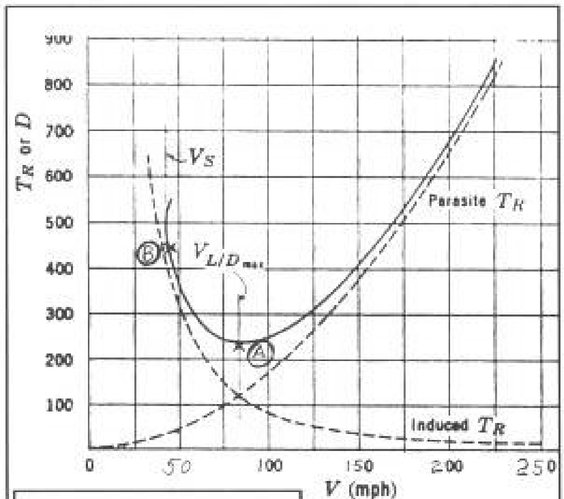
THE BACK SIDE OF THE POWER CURVE

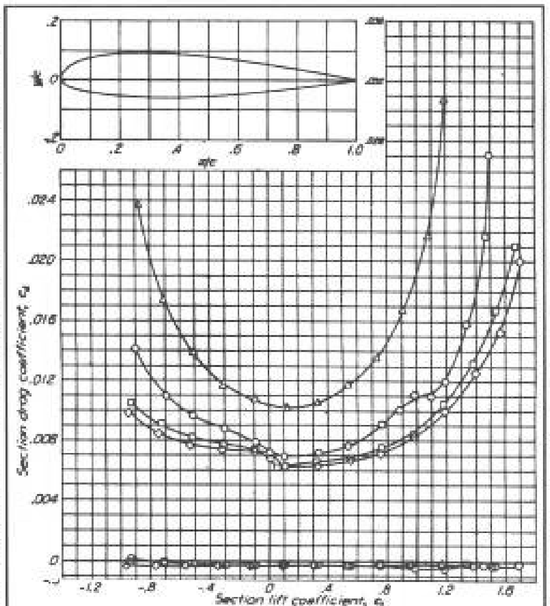
In the second '99 issue of the *RVator*, I wrote an article on "Slow Flight" and referred to the reversed power and control requirements which occur when flying very near stall speeds; a flight regime often referred to as the "Back Side of the Power Curve". This is also know as the "area of reversed command." Let's look at this phenomenon and see if we can learn anything useful.

What exactly is the "power curve"? A better name would be the "power required" curve, or better, the "power required to sustain level flight" curve. To generate a curve, we must plot values as points on a graph. We will plot thrust required (in pounds) vertically and "velocity" (in mph) horizontally. We know that in steady, non-accelerated flight, Thrust = Drag, so the Drag and the Thrust (power) curves must be the same.



THE "POWER CURVE"

The sample Power Curve graph shows three curves. The solid line is a summation of the other two dashed lines. Drag is separated into Induced drag and Parasite drag. Induced drag results from the wing generating lift. The magnitude of this drag varies inversely with the speed, so, at stall speed, Induced drag is very high, and at cruise speed, it is quite low. A copy of a Lift/Drag curve from the book *Theory of Wing Sections* (*Note: The curve here has hypothetical values and does not directly apply to any specific airplane*) indicates why; the curve becomes very steep as the maximum lift coefficient is approached. Parasite drag is the opposite. It increases as the *square* of the speed, so at high speed it is by far the dominant source of drag. At stall speed it is much less significant.



NACA 23015 Wing Section (Continued)

At any speed, the total drag of the airplane is the sum of Induced and Parasite drag. Over most of the speed range, the total drag will increase as speed increases. However, below a certain speed, the Induced drag rises faster than the parasite drag diminishes, meaning the total drag *increases* with further speed *reduction*. In the cockpit, the pilot finds an increase in Thrust (power) is required to offset drag and sustain level flight. This is the dreaded "Back side" of the power curve. More power is required to fly slower.

What does this mean to the pilot in everyday flying? If we had a display on our instrument panel showing these curves with a little airplane moving up and down the curve, the correlation would be obvious. Since we don't (yet), there are other ways of identifying the "back side". If you slow too much and your sink rate increases rapidly, you are entering this region. If you apply full power to arrest the descent, and you continue to descend anyway, you have experienced the ultimate example of "Back Side of the power curve."

Another example would be a take-off where the airplane was pulled off just above stall speed. If thrust did not exceed drag, the airplane would be "stuck." It would continue to fly, but would be unable to accelerate or to climb. It would proceed until it either struck an obstacle, or the surface dropped away allowing a slight descent to accelerate above that critical high drag speed. The best option for a pilot finding himself in this condition is to abort the take off. If the runway is long enough, put the wheels back down on the runway and unload the wing until sufficient speed is attained to get on theright side of the power curve. Then, take off, accelerate, and climb out.

If one slows into the "Back Side" on landing approach, sink rate and power requirements increase dramatically...and quickly. Even if you have sufficient power, but do not apply it soon enough, you can still hit the ground unexpectedly. If sufficient power is available and applied soon enough, speed can be regained into a more comfortable arena. If altitude is available, lowering the nose will build speed to a more easily managed range. If no altitude is available and thrust available is less than drag, you're going to be contacting the ground; ready or not.

How dangerous is "Back Side" operation? It depends upon the airplane and the circumstances. "Back Side" operation is a problem primarily for lower power aircraft or aircraft with high lift systems which reduce stall speeds but produce very high drag in the process. If the total thrust available is equal to or less than the drag of the airplane, it will be unable to climb or accelerate out of this condition. A Helio Courier, with both leading edge slats and large flaps, is an example. Its wing will continue flying (no stall break) at very high angles of attack where drag becomes very high. In this condition it will take a lot of power to prevent a quick descent. It's no accident the Helio was designed with a big engine. Low powered airplanes with high drag flaps, like the Cessna 150/172, can experience critical "power curve" situations. Some jet airliners with their elaborate flap systems can get into "behind the curve" situations. Airplanes with very low aspect ratio wings, like delta wings, but will fly at extreme angles of attack with commensurate high drag and ability to get "behind the curve." Only a surplus of altitude or power can effect a recovery. For most RVs, the potential problem may be less than for some other lower powered aircraft. Most RVs have enough power that they, at normal operating altitudes, can "power out" from behind the power curve.

All of the above examples are based on the premise that the aircraft does not actually stall, but remains under control in the high drag area just above stall speed. In reality, "Back Side" operation will often result in a stall because the pilot attempts to maintain altitude without adding power or sufficient power to offset the rapid drag rise. Speed will decay rapidly and a stall will result.

Another label for "behind the power curve" is the "area of reverse command." This simply refers to what the pilot experiences or what he must do to remedy the situation. Perhaps you have heard the following:

What do you do to go up? Pulll the stick back. What do you do to go down? Pull the stick back further.

For instance, consider condition "B" on the Power Curve graph. You would push the stick forward to lower drag and decrease sink rate. Normally, pushing the stick forward causes a higher sink rate. Similarly, a reduction in speed will require an increase in power to sustain level flight. This also is abnormal. Thus, we see reverse responses from our flight control inputs, or we must use reverse inputs to achieve level flight.

The next time that you go flying why not explore the Back Side?. With plenty of altitude below you, slow your plane down and identify the speed at which you encounter point "A" (minimum power for level flight), and then note the drag, sink rate, and power requirements as you decelerate further. Visualize the Power Curve as you are flying it. It will give you a greater respect for the hazards of this phenomenon.