

An Investigation on Three Jabiru 2200 Fly Wheel Attachments.

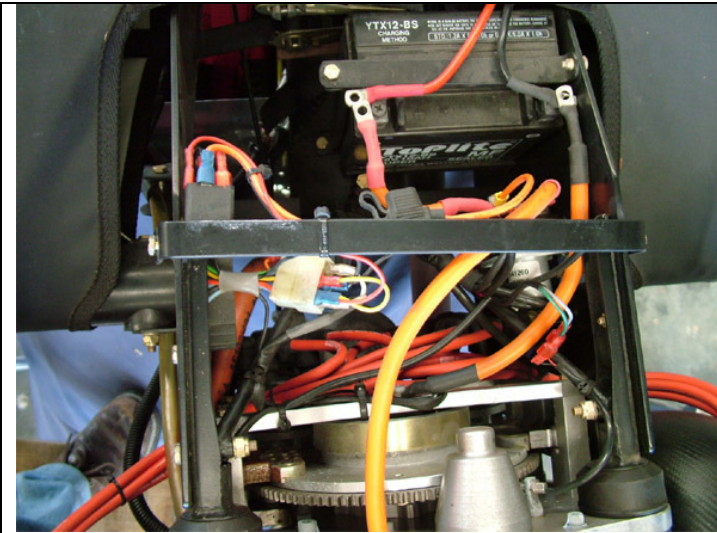
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Anton Lawrence 3/12/2006

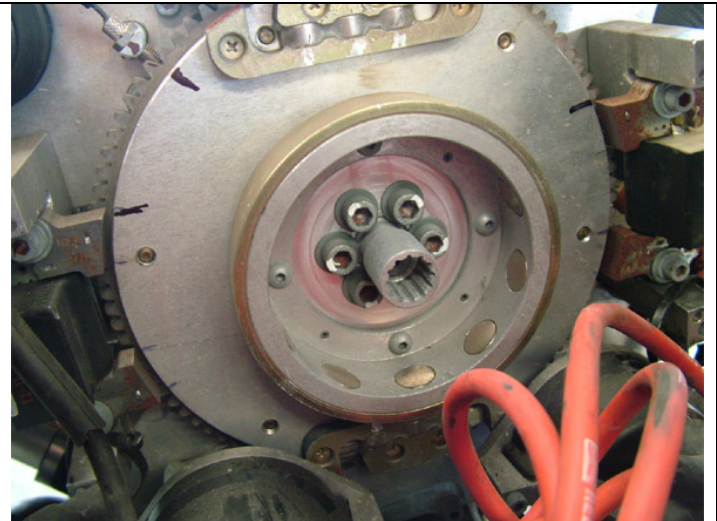
On the 3rd December 2006 three Jabiru 2200 engines had their flywheel bolts replaced and re-torqued, the following shows the process and findings.

The three engines were fitted to Bantam B22J aircraft, each aircraft was fitted with a standard Jabiru propeller.

The first engine was Number 22A 794 and had completed 175.2 hours.



The Bantam requires the battery, starter solenoid, regulator and engine support to be removed to gain access to the stator plate.



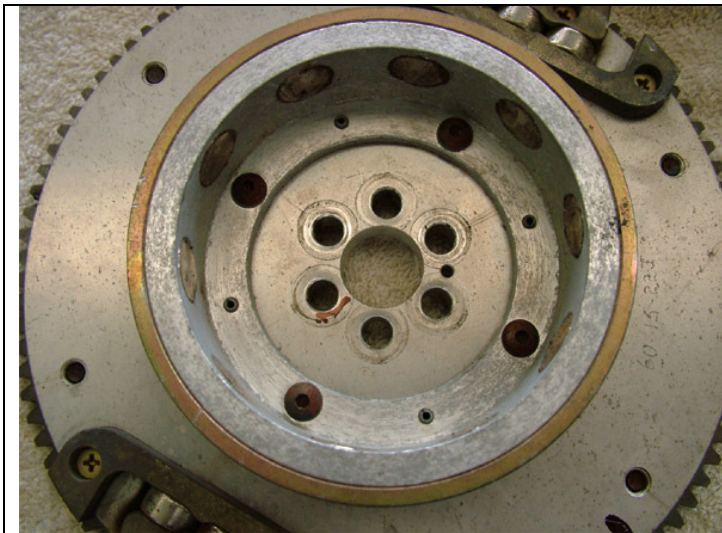
This is engine number 1677 but is the same as number 794. It was decided to remove and inspect the flywheel and vacuum drive. The black registration marks were added to ensure the ignition timing wasn't lost.



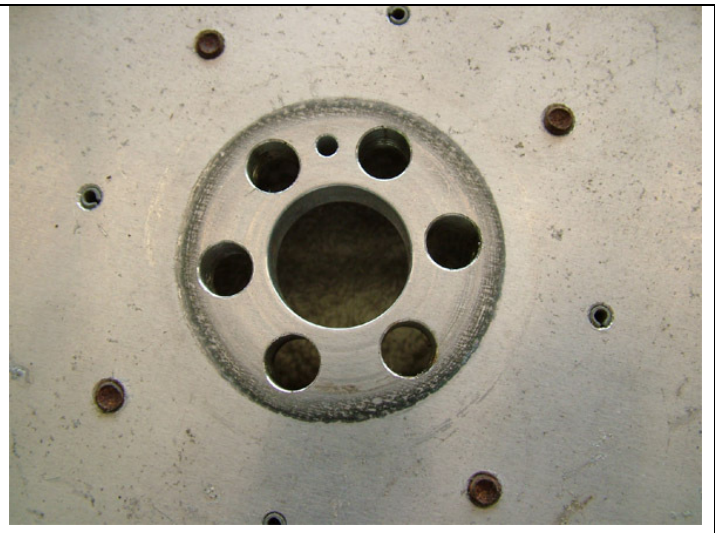
This is the back side of the vacuum drive it is pressed against the timing gear. The fretting is very obvious.



This is the side which presses against the back of the flywheel; there is a ring of fretting here also.



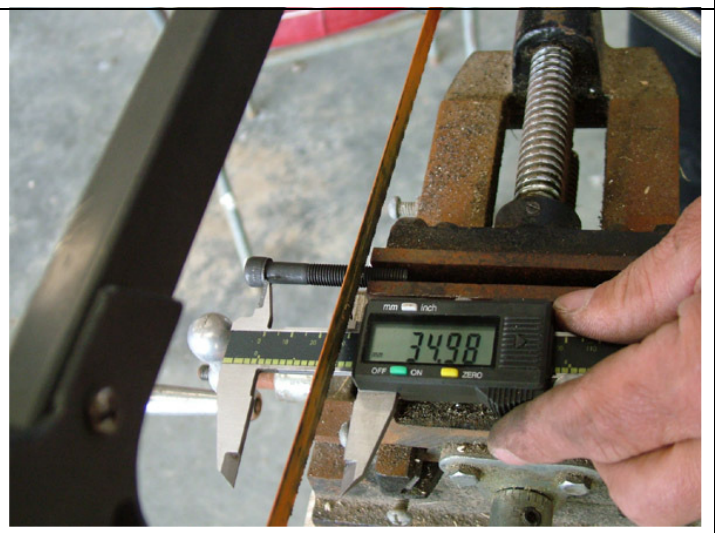
The inside of the flywheel



The back side of the flywheel, light fretting is obvious.

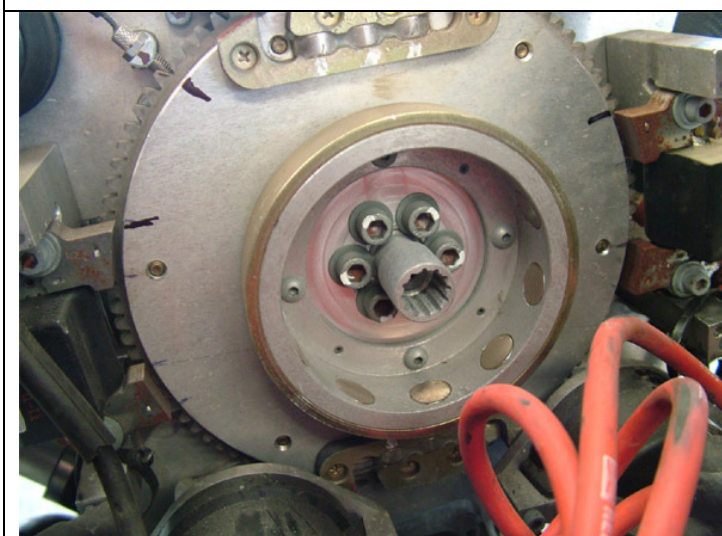


Thread marks are visible in the flywheel holes consistent with fretting. All three flywheels had these imprints.

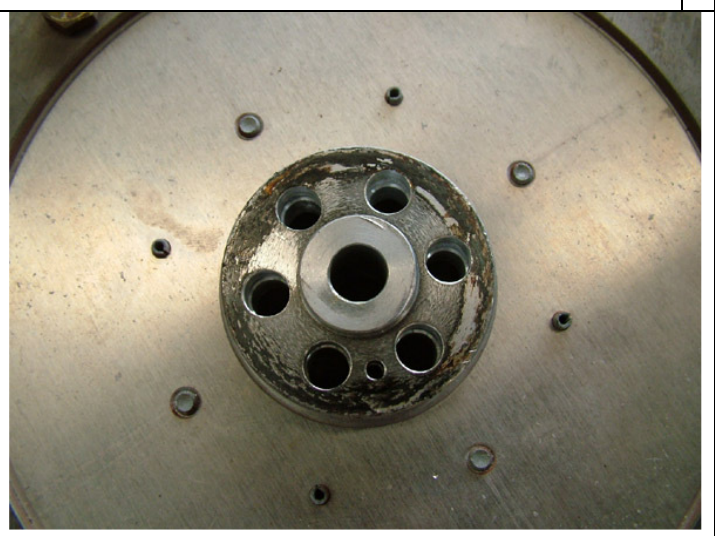


New bolts were cut and fitted and the engine reassembled.

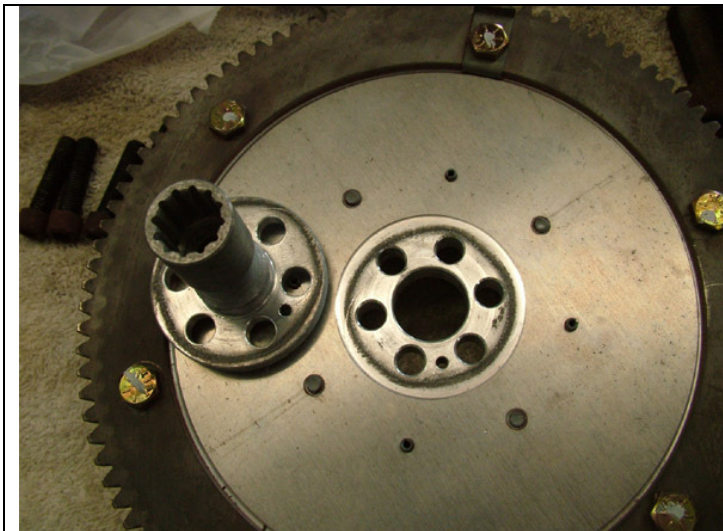
Engine two was number 22A 1677 and had completed 120.6 hours.



Number two flywheel, the flywheel had to be rotated 90 degrees and the mags removed to enable the flywheel to be removed.



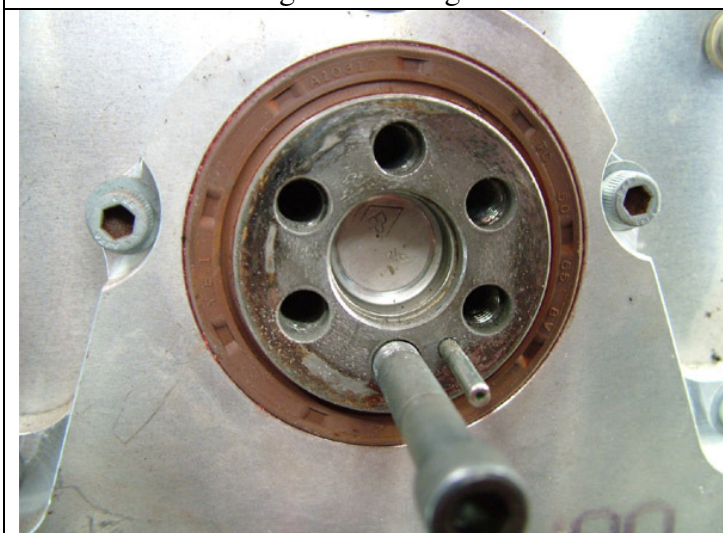
The vacuum drive was very heavily fretted on the back face.



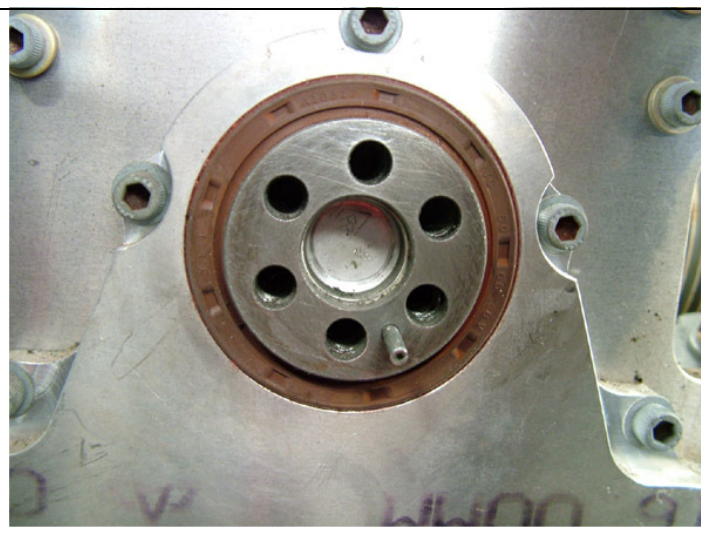
The back of the flywheel and the front of the vacuum drive also showed signs of fretting.



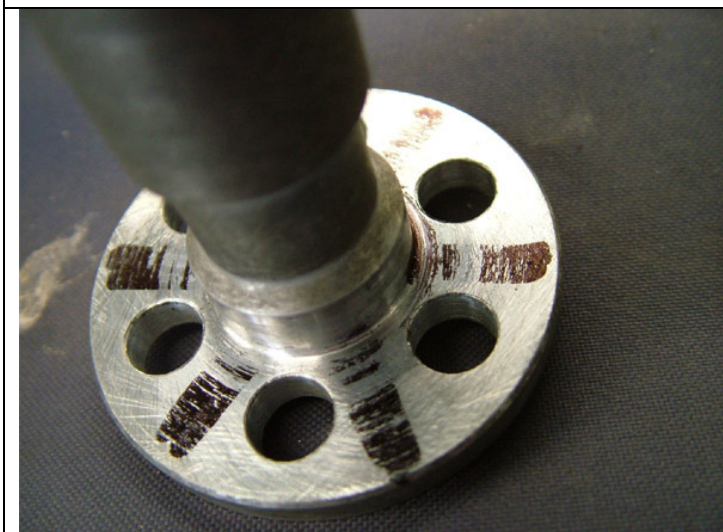
The inside of the flywheel.



This is the part of the timing gear which protrudes the crankcase. The roll pin was factory fitted to assist in alignment. The bolt is a new one being used to clean the threads. Fret marks are clear.



The timing gear after the face was cleaned.



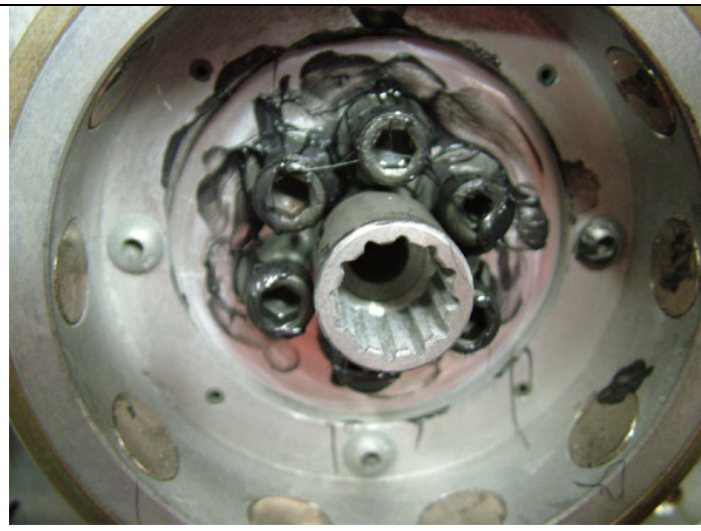
The Vacuum drive interfered with the flywheel at the internal radius. The flywheel had more chamfer removed to prevent this interference, sorry no picture.



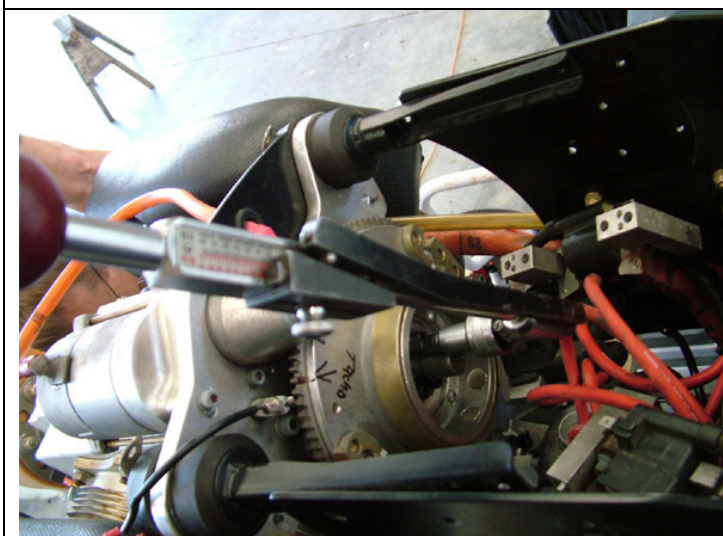
New bolts were cut and the tip finished.



A little molly grease was added to the tip.



Bolts all inserted by several threads and grease applied to the washer faces.



Torque wrench ready for use.

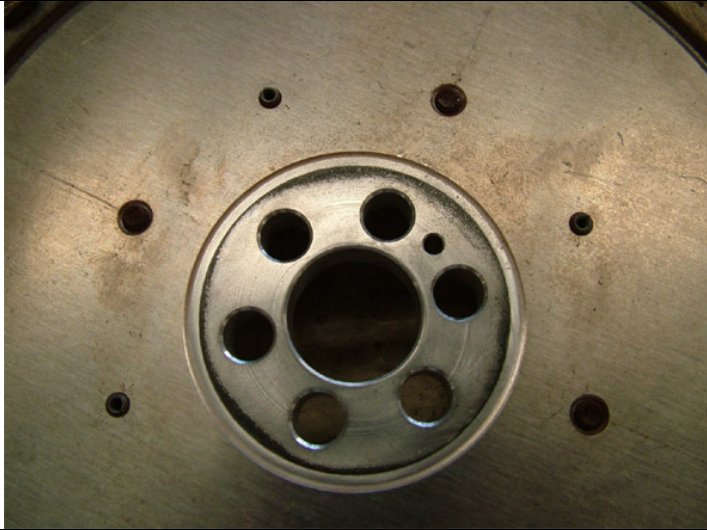
Engine number three was number 22A 1614 and had completed 116.7 hours.



The back side of the vacuum drive.



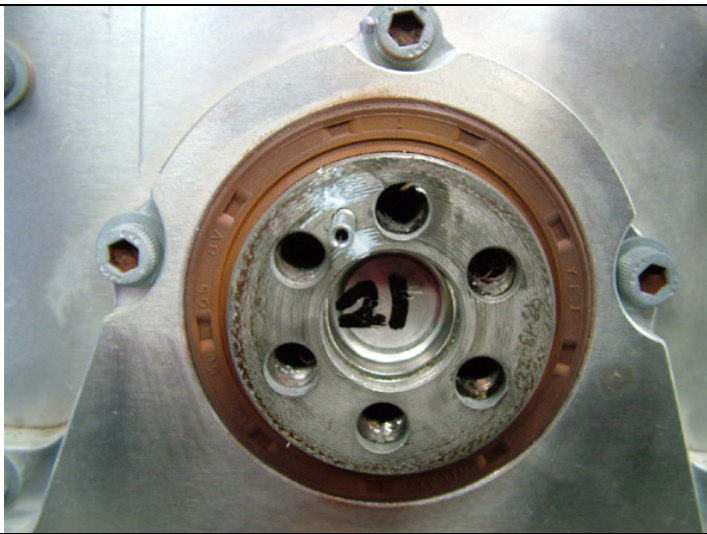
The vacuum drive which faces the flywheel.



The vacuum drive side of the flywheel.



The inside of the flywheel.



The timing gear face.

The three aircraft props.



The prop extension, same on all three aircraft.



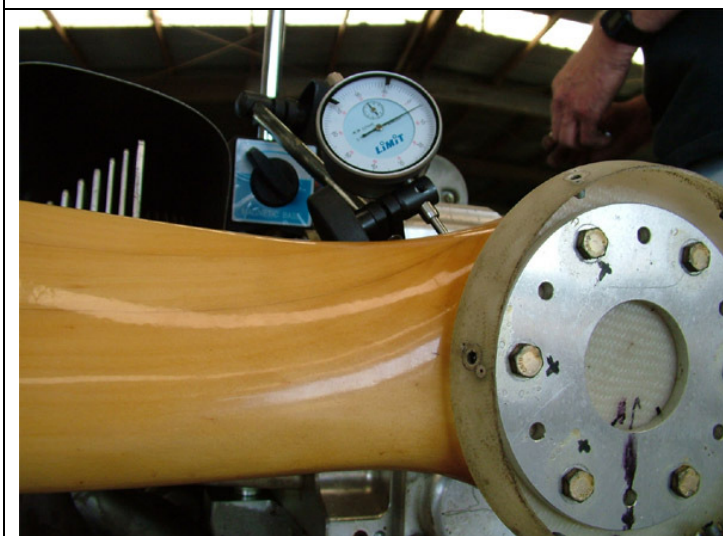
Aircraft one.



Aircraft two.



Aircraft three.



A dial gauge was used to check the prop flange run out.




Cap Screws.



Umbrako Cap Screw



SEP Cap Screw

	
<p>Brighton Best/YFS Cap Screw</p>	
<p>Washers</p>	
	
<p>Two types of hardened washer. (grade 8/10.9)</p>	<p>Washer on bolt for relative thickness.</p>

Crack off torque.

We used a simple bar and long needle type torque wrench to remove the bolts, this was used in order to gauge the tightness of the restraining compound versus the clamp pressure.

Engine 1 Required 12 to 15 foot pounds (ft/lb) to break the static friction (crack off) and then took about 10 ft/lb to undo out of the crank. Once the bolt disengaged from the crank it was easily removed from the three clamped components.

Engine 2 required 20 ft/lb to crack off and then 18 ft/lb to unscrew; it was easily removed once the threads had disengaged the crank.

Engine 3 required about 25 ft/lb to crack off and then 20 plus ft/lb to unscrew; it also removed easily once it had disengaged the crank.

Prop Flange Run Out and Tracking.

Engine 1, 0.06mm and 2mm respectively.

Engine 2, 0.06mm and 2mm respectively.

Engine 3, 0.2mm and 0mm respectively.

Summery.

Engine one clearly had less bolt torque than the other two engines, none the less engine two showed greater signs of fretting. Engine twos hours are similar to engine threes but engine three showed the least fretting.

The crack off test did not reveal the actual bolt preload but it would seem fair to conclude that engine 3 did in fact have the higher preload. Although engine one took less torque to undo the bolts it had more running time and less fretting than engine two but more than three.

It would also be fair to conclude that the higher the preload on the bolts the less the fretting.

We removed the flywheel and the vacuum drive but not the timing gear as this would have required engine removal and rear strip down. This will be reviewed in 50hrs.

New Hardware.

I had purchased new SEP brand (owned by Brighton Best) 2 inch 5/16 socket head cap screws (SHCS). I had also purchased new 5/16" grade 8 hardened washers. The intention was to replace the thin "Belleville" type washer to better spread the load over the aluminium flywheel. On inspection it was found that the head of the SAP SHCP was 1mm smaller in diameter than the removed Umbrako brand and the washer had 1mm clearance around the bolt shaft. This added up to very little bolt resting on the washer and it was felt prudent to just reuse the existing washer. Remember to install them the correct way round (high centre out).

I have since been back to Brighton Best and discovered that the YFS brand are the same dimensions as the Umbrako brand.

Why the difference? The Umbrako and Brighton Best YFS brands are made to the 1960 specification and SEP to an older specification; this is because a lot of machinery requires the smaller head cap screw, the material is none the less of a high standard.

DON'T USE SEP CAP SCREWS OR ANY OTHER WITH THE SMALL HEAD DIAMETER.

The Installation

After cleaning out the threads we decided to use "molly" grease in the threads and under the washer face of the SHCS, the higher preload attainable and the ability to re-torque the bolts made the decision easier. We first tightened the bolts to 20Nm (this was achieved from snug tight in about 15deg) and then attempted to take them to 40Nm. This was impossible for two reasons. Firstly the strength of the hex wrench was not up to it and they continually self destructed at about 31Nm, secondly I had calculated the turn of the nut to be about 50 degrees, we had gone way past that and it was evident that the aluminium parts were compressing under the strain.

With the grease in the thread and under the bolt head we were able to consistently torque the bolts to 30Nm so that's what we did.

Theory says that with Loctite in the thread and no lube under the bolt head 30Nm gives about 4600Lbs of axial force through the bolt and with lube 5800lbs, a significantly big margin. 41Nm has been achieved on other engines, with the correct load spreading it should be possible on these engines.

The Next Inspection

In 50 hours we are obliged to do the whole process again. We will use Umbrako or YFS (Brighton Best) branded bolts and will install hardened washers. The flywheel will be removed to see if the fretting has been minimised or stopped completely. If the fretting has returned it may be best if the engines get dowels fitted ASAP.

Problems in design.

The fact that one is trying to restrain aluminium alloy parts in a clutch like manner against steel parts with high strength fasteners is in its self a problem. The compressive strength of the aluminium is less than the steel. The load needs to be better spread or the aluminium replaced with steel. The "belleville" washers were designed as a variation on the spring washer, they simply crush flat under the high load of these fasteners and spread the load little. Hardened washers would help to spread the load further. A hardened steel ring under the heads could also help. Dowels one would think should help prevent this

fretting but it should be remembered that two of the restrained parts are aluminium alloy and could flog out around the dowels if exposed to excessive shear forces.

Currently the parts are fretting, and between 150 to 250 hours, no problems are seen, but as the fretting goes on the preload on the bolts drops off, a critical point is reached where the preload falls to a significantly low level allowing the fretting to rise exponentially. The bolts then become exposed to shear loads they were never designed for, they develop flaws which propagate through the bolt on the shear line, and then as the tensile stress area becomes too small to with stand the loads, they break one by one. Sometimes the load of starting will cause the final failure and sometimes they will break in the air. Neither is satisfactory.

Conclusion

If one replaces the bolts at 50hr intervals you will avert a disaster but one can not comment on the state of your parts as time goes on if you do not inspect them properly. S/B JSB012 instructs you not to remove the flywheel or vacuum drive as you will loose valve timing. It has been shown that it is very easy indeed to remove the flywheel and drive unit and check these surfaces. Newer engines even have a roll pin which appears to drive into the crank to ensure timing is not lost (don't spin the prop) and locates the flywheel on re-assembly. If you do not inspect these parts properly you can have no idea of problems ahead, if these parts are badly fretted then it would be advisable to pull the engine out, remove the back cover and check the timing gear. If you leave badly fretted parts in place with out resurfacing the time before failure will be greatly shortened.