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Determine Aerodynamic Characteristic for FX63-137 Aerofoil

Magedi Moh. M. Saad[1], Norzelawati Asmuin[2], Abass Bin Abdul wahab[3]
University Tun Hussein Onn Malaysia (UTHM), Parit Raja, 86400 Batu Pahat, Johor.

Abstract:- this paper mainly concentrated on determine aerodynamic characteristic for FX63-137 aerofoil experimentally and by computer aided to choose best angle of attack at maximum lift low drag. This paper divided into many stage, Firstly manufacturing aerofoil using aluminium alloy with using CNC machine ,secondly Testing process using subsonic wind tunnel ,finally display results at low Reynolds number at speed of 20m/s, 30m/s in chart and compare this results with reference and select best angle of attack at maximum lift.

Keywords:- Aerofoil, Wind Tunnel, lift, Drag, angle of attack, XFOIL.

I. INTRODUCTION

As aerofoil become more efficient and reliable, they are also becoming more complicated. This can be seen when calculating the aerofoil characteristics for a certain airplane, for example. Integrated systems design now takes the focus in any new aircraft development project. Complex systems modelling require accurate knowledge of subsystem and component performance.[1] Although engineers can manage to get component performance predictions using practical experiments, these test programs can be very expensive.[2] The range of this operating system, characterized by the range of operating conditions (which include inlet pressures, flow rates, altitude and many others), continues to increase as companies extend the use of each aircraft component.[4]

In this paper will be describe the aerodynamic features of an aerofoil at low Reynolds number. Literature survey related to wind tunnel that is used for aerofoil testing is also discussed and computational simulation using XFOIL program. And will previous research relating to the aerodynamic characteristics of the airfoil are described in feature.[3]

II. AEROFOIL OPTIMIZATION

Aerofoil design is considered an important factor in the manufacture of this type of aircraft. So this type of aircraft need high coefficient of lift because needs to take off within 100 feet.[3] Therefore, we will test this aerofoil with minimal drag on at speed about 30 m/s. in this case we need to low Reynolds number.

III. AEROFOIL DESIGN

The Airfoil data at low Reynolds number from seldom get it. However would be found airfoil performance at low Reynolds numbers for airfoil (FX 63-137). [5]For maximum endurance must obtain the best design for the wing because he is one of the fundamental factors and the essential for that.

We chose FX 63-137 because it is superior in aerodynamics characteristics at low Reynolds number and at Low Speed. This airfoil has characteristic high lift coefficient where reach about 1.6, this property not found in other aerofoils. Figure1: shows the FX 63-137 airfoil. [6]

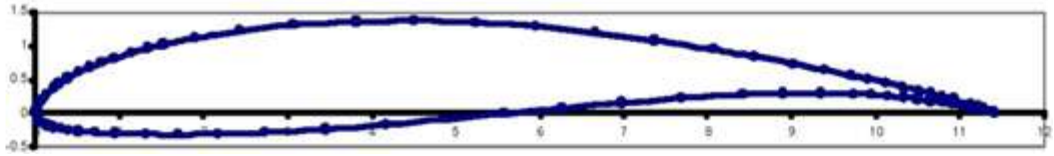

Fig.1: FX63-137 Aerofoil [3]

IV. PRINCIPLE OF AERODYNAMIC

There four forces acting on aircraft this forces are lift, thrust, drag weight. As shown in fig.2 these forces are produced by the interaction between the aircraft and the motion of the wind. These forces contribute to the performance of the aircraft whereby it influences the aircraft in speed flight, and endurance. This forces resulting from interaction between the motion of the wind and aircraft. The lift, drag and moment are functions of attitude and configuration geometry.

Aircraft performance depends on the effectiveness of the wing, which is measured by lift to drag ratio. The lift to drag ratio for all aircraft not associated with wing drag only but includes also drag contributed by the rest of the aircraft.

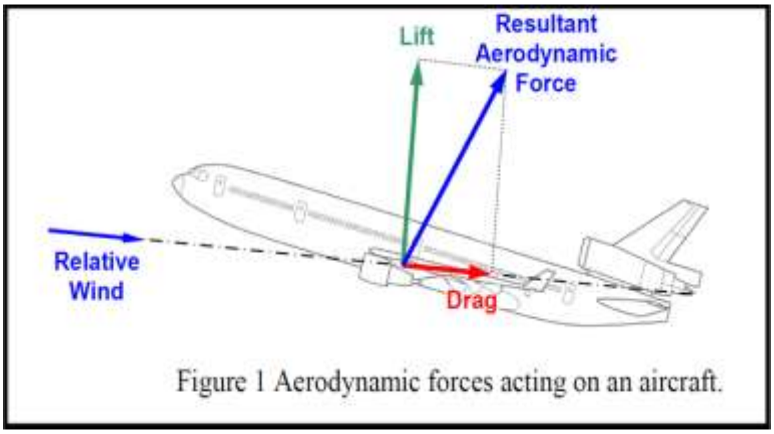

Fig. 2: Aerodynamic forces acting on an aircraft

A. Lift Force

Of the key factors affecting the endurance is the lift force in the plane of symmetry in the direction perpendicular to the flight line. Lift force has to be balanced by the aircraft weight for steady level flight and must has to be balanced with the aircraft weight the lift is stated as follows.

$$L = \frac{1}{2}\rho V^2 S C_L \quad (1)$$

Where L is the lift force, ρ is the air density, V is the air velocity, S is the reference area and CL is the lift coefficient. [2]

The dominant factor on conventional aircraft is the lift coefficient that was created from the wing. Tail and fuselage also contributes to the lift generation but in a few percentages, but vertical and horizontal tail functions control stability and will provide a negative lift or down force.

The generation of lift is achieved by producing a greater pressure at the lower surface than upper surface of the body. The difference of the pressure is achieved when the airspeed at the upper surface is higher compared to the lower surface. Inclination of the body relative to the air flow, also contributes to the lift. Lift coefficient measures how efficiently the wing is changing velocity into lift. The higher lift coefficient indicates an efficient airfoil design. The formula of lift coefficient is:

$$C_L = \frac{L}{\frac{1}{2}\rho V^2 S} \quad (2)[6]$$

B. Drag Force

Drag is one of the important factors that affect the plane with extended region of separated flow. when the vehicle produces a lift there are drag is called induced drag. The total of form drag and skin friction is called viscous or profile drag.

In general, drag is a force that causes a resistance in motion. It is the force developed parallel to the relative wind, and is defined as:

$$D = \frac{1}{2}\rho V^2 S C_D \quad (3)$$

Where D is the drag force, ρ is the air density, V is the air velocity, S is the reference area and CD is the drag coefficient. The aerodynamic drag can be defines as the sum of the tangential or skin friction force and the normal or pressure forces parallel to but in the opposite direction of the vehicle’s velocity vector. . The drag coefficient is expressed as:

$$C_D = \frac{D}{\frac{1}{2}\rho V^2 S} \quad (4)$$

C. Reynolds Number

In 1883, Osborne Reynolds introduced a dimensionless parameter knowing as Reynolds number which gave a quantitative indication of the laminar to turbulent flow.[7] It depends on the chord length, velocity and properties of fluid at different altitudes. High Reynolds number is achieved with large chord length, high velocity and low kinematics viscosity. When aircraft design take in your mind scale effect and as an index to predict various types of flows from during calculate Reynolds number. The formula of Reynolds number as:

$$Re = \frac{\rho V l}{\mu} \qquad (5)[8]$$

Where ρ is the density of air, V is the mean velocity of air, l is the characteristics length, and μ is the coefficient of viscosity.

V. MANUDACTURING AIRFOIL FX63-137

These steps carried in the CNC machine is VERTICAL CENTER NEXUS 410A-II (MATRIX CAM) workshop of the UTHM University:

- Create AutoCAD file version 2007 and exported to the machine program.
- Select Set and Program Edit to check form final shape.
- After the completion of manufacturing pieces airfoil as shown.

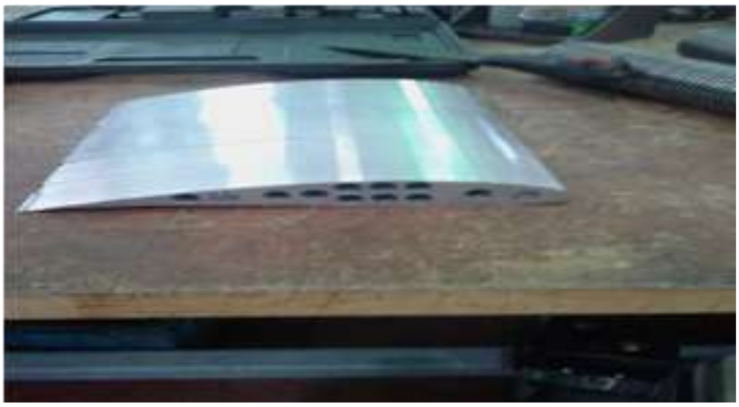

Fig3: Final shape of aerofoil before fixated together

- After prepare slot at quart airfoil with diameter 1.1 Cm prepare rod with same diameter and with length 67.3 Cm (45 cm inside aerofoil).
- Passes the rod inside the aerofoil to connect all pieces together and to fix the rod in the aerofoil.[9]

VI. TESTING THE WING WITH SUBSONIC WIND TUNNEL

- Switch on the electrical isolator on the Control and Instrumentation Frame.
- Press the red START button.
- Set the speed control to the minimum position (fully anticlockwise).
- Gradually turn the speed control clockwise until the tunnel is operating at the speed needed for the experiment.[10]

Table1: Mach number and Reynolds number at different flow speed

Speed (m/s)	Mach number	Reynolds number
20	0.0589	2.0073×10^5
30	0.0883	3.011×10^5

VII. XFOIL PROGRAM

The XFOIL is a well-known and widely accepted open source code for computation of the aerodynamic characteristics of aerofoil in case of two dimensional flows. XFOIL uses the potential theory vortex panel method, combined with a higher order boundary layer method that allows for prediction of transition and separation effects even under low Re conditions. This makes the program especially suitable for UAV applications that operates at low Reynolds numbers (low speed and/or small dimension). The code includes compressible effects, applying Prandtl-Glauert correction to the calculation results.[11] The program allows for certain geometry modification in order to include a plain flap for example or to enhance trailing edge thickness.

a) Draw FX63-137 aerofoil data to a text file and save with .DAT extension.
b) This DAT file containing the data, export file into XFOIL software to calculate characteristics about the airfoil.
c) Write Mach number and Reynolds number and specify angle of attack.[12]

VIII. RESULTS AND COMPARATIVE

After determine results with subsonic wind tunnel and XFOIL computer aided design, can be display and compare results to identify best angle of attack and the best lift coefficient for each speed.

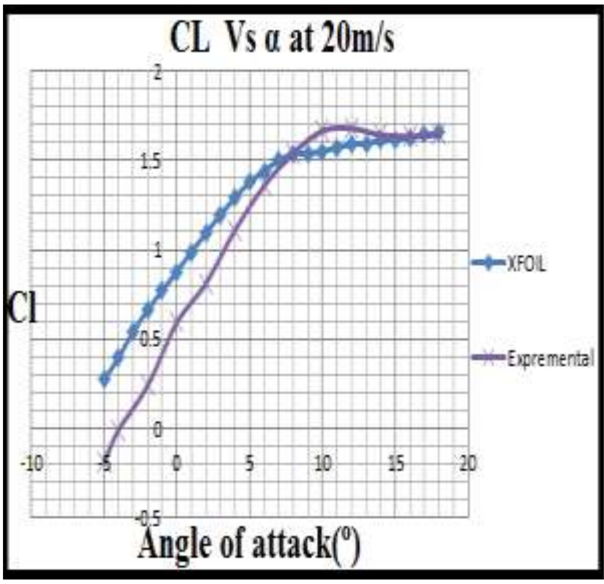

Fig4: CL-α slope for U=20 m/s

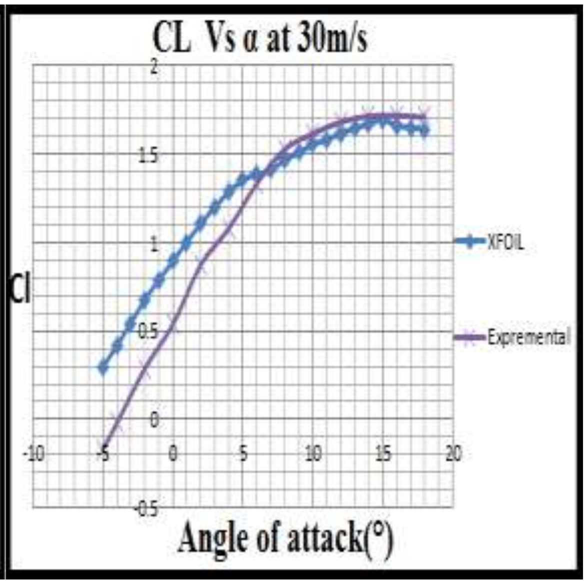

Fig5: CL-α slope for U=30 m/s

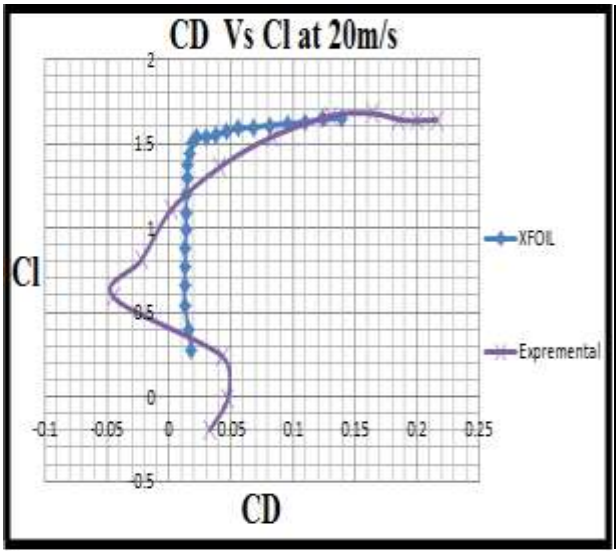

Fig6: CD polar for U=20 m/s

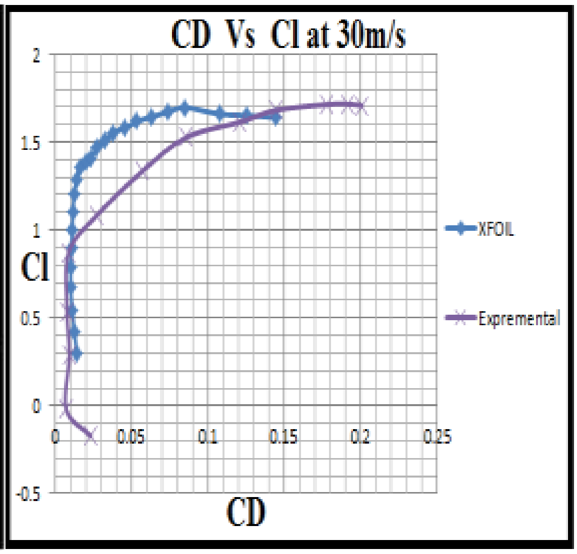

Fig7: CD polar for U=30 m/s

XI. CONCLUSION AND FUTURE WOR

Through previous studies found that the lift coefficient of approximately 1.6. To get a successful design and with good effectiveness must be a high coefficient of lift and low drag coefficient.[13]

The airfoil plays a critical part of the aircraft's performance, and it generates more than 85% of the lift of the airplane, and the airfoil also affects the endurance of the airplane. There are many experiments and simulations to analyses especially on aerodynamic characteristic for an airfoil. The results will compared and been obtained using XFOIL simulation software and experiment, as well as comparing these results with the simulation results using the CFD software. Can be argued that the best lift coefficient of 1.677586 is at angle of attack 12º at 20m/s and best lift coefficient of 1.681103 at angle of attack 12º at 30m/s.

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