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Molecular Impact Theory for Dynamic Lift in Airfoils

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Abstract: ***Airplane wings are airfoil shaped and that is why they generate lift force. I set up an investigation to establish how they work. In my investigation, I carefully studied the symmetrical and cambered airfoils' shapes to check their contribution to their working principles. I found out that the airfoil's upper surface's slant makes air molecules collide with it with a lower force of impact compared to the lower surface where air molecules collide with it with a higher force of impact. I concluded that the difference between the molecular forces of impacts on the two surfaces is what generates lift force.***

Keywords: Airfoil, Molecular force of impact, Lift force

1. Introduction

Airfoils generate Lift force that makes airplanes airborne. Air molecules possess molecular kinetic energy. I believe that the momentum possessed by air molecules is responsible for lift generation in airfoils. I hypothesize that air molecules collide with the lower surface of an airfoil with a higherimpact compared to their impact with the upper surface. Therefore, the difference in gaseous molecular impact between the two surfaces generates lift force.

2. Problem Definition

In all previous researches, explaining how energy is dissipated in airfoils to generate the force of lift has proved to be a challenge. For example, Bernoulli's principle does not explain in terms of energy how the gaseous velocity difference between the upper surface and the lower surface of an airfoil results into the lift force.

I saw the need for a better theory that explains the working principles of an airfoil in terms of energy and energy related factors. I did this research to determine the influence of gaseous molecular impact on airfoils as a result of molecular kinetic energy and derived my theory.

3. Methodology / approach

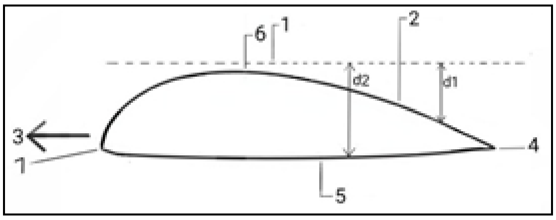

Figure 1

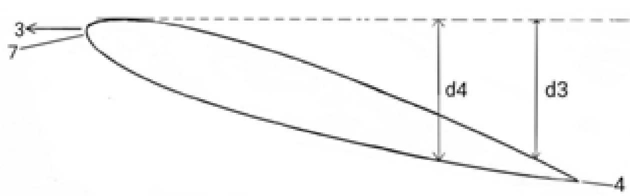

Figure 2

To investigate my hypothesis, I first studied the airfoils' shapes to check if they are a contributing factor to my hypothesis. I obtained several diagrams of airfoils and carefully observed them. I selected a cambered airfoil (Fig.1.) and drew a straight line (1) along it's length slightly above the upper chamber (2) and parallel to the airfoil's direction of travel (3). I measured the perpendicular distance (d1) between the straight line and the upper cambered surface in equal intervals from the point of maximum airfoil's thickness (6) to the trailing edge (4). I repeated the above distance measuring procedure with the lower surface (5) where I measured distance (d2) from the Airfoil's point of maximum thickness to the trailing edge. I repeated all the above procedure with a symmetrical airfoil (Fig.2.) but this time measuring distances (d3) and (d4) from the leading edge region (7) to the trailing edge.

4. Results & Discussion

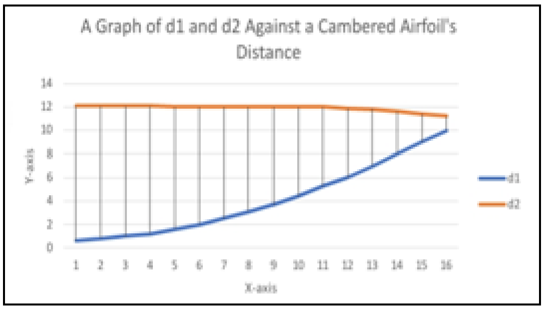

Figure 3

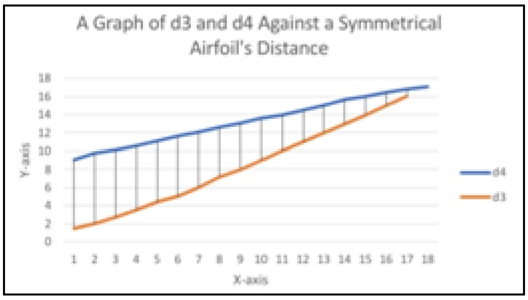

Figure 4

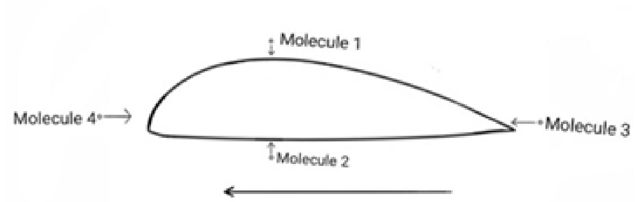

Figure 5

For a cambered airfoil, distance d1 kept increasing with the Airfoil's distance from the point of maximum thickness towards the trailing edge while distance d2 remained constant as illustrated by the graph in figure3. For a symmetrical airfoil, both distances d3 and d4 kept increasing with the Airfoil's distance from the leading edge region to the trailing edge as illustrated by the graph in figure 4.

The above diagram (Fig.5.) shows a stationary airfoil and a simple demonstration of how air molecules collide with it in all directions. The impact of molecule1 on the upper surface is counteracted by the impact of molecule2 on the lower surface. The impact of molecule3 on the trailing edge side is counteracted by the impact of molecule4 on the leading edge side. Therefore all the molecular impacts on the airfoil cancel each other.

When the airfoil moves in the direction shown by the arrow, the distance between molecule1 and the upper surface keeps increasing while the distance between molecule2 and the lower surface remains constant. The above means that the upper surface keeps withdrawing itself from molecule1 while the lower surface for a cambered airfoil does not withdraw itself from molecule 2. When it comes to symmetrical Airfoils, molecule2 and the lower surface keep moving towards each other. The above means that molecule 1 collides with a surface that is constantly moving away from it. The momentum possessed by the molecule relative to the constantly withdrawing upper surface can be summarized by the equation below.

$Momentum(m1) = Mass(m1) \times (Vm1\text{-}Vu)$ where "m1" represents molecule1, "Vm1" represents molecule1's velocity and "Vu" represents upper surface's velocity in molecule1's direction of travel.

In a cambered airfoil, molecule 2 collides with a stationary surface relative to it's direction of travel while in a symmetrical airfoil it collides with a surface that is moving towards it in it's direction of travel. The momentum possessed by the molecule can be summarized by the equations below.

$$Momentum(m2)(cambered\ airfoil) = Mass(m2) \times (Vm2 \pm 0)$$

$Momentum(m2)(symmetrical\ airfoil) = Mass(m2) \times (Vm2 + Vl)$ where "Vm2" represents molecule2's velocity and "Vl" represents lower surface's velocity in the direction of molecule2's direction of travel.

Resultant molecular momentum for a cambered airfoil= $[Mass(m2) \times (Vm2 \pm 0)]\text{-}[Mass(m1) \times (Vm1\text{-}Vu)]$
Resultant molecular momentum for asymmetrical airfoil= $[Mass(m2) \times (Vm2 + Vl)]\text{-}[Mass(m1) \times (Vm1\text{-}Vu)]$

5. Conclusion

Momentum possessed by each molecule is directly proportional to it's force of impact when it collides with the airfoil. Therefore, molecules colliding with the upper surface have a lower force of impact compared to the force of impact of the molecules colliding with the lower surface and the difference in the molecular force of impact creates lift force.

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