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AERODYNAMIC MEASUREMENTS OF MODIFIED EPPLER 61 AIRFOIL

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ABSTRACT

To provide better coefficient of lift low angle of attack at low Reynolds number. That way a low Reynolds number airfoil was taken it was Eppler 61 airfoil. The Eppler 61 airfoil was modified by changing its coordinates with help of javafoil software. To get the aerodynamic characteristics the chord of 150mm and span wise length of 498mm was fabricated by a fine teak wood and it was a tested in a 50m/s low speed wind tunnel in the incidence range of -4^0 to 10^0 at a Reynolds number of 46000, 67000, 87000. Pressure differences of upper and lower surface of the airfoil were measured. From these aerodynamic characteristics in terms of lift, drag, lift due to ratio and pitching moment coefficients were computed and compared with the already existing Eppler 61 airfoil. Comparison shows at low angle of attack lift is maximum than existing value and also drag is reduced at low angle of attack and it was associated with lower pitching moment coefficient. Sudden stall was occurred at lower angle of attack. Even at negative angle of incidence it gives better coefficient of lift than existing value. At all Reynolds number the lift value is mostly common while the drag was varied slightly. This made a change in coefficient of lift due to drag. On the upper surface of the modified airfoil has a bubble like structure. Due to the bursting of bubble the early stall has been happened.

Keyword: Low Reynolds number, laminar separation bubble.

NOMENCLATURE

C_l	Lift Coefficient
C_d	Drag Coefficient
$C_{ML.E}$	Pitching moment coefficient about leading edge
$C_{Mc/4}$	Pitching coefficient about quarter chord
α	Angle of incidence
α_{stall}	Stall angle of incidence
C_P	Coefficient of pressure
C_{PU}	Coefficient of pressure on upper surface
C_{PL}	Coefficient of pressure on lower surface
p	Local static pressure
p_∞	Free stream static pressure
q	Dynamic pressure in the wake
q_∞	Free stream dynamic pressure
c	Airfoil chord
Re	Chord Reynolds number

1. INTRODUCTION

Studies at low Reynolds number has generated a lot of interest to create a newer generation of airfoil in the development of micro air vehicle for both civil and Strategic purposes. These studies have shown that the characteristics of flow at low Reynolds number. Studies at lower Reynolds number initiated to develop the MAV configuration airfoil. Also the literature has shown that eppler 61 airfoil has a better aerodynamic characteristics and better stability to MAV. This was created an interest to make better stability than eppler 61 airfoil. The first thing is to carry the pressure measurements of the airfoil to determine its aerodynamic efficiency and the second thing was to comparing the existing and the newer data.

2. EXPERIMENTAL DETAILS

Experiments were carried out on 150mm chord of modified airfoil in 50m/s low speed wind tunnel at a free stream velocity of 5, 7.5, 10m/s corresponding to the chord Reynolds number of 46000, 67000, 87000 in the angle of attack of -4^0 to 10^0. Freestream turbulence level in the freestream velocity range of 5 to 13.5 m/s. The modified Eppler 61 airfoil is embedded with 7 static pressure ports on the upper surface while the lower surface having 6 pressure ports. The airfoil was fabricated with teak wood with span wise length of 498 mm and mounted between the two walls of the tunnel. It has maximum thickness at 7% at 29.54% chord and maximum camber at 5.55% at 79.4% chord. the last location of the pressure port was at 83% and no more pressure port was fixed due to the minimum thickness of

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the trailing edge of the airfoil. Freestream static and total pressures were measured and it was compared finally.

3. DATA REDUCTION

Surface pressure were no dimensionalized and expressed in terms of coefficient of pressure (C_P).

$C_P = (P-P\infty)/q\infty$

Using coefficient of pressure on upper and lower surface, normal force and axial force coefficients were computed.

$$C_n=\int_0^c (C_{PL}-c_{PU})dx$$

$$C_a=\int_0^c (C_{PU}-c_{PL})dy$$

Using this lift coefficient was computed using

$$C_L = C_n cos\alpha - C_a sin\alpha$$

Drag coefficient was computed using

$$C_D=2\int\sqrt{\frac{q}{q\infty}}\left(1-\sqrt{\frac{q}{q\infty}}\right)d\frac{y}{c}$$

Pitching moment coefficient about the leading edge is computed by

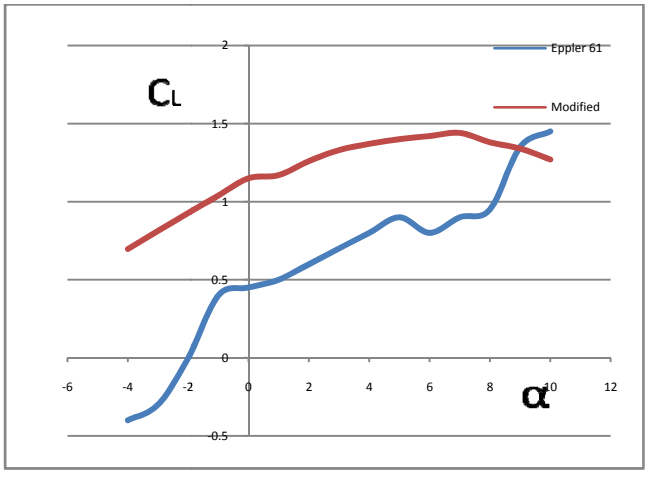
$$C_{MLE}=\frac{1}{c^2}\int_0^c (C_{PL}-c_{PU})xdx+\frac{1}{c^2}\int_0^c (C_{PU}-c_{PL})ydy$$

Pitching moment about the quarter chord is computed using

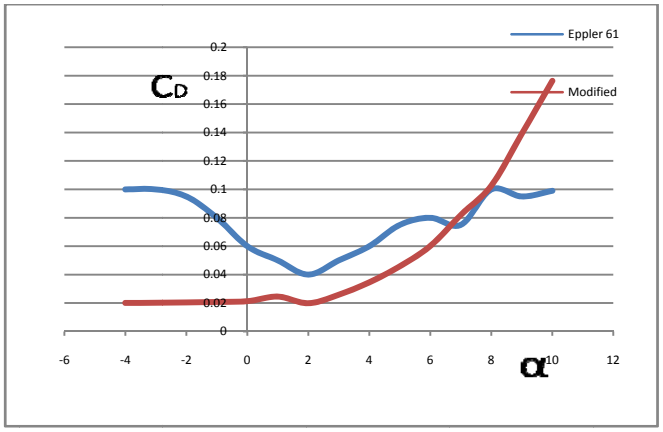
$$C_{Mc/4}=C_{MLE}+C_{n/4}$$

4. DISCUSSION OF RESULTS

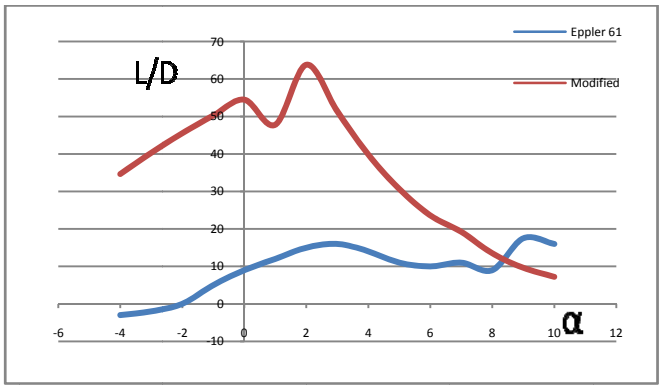
At Reynolds number of 46000 the lift is compared with the already existing value taken from some literatures. It clearly shows that at negative angle of attack the new airfoil gives a coefficient of lift more than the existing value. At 0^0 angle of attack the lift is maximized to 0.74 but the eppler 61 has 0.52. But the early stall has been happened at 8^0.



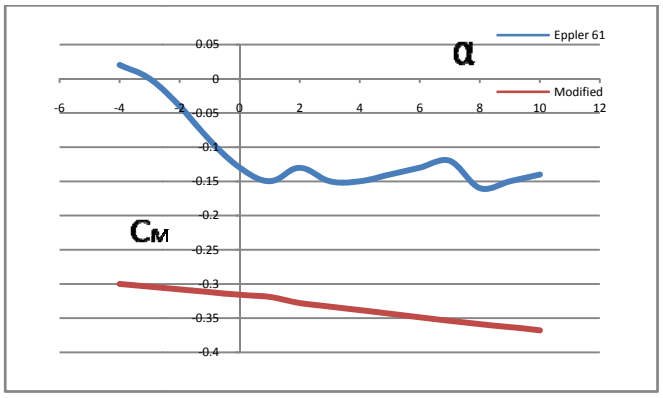
At that time the drag obtained was minimal amount. From the range of -4 to 8 degree the drag was lower than the existing value taken from the literature. After that the drag was increased gradually.



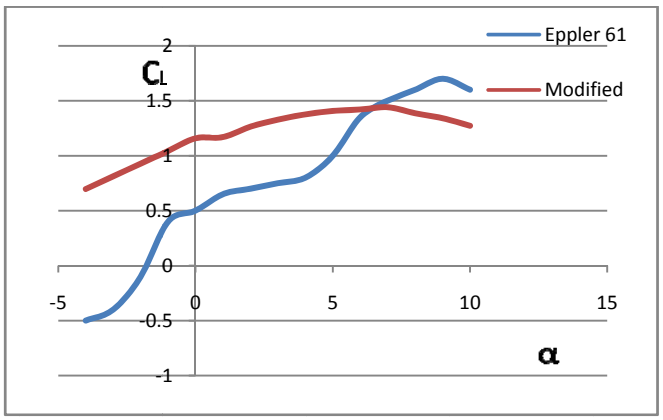
As same as that the coefficient of lift due to drag ratio in very much higher than the existing value at a range from -4 to 8 degree. After that it could be reduced.



The pitching moment coefficient was further reduced when compared to the existing value.



At Reynolds number of 67000 the coefficient of lift is compared with the existing value of same Reynolds numbers. The lift obtained is mostly same as before.



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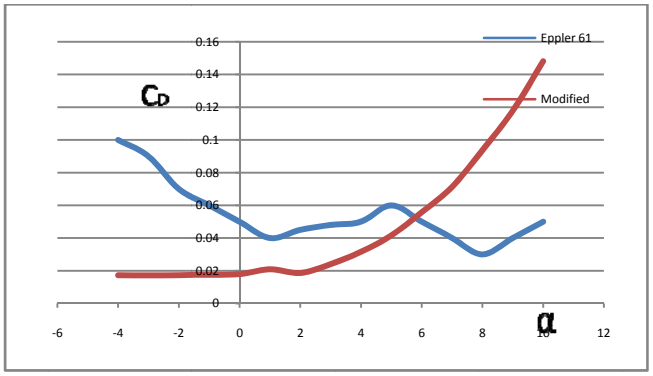
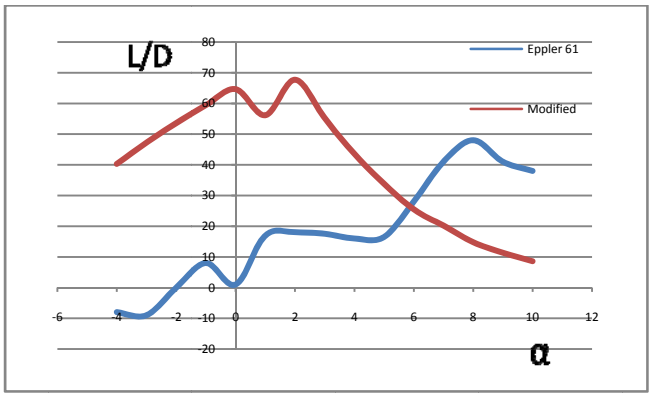
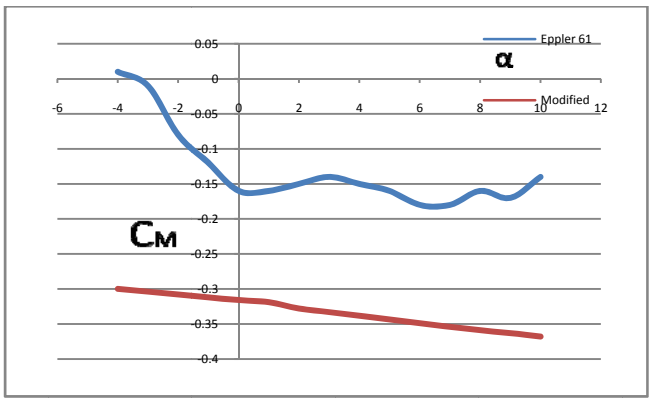
The drag coefficient is also obtained is compared and it is slightly maximized than before.



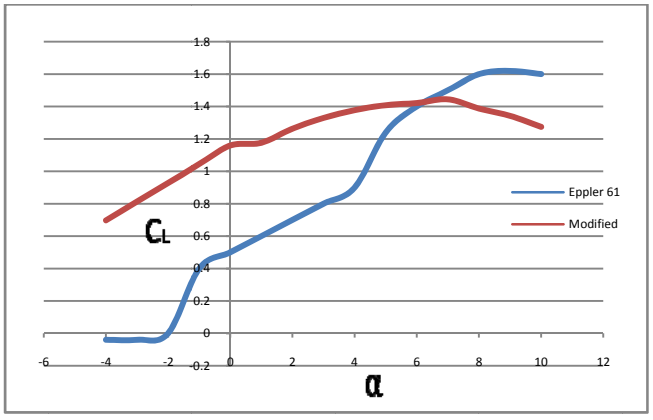
The coefficient of lift due to drag versus angle of attack for 67000 Reynolds number was obtained below.



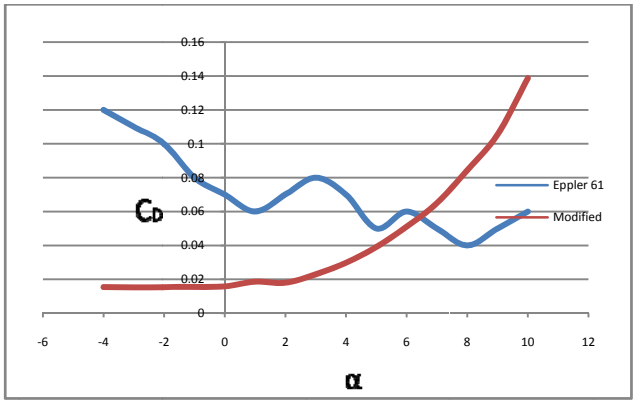
The pitching moment coefficient versus angle of attack for 87000 Reynolds number was obtained as



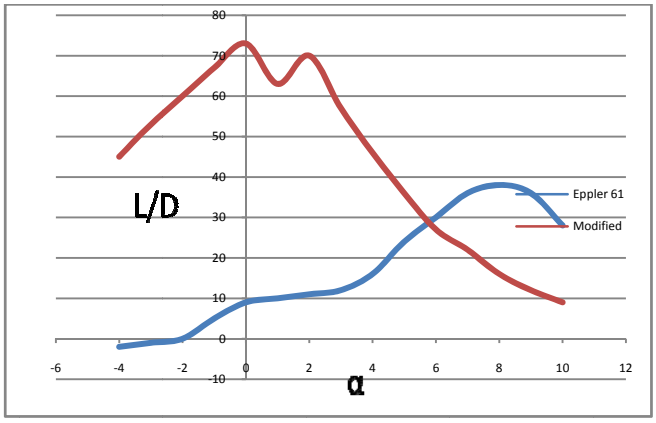
The coefficient of lift due to drag versus angle of attack at 87000 Reynolds number was obtained below



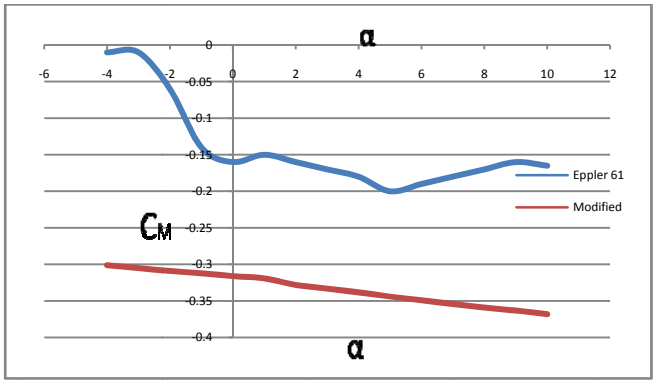
The drag coefficient is also obtained is compared and it is slightly maximized than before



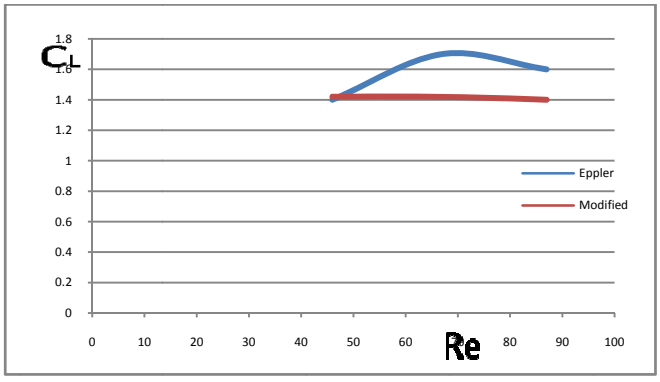
The coefficient of lift due to drag versus angle of attack for 67000 Reynolds number was obtained below



The pitching moment coefficient versus angle of attack for 87000 Reynolds number was obtained as



Aerodynamic characteristics of maximum coefficient of lift for 46000, 67000, 87000 Reynolds number.



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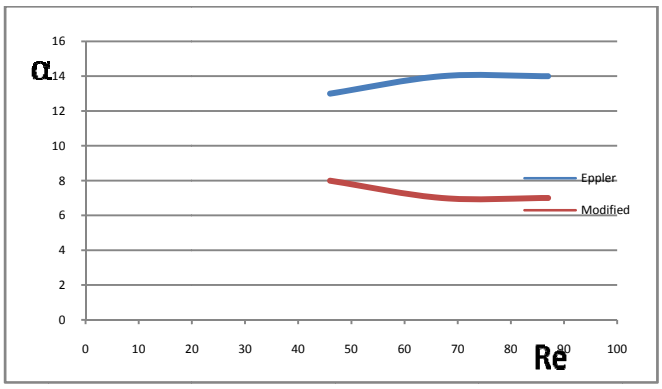
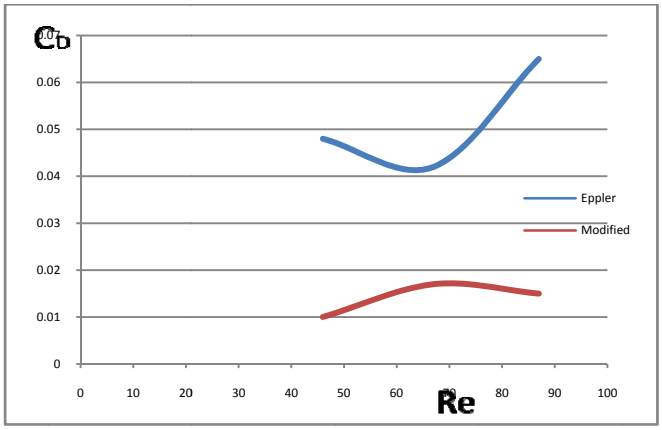
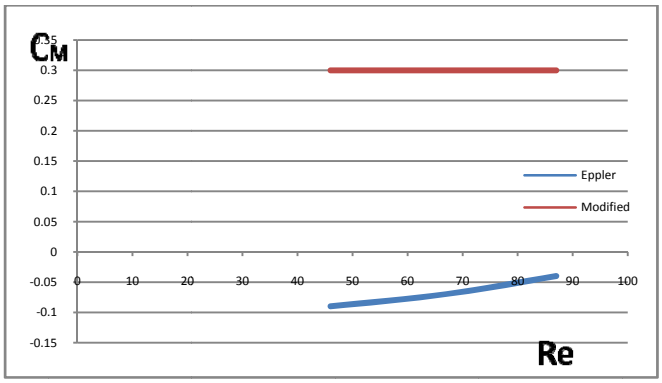
Aerodynamic characteristics of stall for 46000, 67000, 87000 Reynolds number



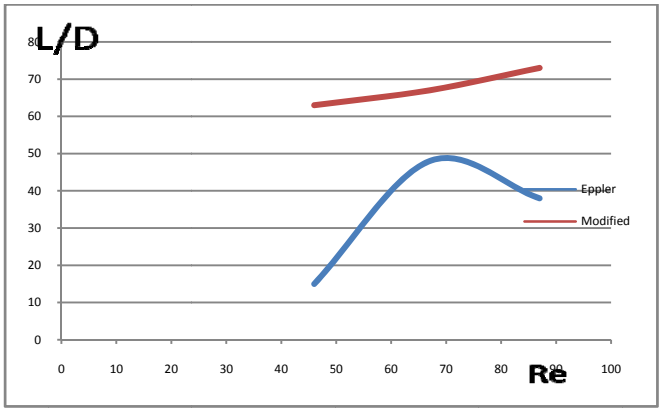
Aerodynamic characteristics of minimum coefficient of drag for 46000, 67000, 87000 Reynolds number.



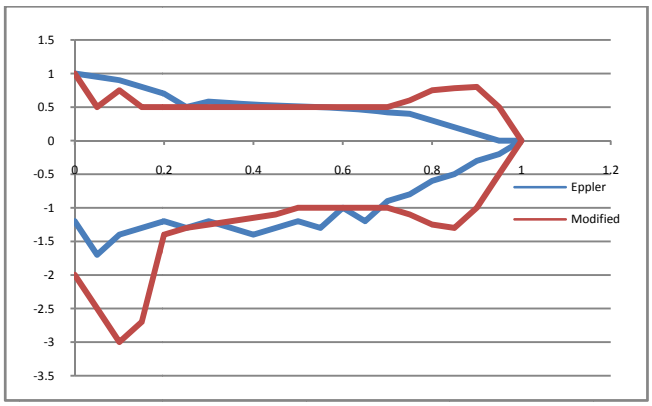
The pitching moment coefficient for 46000, 67000, 87000 Reynolda number.



The aerodynamic characteristics of maximum Lift due to drag ratio for 46000, 67000, 87000 Reynolds number



Pressure coefficient of Eppler 61 and modified airfoil of Reynolds number 87000 at 6^0.



5. CONCLUSION

The modified version of the Eppler 61 airfoil was designed to provide a better result for MAV configuration. The experimental analysis was carried out for 46000, 67000, 87000 found the surface pressure for the modified airfoil. The lift at low incidence was a better result found. The flow was separated near the trailing edge of the airfoil section and it was reattached to form a bubble like structure. This bursting of bubble was a reason for the early stall of the airfoil.

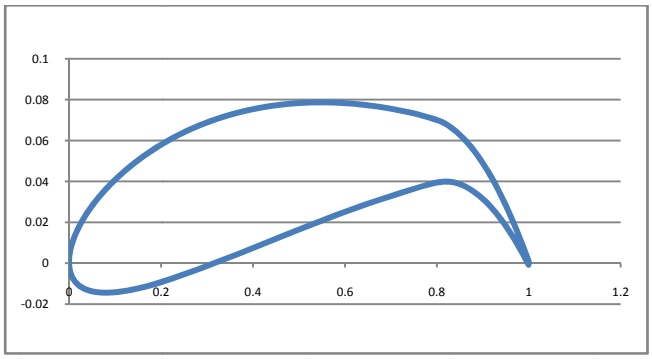


Figure 1 Geometric airfoil of modified version.

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