Test Pilot – Part II

By Will Fox – May 2015

Last month I was telling you about a friend of mine that wanted to modify the wings on his homebuilt in the hopes of improving his aircraft's performance. This month I can tell you about the preliminary testing we did. It was interesting to say the least. I guess I'll start by telling you about the stall tests.

The first thing to remember when flight testing a homebuilt aircraft is that you should ***expect the unexpected***. The second thing to remember is that ***the kit manufacturer wants to sell airplanes and airplanes with warts don't sell as well, so they don't like to talk about the warts.*** The wart in our case has to do with stall behavior and lack of elevator authority. According to the factory this particular aircraft won't stall. Power off, with the stick all the way back it reportedly simply develops a mush with a high rate of descent, and with power on, it just keeps climbing. The factory was right about the power off stall characteristics, however with power on, the aircraft did stall with the stick all the way back and it did so with a very abrupt break and strong roll to the right. It felt sorta like a spin entry. The aircraft recovered quickly upon releasing the backpressure on the stick and applying full opposite rudder to stop the rotation, and then pulling out of the dive. "Hmmm, I thought it wasn't supposed to stall, want to try another one", I said to Thomas, my buddy. But now I'm getting ahead of myself, so let me give you a little more background on our test program.

Figure 1. Real test pilots wear cool helmets.

We had started our test program with the aircraft in its original configuration with the slotted leading edge as supplied by the factory. The goal however, was to ultimately eliminate the slot and add vortex generators, because according to some Internet sources, it would improve cruise speed, save a little weight, and improve the STOL performance of the aircraft. My thinking was, why would you want to modify an aircraft that has a proven reputation as an excellent STOL aircraft and is very safe and forgiving to fly? I guess the lure of a few more knots in airspeed and saving a few pounds in weight, outweighs the potential downside of reducing its STOL performance and docile stall characteristics. Honestly, I thought the modifications weren't a very good idea. But one of the things that is great about building experimental aircraft is that you can do some experimenting. So if Thomas was determined to make some modifications, then we should at least make sure that we thoroughly tested them out. We decided to characterize the aircraft performance in its original configuration so we could better understand the changes that occurred after the wing was modified. It was also important to understand how the stall behavior changed with the modifications. So, the plan developed that we would first fully test the airplane in the original configuration, then test it without the slot in the wing, and finally test it with vortex generators on the unslotted wing. We would document the change in aircraft weight, cruise speeds, stall speeds, STOL characteristics, stall characteristics, and general handling of the aircraft with each change. This way we could decide with some certainty that the modifications were worth it.

In the original configuration, the aircraft was very docile to fly. Control harmony was good, other than a high breakout force for the rudder due to the nose wheel-rudder interconnect design. Pitch, roll, and yaw stability were good and the aircraft was easily flown hands off, with the rudder only when trimmed properly.

Most pilots lie about how fast their aircraft are. They can't help it; it's a genetic thing. You can usually figure their plane is 5 to 10 knots slower than they say. In Thomas's case though it was different. A three way run produced a corrected cruise speed of around 92 mph at 75% power compared to the 85 mph he had been advertising. Personally, I think he was setting up his Super Cub and Taylorcraft buddies to win a few beers off them in a race next time they flew out for breakfast.

Steep turns produced a rumble from the skylight as the flow separated over the top of the fuselage and required considerable power to maintain altitude. Slow flight was stable, and while the flapperons remained quite effective, the rudder became less so. Power off stalls, both normal and accelerated, were very benign other than developing a high descent rate with the stick held all the way back. Power on stalls were a different story. As I indicated at the beginning they arrived with a sharp break and strong roll to the right. Recovery occurred after about 90 degrees of rotation with stick neutral and opposite rudder. Rudder response seemed a bit sluggish and pretty ineffective until the stick was neutralized. Thomas wanted to try a few more of these to get comfortable with the recovery. With the ball centered, the aircraft stalled the same each time, with a sharp break and pitch down to about 30 degrees below the horizon, and a roll to the right of 60 degrees or more. The rudder didn't do much until the stick was moved to the neutral position, then the aircraft would stop rotating and could be recovered from the dive.

Soft field takeoffs were quick, but the aircraft became very pitch sensitive as it approached rotation speed and it was easy to over rotate if one started the takeoff roll with the stick all the way back to the stop. Short field landings were challenging, because of a tendency for the elevator to run out of authority at low approach speeds. If the pilot wasn't careful it was easy to turn a short field approach into a firm nose plant instead. The lowest comfortable indicated approach speed was 55 mph with full flaps and carrying some power to maintain sufficient elevator authority to land on the mains instead of the nose wheel. This unduly limits the short field landing capability for an aircraft with a stall speed of 35 mph. A larger, more effective elevator would be desirable to allow slower approach speeds while countering the strong pitching moment produced by the slotted wing with flaps deployed.

A word about the elevator is in order here. Thomas had added vortex generators to the leading edge of the elevator prior to our flight tests. He had read about doing this on the Internet, and felt that it made a significant improvement in the flare authority of the elevator. This might explain the sharp break with a power on stall that we experienced. Without the increased coefficient of lift that the vortex generators provide, the elevator isn't powerful enough to pitch the wing to an angle that it will stall at. But with full power and vortex generators on the elevator, there is enough prop blast over the elevator, that it has enough authority to stall the wing. This would explain why the factory aircraft design does not stall and Thomas's does. It probably also explains why the aircraft does not have a bigger elevator to begin with. The designer more than likely wanted to limit the flare authority of the elevator to make it difficult to stall the aircraft and thus improve its safety. The down side is that the standard elevator does not have enough authority to make low speed, power off approaches. There are always compromises in aircraft design.

We also came up with a possible explanation for the sharp wing drop with the power on stalls. As we removed the slots on the leading edge for the next flight test, it became apparent that the gap in the slot on the right wing narrowed considerably from the root to the tip. Since the gap is supposed to be constant, it is possible that the maximum coefficient of lift was also varying from the root to the tip of the wing, and this might be causing the right wing to stall before the left wing and that could produce the large rolling moment we experienced.

Next, we removed the small airfoils that create the slots in the leading edge of the wing and in the process saved 14 pounds. We then reran the flight tests. When the slots are removed, the leading edge of the factory wing retains a very large nose radius. This is generally a good thing for generating a high coefficient of lift, so we thought the aircraft would still have a low stall speed, but perhaps not as low as before. The aircraft had better flying characteristics in many ways without the leading edge slots. Climb rate was improved by around 100 fpm and less power was needed to maintain altitude in steep turns. The cruise speed increased to 98 mph, however so did the propeller rpm, resulting in the engine producing more than the 75% of maximum horsepower that we had in the original configuration test. When we reduced the engine rpm to the same values as in the original test the cruise speed dropped back to 93 mph. However, a higher cruise speed could be obtained at 75% power by choosing a courser pitch for the propeller. My guess is that cruise would be close to 96 mph at 75% power.

Power off stalls produced only a mush with a high descent rate, similar to the previous tests with the slots in the leading edge of the wing. We didn't do any power on stalls because the mounts for the slotted wing leading edge airfoils projected several inches into the air stream and that might result in some unusual stall and spin behavior that I did not want to explore without a parachute. Normal landings were easier to manage because the unslotted wing requires less elevator authority to flare making it possible to approach at lower speeds with power off. Approaches at 50 mph with power off were now possible with sufficient flare authority to land on the mains first. We haven't had a chance to fully exercise the STOL behavior of the aircraft with the unslotted wing, or test the unslotted wing with vortex generators yet, so you will need to stay tuned to hear the "rest of the story" in next month's article.

The long and short of it so far however, is that the unslotted wing appears to have better overall flying characteristics than the slotted wing. It has less drag, is a bit faster, easier to flare at lower speeds, and climbs better. However until we complete the STOL tests we won't know if it lands and takes off shorter and we don't now how it behaves with power on stalls. The next tests will be interesting.