Determine Aerodynamic Characteristics for FX63-137 Aerofoil by using Subsonic Wind Tunnel

Magedi Moh. M. Saad a, Norzelawati Asmuin b

University Tun Hussein Onn Malaysia (UTHM), Parit Raja, 86400 Batu Pahat, Johor

a Magedi983@yahoo.com, b norzela@uthm.edu.my

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Abstract. This paper is primarily concentrated with determining aerodynamic characteristics and choosing the best angle of attack at a maximum lift and low drag for the FX 63-137 aerofoil at a low Reynolds number and a speed of 20m/s and 30m/s, by using subsonic wind tunnel through manufacturing the aerofoil by aluminum alloy using a CNC machine. The proposed methodology is divided into several stages. Firstly, manufacturing the aerofoil using an aluminum alloy. Secondly, the testing process is carried out using subsonic wind tunnel. Thirdly, the results are displayed and compared with results produced from related works, in order to find out the best angle of attack at a maximum lift.

1. Introduction

The FX 63-137 was chosen for its superior low Reynolds number characteristics. It has been publicized to produce a maximum lift coefficient higher than 1.5, whereas conventional airfoils are known to degrade well below this level at low Reynolds numbers. The design of an airfoil structure with the curved surface is to give the most favorable ratio of lift and drag [1]. Numerous research experiments have occurred on the most specific characteristics of the aerofoil, with the objectives of better lift, higher performance, and higher endurance [2]. The most optimal characteristics of the aerofoil are be calculated using a wind tunnel, and the results are displayed after a practical experiment. These results can be used to check how accurate the simulations are and how these characteristics can contribute to better lift and endurance.

At a small angle of attack, the stagnation point is the point at which the particles of air slowing down and at which they are divided into two, which are divided into two parts of surface. Figure 2.2 shows the streamline division produced from an increase of velocity at the upper surface, while the velocity decreases at the lower surface [3].

The FX 63-137 was chosen because it is superior in aerodynamics characteristics at a low Reynolds number at low speeds. This aerofoil has high lift coefficient characteristics that reach about 1.6. This property is not found in other airfoils [4].

2. Methodology

2.1. MANUFACTURING AIRFOIL (FX63-137)

These following steps are carried out, and the CNC machine is a Vertical Center Nexus 410A-II (Matrix Cam) located at the workshop of UTHM University to manufacture the FX 63-137 wing, which will be tested with subsonic wind tunnel for the aerodynamic characteristics:

- 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.
After that, prepare slot at quart aerofoil with a diameter of 1.1 cm, and prepare a rod with the same diameter and with a length of 67.3 cm (45 cm inside aerofoil).

Pass the rod inside the aerofoil to connect all pieces together and fix the rod in the aerofoil.

2.2. TESTING THE WING WITH SUBSONIC WIND TUNNEL.

This experiment is carried out at UTM University.

A. Wind tunnel body.
   - The Main Frame.
   - The Silencer.
   - The Effuser Cone.
   - The Control and Instrumentation Frame [5].

B. The steps of operation of the wind tunnel (Assembly procedure):
   - Make sure that the electrical supply to the Wind Tunnel is connected.
   - Remove the upper window.
   - Tighten the Centering Clamps. From outside the Wind Tunnel, insert one of the airfoil into the collect so that its support shaft passes into the Wind Tunnel Working Section.
   - Inside the working section, measure the distance from the center of the airfoil shaft to the bottom surface of the working section.
   - Close the upper window and make sure it is properly supported.
   - Set the manometers to zero and take readings of the ambient air temperature.
   - Connect the electrical supply to the Wind Tunnel and computer to take the reading [6].
• Change angle of attack properly.
• Press the red START button.
• Slowly turn the speed control.
• After sport speed, take reading exactly from computer [7].

Table 1: Mach number and Reynolds number at different flow speed.

<table>
<thead>
<tr>
<th>Speed (m/s)</th>
<th>Mach number</th>
<th>Reynolds number</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.0589</td>
<td>2.0073 x 10⁵</td>
</tr>
<tr>
<td>30</td>
<td>0.0883</td>
<td>3.011 x 10⁵</td>
</tr>
</tbody>
</table>

2.3. Aerodynamic forces on aircraft

\[
L = \frac{1}{2} \rho V^2 S C_L
\]  
(3) [8]

Where \(L\) is the lift force, \(\rho\) is the air density, \(V\) is the air velocity, \(S\) is the reference area and \(C_L\) is the lift coefficient.

\[
D = \frac{1}{2} \rho V^2 S C_D
\]  
(5)

Where \(D\) is the drag force, \(\rho\) is the air density, \(V\) is the air velocity, \(S\) is the reference area and \(C_D\) is the drag coefficient.

3. Results

The work described in this project gives the general perspective for the application of aerofoil aerodynamic characteristics to an aircraft and wind turbine industry. The results were compared to the results obtained by the wind tunnel and then presented.
4. Summary

After the completion of the manufacture of the airfoil by aluminum alloy, and the testing process by the wind tunnel, it can be argued that the best lift coefficient is 1.677586 at angle of attack of 12° and a speed of 20m/s. The best lift coefficient is 1.681103 at angle of attack of 12° and a speed of 30m/s. It could also be argued that airfoil manufacturing by the use of aluminum alloys are considered relatively expensive and heavy when compared with using composite materials.

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References


