Test Pilot – Part I

By Will Fox – April 2015

"I don't think I can fit in your plane with my parachute on, so you are going to have to do the power on stall testing yourself". "I'll be glad to loan you my chute, I just want a deposit on it, you know, just in case". This is what I told a good friend of mine that wanted to modify the wings of his aircraft to make it go faster. If you read my previous note about Tinkerers, Builders, Experimenters, and Pilots, then you will appreciate the fact that there is a big difference between Tinkerers and Experimenters. Experimenters, in particular, have a good technical understanding about their aircraft and how design changes that they plan to make will affect it. In this particular case, my friend was going from Tinkerer to Experimenter in one fell swoop with maybe not quite enough understanding about the implications of the changes he was making, and it was causing me considerable concern. He wasn't just adding a new LED strobe or mounting a GoPro camera on his plane, but rather he was changing his basic wing design. This is a big deal, requiring a thorough shakeout of the design and I was suggesting that whoever the test pilot was going to be, they should be wearing a chute during the more risky portions of the flight tests.

Let me give you a little background. My good buddy has a popular LSA STOL aircraft that he had built and began flying a year or so ago. He had completed the Phase I testing and graduated to Phase II operation. He was enjoying flying the aircraft he had built and continued to make a number of small improvements in it.

Figure 1. Bob Hoover was a true test pilot.

One day he decided that it wasn't fast enough and wanted to make it go faster.

He found some information on the Internet that said that some folks had made a modification to the leading edge of the aircraft and this made it several knots faster. The modification also supposedly improved the handling and made the aircraft easier to land. Furthermore, after the first modification was completed, if you wanted to improve the performance even more, you could install vortex generators on the wing to reduce the aircrafts stall speed and improve its low speed handling characteristics. As is often the case, the evidence for this improved performance for these modifications, was coming from the same entrepreneur that was selling the vortex generator kit. Boy, what's not to like about these modifications, a faster airplane that also has a lower stall speed and better short field performance. Almost sounds too good to be true, doesn't it. So, my buddy made the first modification to wing without the vortex generators and began flying it around. He found it was indeed faster, and landings were easier. After a couple of routine flights, he decided that he wanted to leave it that way. One day, he was telling me about his modification, and I asked him if he had put it back into Phase I testing while he evaluated it, because it sounded like a major modification. Oops, he had forgotten to do this. He quickly made arrangements to do so with our local FSDO and they suggested he complete a minimum of five hours of Phase I testing before going back to Phase II operations. He and I then began talking about a flight test program that would ring out the aircraft performance with the modification to the leading edge of the wing.

My biggest concern from the get-go was the stall characteristics of the aircraft with the new leading edge. The previous design was known to have a very docile stall, if you could get it to stall at all. How would the new design behave in a stall, I wondered? So a few questions for my buddy were in order. *"So, how did the old wing design behave in a stall"*, I asked *"Just fine, it wouldn't stall, just mushed"*, my buddy said. *"Did you stall the new design"*, I asked. *"Yes"*, he said. *"How did it behave"*, I asked. *"Just like the old design"*, he said. *"That's great news"*, I said. *"What kind of stalls did you try"*, I said. *"Power off stalls"*, he said. *"What about, power on stalls, accelerated stalls and cross controlled stalls in all configurations"*, I said. *"I didn't try those"*, he said. *"Oops"*, I said.

You see, generally in the aircraft that we home builders tend to fly, the most benign stall characteristics occur when the aircraft is in the clean configuration with power off. Stall characteristics usually get worse as you add power and change the configuration with flaps. Stalls also get more exciting as you aggravate them with crossed controls and steep turns (accelerated stalls). Sharp breaks, large wing drops, and spin entries can be the result of stall testing with the addition of any of these aggravating conditions. Nevertheless, testing with these conditions is extremely important because it is easy to find yourself in a position where that is exactly what is going to happen. Let me give you a few examples. Suppose you are flying in the mountains one day and you find yourself entering some unanticipated sink and need to make a steep turn away from terrain at full power with partial flaps. And in the process, you start skidding the turn as you unconsciously rudder the aircraft around in an attempt to turn the aircraft quicker. Guess what might happen if you increase the angle of attack just a hair too much, an accelerated cross-controlled stall, that's what. Or, suppose you takeoff from a short field with an obstacle in front of you and find that you need to make a climbing steep turn to avoid it and don't keep the ball centered as your airspeed slows and P-factor begins to yaw the aircraft to the left. Same thing, a cross-controlled accelerated stall. In either of these situations, if you accidentally increase the angle of attack too much and stall an aircraft with poor stall characteristics, you may find yourself looking straight down at the ground rotating around in your windscreen with insufficient altitude to recover. Poor stall behavior that leads to a spin entry, can get you killed in a hurry. Aircraft that break straight ahead or mush, and that maintain aileron control in a stall are much more likely to be recovered from a stall by the pilot with minimal altitude loss. I've had pilots tell me that they can't imagine how a "good" pilot could ever stall an airplane accidentally. They are just kidding themselves. I don't care how good a stick you are, you are still human and humans make mistakes. The reality is in the accident statistics, and they indicate that a stall or a spin precedes 45% of the fatal accidents in experimental aircraft. So given a choice, anyone with a lick of sense would want an aircraft with stall behavior as benign as possible so that when they make that mistake, the aircraft will give them a second chance.

So what defines good stall behavior? The stall should be gradual and symmetrical so that there is no sharp break and the aircraft does not roll appreciably. When a sharp stall break occurs or the stall is not symmetrical and a large roll occurs during a stall, there is going to be more altitude loss before recovery and a much greater likelihood of the pilot aggravating the stall unintentionally before executing a recovery. Why would the pilot aggravate the stall unintentionally? Because it takes a second or two to recognize a stall when you are not expecting one, and the natural reaction when the nose drops suddenly, is to pull back on the stick which we all know doesn't usually help with stall recovery. Likewise when the wing drops suddenly, it is natural to try to roll level with ailerons, which will generally cause the wing to drop further and possibly enter a spin.

In a properly designed wing, the stall progresses from the root of the wing towards the wing tip. The wing tip should not stall first. Tip stalls create large rolling moments and loss of roll control. The ailerons should remain effective in a stall, since a pilot's first reaction when a wing drops is to use ailerons to correct any rolling tendencies. The rudder should also remain effective during a stall so that any yawing tendencies can be quickly and easily corrected to prevent a spin from developing.

The stall behavior of a wing is strongly influenced by the shape of the leading edge. Since my buddy was modifying the leading edge of his wing, it was reasonable to expect a change in stall behavior. What that change would be, and whether it would improve or worsen the stall behavior was a big question. Power off stalls alone wouldn't even begin to tell the story. We needed some more answers and the best way to get them would be to execute a well thought out test program. To begin with, we needed to understand thoroughly how the original wing design behaved so that we would have a good basis of comparison with the modifications. So that is where we planned to start. Stay tuned, for a report on that and more in the next TC corner.