Rotec liquid cooled heads (LCH) conversion for Jabiru

Background

This particular conversion came about due to my search for a method to keep the Cylinder Head Temperatures (CHT) in my 6 cylinder Jabirus at safe operating levels encountered during normal conditions. I bought my SP6 from Kevin Berry in August 2002; I subsequently used this in order to commute between Shepparton and Albury. As the SP6 had limited room, when an experienced builder, Geoff Hamilton, offered to help build a J200 (provided he did not have to help finish it (dust and sanding) I jumped at the opportunity.

As the J200 was being completed I started having all sorts of problems with the SP6 engine, high cylinder head and oil temperatures, burnt out exhaust gaskets, burnt out valves and finally a cooked cylinder head. I was keeping Norm Edwards at Shepair busy for a few weeks with the repairs and even busier working to pay for them. The oil temperature problem was solved by fitting a PosiTech oil cooler.

Unfortunately the high CHT seemed almost unfixable. Due to these ongoing issues with the SP6 and wanting to complete the J200 I parked the SP6 in the back of the hanger. But I fitted a Grand Rapids engine information system (EIS) to the J200. (The Grand Rapids EIS is an excellent instrument, relatively cheap and it supplies EGT and CHT for each cylinder, plus OT OP Oat and carb ice warning etc.). During initial flights I realized that my problems in the SP6 had transferred to the J200 but were much more apparent and alarming, not only were the back cylinders getting hot but the front CHT and EGT were at melting point. If I had relied on my steam driven instruments I would have been blissfully unaware of any problems.

To cut a long story short I went down the pathway that most 6 cylinder Jab owners seemed to have endured, experimenting with various cowl and ram air duct set ups, carburettor needle and jet settings, fitting an anti swirl vane into the carb cobra neck etc. I would say now I almost have the J200 under control for days that are under 30°C. I can keep the CHT`s just under 150°C and the EGT below 720°C provided I climb out at 90+ kts and using maximum jetting (rich) running at about 30lt/hr, (engine must almost be fuel cooled), with the cowl flap full open and juggling the carb heat to stop the heads from cooking.

During my efforts to reduce the CHT`s came the realisation that fuel and mixture was a major part. I had a conversation with Paul Chernikeeff at Rotec about his TBi injection system. He mentioned that they had some air cooled tappet covers as well as the TBi that could help reduce the temperatures. While the covers helped a bit they did not achieve a quantum change. However Paul

also mentioned that Rotec was in the process of developing liquid cooled heads for the 6 cylinder Jabiru but were being held up by the lack of a suitable engine, my old SP6 was fretting away at the back of the hanger hoping that my son would get back into flying. I worked out an arrangement with Paul to loan it to Rotec to use for the prototype and I would be one of the first in line for new heads for the J200

I would like to say at this stage that I like flying my Jabirus. The SP6 is light on the controls, nimble and a delight to fly. The J200 is more solid with heaps of room which I tend to use like the family station wagon, in the cruise it can be flown hands off with light rudder input to correct for turbulence. Alan Seale who did the weight and balance, when I was getting the certification for the J200, commented that if it was a VH registered aircraft that I could put two 90kg suitcases in the back.

This article is not meant to be a critique of Jabiru, as Paul said when we started the project. "If the engine was no good he would not waste his time on it", and likewise all I wanted to do is to realize the full potential of the airframe and engine by having a reliable engine that can operate under normal conditions without overheating. The SP6 hadn`t been flown for many months so I gave it a quick check over and flew it from Shepparton to Tocumwal, it ran well but appeared to be down on compression (no wonder we found that 4 of the heads were leaking when removed at Rotec). A friend Eddie Madden at Sport Aviation helped to remove the engine and stowed the airframe. The next weekend I delivered it, via trailer to an enthusiastic Paul at Rotec.

Several months later Paul rang and suggested I should bring down the fuselage and they would fit the engine at cost, as they needed to fiddle and experiment with the plumbing, radiator etc and they would provide all the labour at no charge. There were a few startled looks from other drivers when I heading down the Hume Hwy with a Jabiru fuse sitting on the trailer.

Rotec fitted the 3300 engine to the SP6 and in no time had it running on the ground. From their previous runs on the test stand they concluded that they could even do without the oil cooler as the engine ran so cool. I was pretty sceptical about this, but Paul assured me he would come up if it ran into trouble. So onto the trailer it went back to Tocumwal to fit the wings and start test flying. I was fortunate that Eddie Madden the CFI at Sport Aviation was available to assist in rigging, safety checks and initial test flights. Ed has thousands of hours in gliders, tow planes, light aircraft and is a RAA level2 instructor. We have both flown gliders since 1967 and instructed in gliders on and off from the 1970`s, Ed for a living, myself as a hobby.

On the initial flights in December it was found that the oil temperature was high and still rising at 3000 ft. The maximum temperature in the climbs was not established. It was decided that

the oil cooler should be fitted again. However the CHT`s were at maximum 115°C (measured on number 6 cyl LHS back), Water 85°C (measured Number 5 cyl RHS back). Very Impressive!!! I rang Paul to say" I told you so "which he completely ignored and only wanted to talk about the CHT and water temps! You can`t argue with an enthusiast!! We had previously decided at the factory that if oil temp was a problem, to refit the Oil cooler by mounting it near the firewall using 70mm scat hosing ducting the air from the top cowl left hand side intake. Paul offered to come up but as it was close to Christmas and gliding was in full swing I said I could manage and promptly went back to flying the ASH26e in the OLC competition. If only I had known, the week after Christmas I managed to slice the top my right index finger which made refitting the oil cooler agony.

We did several flights in January using the scat hosing inlet which stabilised the oil temp but it was still too high getting up to110°C at the same time the CHTs were beautiful (110-115centigrade). I decided to then mount the oil cooler above the radiator sitting below the sump where it had been before the conversion. The results were excellent. The oil temperature has never got above 100°C even with a full powered climb to 5000ft on a 32°C day (see installation photos below).

I then arranged for Eddie to give Liam Watt, his young tow pilot, a check out on the SP6 so we could do some in depth testing which basically consisted of full powered climbs to 5000ft followed by a short cruise then descent. Listed below are Liam's detailed observations.

The initial flight was on the 25.02.2011 with an OAT of 32°C and the CHT on Number 6. After take off the Aircraft was climbed to 5000ft at 60kts on full power.

All the temperatures at the top of climb (TOC) had stabilised to Water Temp: 95° Oil Temp: 100°C, and CHT 120°C. After 6 flights this was the highest temps recorded because of the slow climb out speed and slightly higher OAT.

After landing and removing the top cowl it was apparent that there was an oil leak. There

was a layer of oil on the underside cowl, predominantly on the left hand side (LHS). Upon closer inspection oil had collected on the underside of the cylinder heads, again predominantly on the LHS.

Oil Leaks solved

It was decided that flights should not be longer than 30 minutes in order to prevent excessive oil build up. The A/C undertook further flights with the CHT on 2 and 5 and it was found that the temperatures remained very similar.

Because the oil was sitting on the underside of the heads, mainly on the LHS it was concluded that the leak was coming from the rocker arms. After further discussions with Paul at Rotec it was established that oil could be forcing its way out through the rocker arm shafts and they needed a modification. Paul decided he would come up to Tocumwal the next weekend and on Sunday flew in with his Rotec powered FlyBaby accompanied by Matt in the front seat. In no time the offending heads came off and new rocker arms seals were fitted to prevent oil leakage. Further test flights showed that the oil leaks had stopped.

Water pump failure

The water pump is electrically driven. On the 07.03.2011 a test flight was done to assess the outcome of a water pump failure in flight. Paul assured me that the heads being cast alloy were good for at least 200°C without deforming.

In a cruise at 4000ft QFE and 3/4 throttle at 95kts indicated, the water pump was switched off for 3 minutes. The initial temperatures prior to the simulated water pump failure were, oil 95°C, water 110°C and CHT 100°C. Initially the water temperature rose rapidly and the dial went off the gauge. After three minutes the temperatures were as follows, oil 100°C, water OFF, and the CHT 140°C. The CHT did not rise rapidly and it is believed that the engine would now have similar temperatures to an air cooled Jab 3300. After three minutes there was a distinct smell of glycol the water pump was switched back on and the temperatures quickly returned to normal.

After landing the cowls were removed for inspection and it was clear that the water/coolant reservoir was inadequate as it did not allow for a discharge of more than .5 litre of coolant. As such the heat caused the water to boil out and overflow the reservoir. Once the pump was switched back on the suction back into the water system caused the reservoir to compress. About .5liter needed to be added to top up the system after this test. I suppose if a water pump failure in flight was fixable (e.g. a fuse) then clearly there needed to be a reservoir capable of resupplying the system with

coolant. A larger, stronger reservoir was fitted with over flow and a capacity for the full amount in the cooling system approximately 2.3 litres. Further flights in unusual attitudes etc concluded that the engine temperatures remained stable e.g. high angles of bank, nose high climbs just below stall etc.

Summary

1. All the tests so far have demonstrated that the Rotec liquid cooled heads work very effectively and I look forward to fitting them on my J200.
2. Rotec have a very CAN DO attitude and will back up their work with actions as well as advise.
3. The installation is not complex it is relatively simple. Installing it into the SP6 necessitated making extra ducting because of the small cowl size, however the J200 will be easy. Some of the installation on my SP6 was very much experimental, Rotec now know several other space saving tricks that can be incorporated in future conversions.
4. From my observations I would conclude that if there was a catastrophic failure of the coolant pump you would be no worse off than in an air cooled engine as the manufacturer states the heads are good for up to 200°C. It would be wise to land ASAP however; if you were over tiger country you should have 20 to 30 minutes grace.
5. I also fly a Rotax 912S powered Sonerai as well as the ASH 26E rotary powered self launching, 18 metre glider. Both of these are liquid cooled and can be operated in the extremes of summer. It will be nice from now on to be able to fly home during the summer time in the Jabiru.

Thanks to Paul Chernikeeff at Rotec, Eddie Madden and Liam Watt at Sportaviation Tocumwal.

Terry Ryan.

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 25/02/2011 Outside Air Temp: 32°C Pilots: Ed and Liam

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
Climb to 5000ft	60	Full	100	95	120	16:42
On Descent 2000	90	¼	80	80	95	16:45

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 25/02/2011 Outside Air Temp: 29°C Pilots: Ed and Liam

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
Pre Take off	-	Systems Check	60	70	95	17:36
Circuits: 10	-	Circuits	95	90	105	18:36

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 26/02/2011 Outside Air Temp: 32°C Pilots: Terry and Liam

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
3000	80	Full	90	90	105	18:03
4000	80	Full	98	90	120	18:04
5000	80	Full	100	90	120	18:05
5000 Cruise	100	¾	100	80	105	18:07
Descent 3000	100	½	95	75	85	18:09
Descent 2000	100	½	85	70	85	18:10
Descent 1000	90	½	85	75	85	18:14
Land	0	Idle	80	75	80	18:20

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 27/02/2011 Outside Air Temp: 28°C Pilots: Liam Watt

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
Take Off	-	Systems Check	60	80	80	16:20
1000	75	Full	80	80	105	16:21
3000	75	Full	90	90	115	16:23
4000	75	Full	90	90	115	16:24
5000	75	Full	90	85	115	16:26
Cruise 5000	100	¾	95	85	105	16:30
Descent 2000	95	¼	85	65	90	16:33

CHT Probe on No. 2 Cylinder

Jabiru SP6 19-3498 Date: 2/03/2011 Outside Air Temp: 23°C Pilots: Liam Watt

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
Pre take off	-	System Check	50	60	70	14:30
1000	80	Full	60	70	115	14:32
2000	75	Full	65	80	115	14:33
3000	75	Full	80	80	120	14:34
4000	75	Full	85	80	120	14:35
5000	75	Full	90	80	120	14:36
Cruise 5000	100	¾	90	80	105	14:38
Descent 2000	95	¼	80	55	75	14:40
Post Land	-	-	65	65	60	14:51

CHT Probe on No. 5 Cylinder

Jabiru SP6 19-3498 Date: 2/03/2011 Outside Air Temp: 22°C Pilots: Liam Watt

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
Pre take off	-	System Check	50	60	75	16:06
1000	75	Full	60	70	105	16:08
2000	75	Full	65	80	105	16:09
3000	75	Full	80	80	110	16:10
4000	75	Full	85	80	115	16:11
5000	75	Full	90	80	115	16:12
Cruise 5000	95	¾	95	80	115	16:14
Descent 2000	95	¼	75	55	80	16:16
Post Land	-	-	65	60	75	16:30

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 7/03/2011 Outside Air Temp: 25°C Pilots: Terry and Liam

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
1000	75	Full	50	70	105	18:19
2000	75	Full	70	80	110	18:21
3000	75	Full	80	80	115	18:22
4000	75	Full	95	85	115	18:23

Test for water pump failure

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 7/03/2011 Outside Air Temp: 25°C Pilots: Terry and Liam

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
4000 water pump off	100	¾	95	110	100	18:24
Water pump off	100	¾	95	120	135	18:27
Water Pump off	100	¾	95	120	140	18:30
Water Pump on	100	¼	85	85	95	18:31
Water Pump on Descent 2000	100	¼	80	65	75	18:33

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 11/03/2011 Outside Air Temp: 24°C Pilots: Terry and Liam

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
1000	80	Full	60	80	110	18:26
2000	75	90%	80	80	110	18:28
3000	75	90%	85	90	110	18:29
4000	75	90%	90	85	110	18:30
Descent 1000	100	½	85	75	80	18:40

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 12/03/2011 Outside Air Temp: 29°C Pilots: Terry and Liam

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
Pre Take off	-	-	50	60	70	16:59
1000	70	Full	60	80	100	17:03
2000	70	Full	75	85	110	17:04
3000	75	Full	90	90	110	17:06
4000	70	Full	95	90	110	17:07
5000	70	Full	95	90	110	17:08
5000 Cruise	100	¾	90	75	80	17:11
Descent 3000	75	1/5	80	60	75	17:12
Descent 1000	100	1/5	65	55	70	17:13
Post Land	-	-	70	80	60	17:21

Check Cruise Temps

CHT Probe on No. 6 Cylinder

Jabiru SP6 19-3498 Date: 13/03/2011 Outside Air Temp: 29°C Pilots: Liam Watt

Height	Kts	Power	Oil Temp C°	Water Temp C°	Cyl Head Temp C°	Time
1000	75	Full	75	85	105	13:44
2000	75	Full	85	90	110	13:45
Cruise 3000	100	¾	95	90	100	13:46
3000	100	¾	95	90	105	14:44