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Investigation On The Aerodynamics Of Symmetrical Aerofoil At Low Reynolds Number

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Abstract
This experimental investigation of the flow field over NACA 0014 aerofoil is done under the influence of different velocity of air and angle of attack. A low speed open type wind tunnel was used to perform the investigation. Main objective is to perform this investigation is to determine the aerodynamic (lift and drag) force coefficient of the aerofoil under two different Reynolds number $2.2x10^5$ and $2.7x10^5$. Attack angle was varied from 0^o to 18^o. Maximum lift coefficient was obtained at 15^o attack angle.
Keywords: *Aerofoil, angle of attack, pressure coefficient, Reynolds number, lifts and drag coefficient.*

Introduction

The aerodynamic is the branch of gas dynamics in which we consider only air as the working media. Whenever a body flow inside the air or air passes over a body aerodynamics forces acts on the body. Cross sectional area of the wing is known as the aerofoil. National Advisory Committee of Aeronautics (NACA) investigated and nominated the aerofoil in various series like 4 digit series and 5 digit series. Sir Isaac Newton with his famous publication Principia considered as the first aero dynamist of modern world. He observed that the analysis of solid bodies is much easier than that of liquids because liquids are squishy substances. Sir George Cayley gave four fundamental of flight of the object i.e. lift, weight, drag and thrust. Wright brothers were the first who get success in first human flight. Whenever aerofoil travels through the air, then air impinges aerodynamic forces (Lift and Drag). In recent years many experiments has been conducted to enhance the performance of aerofoil that means to enhance the lift force and to reduce the drag force. The characteristics of aerofoil are mainly dependent on two factors, first is angle of attack second is Reynolds number

Experimental set-up

An open circuit, suction type, sub sonic wind tunnel which has maximum velocity of 35 m/s was used in this experiments. The flow of air is generated by a single stage axial flow fan which is controlled by rpm regulator to make variation in the velocity of air. Test section of the wind tunnel is rectangular cross section and having the dimension of (LBH) 900mm x 300mm x 300mm. Test section has holding pegs on which the specimen (aerofoil) is fitted. Honey comb structure of the wind tunnel also have MS screen to eliminate the turbulence eddies in the flow of air. Honey-comb structure is used to generate laminar flow. Contraction zone is provided in the wind tunnel to accelerate the flow of air. Flow of air is discharged in the test section through the contraction zone. Strain guage meter is provided beneath test section which has digital meter to show the coefficient of drag. Wind tunnel which is used for this purpose is shown in figure below.

Fig. 1 View of wind tunnel

Aerofoil used is symmetrical and has maximum thickness of 14 percent of its chord length (NACA 0014). The aerofoil is of wooden material having chord length 145mm and span length of 200 mm. Aerofoil was mounted at the half height of test section. To measure the pressure distribution over the surfaces, pressure tapping is provided on upper and lower surface of the aerofoil. A round protractor is provided at one side to set the desired angle of attack for the aerofoil.

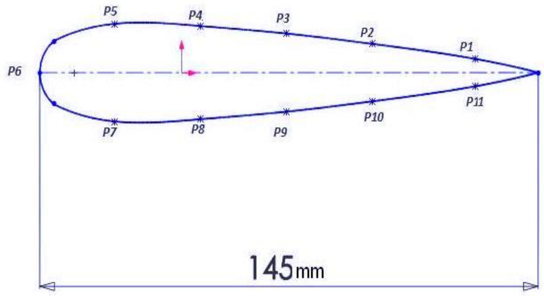

Fig. 2 Location of pressure tapping

Pressure measurement distributed on the surface of aerofoil was done with the help of pressure tapping as shown in figure. These pressure tapping were connected with the U- tube manometer where pressure on the desired point can be calculate. The required velocity was set with the help of suction fan and pitot tube. Experimental investigation was performed from 0^o to 18^o angle of attack. Coefficient of pressure C_p was calculated with help of expression $C_p=(P-P_\infty)/0.5\rho V^2_\infty$, where P is static pressure measured at tapping, P_∞ is the static pressure of free stream, ρ is density and V_∞ is free stream velocity. Coefficient of lift was calculated with help of Coefficient of pressure at lower surface (C_{pls}) and Coefficient of pressure at upper surface (C_{pus}) in the expression as given below

$$C_L = \frac{1}{c}\int_0^1 (\mathrm{Cpls} - \mathrm{Cpus})\, dx$$

Drag coefficient observed with the help of strain guage meter which gives value on digital meter.

Results and discussion

Results which are obtained are discussed in this section. Pressure coefficients are shown for the aerofoil. Calculations for C_P with respect to x/c (where x is distance from leading edge along the chord) were done and the related graphs are shown in this section. Stream wise variation for the coefficient of pressure showed nearly same distribution for both the Reynolds number. For 0^o angle of attack the pressure distribution is similar on both the surfaces, but as we increase the attack angle it varies gradually. Fig. 3 and 4 shows the pressure coefficient at the upper surface of the aerofoil and Fig. 5 and 6 shows the pressure coefficient at lower surface of the aerofoil. As we taken a pressure tapping at the leading, it is found that the stagnation points get shift to lower surface from leading edge with increase of attack angle.

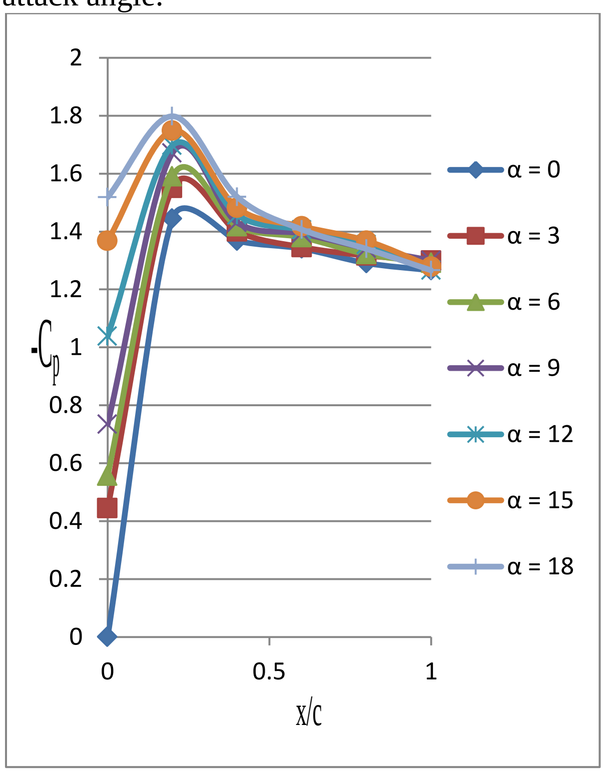

Fig. 3 Upper surface pressure distribution at RE= 2.7x 10^5

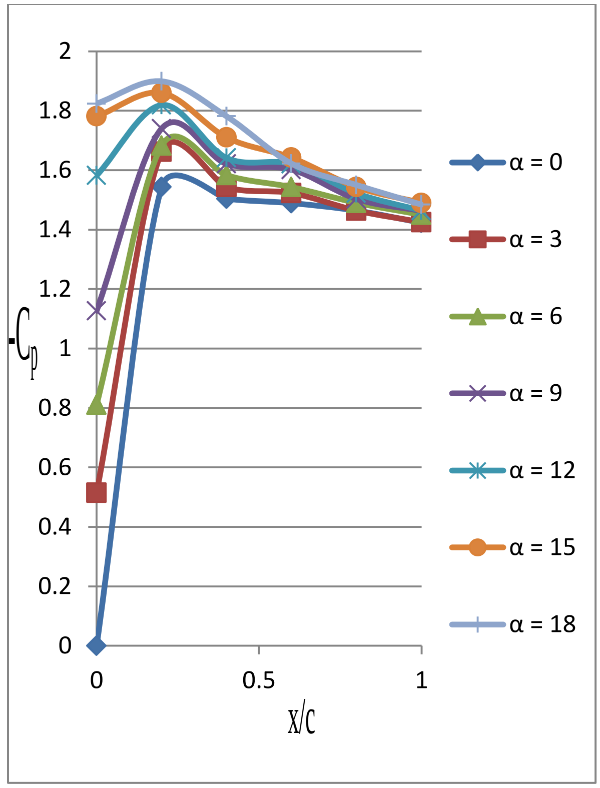

Fig. 4 Upper surface pressure distribution at RE= 2.2x 10^5

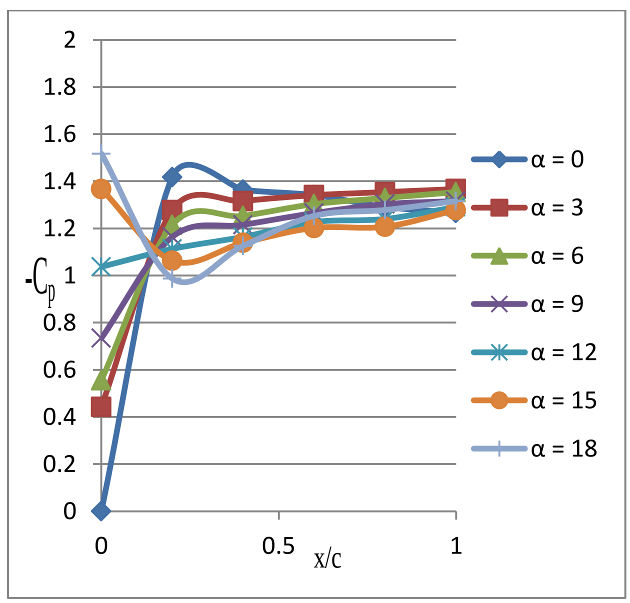

Fig. 5 Lower surface pressure distribution at RE= 2.7x 10^5

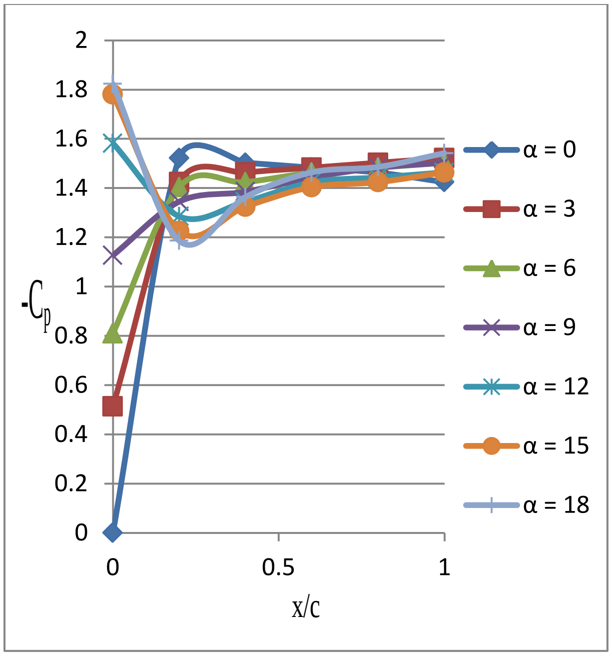

Fig. 6 Lower surface pressure distribution at RE= 2.2x 10^5

Coefficient of lift and drag variation of NACA 0014 aerofoil is given in fig. 7 and 8. Value of lift coefficient increased monotonously with angle of attack and reached the maximum value of 1.465 and 15^o angle of attack at higher Reynolds number.

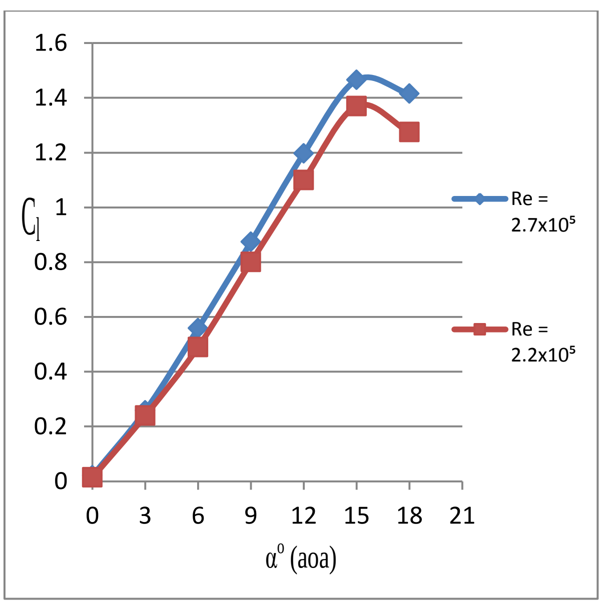

Fig.7 Lift coefficient at both Reynolds number

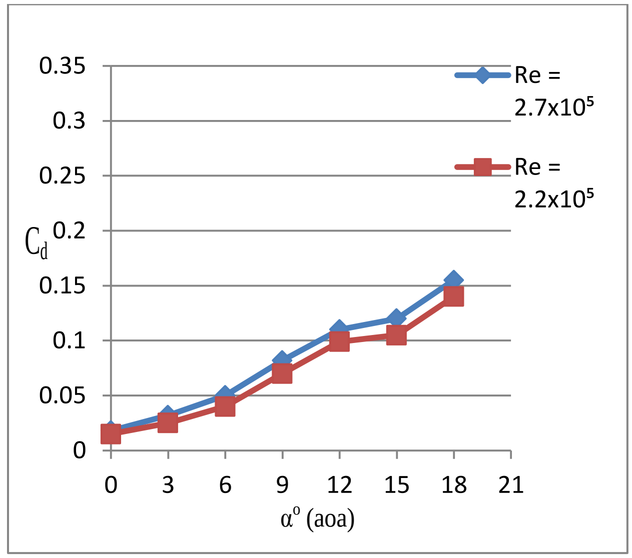

Fig.8 Drag coefficient at both Reynolds number

Conclusion

Aerofoil NACA 0014 has been tested under the influence of attack angle and Reynolds number. It has been concluded that the lift and drag coefficient both are increased with increase of Reynolds number and angle of attack. Stall condition achieved at 15^o attack angle and maximum value of lift coefficient and drag coefficient achieved are 1.465 and .155 respectively.

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