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Airfoil Refinement Of A Helicopter Rotor Blade

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ABSTRACT
Rotor blade of helicopter is responsible for producing lift and by altering this lift; the maneuvering of helicopter can be carried out. To obtain better aerodynamics of the rotor blade it is desired to have an airfoil with maximum lift and minimum drag, which is referred as L/D ratio. Moreover, the manufacturing of rotor blades is quite complex. Keeping in lieu, the ease of manufacturing, the curvature of the airfoil must be smooth at all points. This paper focuses on the method that can be used for the airfoil refinement of an existing rotor blade so as to achieve better L/D ratio and smooth transition of curvature for ease of manufacturing.

Keywords
Helicopter Rotor Blade; Airfoil refinement; curvature analysis; L/D ratio; ease of manufacturing; CFD; CATIA V5

1. INTRODUCTION
An airfoil resembles a cut of a wing's cross section and on account of its shape is designed to produce a suitable lift-drag ratio. More curvature at the top of the wing than the bottom results in different movements of the helicopter in the air. The top surface being more positively cambered makes air move faster over a wing than air below the wing. The rotor system of a helicopter helps in providing the lift for the helicopter to fly and allows the helicopter to maneuver.

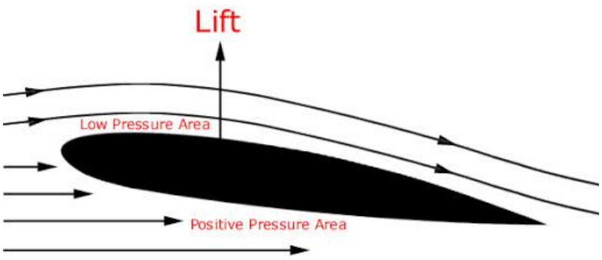

Fig.1 Lift for an airfoil

The rotor blade must be able to adjust the angles to provide the ease in movement. All these communication is done by the pilot through a device called the swash plate assembly which consists of two parts; the upper swash plates and the lower swash plates. The upper swash plate connects to the mast or the rotor shaft through special linkages. The lower swash plate is stationary. The lower and upper swash plates have ball bearings between them which allow the upper swash plate to move freely. Utilizing this rotor plan, a pilot can control the swash plate assembly and control the helicopter's movement. With the cyclic, the swash plate assembly can change the point of the edges independently as they rotate. This permits the helicopter to move toward any path around a 360-degree hover, including forward, reverse, left and right. The collective permits the swash plate to change the point of all cutting edges all the while. This increases or diminishes the lift that the primary rotor supplies to the vehicle, permitting the helicopter to gain altitude or lose elevation.

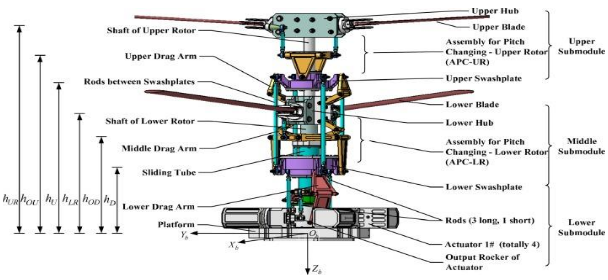

Fig.2 Rotor assembly of a helicopter

The angle of attack in the field of aerodynamics is the angle between the chord line of the wing of an aircraft to the vector representing the relative airflow.

We are intending to refine and improve the discontinuity on the leading edge curvature and the L/D ratio for a better efficiency, and also to provide ease for airfoil tool manufacturing processes.

2. OBJECTIVE
The main objective of this project is to refine the existing blade profile to obtain an increase in the Lift to drag ratio (L/D ratio) and providing ease in the manufacturing of developing tools for the airfoil.

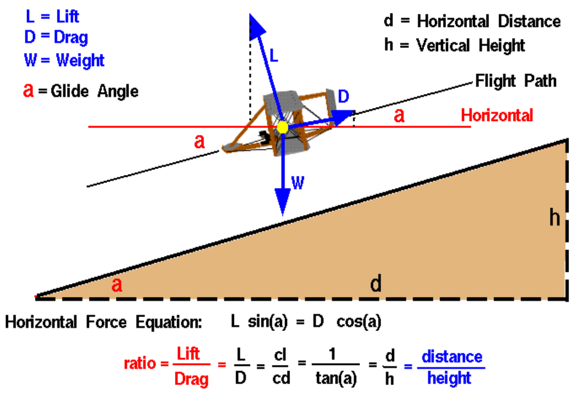

Fig.3 L/D ratio depiction

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3. METHODOLOGY

3.1 Creating airfoil in CATIA V5 using coordinates of the existing rotor blade

1. The coordinates of the existing rotor blade (as shown in Fig. 4) were imported in CATIA V5 for the creation of spline (as shown in Fig. 5)

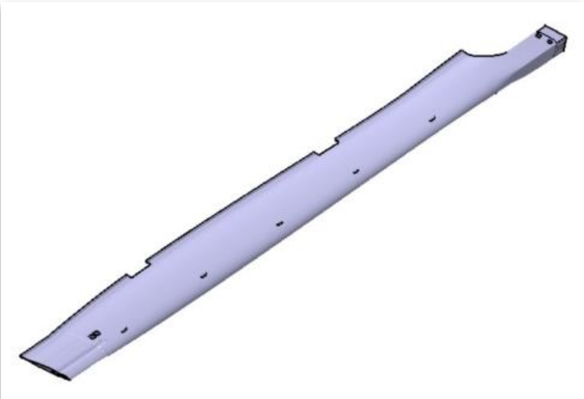

Fig. 4: Existing rotor blade

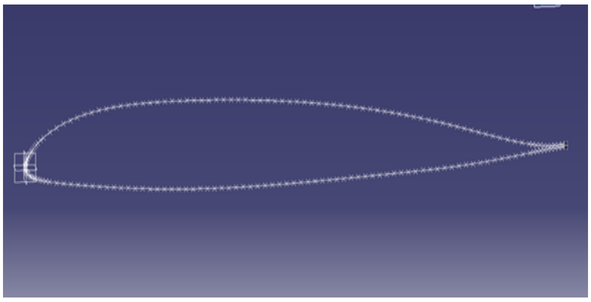

Fig. 5: Airfoil created using spline resulting from the coordinates of the existing airfoil

2. For inspection of the airfoil curvature, porcupine curvature analysis was carried out in CATIA V5 to identify the abrupt changes in the curvature of the airfoil, as shown in Fig. 6.

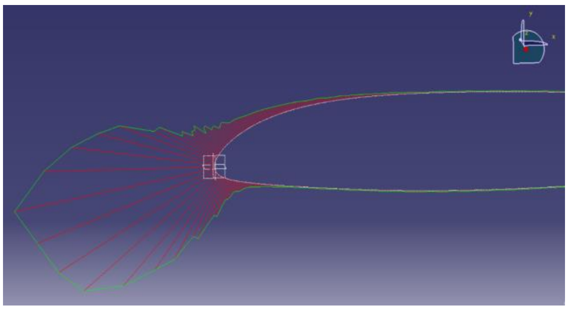

Fig. 6: Procupine curvature analysis of the existing airfoil

3. As seen in the above figure, there is an abrupt change in curvature at the leading edge. So as to refine this curvature, the points at the leading edge have been manipulated to achieve a smooth transitional curvature curve as shown in Fig. 7.

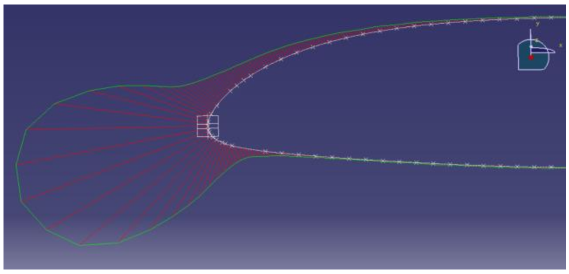

Fig. 7: Procupine curvature analysis of the modified airfoil

4. The final coordinates of the modified airfoil are then used to create the final airfoil spline in CATIA V5 as shown in Fig. 8.

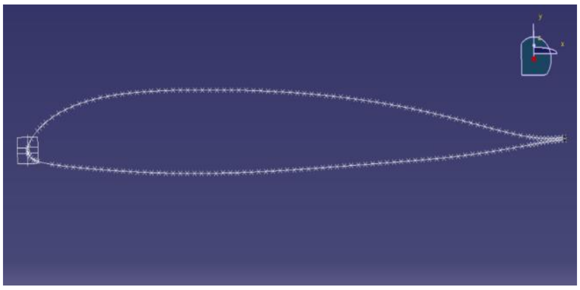

Fig. 8: Airfoil created using spline resulting from the coordinates of the modified airfoil

5. Hereafter, Computational Fluid Dynamics (CFD) was used to arrive at C_l, C_d, pressure and vector contours using ANSYS FLUENT as shown in the following figures.

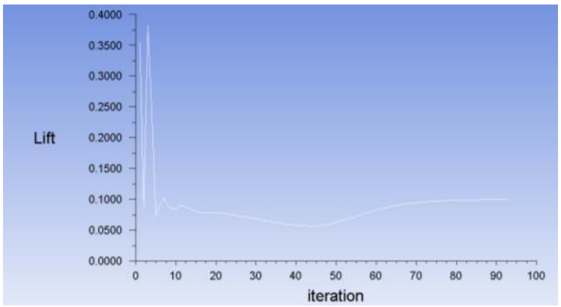

Fig. 9: C_l graph for modified airfoil

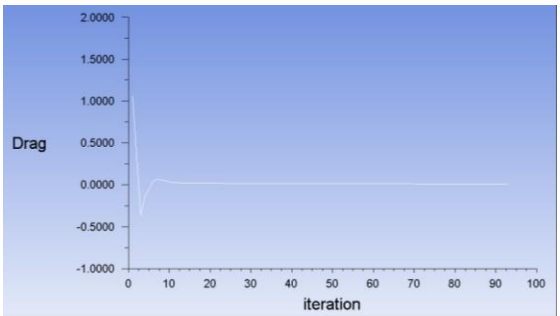

Fig. 10: C_d graph for modified airfoil

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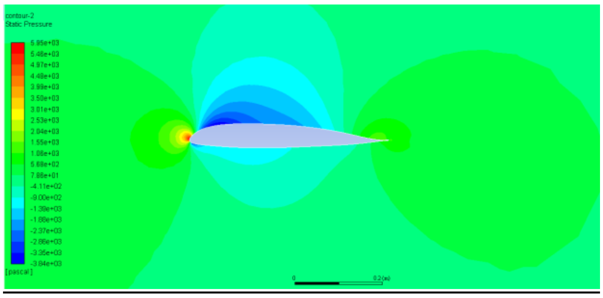


Fig. 11: Pressure contour for modified airfoil

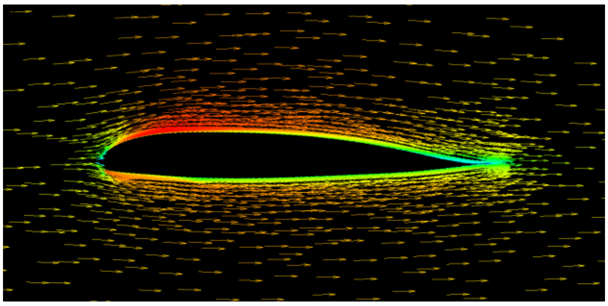
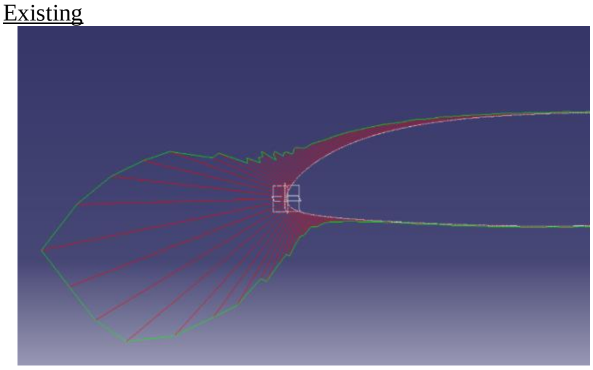


Fig. 12: Vector contour for modified airfoil

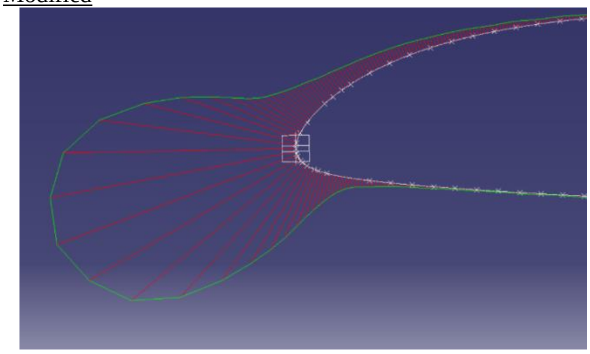
4. RESULTS

4.1 Curvature Analysis

Existing



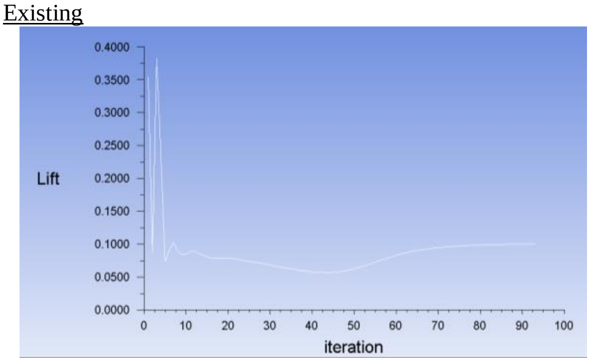
Modified



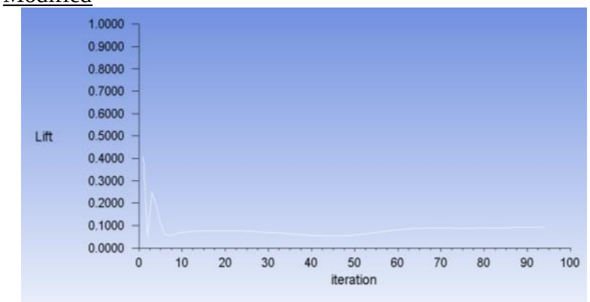
4.2 Coefficient of lift and drag

Coefficient of Lift (C_l)

Existing

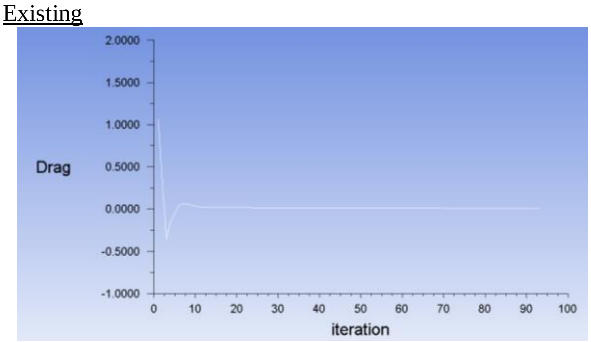


Modified

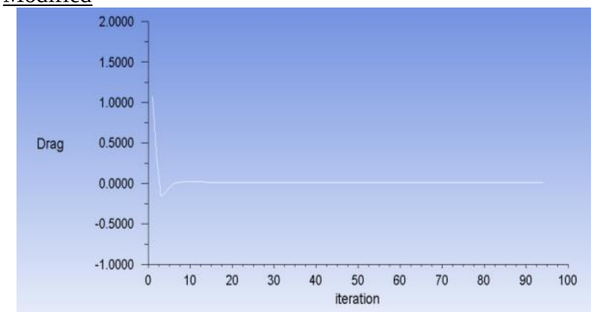


Coefficient of Drag (C_d)

Existing



Modified



AIRFOIL	C_l	C_d	C_l/C_d
Existing	0.097	0.011	8.8
Modified	0.101	0.01	10.1

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5. CONCLUSION

Better curvature transition was achieved at the leading edge of the airfoil which resulted in 1.2 percent increase in C_l/C_d ratio.

6. REFERENCE

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[2] Theory of Wing Sections by Ira H. Abbott, A. E. von Doenhoff

[3] Fluid Dynamic Drag by S. F. Hoerner

[4] Fluid Dynamic Lift by S. F. Hoerner