Air is a Fluid

When most people hear the word "fluid," they usually think of liquid. However, gasses, like air, are also fluids. Fluids take on the shape of their containers. Fluids generally do not resist deformation when even the smallest stress is applied, or they resist it only slightly. We call this slight resistance viscosity. Fluids also have the ability to flow. Just as a liquid flows and fills a container, air will expand to fill the available volume of its container. Both liquids and gasses display these unique fluid properties, even though they differ greatly in density. Understanding the fluid properties of air is essential to understanding the principles of flight.

Viscosity

Viscosity is the property of a fluid that causes it to resist flowing. The way individual molecules of the fluid tend to adhere, or stick, to each other determines how much a fluid resists flow. High-viscosity fluids are "thick" and resist flow; low-viscosity fluids are "thin" and flow easily. Air has a low viscosity and flows easily.

Using two liquids as an example, similar amounts of oil and water poured down two identical ramps will flow at different rates due to their different viscosity. The water seems to flow freely while the oil flows much more slowly.

As another example, different types of similar liquids will display different behaviors because of different viscosities. Grease is very viscous. Given time, grease will flow, even though the flow rate will be slow. Motor oil is less viscous than grease and flows much more easily, but it is more viscous and flows more slowly than gasoline.

All fluids are viscous and have a resistance to flow, whether or not we observe this resistance. We cannot easily observe the viscosity of air. However, since air is a fluid and has viscosity properties, it resists flow around any object to some extent.

Friction

Another factor at work when a fluid flows over or around an object is called friction. Friction is the resistance that one surface or object encounters when moving over another. Friction exists between any two materials that contact each other.

The effects of friction can be demonstrated using a similar example as before. If identical fluids are poured down two identical ramps, they flow in the same manner and at the same speed. If the surface of one ramp is rough, and the other smooth, the flow down the two ramps differs significantly. The rough surface ramp impedes the flow of the fluid due to resistance from the surface (friction). It is important to remember that all surfaces, no matter how smooth they appear, are not smooth on a microscopic level and impede the flow of a fluid.

The surface of a wing, like any other surface, has a certain roughness at the microscopic level. The surface roughness causes resistance and slows the velocity of the air flowing over the wing. *[Figure 4-1]*

Molecules of air pass over the surface of the wing and actually adhere (stick, or cling) to the surface because of friction. Air molecules near the surface of the wing resist motion and have a relative velocity near zero. The roughness of the surface impedes their motion. The layer of molecules that adhere to the wing surface is referred to as the boundary layer.

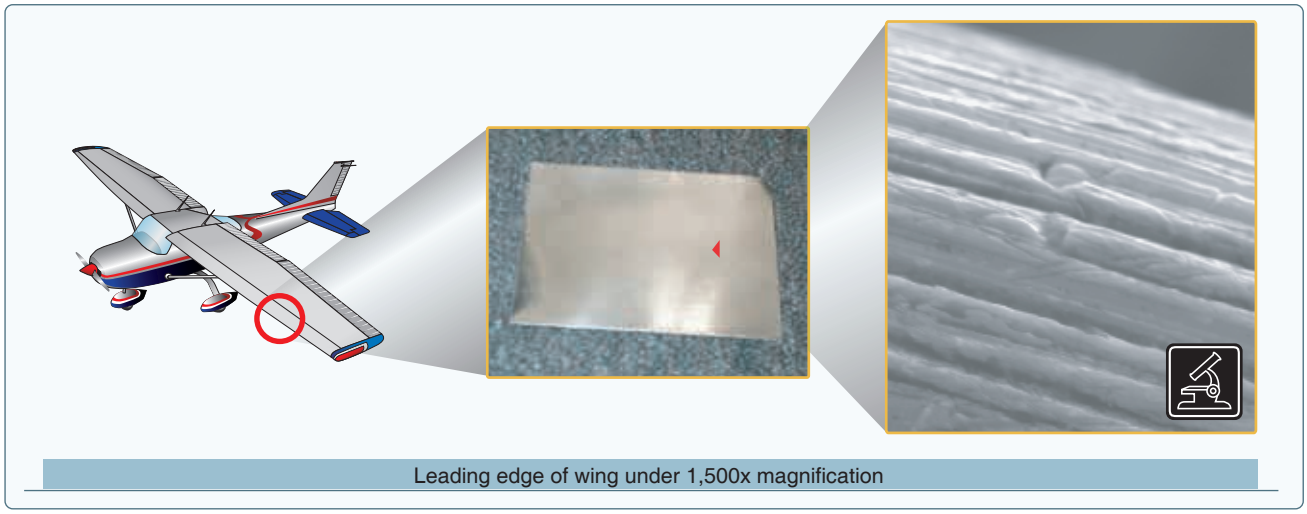

Figure 4-1. *Microscopic surface of a wing.*