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AERODYNAMIC STUDY OF SYMMETRIC AEROFOIL

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Abstract

A detailed study is done on symmetrical aerofoil of NACA family. The study is related to four symmetrical aerofoil which are NACA 0012, 0015, 0017 and 0018. All four aerofoil were tested in low speed wind tunnels. The parameters which plays important role in the performance of aerofoil are Reynolds number and angle of attack. In the aerofoil the pressure on the upper surface is lower than that of lower surface, this pressure difference lead to generate the lift force on the aerofoil. These types of experiments can be extended on other symmetrical aerofoil.

Keywords: - *Aerofoil, angle of attack, Reynolds number, Coefficient of lift.*

Introduction

Aerodynamics is the science which relates the study of air flowing past over the objects like airplane, train and other objects. Basically it is a subfield of Fluid mechanics in which the fluid considered is air only. The cross sectional area of wings is known as aerofoil. Main function is to provide the lift force. Sir Isaac Newton was considered as the first aero dynamist of modern world because of his famous publication Principia and gave theory related to air resistance Aerodynamics comes in the main stream of engineering in the early of 18th century. Sir George Cayley gave four fundamental of flight of any object i.e. lift, weight, drag and thrust. A great effort was done by the Wright brothers in starting of 19th century. In 1901, they made their own wind tunnel which is 6 feet long and 16 inches squared wind tunnel and using twin blade fan connected to the gasoline engine. In their wind tunnel they tested nearly 200 specimens including flat plate, curved plates, wings, aerofoil with sharp and rounded leading edge and many multiple wing configurations. In First World War engineers switched from sharp leading edge aerofoil to rounded leading edge aerofoil. Now a day's low Reynolds number applications in aerodynamics are very important aspects for both civil and engineering applications. It is commonly known thing that many aerodynamic problems come in low Reynolds number region. Applications included wind turbine, micro air vehicles, propellers e.t.c. Aerofoil

shaped body which while travels through the air have to handle the aerodynamic forces (Lift and Drag). In recent years many experiments had been done to enhance the performance of aerofoil e.g. to enhance the lift force and to reduce the drag force. A number of engineering devices employ aerofoil of various shapes for their operations like wings of airplane, blades of pumps and turbines, submarines, torpedoes e.t.c. Aerofoil at low Reynolds number have great applications in daily industrial and engineering fields. Engineers and scientist in the entire world are doing a number of experiments related to aerodynamic characteristics of aerofoil. Aerofoil characteristics are mainly dependent on two factors, first is angle of attack and other one is Reynolds number. Symmetrical aerofoil has been used on many engineering fields. Experimental investigations on symmetric aerofoil on low Reynolds number have been performed by investigators and still researches going on. Since in our daily life we don't face the sonic and supersonic speed of air that is why mainly researches have been done with sub sonic air velocity. For this purpose sub sonic wind tunnels are used. Sonic and supersonic wind tunnels are only used in the analysis of high speed vehicle like airplanes, racing cars, missiles, rockets and special purpose vehicles.

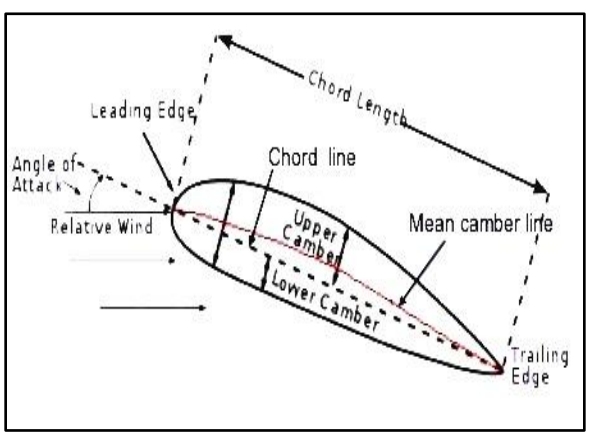

Fig. Terminology of an aerofoil

Terminology of Aerofoil

1. Leading edge – It is the forward end of any aerofoil where it has maximum curvature or it the point which faces the free stream of air.

2. Trailing edge – It is the most rear end of any aerofoil of the point of minimum curvature.

3. Chord line – It is the line which join the leading and trailing edge of the aerofoil.

4. Mean Chamber line – It is the line which joins all the points midway of the upper and lower surface.

5. Chord – It is the length of chord line.

6. Angle of attack – It is the angle between the chord line of the aerofoil and direction of free stream of air.

Literature Survey

Ahmed and Sharma has carried out their valuable experimental investigation with symmetrical airfoil NACA 0015 at low Reynolds number and varied angle of attack. The mean velocity profile over the surface of airfoil has obtained, the pressure distribution on the surface of airfoil has measured and lift and drag forces were also evaluate. Experiments were carried out with changing the angle of attack from 0^0 to 10^0. It was found that high pressure obtained at the entire lower surface for the high angle of attack when airfoil is close to the ground and high value of lift coefficient was obtained. The pressure coefficient at the upper surface of airfoil did not change much with high angle of attack at the ground clearances. The suction or negative pressure gradient causes fall in kinetic energy on the upper surfaces at the higher angle of attack, this leads to the higher turbulence level and thick wake and

hence high drag is induced. It was also found that there is drop in the lift force at ground clearance on lower angle of attack. Higher values of turbulence intensity and thicker wake region were obtained at 12^0 of angle of attack.

Yemenici In this investigation, experiments have been done on a symmetrical airfoil in a low speed wind tunnel. The experiments were done with NACA 0012 airfoil under the influence of angle of attack and Reynolds number. Reynolds number which is based on chord length varied from 9.7x 10^4 to 1.9x 10^5 & angle of attack was varied from 0^0-14^0. Finally in this experiment it was conclude that initially the pressure coefficient at the suction side increased at the leading edge and get diminished at the trailing edge at all angle of attack, it was also observed that both lift and pressure coefficient are highly dependent on angle of attack and Reynolds number.

Rathod Investigator did his experiments with the help of sub sonic wind tunnel with variable wind velocity. Symmetric aerofoil NACA 0017 was used in this experiment. Characteristics curves were drawn at different angle of attack with different Reynolds number. In this experiment result comes that the stalling condition was found nearly to the 16^0 angle of attack. It is also conclude that with increase in velocity drag reduced up to a certain limit and after that it is considerably high. Coefficient of lift increases linearly with angle of attack up to stall condition comes and with further increase of angle of attack its value gets diminished. From pressure variation graph it was conclude that pressure over the upper surface decrease with increase in Reynolds number.

Gerakopulos et al. In this experiment the lift and separation bubble characteristics of a symmetrical aerofoil (NACA 0018) has been analyzed. Pressure distribution at the surfaces was measured and calculation has been done to figure out the relationship between the performance of aerofoil and the development of separated flow region. The variation in angle of attack is from 0^0 to 18^0 and in Reynolds number is from 80 x 10^3 to 200 x 10^3. With the help of measured data two distinct regions have been identified, first is of rapid and linear growth of coefficient of lift at low angle of attack and second is of more gradual and linear growth of at the high pre- stall condition.

Yemenici has carried out their investigation in a low speed wind tunnel with a symmetrical airfoil. Experiment has been carried out under the influence of Reynolds number of $1x10^5$ to $3x10^5$ and angle of attack from 0^0 to 14^0. Velocity and static pressure measurement has been done with the help of constant temperature anemometer and micrometer respectively. And it was analyzed that similar variation in pressure coefficients distribution of the airfoil at both the Reynolds number, it is also found that the lift coefficient and stall angle both are increased with the Reynolds number.

Islam and Hossain Investigators had been done analysis through their experimental investigation in a sub sonic wind tunnel on a base line airfoil NACA 0015 model. Experiments have been done over a wide range of angle of attack from 0^0 to 20^0 with fixed stream velocity of 12m/s. and with the Reynolds number 1.89×10^5. Pressure distribution measurement has been done on both upper and lower surface of the airfoil and after analysis it has been found that C_l & C_D are 1.3 and 0.31 respectively.

Munzarin and Sayeed has analyzed four different profile objects - a symmetrical airfoil (NACA 0015), a cambered airfoil (NACA 4415), a cylinder and a sphere.

These objects have been tested in a sub sonic wind tunnel. The experimental data has been observed at different Reynolds number and angle of attack. Two airfoils have been tested from 3^0 to 18^0 of angle of attack with 3^0 of steps whereas cylindrical profile and spherical object have been from 0^0 to 180^0. Experiments concluded that the cambered airfoil (NACA 4415) has the least coefficient of drag while sphere has provided maximum drag.

Uddin and Hossain has carried out their experimental investigation to measure the drag and lift coefficient for multiple wings. For the investigation a model of multiple wing was constructed and experiments was conducted through it in a subsonic wind tunnel. Symmetrical airfoils NACA 0012 of chord length 21 cm was used for tri-plane configuration. Angle of attack was varied from 0^0 to 20^0 with 5^0 steps.

Conclusion

After study and analysis of above research papers, I appreciate Ahmed M.R., Sharma S.D., U Rathod Narayan , Yemenici Onur & Munzarin Morshed & Shehab Bin Sayeed contribution in aerodynamic science. In research paper of Ahmed M.R., Sharma S.D pressure measurement methodology had been used. He analyzed the pressure variation on upper and lower surface and findout the lift coefficient and wake region and boundary layer separation. In research paper of U Rathod Narayan, they analyzed aerofoil on a appropriate range of angle of attack with variable velocity of air and Reynolds number. Basically they wants to do alteration mainly velocity of air and find out the coefficient of lift and drag. In research paper of Yemenici Onur, he made variation in angle of attack as well as in reynolds number and find out the lift coefficient of lift by the pressure measurement technique. Munzarin Morshed & Shehab Bin Sayeed also analyzed four different objects including a symmetric aerofoil in a low speed wind tunnel and measured the drag coefficient. In all above research papers, pressure measurement method had been used on the upper and lower surface of aerofoil through which negative and positive pressure difference had been observed.

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