Rotec Liquid Cooled Heads and Electronic Ignition in a Jabiru 3300 Powered Sonex

A Report

By

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Disclaimer

First, let me make it clear that I am not associated with Jabiru, Sonex Aircraft, or Rotec Aerosport in any way other than using their products described in the following. Second, The following is an accounting of my results alone, and your mileage may vary. Third, the results presented here are empirically found, and as such, will likely have significant error.

A Little Background

My Jabiru engine is of early vintage: S/N 299. I purchased it from used with zero hours on it. It had been mounted on a homebuilt aircraft, and the builder had a stroke, so he parted out, to my benefit. After appropriate baffling modifications, I finally got the CHTs under control, and the engine ran fine for 640 hours. I admit I was somewhat mean to it. I would do stuff like take off at full throttle and leave it there till I leveled off at 8000 ft. I also developed a bad habit of cruising at 3150 rpm almost everywhere. Eventually, this takes its toll

At 640 hours, I landed in KOSH, and discovered I had a valve seat sink into the head. I purchased a used one from Pete to get me home. When the failure occurred, I decided that when I got back home, I would do a full top end, and did so. I found in general that the cylinders were still fine, but the tops of the pistons had some signs of detonation on the cylinders where the cracks initiated. I surmised that the hot corners of the cracks were the culprits. I sent the heads to Jabiru USA for reworking. Two of the heads were replaced as they were damaged during the re-work, and needed to be replaced. The "new" heads were used and of a later design, with larger spacing between the valves (~3/8") and higher fin count. So I re-ringed the cylinders, and started flying again. About 150 hours later, I started to detect low compression again on cylinder 6. I borescoped all heads, and found cracking between the valve seats on two of the remaining original heads, and indications that the last one would also soon crack. It was clear that the space between the valve seats was too small (~1/8"). There were 4 of the old version heads on the engine, and to replace these with used heads would cost about $2500. At this time, CAMit had closed its doors, and getting new heads of the appropriate vintage would be difficult if not impossible. So what to do?

Choices

I did not consider Rotec Liquid Cooled Heads initially because I had looked at them at KOSH once and the display model on display had a sever casting defect that would render the head unusable. If this was an example of their finest work (it was on display at Airventure), their workmanship was in question. I had heard that their electronic ignition system worked well and solved the cold starting issues, so I contacted them. With such an expensive repair imminent, I wanted to see what the cost was. Paul of Rotec told me he would sell the electronic ignition system, and all six heads and ancillary hoses and tubes, and a water pump, for $3500. All I had to do was buy a radiator. I thought about it, and despite my concerns about quality, purchased the heads. And so the story begins.

Purchasing the heads from Australia is something of a burden, especially if you screw up the credit card info. It will get the interest of the bank security people for sure. However, with diligence, you will succeed. It also costs an additional $250 for shipping and handling, and $30 for import duties.

Inspection of the heads on arrival:

On arrival, I carefully inspected the heads for any flaws common in castings, as well as machining flaws. They were, in general, apparently of good quality casting. I did discover about a tablespoon full of grit blasting media jammed inside the water jacket between the valve guide bosses, that I had to scrape out, but otherwise were OK. I also noticed that the valve seats were spaced the same as the old version of

the heads, which is the cause of the motivating failure. I also did not like the location of the inlet tube; directly between the pushrod tubes. I also weighed each head and found them all to be about ½ lb. less than the original heads (the newer style). This did not include the hoses, tubes, and assorted other stuff. The radiator was less than a pound.

Installation

The kit came with an assortment of fittings, clamps, and a water pump made by Davies Craig. The electric water pump is an intercooler pump used on assorted aftermarket superchargers and turbochargers. After lapping in the valves, assembling the heads (you have to use the original valves, rockers, etc.) I put the heads on the engine, and cranked it. All is good, so now on to the plumbing.

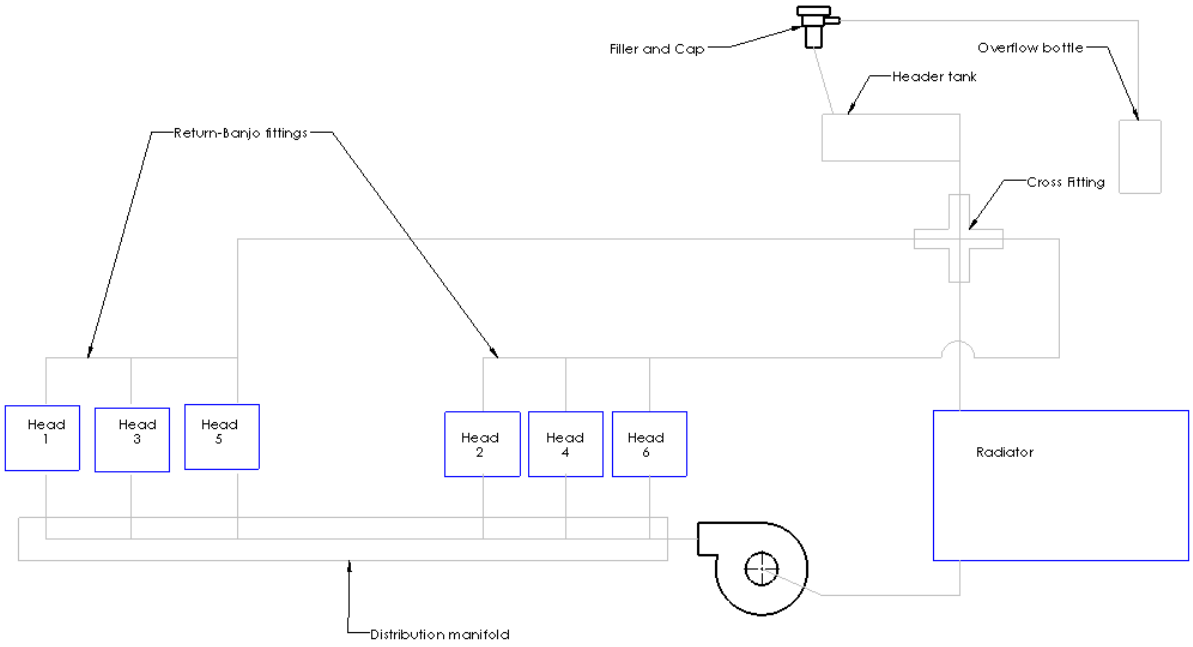
I wrote several emails to Paul and Nilay both about suggestions for a radiator, and they did not respond. So I purchased a radiator for a Suzuki Bandit GSX 650F based on the dimensions provided, and decided to mount it inside the cowl near the bottom of the cowl (as far back as I could). I hung it from the engine mount to get some reference. See Figure 1 below.

Figure 1. Location of the radiator. Suspended from the engine mount, baffled to the cowl wall

Figure 2. Radiator; view from below

The general philosophy was that the heat load from the engine would not change, so I saw no reason to put the radiator out of the cowl, but rather exhaust the existing cowl air through it. More will come about this later. I also elected to keep the original Sonex baffling on the heads and cylinders, so that if the cooling system ever did fail, at least the air flowing over the cylinders and heads would slow the disaster down. I would add some SCAT tubing from each side to point at the radiator.

I had to make an assortment of fittings and manifolds to make this work. The pump is 1.5” hose barbs on both in and out; the heads both in and out are 5/8” hose barbs. The radiator has ¾” hose connections, and the filler neck was 1”. I made a distribution manifold from the pump, and a header from the filler, a ¾ x 1.5” bell reducer, and a 5/8x3/4x3/4 Tee out of steel so all the different hose sizes would work. A schematic shows the general arrangement below.



I had to add a new switch, and circuit breaker for the pump. This is not easy, as I am getting kind of old and fat, therefore working under the instrument panel is, well awkward. I filled the system with 50/50 water/antifreeze (required, as Evans waterless coolant is not recommended by Rotec), and blead the system. It is easier to do if you raise the tail up higher than level flight attitude. A persistent leak was found on Cylinder 1. I thought at first the O-ring on the inlet side was leaking, but it turned out to be the tapped hole that holds the tube in the head had intersected a casting flaw, so the coolant would leak through the threads. I applied some thread sealant and the problem was fixed. Time to run the engine with new heads! It cranked and ran well with the new heads. I let it run a few minutes, and saw no issues. I finished mounting the radiator, and modified the cowl for the radiator exhaust.

I modified the cowl by removing the normal air dams at the old exhaust tunnels, and cut a couple of new holes near the back bottom of the cowl under the radiator. I added air dams to these holes. Time to test run this with the cowl on. A fair amount of ground running was in order, so several high power runs down the runway to get the temperature up to high temperatures (above 180F). After about 5 minutes of going up and down the runway, I remove the cowl because of a coolant leak. It turns out the seal on the water pump was leaking. I disassembled the pump to find the problem, and found the glass filled nylon pump housing was about 0.010” bigger than the seal. As soon as the water got hot enough to thin the assembly grease, it leaked. I contacted Paul again via email (took two emails to get a reply), and he said he would replace the pump, but it would likely take a month to for me to send it back, and get it replaced. Curious if I could remedy the problem, I put a clamp around the seal boss (Figure 3) to put the boss in hoop compression, and voila, it worked. I will take it off at some time later after testing and I am convinced the system works.

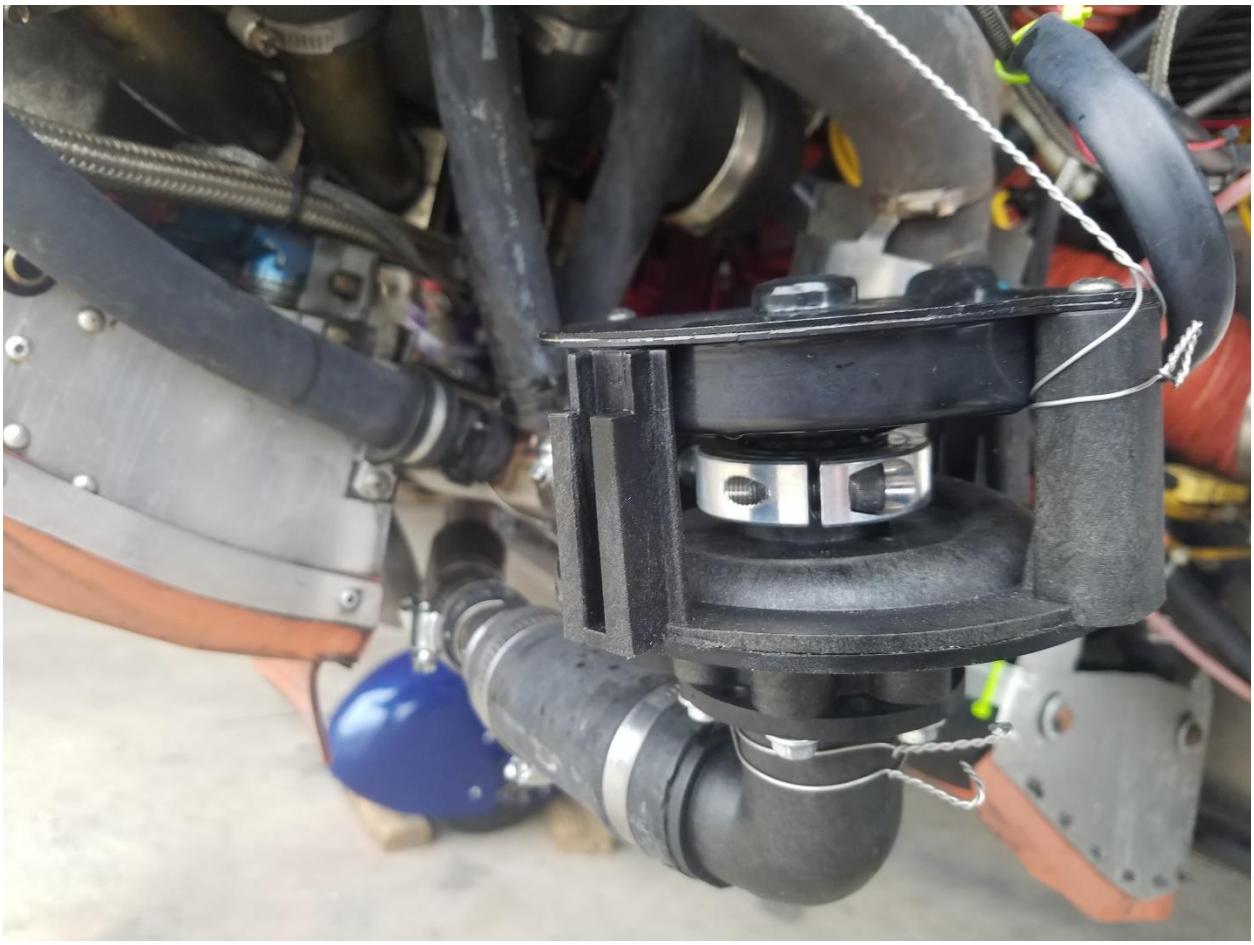


Figure 3. Clamp on Seal Boss. Poor quality control. The pump will come off soon enough and be replaced with something of better quality.

Flight testing

After all is said and done, this is what counts. Staying near the airport, I ran assorted test speeds, tweaked the baffling here and there, and eventually got the coolant temperature to settle around 150-160F range at a modest cruise (2800 RPM). Oil temperatures were another story. They were about 30 F higher than before. After much fiddling, I determined that the lack of fins on the rocker boxes was the culprit, and added a couple of small NACA ducts just in front of the oil cooler to increase the flow as shown in Figure 4. It worked. Oil temperatures are 205 F if I am flogging it.

Figure 4. Modified cowl. Note the original cowl opening, and the new cowl opening with the air dam. Also note the new oil cooler NACA duct. One on each side.

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After tweaking, the numbers fall as follows:

2850 RPM, straight and level, 140 mph-ish, CHT 220F, coolant temp 155-160F, Oil temp 185-190 F

2950 RPM, straight and level, 150 mph-ish, CHT 230F, coolant temp 160-165F, oil temp 190-197 F

3050 RPM, straight and level, 155mph-ish, CHT 245F, coolant temp 170-175F, oil temp 200-205 F

I can also go to full throttle and climb to 3000 ft. AGL at 110 mph before needing to lower the nose to a speed of 125 and still keep the coolant temperature below 190F. Overall, these are quite good numbers. However, it remains to be seen what the small spacing between the valve seats will cause. Will the generally lower temperatures mitigate the effect of the extreme temperature difference at this spot? Only time will tell.

Cooling System Discussion

There are a few things I would change about the design of the water cooled heads; add some cooling fins so as to cool the oil in the rocker box, and perhaps elsewhere on the heads so as to minimize the effect of a loss of coolant, additional spacing between the valve seats, and a better coolant inlet location. The location of the inlet tube prevents practical head torqueing, as it covers the bottom head bolt. I am happy with the head temperature, but am a natural skeptic, and a mechanical engineer, and know that temperatures alone will not tell the whole story. I also have discovered small oil leaks that appear to be coming from the push rod tubes at the rocker boxes. These leaks are small, but annoying. Why do they leak? I simply don't know yet. When I figure it out, I will let the universe know.

Is this the best way to install the radiator, and cooling system? There are many ways to do this, but I tried to keep this as minimal as possible, without additional drag. I think I succeeded somewhat on this. An interesting side effect- I can feel the turbulence created by the radiator exhaust on the floor of the cockpit. Not a large affect, but it is there. The airspeeds seem to be near the same if not identical. The added weight is not significant. I weighed the plane afterwards, and could not tell if it changed much, as the weight was about 2 lbs. more than it weighed before but then I realized I had not weighed the plane after stripping and wrapping in vinyl, so I have to guess. The system holds about 0.65 gallons of 50/50 or roughly 5 lbs. of water. The hardware (hoses, pump, fittings, and radiator) perhaps weighs 4lbs. So, lose 3, and add 9, about 6lbs of increase.

Would I do it again?

No. I would get the appropriate air cooled heads. Any high cylinder head temperature issue can be solved with appropriate baffling, and the entire firewall forward is far less… complicated… It was a real pain to get it all made and stuffed in the cowl. While I am happy with the numbers I get, and not seeing any creep afterwards, still no.

Would I recommend doing it?

No. The Rotec quality control is less than it should be. Their help in installation is not great either. I asked thrice about the radiator, and twice about the pump. I never received any replies about the radiator, and only heard once about the pump. I also asked troubleshooting questions about the electronic ignition system. Four emails, with no replies. Speaking of the electronic ignition system…

Ignition System Discussion

The Jabiru can be a pain to get going in the winter. I have come to the conclusion that this ignition coils are at least partly to blame. So I installed the Rotec ignition system, and voila! Problem solved! At least until the thing failed about 15 hours in. I surmise the failure was due to inadequate cooling of the module, as I did not have any cool air blowing on it. But it worked perfectly while it worked. Start the prop to spinning, and as soon as the ignition was turned on, it started. I suspect then starting problem is a compound problem; a weak spark and using the Aerocarb; when the weather is cool, fuel evaporates slower, and with the Aerocarb, fuel simply flows in to the carburetor and lays there, hoping the

incoming air will pick it up and atomize/vaporize it. Add a weak spark to a less than ideal fuel mix, and there you have it. I ordered a new ignition module on eBay (Rotec will not answer emails about the ignition system), and will try again with improved cooling. I will let you know how it goes…

Would I do it again?

Yes. If I can get it to keep working reliably, absolutely, but as I said, I suspect as the temperatures rose from winter to spring, without any direct air on it, it quit. I will fix it and try again. This solved the starting problem immediately.

Would I recommend it?

Yes, pending getting it to work reliably.