SETTING UP HYDRAULIC CONSTANT SPEED PROPELLERS IN LAA AIRCRAFT

TL 3.23
ISSUE 1
24 July 14

This technical leaflet sets out a recommended approach to setting up hydraulic constant speed propellers based mainly on setting them up on Lycoming engine RVs but equally applicable to other types, and other engines, with appropriate alterations to the RPM figures to suit the RPM limits for the particular engine model in use. Other pilots testing LAA aircraft may have different methods of achieving the same aims.

ADJUSTMENTS

There are three separate adjustments that the owner/builder, LAA inspector and test pilot need to check/verify and adjust as required: the RPM control system, the governed RPM and the fine pitch stop. The RPM control system check is equivalent to the 'range of movement' checks on your flying controls. The governed RPM check is about setting up the 'high RPM' stop on the control lever of the governor, to ensure that in flight when the pilot's RPM control is fully forward the RPM that the engine/propeller stabilises at corresponds as closely as possible with the max permitted engine RPM. The fine pitch stop is a mechanical stop in the propeller hub, restricting the blades' fine pitch travel. The fine pitch stop only comes into play when the aircraft is static or moving forward at less than normal climb speed, to hold the blade pitch slightly coarser than the governor would otherwise move them to, when the prop control is set to high RPM. This is to hold the RPM down slightly on initial throttle opening so that as the aeroplane accelerates rapidly down the runway, the engine doesn't temporarily overspeed due to the blades not being able to coarsen up quickly enough to counteract the speeding-up tendency as the prop unloads.

RPM CONTROL SYSTEM

It may sound obvious but the control system consisting of the RPM control lever and its push-pull cable must be set up so that the control arm on the governor moves through an appropriate arc and the 'Max RPM' (Fine Pitch) governor stop position must be positively achievable, i.e. the governor operating arm must come up hard against the stop provided by the governed max RPM adjustment screw. In this position, it needs to be checked that the pilot's RPM lever is not against the quadrant stop and that the RPM Teleflex cable has not reached the limit of its travel. This ensures there is still some spare travel available in the system for adjustment, engine vibration/movement, settling in, etc.

On the other hand, at the other end of the range there is no obvious operational requirement for the 'minimum RPM' stop/limit to be able to be reached; indeed the Vans governor instructions make clear that this stop will not be achieved with the supplied parts. However there is the consideration that coarser blades on a windmilling engine can extend gliding range if the prop remains controllable, so even if not used in normal flying, there's some benefit in having the system able to move to, or close to the extreme of coarse pitch travel on the governor as well. This is not a feature that is evaluated during the flight test phase however (unlike the fine pitch end) but it does perhaps merit further investigation.

GOVERENED RPM

For a prop governor supplied for use on a Lycoming 320 or 360 series engine, typically, the governed RPM is set-up accurately at the factory so that when the control arm is on the limit of its travel at the high RPM end, the prop pitch adjusts itself to stabilise at the red line 2700 RPM in flight. This usually doesn't need further adjustment. The governed RPM could only be verified on the ground if the blade fine pitch stops were first backed off a long way so that they don't restrict the travel before the governor comes into effect. With a small highly powered aircraft like an RV, trying to test full-throttle RPMs during ground running is not a good idea because of the risk of jumping the chocks or over heating the engine. Instead, it is recommended that you ensure the test/check pilot is briefed that the governed RPM has not been verified yet, he can then check this on early flights and the stop on the governor pitch control lever adjusted if necessary. The engine should stabilise at 2700 RPM during a full power climb out and when 'flat out' in level flight. If you do find problems in this area though, before wading in and adjusting the governor it's as well to be sure you're not being misled by a calibration error on the tacho.

MAX STATIC RPM (FINE PITCH STOP)

The fine pitch stops are more difficult to verify due to the very transient period that they take effect, and are often overlooked. You are aiming to set the pitch stop so that with the aeroplane at the start of the take-off roll, the RPM is held a hundred RPM or so below the in-flight governed figure. This is to ensure that as the aeroplane accelerates at full power, the prop doesn't overspeed before the governor intervenes to coarsen the blades.

For a certified application, the fine pitch stop (FPS) will be correctly set at the factory for the specific engine power. However, given that most RV owners buy a propeller from Vans without the ability to specify the precise engine model, this invariably requires adjustment to achieve a static RPM of 2600-2650 RPM as specified in the manuals. With a half decent engine installation, exhaust, etc, it's not unusual for the propeller as supplied to yield a value nearer 2900 RPM!

Be sure you are clear what the RPM limitations are for the engine and propeller. Whilst there might be a broad limit of 2700 RPM, engine and propeller will have 'overspeed/overswing' tolerances. To avoid possible damage to the engine, ensure your test practices do not exceed these absolute red line or 'never exceed' values.

The propeller manual may give instructions on setting up the fine pitch stops, e.g. by temporarily backing off the governor control lever stop to a position that would allow an excessive stabilised RPM (i.e. >2700 RPM), and then doing full power ground runs on the engine and adjusting the fine pitch stop to get the desired max static, in much the same way that people do with small ground adjustable propellers on Rotaxes. It's not a good idea to have a chocked RV blaring away while tied down or with people on the tail – the power-to-weight ratio is too high, and the cooling inadequate for your brand new 'not yet run in' engine.

Instead, it's recommended not to interfere with the governor control lever stop and to check the initial RPM seen on the tacho during a quick burst of full power during an 'aborted takeoff' at the culmination of the taxi trials, immediately prior to first flight. With plenty of runway ahead, and prop control at max RPM, smartly apply full power. As the aeroplane accelerates to 30-40 kts there's enough time to observe and mentally note the immediate RPM achieved, and then a couple of seconds later, and just before throttling back, the stabilised RPM reducing after the governor takes effect. At the same time the pilot can get feedback on engine response, other engine indications, a feel for the steering and brakes and as often as not, one or two random EFIS warnings/alarms that the owner has (not) set up.

Of course this aborted take-off test needs to be carried out with the ability to take off if circumstances required it (throttle stuck, for example), with insurance in place, all checks complete, strapped in and the tower aware of what's going on. Particularly with a tailwheel equipped model, the pilot needs to be reasonably in practise with RVs to do this test in safety – but hopefully the LAA process will have ensured this anyway.

Having recorded the figures on your kneepad, provided both RPM values and everything else noted are acceptable, backtrack for the maiden flight itself. If the initial RPM seen in the taxi test was excessive (2800-2900), this time apply power gently, so as to give the governor time to do its job and hopefully keep the RPM to 2700 or below during the ground roll. If, when you glance at the tacho immediately after lift-off you see the RPM has stabilised at above 2700 then be ready to instantly tweak the RPM control back to manually bring it within the red line – we don't want to overspeed the engine or prop for more than the briefest time.

During the first flight, once established in the climb a proper accurate figure for the full throttle governed RPM will be recorded on the kneeboard. After the flight, make initial adjustments to static and/or governed RPM as required by altering the fine pitch stops or governor lever stop respectively. Apart from following the correct procedures (e.g. LAA Inspector, duplicate inspections, adjust iaw the manual), make sure you note exactly how many turns of adjustment are applied each time. The manuals tend to give a guide figure e.g. '1 turn produces 25 RPM change', but these are often inaccurate and you will find that you have to establish the sensitivity figure for this particular engine/prop combination yourself.

On subsequent flights, continue to record peak and governed RPM on take-off. An observer is useful to closely watch and record the initial and stabilised RPM values. It may take 3 or 4 adjustments to get them satisfactory, and avoid an excessive temporary overshoot into red line territory. Even if they are not absolutely 'spot on' by the time you finish the programme, the owner and inspector will by now be familiar with the adjustment process, and realise how easy it is so if further refinements are needed in service, for example as the engine 'runs in', hopefully they will be able to deal with this themselves.

BENEFITS?

With a correctly set up governor and fine pitch stop, pilot workload is reduced since the throttle can be advanced as fast as you like for a 'performance take off', allowing you the most power to be extracted from the engine throughout the take-off and climb, without worrying about overspeeding it. This is even more important with modern EFIS systems (often poorly set up) where even triggering 2710RPM for half a second will set off audio and visual signals more appropriate to a nuclear meltdown. This is distracting at best, and at worst, could mask other really important warnings and issues that might be developing.

As a secondary safety benefit, the slightly 'coarser' blade setting that this procedure usually gives you when the blades are on the fine pitch stops will make a surprisingly big improvement in your gliding range from a failed engine if the RPM lever is inadvertently left in the 'Max RPM' setting and/or if control of the pitch is lost due to loss of engine oil pressure.

There is also anecdotal evidence that a coarser fine pitch stop reduces/prevents RPM 'surging' that sometimes occurs, especially on power application during a touch and go landing or go around.

ELECTRIC C/S PROPS

In all areas except aerobatics this seemed remarkably easy to use and set up. Vans do not recommend such propellers for aerobatic use; however, the LAA may allow aerobatics with electric props subject to the test pilot's report. Correctly handled/set up, there is no more 'hazard' of overspeeding an electric C/S prop than a fixed pitch one; however, care is needed, as even a relatively gently wingover can give an acceleration rate that the propeller cannot keep up with in C/S mode.

HAZARDS

Almost all RVs with hydraulic C/S propellers are 'conventional' configuration, i.e. if oil pressure is lost the blades will move of their own volition to the fine pitch stop, which with any substantial engine power applied in combination with anything even approaching normal cruise speed will overspeed the engine and propeller. With no inverted oil system, this can cause problems when the oil pressure is lost for a second or so, even in a simple slow roll, half-cuban or stall turn. There are special 'aerobatic' (counter-weighted) versions of C/S propellers available - however, these bring undesirable cost, weight and hub size implications. These propellers are suited to the more extreme aerobatic/display routines beyond the scope of most RVs and their pilots.

As a result, with a conventional hydraulic C/S prop great care needs to be taken with any aerobatics potentially involving temporary zero or negative 'g' – for example while carrying out the LAA's aerobatic test schedule. It's a good idea to set 2400RPM prior to any such manoeuvres or sequences, which gives a bit of margin to play with, and not only keep an eye on oil pressure and RPM, but also "listen out" – the first indication of an issue is often the sound of the RPM rising, and a smart throttle reduction should limit this to only ~100RPM.

SUMMARY

It is important that the owner, inspector and test pilot are clear what needs to be tested and adjusted during the test phase, and what adjusts what. The static RPM is the most likely adjustment needed. With the popular Lycoming 320 or 360 series engines suitable 'target' values are:

1. Static RPM 2600-2650
2. Governed RPM 2670-2700

These may take 3 or 4 adjustments to achieve.

With thanks to Andy Hill for his original ideas and text.