Chapter 4 Principles of Flight

Theories in the Production of Lift

Newton's Basic Laws of Motion

In the theories of understanding lift, Newton's third law is one of the most important concepts to understand lift and thrust.

This will be covered in greater detail as described here.

As the airfoil travels from right to left in level flight (Figure 4-1), air is pushed down from the bottom of the airfoil while the top of the airfoil simultaneously pulls the air down where it meets the air from the bottom of the airfoil. This results in the air in back of the airfoil being deflected downward. Newton's third law explains that the force to which the airfoil deflects/pulls the air down exactly matches the lifting force of the airfoil up.

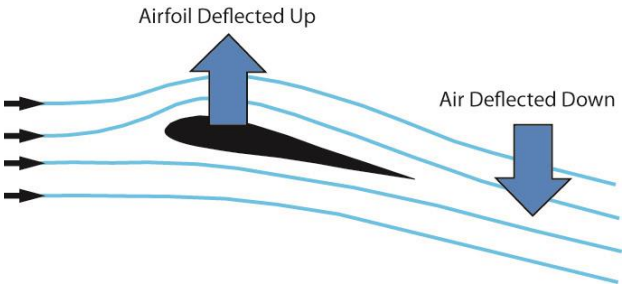

Figure 4-1 Newton's third law of lift production

Figure 4-2 *A good example of air being deflected downward as a jet flies over a cloudbank.*

If someone wants additional reading, the classic "Stick and Rudder" book is great to explain the basics of flight. It is interesting in "Stick and Rudder", Wolfgang suggests "Forget Bernoulli's Theorem" as he describes the theory of lift based on Newton's third law in great detail making it very easy to understand. This is a great book and provides one of the best explanations of the "Art of Flying" and a must read for everyone in a basic and easy to understand perspective.

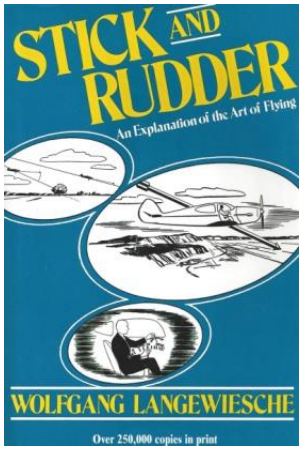

Figure 4-3 "Stick and Rudder" book

Bernoulli's Principle of Differential Pressure

Scientists and engineers like Bernoulli's Principle since it is easy to test and measure the actual pressures and velocities.

Figure 4-4 is used to help explain Bernoulli's Principle for aircraft lift. The airfoil moves through the air from right to left. The air at point A splits and the air on top of the airfoil has a longer way to travel to meet at point B. Therefore, the air on top must go faster which creates a low pressure and sucks the airfoil up. The air on the bottom goes slower creating a higher pressure which pushes the airfoil up.

Bernoulli's principle also makes sense for producing lift. Here we actually have numbers with measurement of lift we can test.

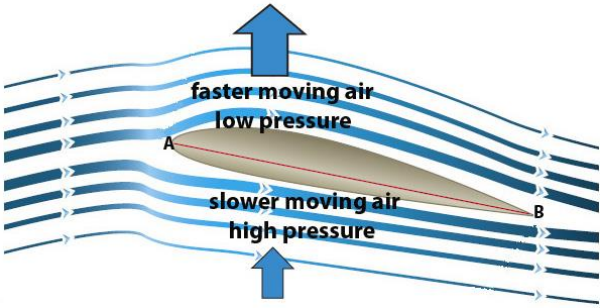

Figure 4-4. *Airfoil showing Bernoulli's Principle of producing lift.*

Newton's Third Law Verses Bernoulli's Principle for the Lift Force

The age old debate is whether Newton's Third Law or Bernoulli's Principle best explains the production of lift. The greatest aerodynamic engineers and lovers of flight will offer different conclusions.

Those who advocate the production of lift by Newton's laws appeal to the clear existence of a strong downwash behind the wing of an aircraft in flight. The fact that the air is forced downward clearly implies that there will be an upward force on the airfoil as a Newton's Third Law reaction force. From the conservation of momentum viewpoint, the air is given a downward component of momentum behind the airfoil, and to conserve momentum, something must be given an equal upward momentum.

For those who advocate the Bernoulli approach to lift point to detailed measurement of the pressures surrounding airfoils in wind tunnels and in flight. Such pressure measurements are typically done with static ports. Correlating the pressures with the Bernoulli equation gives reasonable agreement with observations.

Either belief works and perhaps both support each other. Both explanations approach the production of lift from a different point of view and are supported by solid scientific theory. Both are valid explanations.

Although Newton, Magnus, Bernoulli, and hundreds of other early scientists who studied the physical laws of the universe did not have the sophisticated laboratories available today, they provided great insight to the contemporary viewpoint of how lift is created.