Cylinder Head Temperature & My SQ-2

Configuration:

- Standard Backcountry Super Cub SQ-2 cowl
- RV baffle kit for Lycoming IO-360
- Vettermann exhaust with 1.5” ID exhaust tubing

On my first flight, on a 67° day, and with power only at 21-squared, I was over 425° on all cylinders! Yikes.

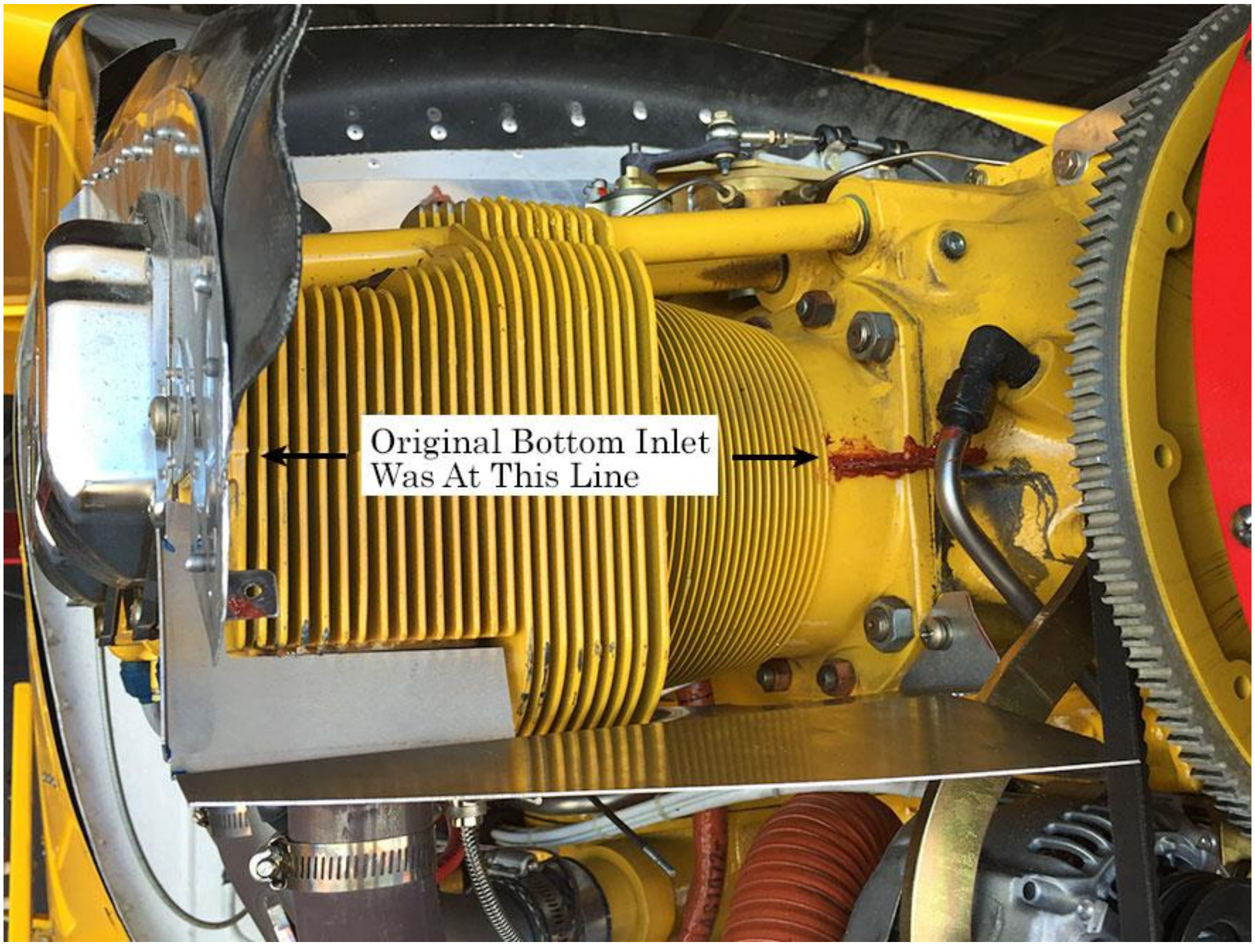
Due to a desire to make it to Oshkosh, and after the long building process, I just lived with low power settings for a long time. What I should have done is stopped & addressed this issue right there at the time. But…

I even resorted to often flying at 19-squared on days over 70°--sucked. By the way, if you're looking at my GPH figure, it isn't accurate—I was still adjusting the fuel flow transducer K-value setting.

Finally, last June I was taking off from Challis, Idaho on an 80+ degree afternoon and needed to gain about 4,000' to get over the ridges toward Johnson Creek. With the oil temp at 230 and #3 Cylinder pushing over 460° (for a very, very short minute) I decided enough was enough. I resolved when I got back home to get after this cooling project in a serious way!

Addressing The Problem

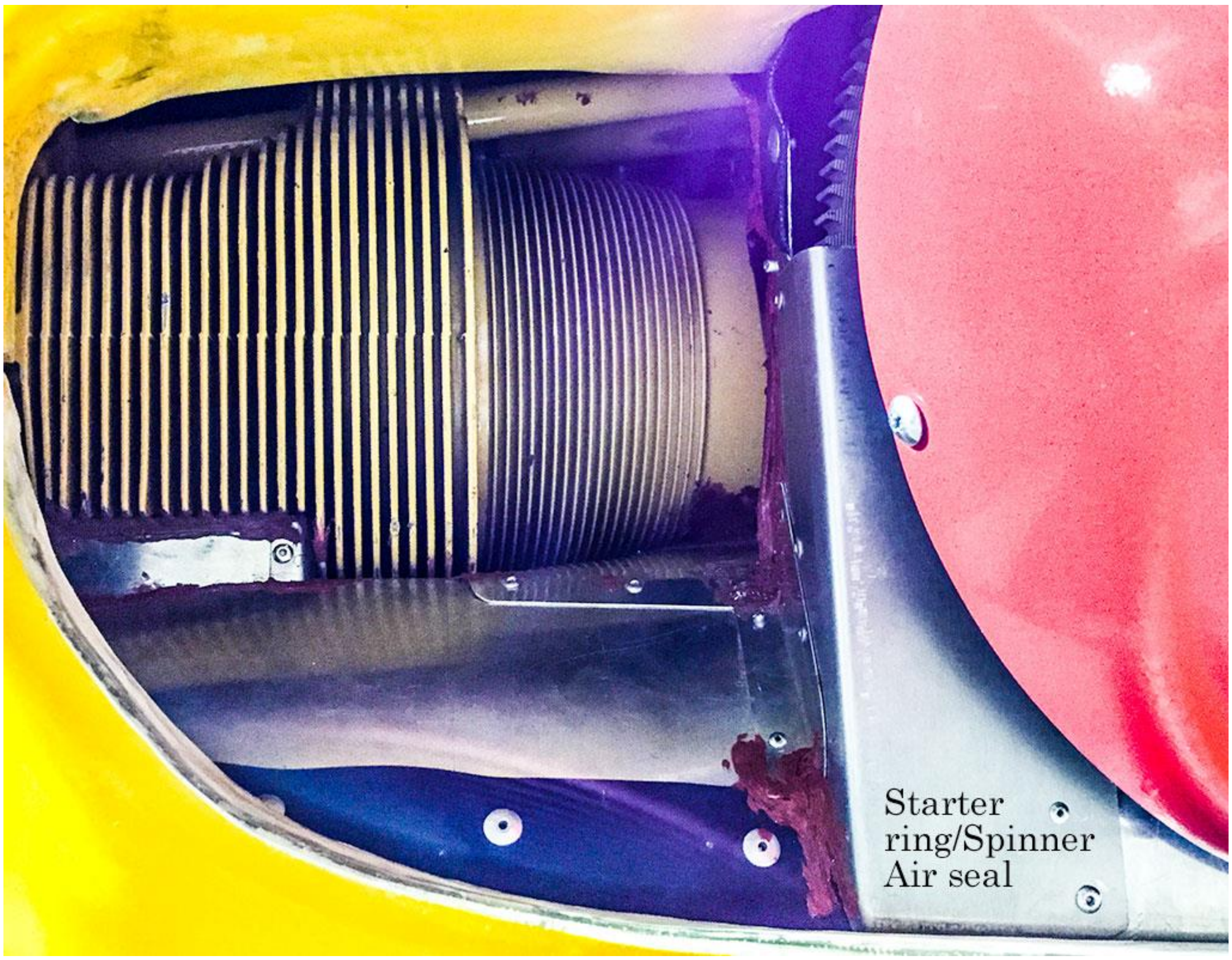
First step: I surmised that I needed to drop the front inlet baffle “ramp” as shown below to give me more inlet air. Of course, I cut the front cowl down to fit the new ramp location as well.



The second thing I tried was to use a very bright flashlight and seal up every tiny little hole that I could see light through everywhere the baffling butted up against the engine. Not pretty, but no one sees under the cowl except me!

Then I added a metal “enclosure” around the back of the starter ring (aluminum, as shown) plus the related “rubber” baffle material to seal the top up against the top of the cowl. I did this step as I read/heard somewhere that inlet air would swirl behind the prop spinner, creating turbulence and reducing the overall inlet cooling air pressure.

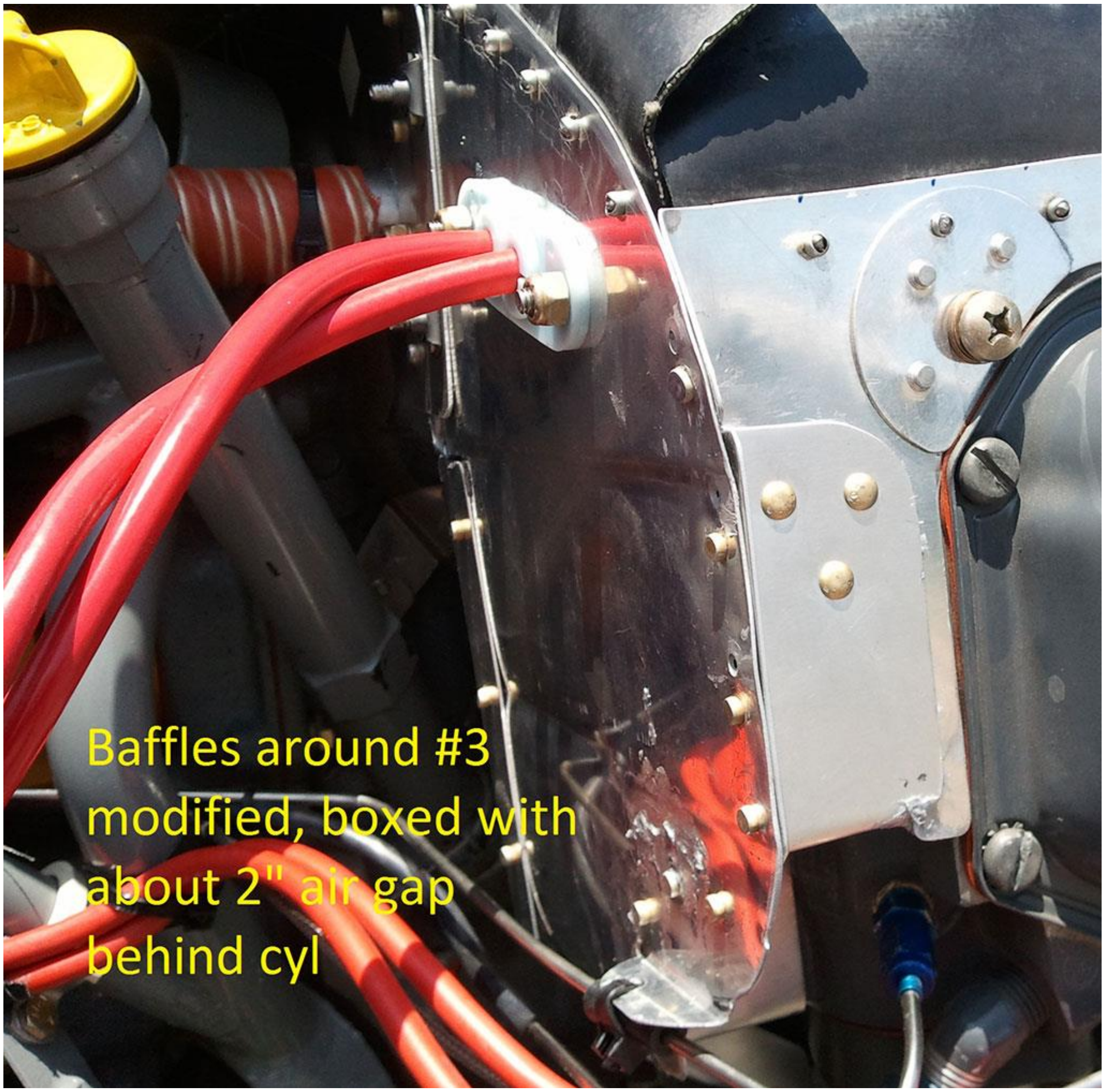
I test flew the plane both before and after adding the starter-spinner air seal. I don’t think adding this made any appreciable difference. Lots of folks told me one gets air “leakage” forward toward the prop/spinner and that one “had to have this” feature. Again, in my opinion, at least at our Cub speeds, this is simply wasted time. Might make some minor difference, but I sure couldn’t discern such in numerous test flights.

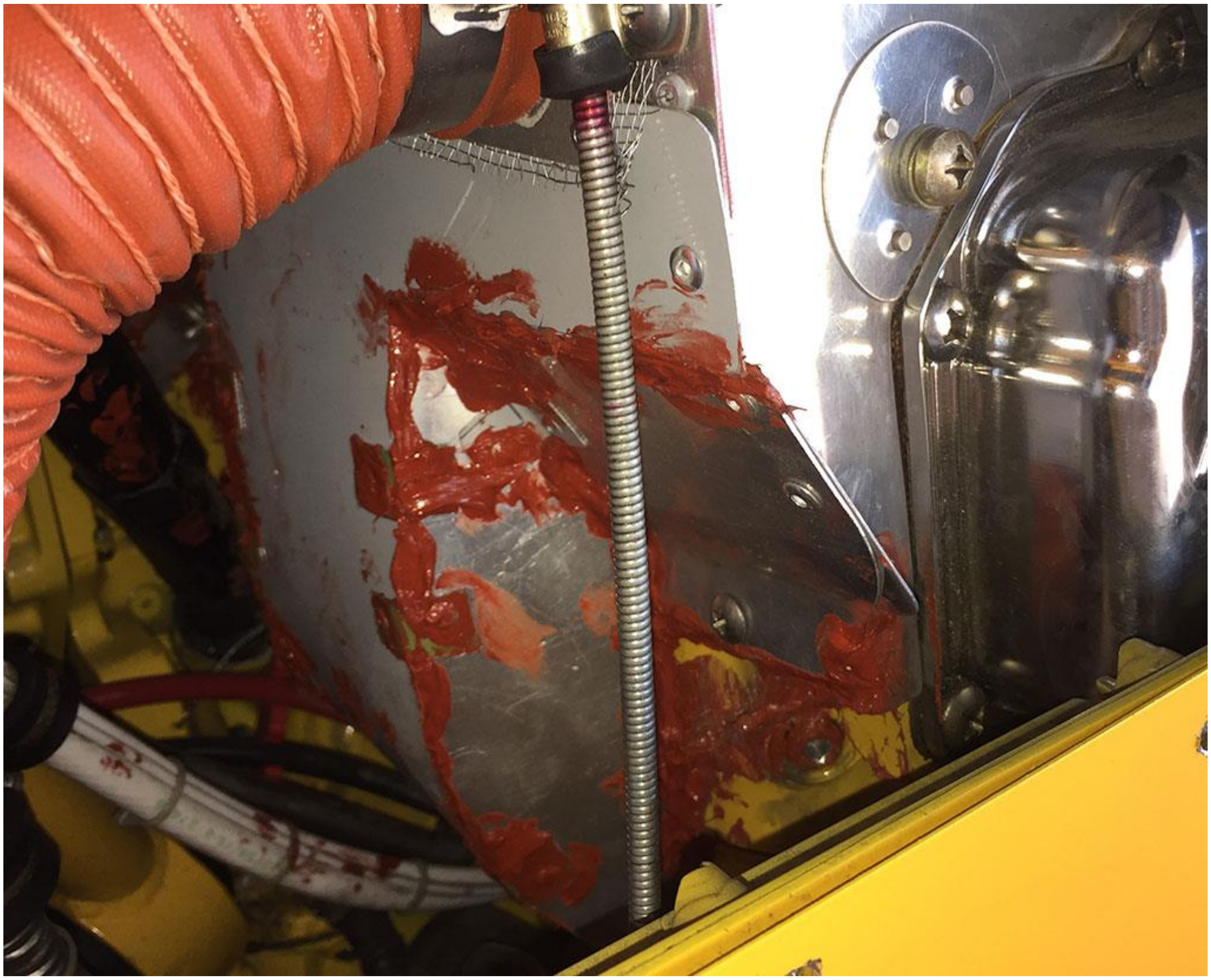


I also added a fiberglass (VANS sells a part for like $35 for the pair—but I can't find it anymore on their website) smoothing piece to each side of the bottom of the front upper cowl to reduce air turbulence at the inlet. Here's a picture of the VANS part:

You can see in the above image that this only addressed the inlet itself. Later I added more fiberglass to smooth the entire front cowl—picture later…

I read on SuperCub.Org that a number of folks with Super Cubs reported drops of up to 20+° on their CHT's by extending the engine baffling behind the rear cylinders. Here are a couple of pictures (one another engine from an RV; one mine—again, no one sees this with the cowl closed!). I was able to make this change without taking more than just the cowl off. I test flew the plane after this step with high expectations. This step didn't have any appreciable effect. Totally wasted time in my opinion.

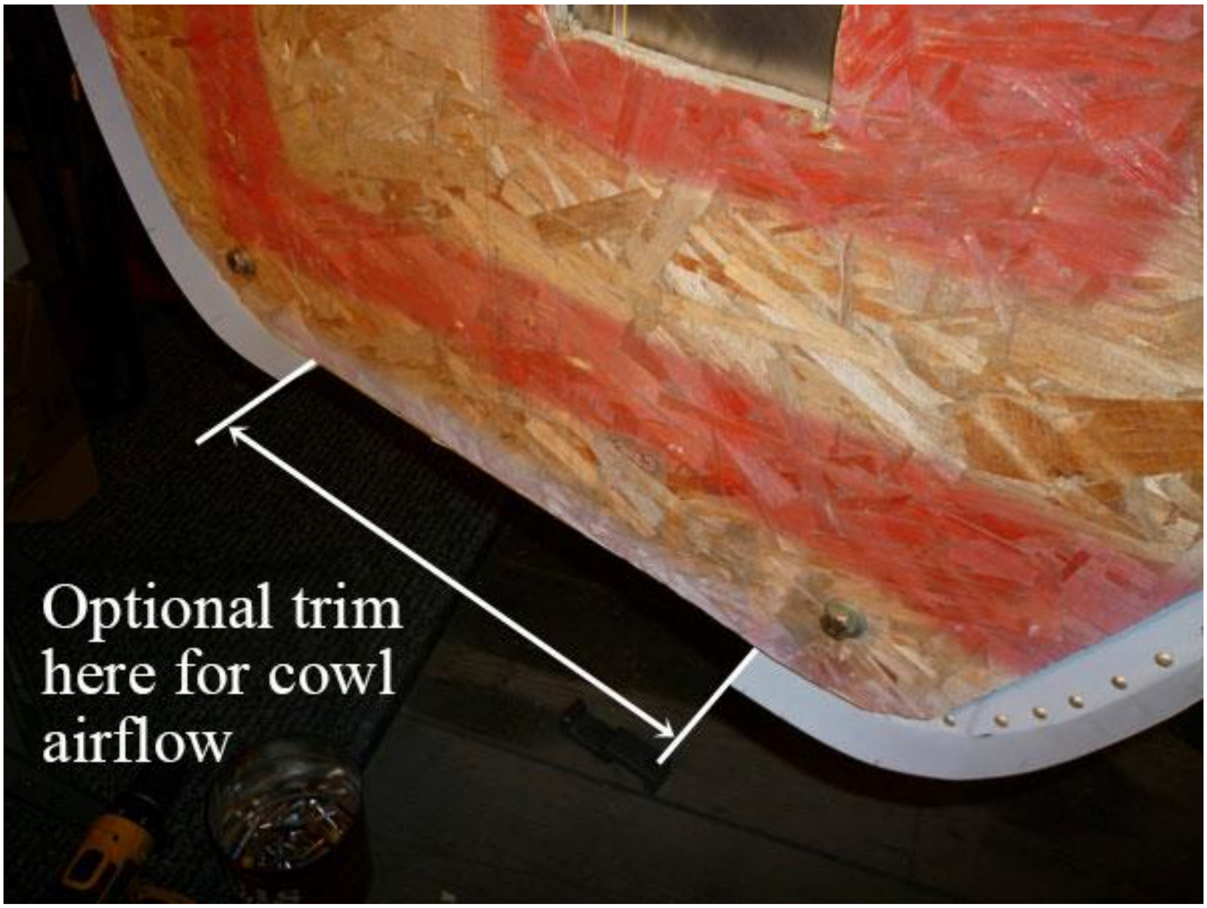




As you can see, liberal amounts of red RTV were employed to seal up every last tiny light hole that I could see when shining a very strong flashlight from the inlet, pressure, side.

At this point I had made some limited progress. Very limited, if at all. Perhaps 10 to 20 degree overall reduction in CHT's. Headed in the right direction, but not nearly enough. On to experimenting with more cowl changes.

During construction, I changed the orientation of my firewall flange at the bottom to permit better exit airflow. This picture illustrates that change. The picture is taken from where the engine would be looking aft. In other words, the wood former is where the firewall would be—the red paint is the front of the firewall.



I came to the conclusion that the standard SQ-2 cowl ends too far forward of the firewall. The result of this premature "end" is, in my theory, a lot of turbulence in the very area that one wants to have smooth exit air.

So I started adding cowl sections with junk aluminum and duct tape.

This effort helped some. Perhaps lowering CHT's by another 10+ degrees.

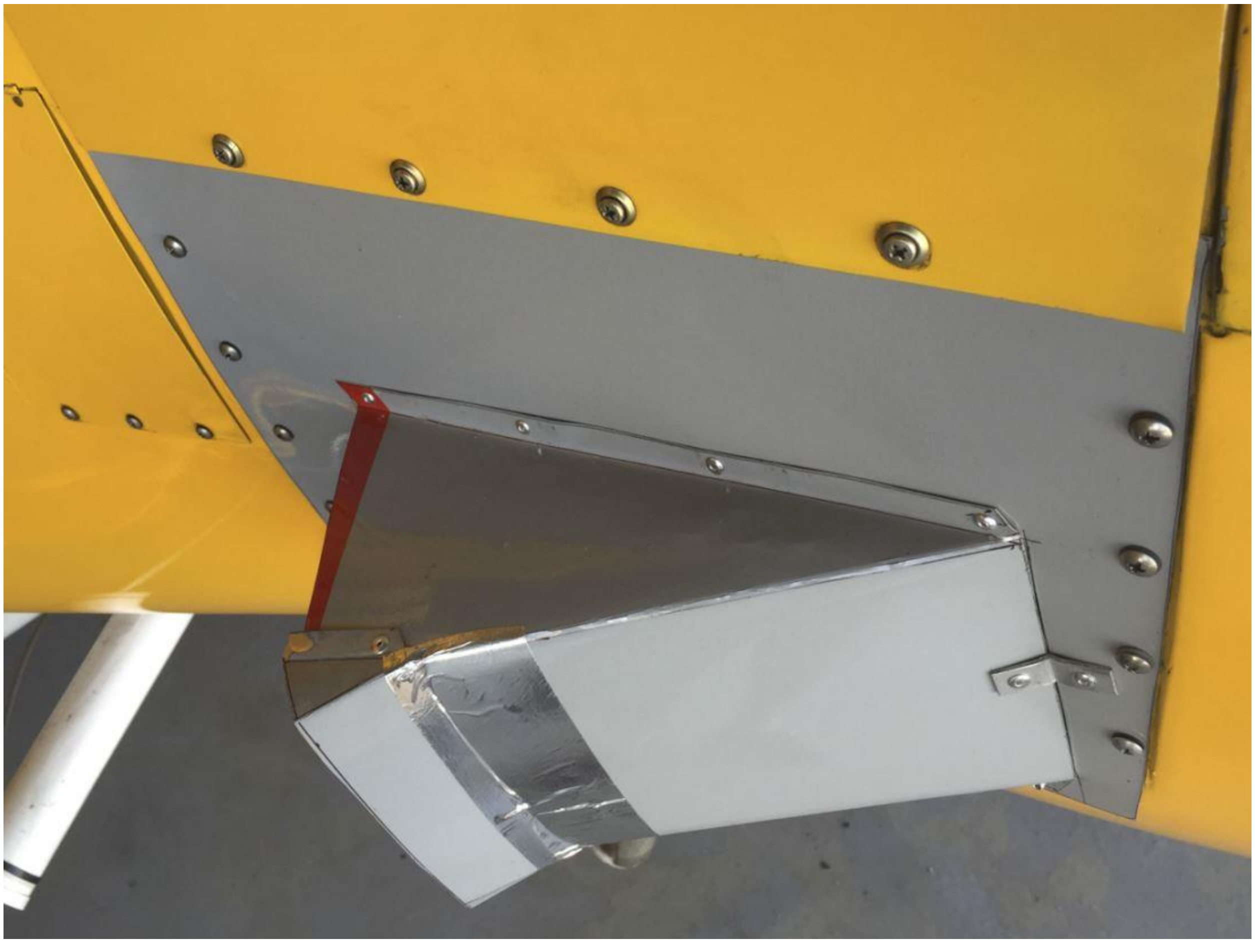
Another theory: Having the oil cooler behind #4 "robs" some pressure from the air plenum by allowing air to exit through the oil cooler. So…Another test I did was to first mount my original single oil cooler up front—thereby closing off the airflow behind #4 that would otherwise "escape" through the oil cooler. The test was to see if by eliminating this escaping air behind #4 whether I'd get better CHT cooling (i.e. more air cooling the cylinders). This change didn't seem to have much of an effect, if any.

When I had the single oil cooler up front—again after the above noted change—one pilot said he added a "scoop" (air dam in below picture) to "channel" air more directly into the up front oil cooler. His theory was that without the scoop, air would flow down the front of the cowl and not get as much into the oil cooler itself. So when I got home I tried the plain aluminum "scoop" you see in the below cowl picture. This change, as far as I could tell, had no effect on better oil temps whatsoever. But, I was willing to try anything reasonable!

I should mention that I later added a 2nd oil cooler. I now have two 13 row Drawn Cup Aero-Classic #8000215 oil coolers. One mounted in the traditional spot behind #4 cylinder and one up front. Now my oil temps never exceed 190°, even on the hottest days/climbs.

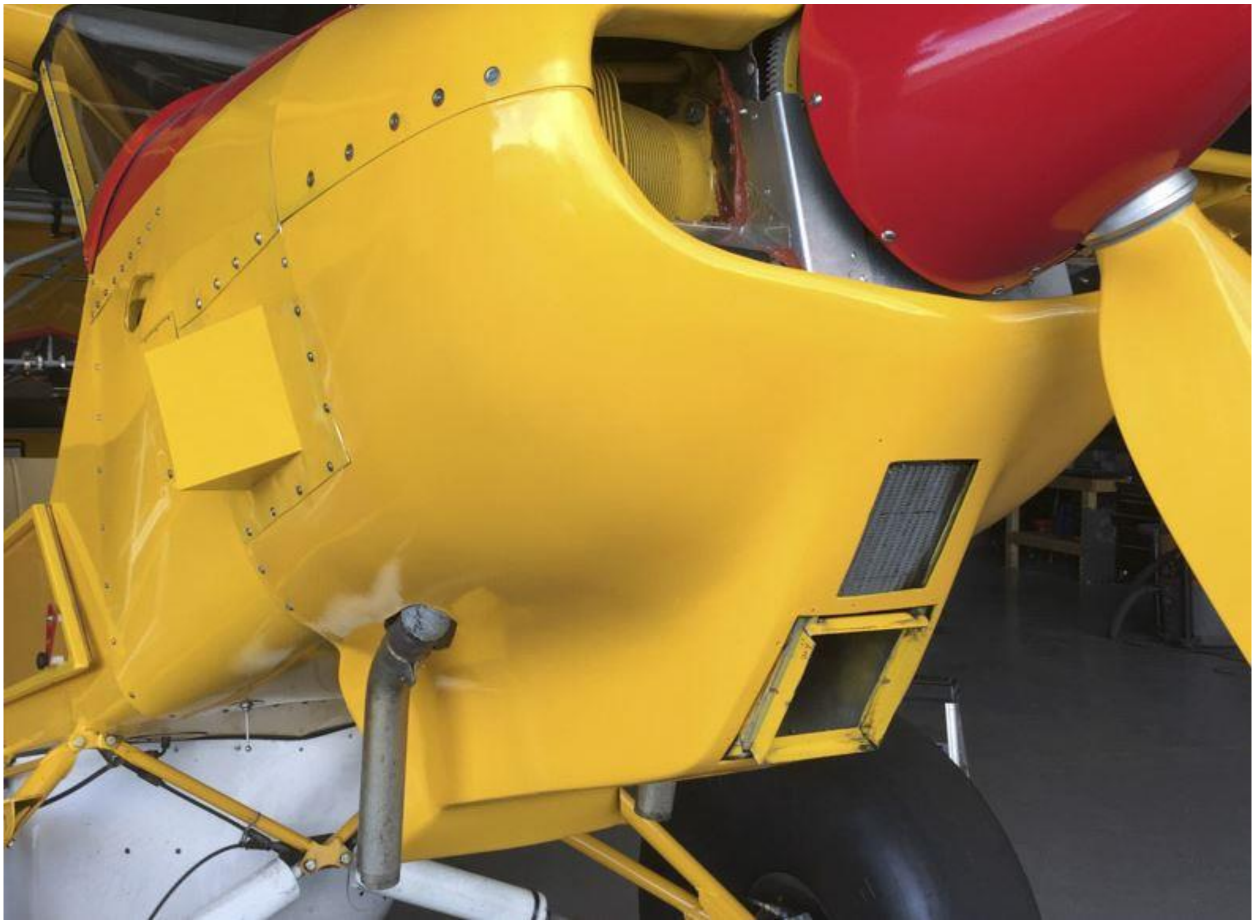
Back to the cowl mods. The extended length on the bottom cowl plus the lips on bottom on sides helped reduce CHT's. I got another 10°+ reduction. Still, I wanted to see lower yet CHT's.

My next change—and the one that had the most noticeable effect of all—was to add side exits. You can see the mock-up on one side below. I got this idea from looking at the cowl design on Carbon Cubs. I figured I'd either make the carbon fiber ones myself or buy them from Carbon Cubs—that was until I found out Cub Crafters wants like $850 for a set—Yikes! So I started out with these aluminum ones. Maybe I'll make carbon fiber versions at some point. Again, testing with junk aluminum & duct tape.



I was able to add this scoop simply by replacing one of my existing cowl doors. So it was very convenient to test—Thankfully I didn't have to cut any part of my existing cowl.

This test on the # 3 side had a big effect—20°+ or more improvement. Hence I made a better looking version and did so on both sides.



After all these changes, cooler weather had set in. Nonetheless, in the below picture you can see that I'm climbing at 350' per min at a high power setting—relatively slow airspeed—with CHT's where I want them.

My next effort was to improve airflow on the top inside cowl. Using clay and foam, I smoothed out all top surfaces so there wouldn't be any inlet turbulence from the top of the cowl. You can see that process underway in the below picture:

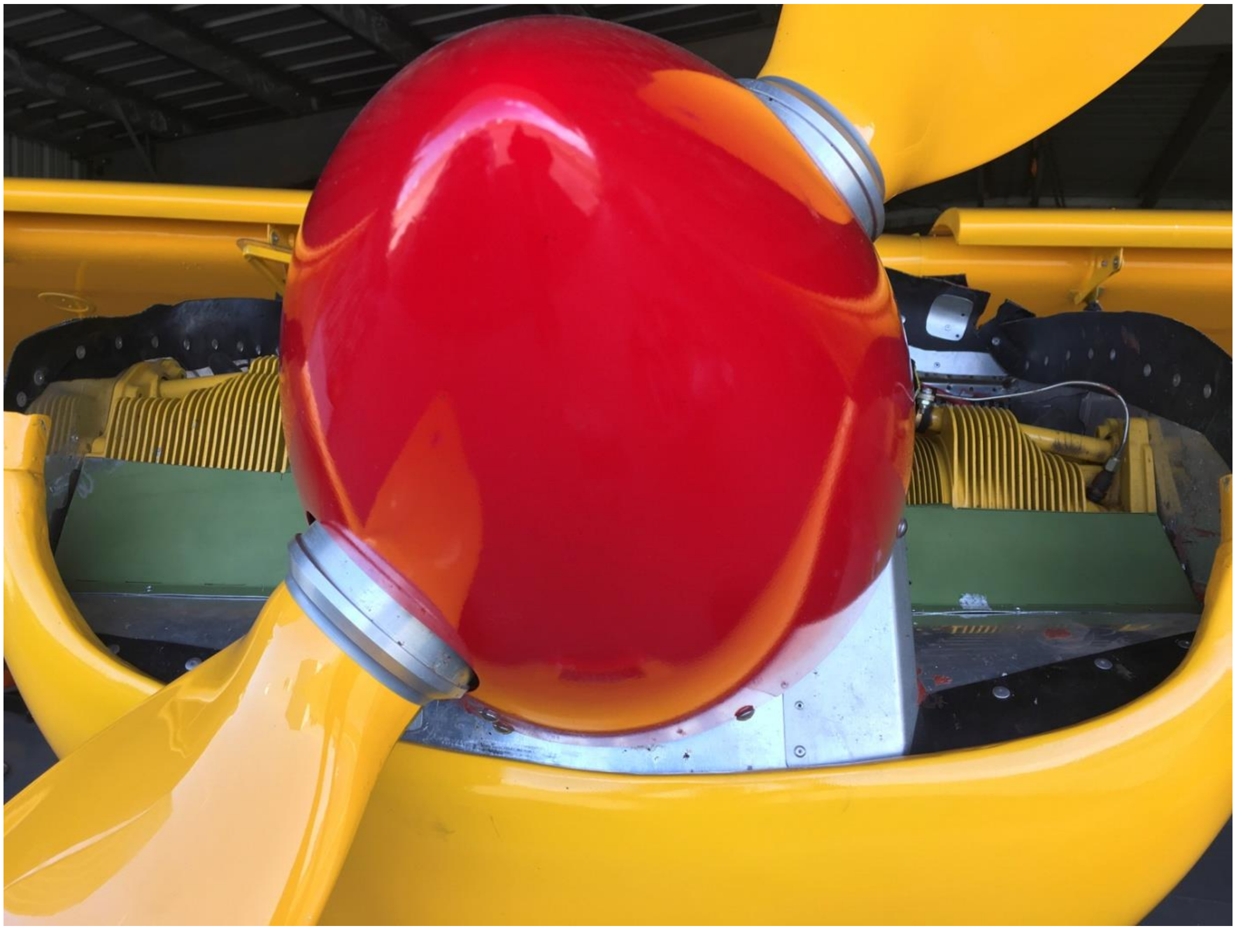
Finished Inside Top Cowl Picture Below

At this point I still had my inlet ramps at the bottom of the front cylinders, as seen on the 3rd page of this PDF. My CHT's were good—not optimal—but a huge improvement from where they had been.

In the below picture you can see that on a pretty warm day, 78°, and relatively high power settings, I had "Ok" CHTs, ranging from 386° to 401°. Again, the gallons-per-hour figure is not right. I was still struggling to get an accurate K-factor setting.

Another friend noticed my inlet ramps and remarked that they were too low. He told me they had to be at mid-height on each of the front cylinders. By this time, as noted previously in this (too long) article, I was pretty dubious of any suggestions. I had heard and tried too many suggestions made both on-line and in person with often dubious results. But…

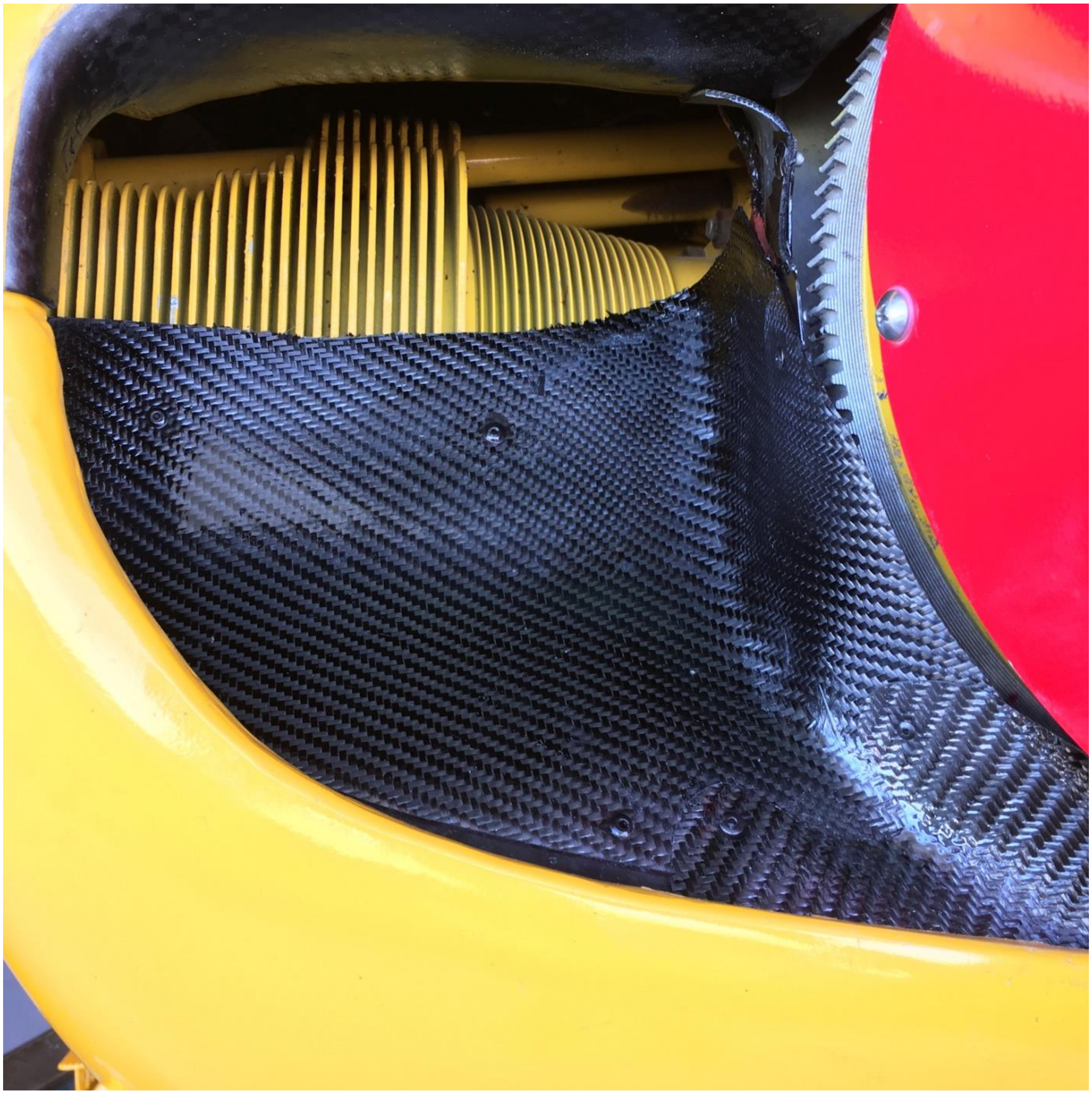
I figured what the heck, and mocked up some higher inlet ramps, again out of scrap aluminum I had laying around. You can see the mock up of higher ramps below:

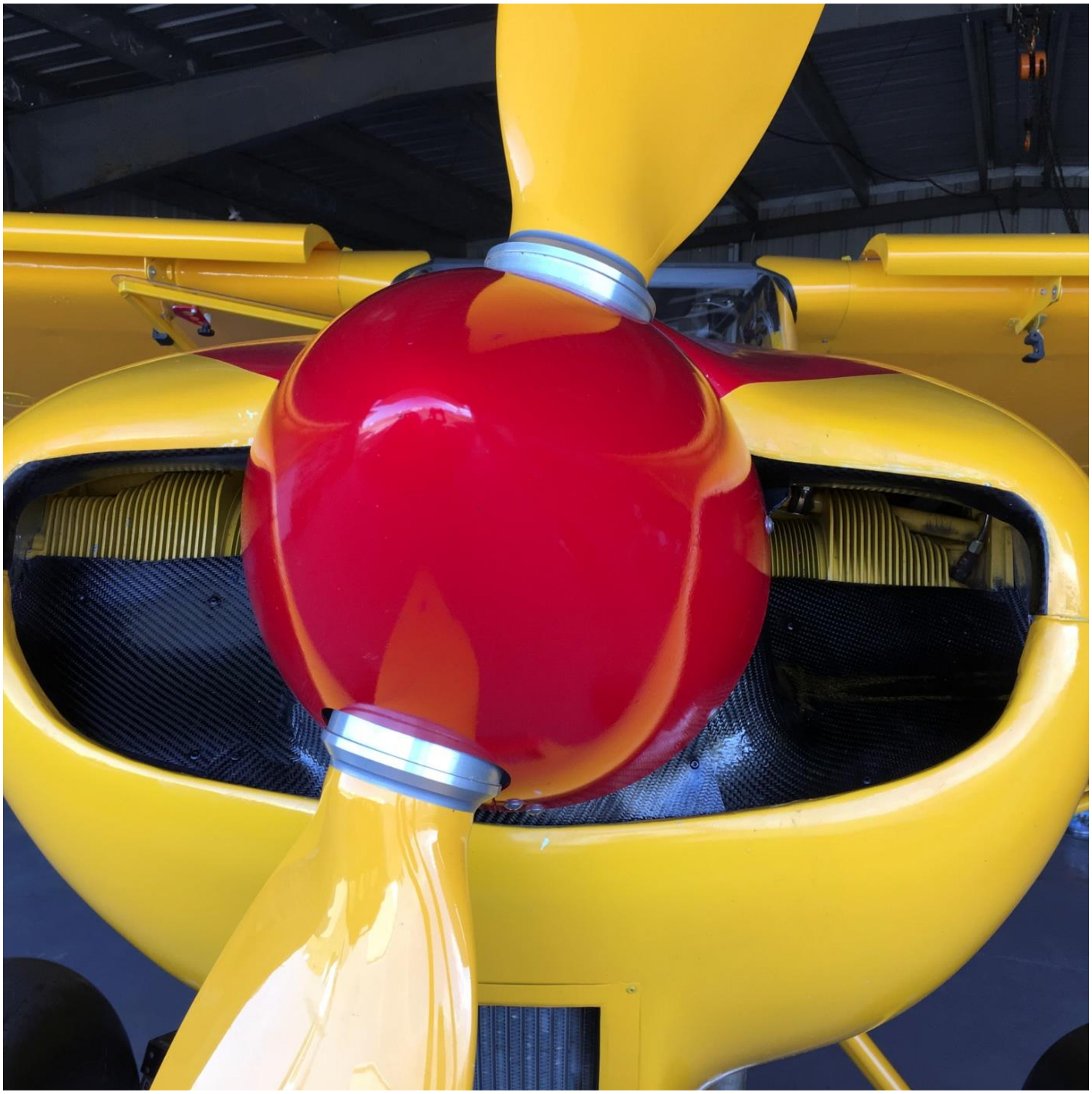


Holy smokes! I couldn't believe the change!! My CHT's dropped 20°. I was thrilled to say the least.

The below picture shows the same power settings, 65° temp, with CHT's from 375° to 382°.

The last step was to make a better inlet, with smooth curves and, as long as I was at it, to do so using carbon fiber. Making the molds, laying up a couple of molds until I was happy, endless sanding, et cetera took about 40 hours or so. Below are two pictures of my current inlet design:





The below pictures shows me in a 350 fpm climb, albeit at a lower altitude (1,600’), but nonetheless at a high power setting, on a 74° day, at a relatively slow airspeed. Note my CHT’s range from 333° to 343°

After several hundred hours of experimenting I’m finally happy with my baffle and cowl design from an engine cooling perspective.

As a footnote, another builder whom I shared the above process with experimented with a rounded side exit on his cowl. More like the typical Cub “cowl cheek” per se.

I modified my cowl with “cheeks” as shown below. This further helped improve airflow & CHT temps.

I have 3.5” of clearance at the maximum point. To help maintain the cheek shape, a good friend used CAD to design and then machined the below custom standoff.

Note that I also redesigned my airbox and related inlet. I flight tested the new inlet with no filter and then with the K&N filter installed—same manifold pressure.

Also note my oil cooler is in front, above the air inlet. Therefore the oil cooler is not in front of any cylinder nor robbing air behind #4 as with some more traditional installations. Picture below.


Sharpie Pen.

A friend installed inverted “vanes” (for lack of a better description) inside the top of his cowl to focus air over the cylinder area. Picture below. I intend to also make this modification in the near future.

I’m going to redo at least my top cowl, and likely the entire cowl, using carbon fiber this summer. Mostly for weight savings. Also to reduce the top cowl height about 1.5” where it meets the spinner as it currently “sticks up” that far above the rear of the spinner. At that redo point I’ll add the vanes as mentioned above (and shown below).