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CFD Analysis of Supercritical Airfoil with Different Camber

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ABSTRACT

The main aim of this paper is to analyze the Aerodynamic characteristics of the two different airfoils namely a seven digit NACA747A315 airfoil and the supercritical airfoil NACA SC(2)-0714. In this work, the supercritical airfoil configuration is analyzed by changing its position of camber in order to increase its lift coefficient and reduce the drag. This result of the supercritical airfoil is compared with respective to the seven digit airfoil. The analysis has to be carried out with the various angle of attack. This analysis is made with the help of ANSYS-FLUENT software.

Keywords: A Supercritical airfoil, Lift Curve Slope, Coefficient of Lift, ANSYS, Drag Reduction.

1.INTRODUCTION:

The main aim to design the supercritical airfoil is to decrease the peak drag coefficient at or around mach number 1. At transonic flights, the formation of shock waves is because of compressibility effects. The free stream Mach number at which local sonic velocities develop is called critical Mach number. It is always better to increase the critical Mach number so that formation of shock waves can be delayed. This can be done by a number of factors such as the change in thickness of airfoil, sweep angle, Area rule, supercritical airfoil. So supercritical airfoil is preferred to increase the critical Mach number. Here, a comparison is made between the supercritical airfoil and cambered airfoil. The cambered airfoil is one in which the camber line is present at some distance from the chord line and the chord line separates the upper and lower surfaces equally. In cambered airfoil, the strong shock wave forms at supersonic flow. So the flow separation is more which produces more drag. To compensate this, the upper portion of the cambered airfoil is modified as the flat surface in order to delay the shock wave formation. Thus forms the supercritical

airfoil. Supercritical airfoil can able to reduce the drag value even with the high thickness which is having structural benefit to provide high stiffness and high wing volume.

2.DESRIPTION:

i)CAMBERED AIRFOIL:

In a cambered airfoil. When the thickness to chord ratio is increased, the lift value increases. But there is a limit for increasing the thickness to chord ratio. Though thickness to chord ratio is increased beyond 14%, the lift coefficient value decreases because of trailing edge flow separation. It is suggested that to use the roughness and vortex generators to reattach the flow. A supersonic flow over a cambered airfoil produces strong shock wave so the value of drag increases. In this paper, we have considered an NACA 747A315 airfoil and its aerodynamic characteristics were analyzed.

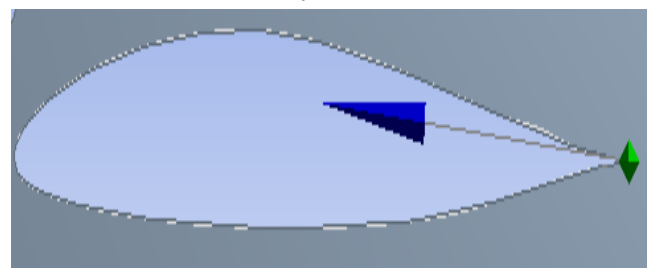


Fig 2.1. NACA 747A315 airfoil at 0° angle of attack.

ii)SUPERCritical AIRFOIL:

The basic design of a supercritical airfoil has flat upper surface and highly negative camber on the bottom surface at almost 60 % of chord from the leading edge. The remaining part of the lower surface has high positive camber. In supersonic flow, the flat upper surface delays the shock wave formation. Eventually, in the bottom surface the 60% of the chord from leading edge does not

contribute in the lift, but the remaining part is highly cambered in order to compensate for the lift. Here, we have used NACA SC(2)-0714 Airfoil. This particular airfoil is analyzed and relevant data for its aerodynamic performance is taken from the ANSYS package.

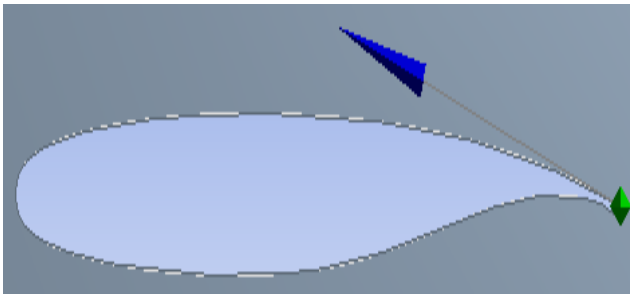


Fig.2.2 NACA SC(2)-0714 airfoil at 0° angle of attack.

iii) MODIFIED SUPERCRITICAL:

In this paper, the referred supercritical airfoil NACA SC(2)-0714 has its high camber on the lower surface at about 80% of chord from the leading edge. We have altered the position of high camber on the lower surface to about 60% from the leading edge by varying the coordinates. By changing the profile, we find some good performance characteristics.

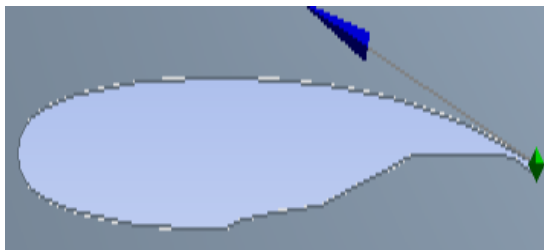


Fig 2.3. NACA SC(2)-0714 with varied camber on lower surface kept at 0° angle of attack.

iv) ANSYS FLUENT:

ANSYS is an analytical software package that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the millions of calculations and it is possible to obtain approximate computer based solution to the governing equation. By using this software, we have obtained the lift drag curve and pressure contours of the above-mentioned airfoils.

3. GRAPHICAL RESULTS – LIFT DRAG CURVE:

i) CAMBERED AIRFOIL:

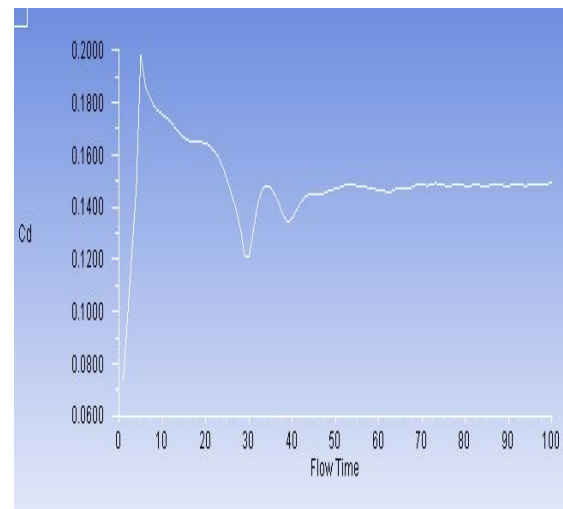


Fig 3.1. Cd curve for NACA747A315 airfoil.

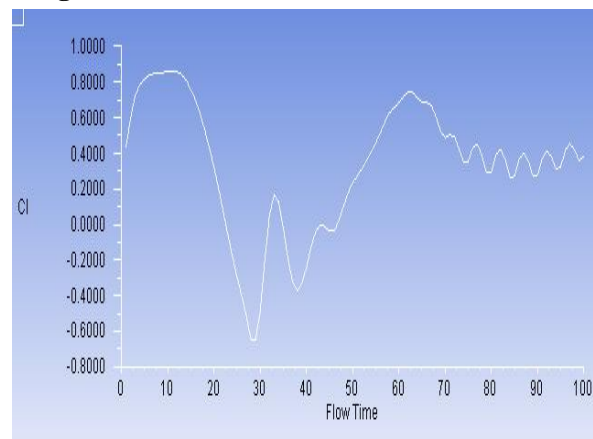


Fig.3.2. Cl curve for NACA747A315 airfoil.

ii) SUPERCRITICAL AIRFOIL:

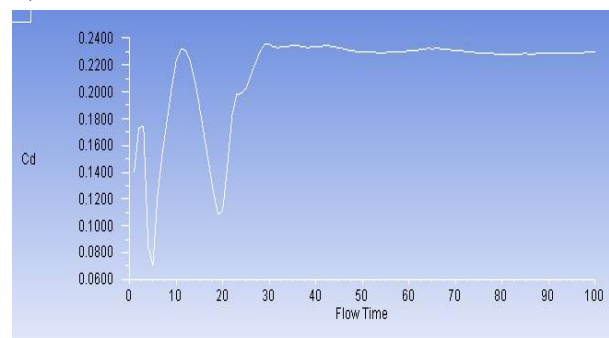


Fig.3.3. Cd curve for NACA SC(2)-0714 airfoil.

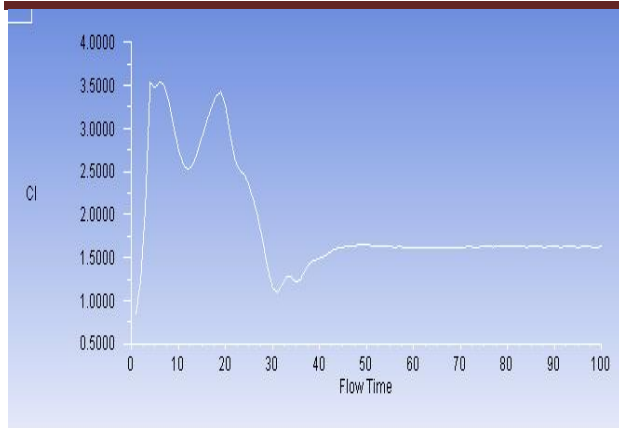


Fig.3.4. C_l curve for NACA SC(2)-0714 airfoil.

iii) MODIFIED SUPERCRITICAL:

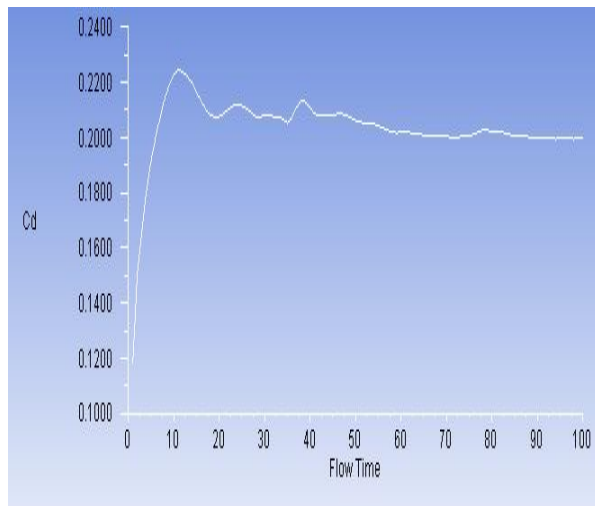


Fig.3.5. C_d curve for NACA SC(2)-0714 airfoil with modified camber position.

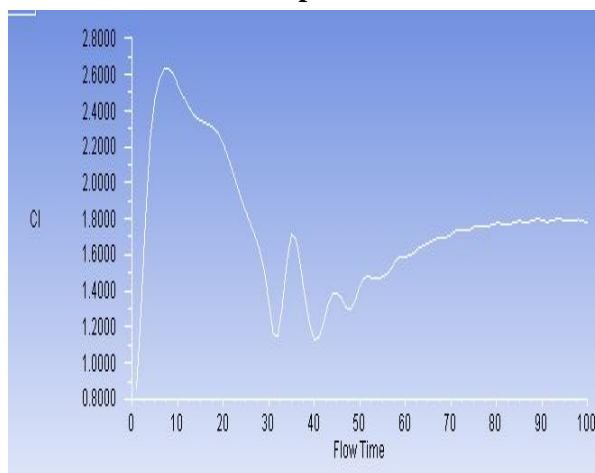


Fig.3.6. C_l curve for NACA SC(2)-0714 airfoil with modified camber position.

4. PRESSURE CONTOURS:

i) CAMBERED AIRFOIL:

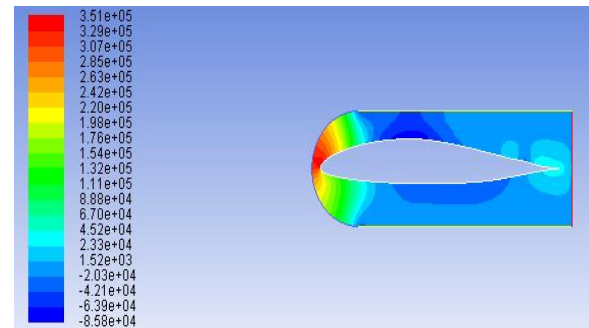


Fig.4.1. Pressure contour of NACA 747A315 airfoil.

ii) SUPERCRITICAL AIRFOIL:

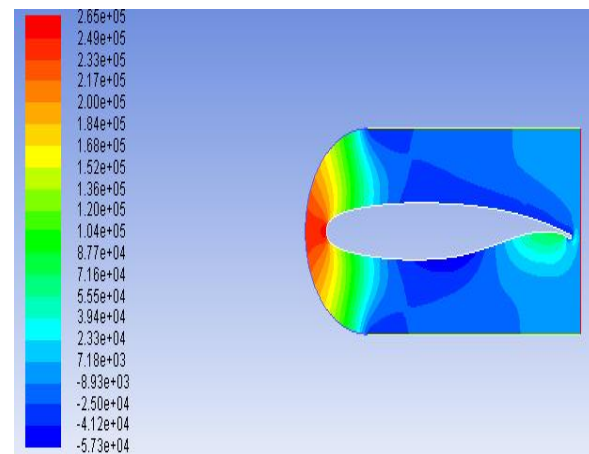


Fig.4.2. Pressure contour of NACA SC(2)-0714 airfoil.

iii) MODIFIED SUPERCRITICAL:

a) AT 0°

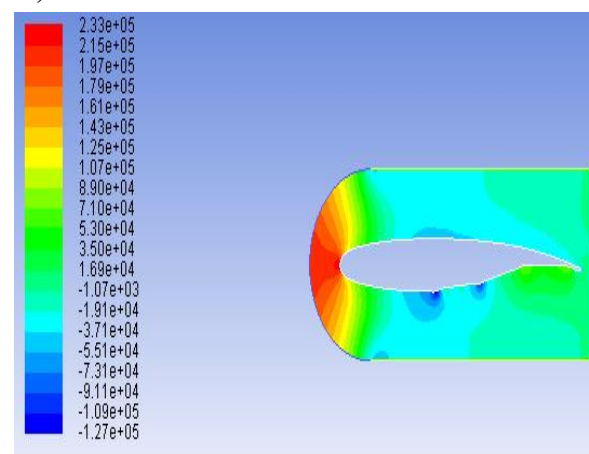


Fig.4.3. Pressure contour of NACA SC(2)-0714 airfoil with modified camber position at $\alpha = 0^\circ$

b) AT 3°

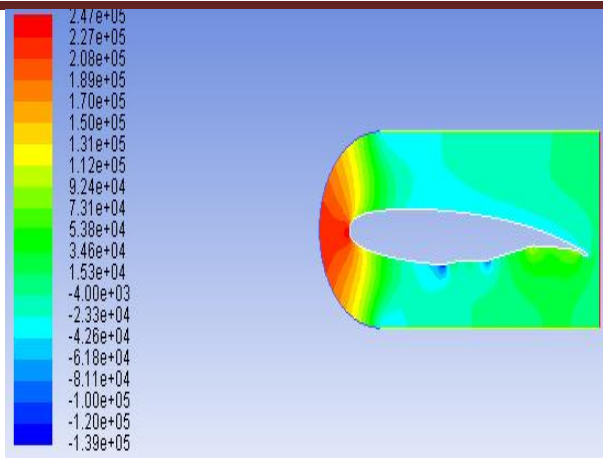


Fig.4.4. Pressure contour of NACA SC(2)-0714 airfoil with modified camber position at $\alpha = 3^\circ$

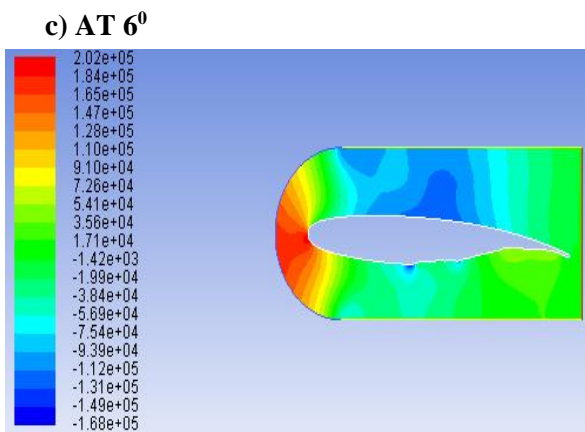


Fig.4.5. Pressure contour of NACA SC(2)-0714 airfoil with modified camber position at $\alpha = 6^\circ$

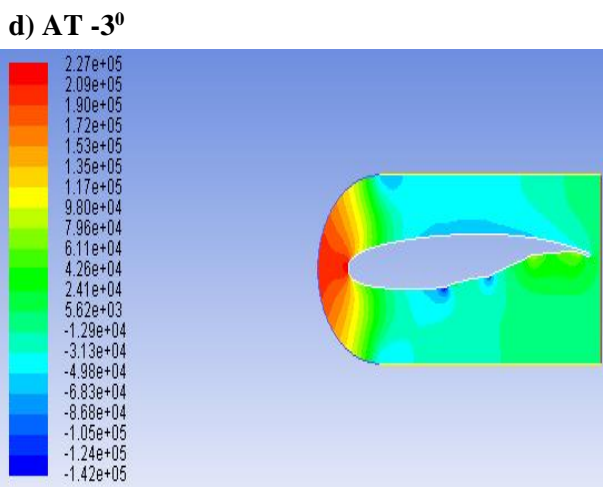
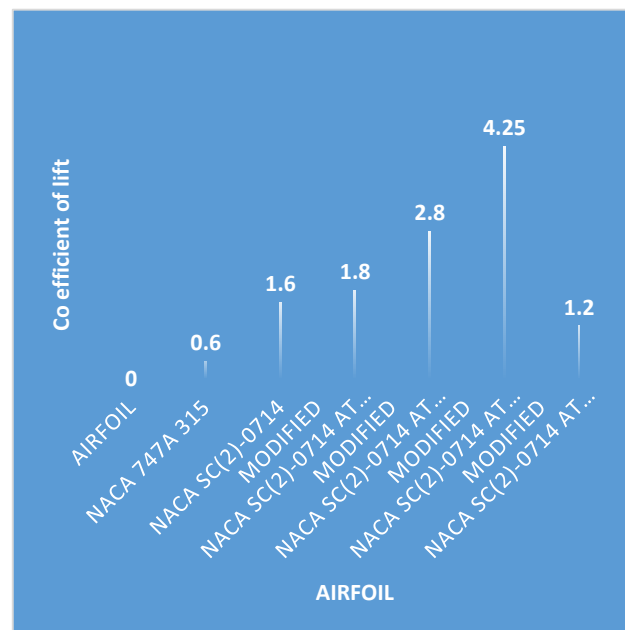
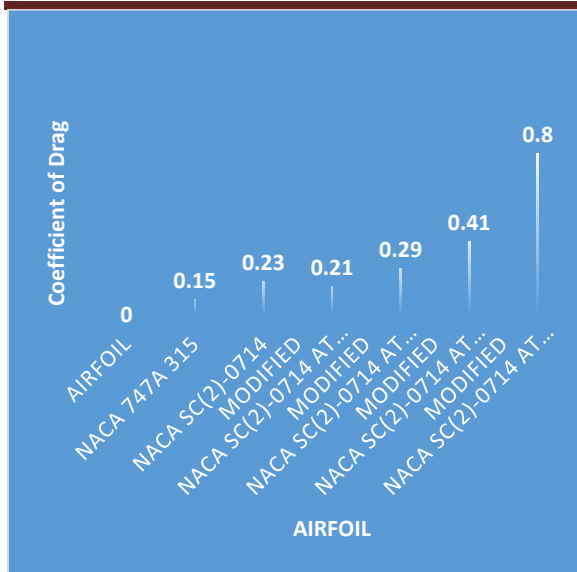


Fig.4.6. Pressure contour of NACA SC(2)-0714 airfoil with modified camber position at $\alpha = -3^\circ$

5.COMPARISON TABLE:

| AIRFOIL | C_l | C_d |
|---|-------|-------|
| NACA 747A 315 | 0.6 | 0.15 |
| NACA SC(2)-0714 | 1.6 | 0.23 |
| MODIFIED NACA SC(2)-0714 AT $\alpha = 0^\circ$ | 1.8 | 0.21 |
| MODIFIED NACA SC(2)-0714 AT $\alpha = 3^\circ$ | 2.8 | 0.29 |
| MODIFIED NACA SC(2)-0714 AT $\alpha = 6^\circ$ | 4.25 | 0.41 |
| MODIFIED NACA SC(2)-0714 AT $\alpha = -3^\circ$ | 1.2 | 0.8 |





6.CONCLUSION:

The final analysis has shown that by shifting the position of the camber in the lower portion of the supercritical airfoil, the lift value has been increased by 20%. And its performance when compared with a seven digit cambered airfoil 12.5 % of C_L was increased and 9.51 % C_D has been reduced. The future scope of this paper is to increase the lift value by placing the rotating cylinder at the leading edge and mid-chord of the airfoil.

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