach number (M) as follows:

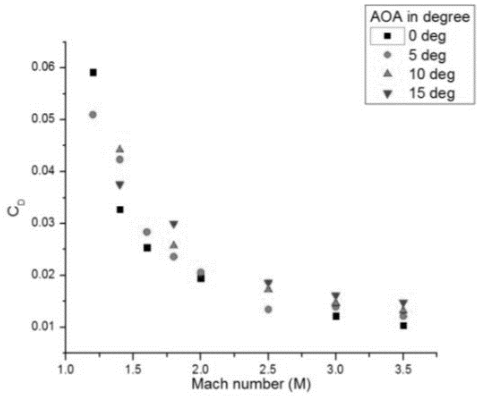


Figure 14 Cd vs M

## CONCLUSION

The double Wedge Supersonic airfoil is hypothetically the most efficiently productive aerodynamic design for an aircraft which has a fixed or movable wing configuration. The accompanying outcomes portray about the supersonic airfoil that it is to have proficient optimal design to beat the drag and to create reasonable lift. The distinction in shock strengths causes the stream on the lower surface to be packed more than the stream on the upper surface.

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