ROTAX ENGINE CHECK OUT

LAA Chief Engineer, Francis Donaldson, passes on some important safety information for those with Rotax 9-series engines

Over the last two decades, if one family of engines has become 'ubiquitous', it's the 80hp, four-cylinder Rotax 912 and its more powerful siblings, the larger capacity, higher compression 912-ULS, the turbocharged 914 and the latest in the range, the fuel-injected 912-iS.

Its competition has chiefly come from relative newcomers Jabiru and UL-Power but one or other of the Austrian-built Rotax engines is used in the lion's share of newly finished LAA microlights and smaller, kit-built 'group A' aircraft, as well as every one of the UK's fleet of factory-built gyroplanes. We've even seen one or two Rotax engine used as replacement powerplants for vintage aircraft, such as the Piper Vagabond, and Pietenpol Aircamper and Jodel DR1050, and they've provided a very effective alternative to the small Continental. The Rotax's integral reduction gearbox allows them to swing a suitably sized propeller despite the powerplant's relatively much smaller cubic capacity than the original, slow-turning, direct-drive motors.

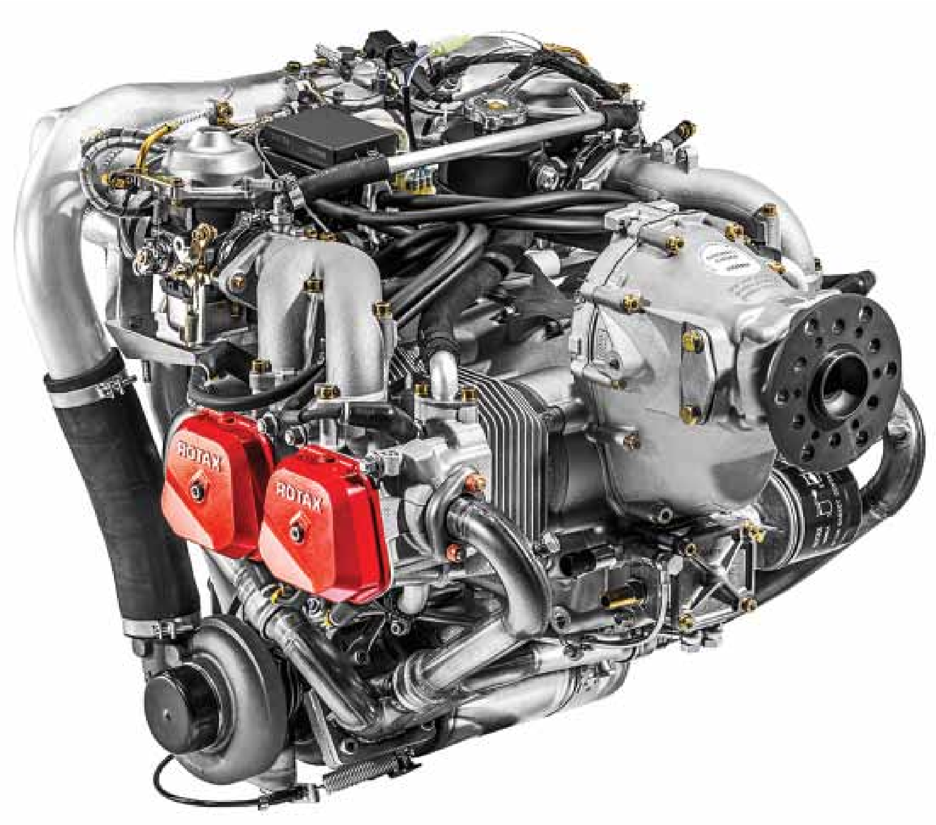
In general, over the years these partly air-cooled, part liquid-cooled four-stroke engines have gained themselves an enviable record for reliability, and where failures have occurred they've usually been attributable to the associated systems (fuel, air, exhaust, cooling) rather than problems with the powerplant's core.

Overall, unlike the preceding range of two-stroke aircraft engines, for practical purposes, it's fair to say that the reliability of the Rotax four-stroke range is perceived as being on a par with that of small Lycomings and Continentals.

Indeed, Rotax do make certified versions of these motors, and I've seen them coming off exactly the same production line as the uncertified models at the Austrian factory, with differentiation only being made at the final assembly stage, where there are some very minor physical upgrades to the engines which are destined for use on certified aircraft (screw-on fuel pipe fittings rather than swaged on, for example) and for the select few, the production records are compiled to create the certified 'paper trail'.

Nevertheless, particularly with the more sophisticated models, over time we've seen some recurring safety issues which have suggested that pilots didn't grasp one or two of the operational features of these engines, and perhaps haven't had a proper briefing or boned up on the operating manuals.

This article shouldn't be taken as an alternative to these important steps but rather as our means of spreading the word about some of the hard lessons learnt, and we hope that it will serve to help avoid some very regrettable incidents and accidents being unnecessarily repeated.



(Above) **Rotax engines, particularly the 914 turbocharged unit, require different installation and operational requirements to conventional, large-capacity, direct-drive aero powerplants.**

THE ROTAX 912-UL AND 912-ULS PRE-FLIGHT CHECK

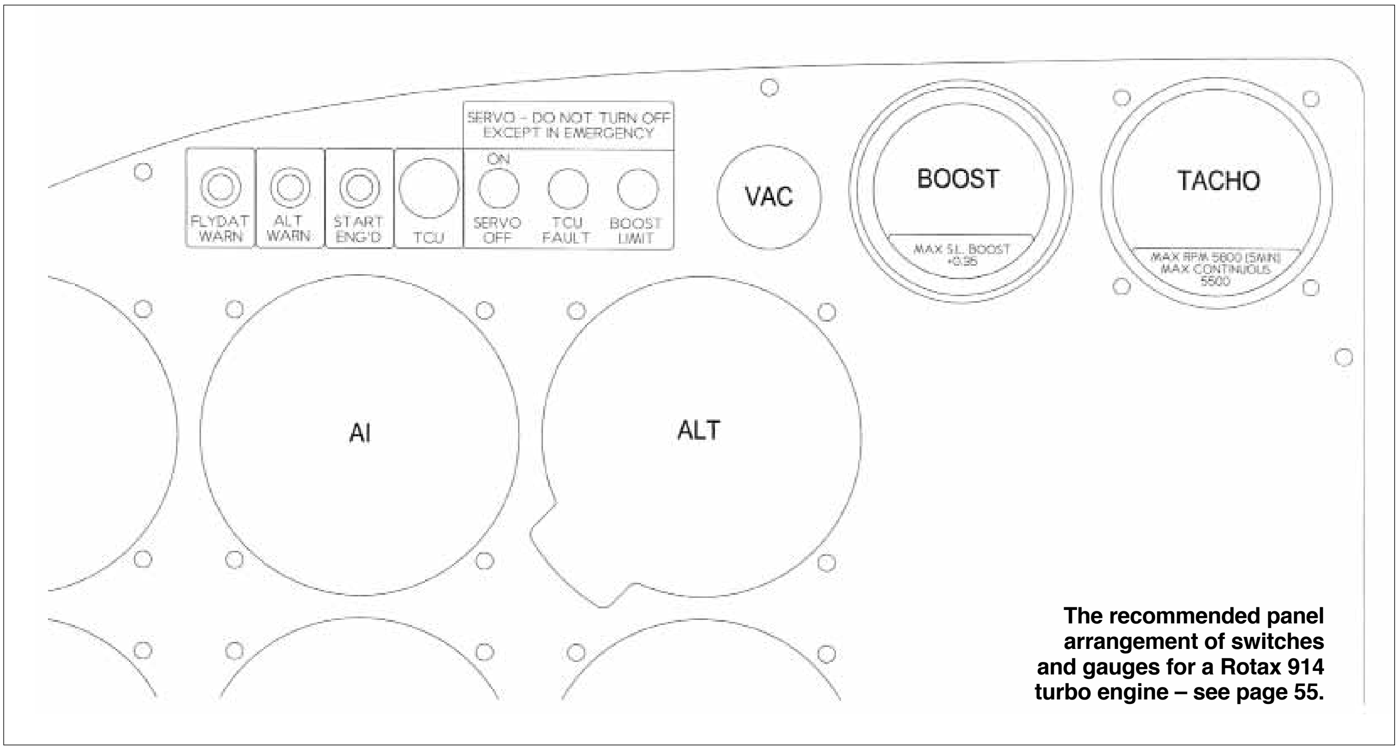
Pilots pre-flighting a Rotax-powered aircraft for the first time may look somewhat askance at the amount of flexible pipework which surrounds the engine, when compared with a typical air-cooled unit, so a good look around for signs of leaks, chafing, cracks, loose fittings, etc, is all the more important.

There are coolant pipes linking the engine to the coolant radiator and coolant collector tank, oil pipes to the oil cooler and remote oil tank, with both coolant and oil systems potentially having thermostats plumbed in to aid rapid warm-up. Separate fuel pipes feed the twin Bing carburettors from the engine-driven pump, and there's a fuel vapour return line, to allow surplus fuel and fuel vapour to recirculate back to the fuel tank.

If you've got more than one fuel tank, be sure you know which fuel tank the return line routes back to, as this will affect the behaviour of the fuel levels in flight. If you take off with full tanks and the vapour return line feeds back to the starboard tank, for example, be sure to select starboard tank (or 'both') for the first part of the flight, otherwise the return fuel flow will cause the starboard tank to overflow and be lost overboard from the right tank's vent. Some of the more sophisticated aircraft include a duplex fuel selector valve (effectively, two valves mechanically ganged together) to automatically put the return fuel flow back into the same tank that the engine is feeding from.

THE DRY SUMP OIL SYSTEM

Unlike the majority of popular air-cooled light aircraft engines, the Rotax 9 series uses a dry sump oil system, but lacks an oil scavenge pump. Instead, these engines rely on 'leak' down' gas pressure from the cylinders, to force the oil that collects in the sump to flow back to the remote oil tank.



The recommended panel arrangement of switches and gauges for a Rotax 914 turbo engine – see page 55.

The oil dip stick is in the oil tank, not the sump, and it's important to understand that it's calibrated for the running mode when there's hardly any oil in the engine's sump. During a pre-flight check, with the engine static, the dipstick will tend to under-read because some of the oil will have collected in the sump.

To get around this, the required practice is to 'burp' the engine by turning the prop manually to the nearest 'top dead centre' and waiting for a moment or two for the engine to emit an audible gurgle, signifying that the leak-down air pressure has done its job and the last of the oil in the sump has transferred to the tank, so it's safe to do your oil dipstick check. Failing to 'burp' the engine could lead to you unnecessarily topping-up the oil tank and over-filling it.

ENGINE START

From the very first twist of the key, or prod of the starter button, the combination of a high compression ratio and the reduction gearbox which links the engine and the propeller gives the Rotax a seemingly abrupt and even violent start-up and shut-down characteristic that takes some getting used to.

The engine both starts and stops with a significant 'thump', especially the high-compression 912-ULS model, in some cases so viciously that over time it may crack the engine mount on the airframe. Later examples are fitted with a 'soft-start' feature, which takes some of the kick out of the start-up by keeping the ignition in its retarded state until the engine is spinning fast enough to deal with the advance without distress.

THROTTLE SPRINGS

Particularly while taxying, pilots need to be aware of the strong springs fitted to the throttle arms on the Rotax's Bing carburettors, which tend to spring the throttle to the 'high power' direction. These springs are fitted to allow the use of a lightweight throttle control cable system only capable of transmitting pulling forces, rather than a heavier push-pull system. The Bing arrangement relies on the cables to pull the throttle butterflies closed and the springs to pull them to the open position. They're also intended to ensure that, if the throttle cable breaks or comes adrift, the system failure mode is to move towards the direction which keeps the engine running and the aeroplane in the air, rather than shutting the powerplant down and causing a forced landing.

Of course, with the throttle stuck open you'd still have a pretty challenging landing ahead of you, shutting the engine down in flight on the magneto switches, but at least you could decide the time and place, and given a half-decent-sized airfield, have a good chance of getting down without damage.

Failure modes apart, how these springs make themselves felt in normal operation is that pilots finds themselves having to be particularly careful that the throttle doesn't open by itself, especially if there's no satisfactory adjustable friction arrangement. The consequences are particularly serious on the ground, where the aeroplane moving forward unexpectedly can be hazardous to other aircraft and bystanders, especially when the engine first bursts into life.

Even after years of exposure, this caught me out once upon landing a Pioneer when, having touched down a little deeper into the farm strip than I planned, I took my hand off the throttle to apply the hand-operated wheel brake, only to find myself unexpectedly airborne again as he released throttle opened itself. The second touch-down was even deeper into the field – had it been a tighter strip, the errant throttle would have forced a go-around.

PROPELLER CONSIDERATIONS

Pilots converting onto the 9 series, whose previous experience has been with direct-drive, four-strokes from the likes of Lycoming, Continental, Gipsy, and even VW, have had to get used to the much higher rpm of the Rotax, which all have a maximum of 5,800rpm and max continuous rating of 5,500rpm, creating a very different sound signature.

With variable-pitch props, preconceptions about 'rule-of-thumb' combinations of rpm and manifold pressure go out of the window. Rotax claims that the 912-UL and 912-ULS are so resistant to detonation that they're happy to run all day at full throttle, with a propeller which holds the engine rpm down to well below the 5,500rpm 'max continuous' setting. The manufacturer also claims that, with a variable-pitch or constant-speed propeller, the engine won't be damaged by high manifold pressure / low rpm scenarios – after all, many Rotax engines run ground-adjustable and fixed-pitch props which hold the max static rpm to not much more than 4,200, so perhaps there's truth in what the company says. But given the capabilities of the constant-speed prop, it still seems more sympathetic to the engine to avoid this type of 'holding on to top gear while climbing the hill' situation – much kinder on the crankcase and crankshaft.

One of the great advantages of the Rotax 9 series engines is that the 'upwards offset' reduction gearbox raises the propeller thrust line, to give the maximum possible propeller diameter without running into ground-clearance problems. The gearbox configuration also allows variable-pitch and constant-speed propellers to be fitted which can be mechanically operated via a push-pull rod passing through the hollow propeller shaft, using a simple swivel arrangement to accommodate the propeller rotation.

There are a plethora of VP props available, with different types of operating systems, the pitch-change rod being actuated by an electric servo, an hydraulic slave cylinder or even a simple rack-and-pinion activated by a multi-turn hand crank in the cockpit via a rotary cable. Others are operated by an electric motor and reduction gearbox mounted on the front of the prop hub, enclosed by the spinner, with the electrical connections to the motor being via slip rings and brushes mounted to the rear of the prop. It's important that pilots are aware of the type of system fitted and appreciate the limitations of the installation – slip rings and carbon brushes don't always take kindly to operating when wet, for example, so rapid brush wear may occur if flying through rain with this kind of system, leading to an intermittent connection.

The pitch-change systems on non-certified VP props haven't usually been › shown to meet any particular reliability criteria, so LAA practice is to limit the range of pitch travel available (preferably using mechanical stops, rather than just electrical microswitches) so that should the propeller pitch change system jam anywhere within the achievable range, it'll neither be too coarse or too fine, which allows the aeroplane to continue to fly, including the ability to climb at a viable rate with the prop stuck in either extreme pitch position.

Providing that the propeller stops have been properly set up to achieve this, failure of the pitch change system while at altitude needn't mean a forced landing, but a failure during the take-off run, or at low-altitude, may put you in a difficult position and this is something to bear in mind if making a take-off from a strip which calls upon the full thrust capability to get over obstacles. Of course, with any type of variable-pitch or constant-speed prop, a manifold pressure gauge needs to be fitted as, along with the rpm gauge, it's an essential aid to monitoring engine operation.

(Right) **The exhaust side of the Rotax 914 turbo. You can see the exhaust turbine, the circular wastegate 'flap' and the wastegate operating lever below it.**

OPERATING THE TURBO ENGINE

Back in the early nineties, even before coming up with the 912-ULS version, Rotax added a turbocharger to the 912, to produce the then top-of-the-range 914 variant.

Pilots transitioning to the 914 engine will normally need appropriate Differences Training, to satisfy the legal requirements of their Pilot's License. However, it should be noted that the arrangements for controlling the turbocharger on the 914 are unlike those on other turbo-equipped light aircraft engines, so even pilots who are previously experienced with the latter need to take the time to acquaint themselves with the features of the 914 before taking flight.

The nominal normal maximum engine power of the 914 is 100hp and boost pressure is regulated by a servomotor-actuated wastegate that's controlled by an electronic Turbo Control Unit (TCU). The TCU limits boost pressure to allow 115 per cent nominal power, to produce 115hp. Operation of the engine at this 'take-off' condition of 115 per cent nominal power is limited to five minutes, to ensure against exceeding the mechanical and thermal stress limits of the engine and turbocharger.

The primary parameter that controls the wastegate position, and hence boost, is throttle position. Fig 1 shows the nominal airbox target pressure, plotted against throttle position. Data from sensors measuring engine speed, airbox pressure and airbox temperature is also fed into the TCU, which controls the wastegate, to give the correct boost – for example, closing the wastegate as altitude increases, or opening it and backing off the boost if the airbox temperature gets too high.

The throttle on the 914 is used as normal between idle and 100 per cent throttle position. However, because the boost pressure rises rapidly between 108-110 per cent throttle, to avoid unstable boost, Rotax recommends that this range is avoided, and the throttle should be treated almost like a switch and advanced directly (but smoothly) straight from the 100 per cent to the 115 per cent position.

THE ROTAX 914-UL – WHAT IS A TURBOCHARGED ENGINE?

Andy Draper explains the principles & practicalities…

A NORMALLY aspirated engine (ie one that sucks the air it needs from the atmosphere) is fed with an air/fuel mixture that's burned in the cylinders to produce its power. The power produced depends on the amount of air that can be drawn into the engine. Correspondingly, the higher an aircraft flies, the less dense the air, hence less air is drawn into the engine and the less power it's able to produce.

For example, at around 8,500ft, a normally aspirated engine is only able to produce about 75 per cent of its maximum sea-level-rated power. Additionally, if a normally aspirated engine doesn't have mixture compensation, the air/fuel ratio will richen at altitude, causing power loss and rough running. An ability to compress the inlet air would enable more power to be produced at low-altitude and full-power to be maintained at much higher altitude. And provided that the carburetion system maintains the optimum air/fuel ratio, the engine would run smoothly at altitude. Enter the turbocharger…

A turbocharger consists of a turbine and a compressor, mounted on a common shaft. The fast-moving exhaust gases from the engine exhaust manifold are fed past the turbine, causing the turbine wheel to rotate at high speed. This rotation drives the compressor, compressing ambient air and delivering it to the air intake of the engine – because the air is compressed, this allows more air to enter the cylinders.

This means that an engine can produce greater power at sea-level and also maintain this power as the aircraft climbs to altitude, and so better benefit from the higher true airspeeds which can be achieved when cruising in the less dense upper air.

In principle, the faster the engine runs the faster the exhaust gases are and so therefore the faster the turbine and compressor spins, so the higher the inlet air pressure or boost pressure.

Because the strength of the engine's components and its ability to dissipate heat limit the amount of power it can safely generate, the turbocharger must be limited in the amount of boost pressure it can provide. However, for the turbocharger to be able to provide adequate boost pressure at altitude, in an aircraft engine it must be sized so it's capable of producing more than a safe boost pressure at sea-level. To protect against engine or turbocharger damage, an automatic system to reduce boost is necessary, to prevent inadvertent over-boosting. This system is called a wastegate.

A wastegate is effectively a valve which, when open, diverts exhaust gases away from the turbine wheel, thus causing the turbine to lose speed, and that in turn reduces the rotating speed of the compressor. The wastegate is opened and closed by an actuator, which is controlled by various engine parameters.

Apart from allowing an engine to generate more power and to maintain this power at high-altitude, the turbocharger has the secondary benefits of eliminating carburettor ice problems – the intake air is heated by the act of compression – and also of reducing exhaust noise, as some of the exhaust energy is extracted by the turbocharger.

On the downside, the turbocharger body gets very hot and acts as a significant heat source under the cowlings, which can cause cooling issues as well as local scorching, etc. Also, the beneficial effect of compressing the intake air in the compressor is slightly reduced by the effect on the density of the induction air, due to the temperature rise which occurs as it's compressed.

To counteract this, and get the full benefit of a turbocharger, an intercooler is sometimes fitted – between the turbocharger and the carburettor – to cool the compressed induction air.

With carburettor-equipped turbocharged engines, an additional complication is the need to supply fuel to the carburettor inlet at the correct elevated pressure, otherwise the raised pressure of the induction air would prevent the fuel being drawn from the jets.

To ensure that the correct mixture strength can be achieved across the power range, a higher-pressure fuel pump must be fitted and a fuel pressure regulator has to be included, between the fuel pump and the carburettor, to moderate the fuel pressure in response to changes in the carburettor inlet air pressure, usually using a diaphragm-controlled valve arrangement.

Similarly, when retarding the throttle, it should be done so briskly down to the 100 per cent position or less. In order help pilots know where the throttle is in the range, to avoid inadvertently exceeding the five-minute limit and to achieve this 'step' action, Rotax recommends that the throttle have a detent or 'gate' which clearly indicates the 100 per cent position.

The maximum airbox pressure is controlled to about 40in HG (1,370 hPa), sea level pressure is normally about 30in HG, and the turbocharger is capable of producing sufficient boost to maintain maximum continuous power output up to about 16,000ft. At that altitude, the wastegate will be fully closed at full throttle, and exceeding maximum boost is no longer possible. Climbing higher will see the available power output gradually reduce, as for a normally aspirated engine, ie one without a turbo or supercharger.

The servo which controls the wastegate on the 914 is a separate item from the engine, being mounted in a convenient place in the forward fuselage or engine bay, and operating the wastegate lever via a length of stranded steel cable, one end of which is connected to the wastegate arm and the other wrapped around a rotating drum on the servo.

The proper operation of this servo and the cable connection to the wastegate is vital, not only to achieving the expected power from the engine as directed by the pilot but, even more importantly, to prevent the engine self-destructing through over-boost. If the engine is inadvertently run up to full throttle at sea level, without opening the wastegate, the resulting over-boost would make the engine produce about twice its rated horsepower – but costly experience has shown that this lasts for a very few seconds because the resulting enormous engine torque is enough to literally twist the multi-piece pressed-together crankshaft of the 914, putting the throws and journals out of proper alignment and seizing the engine.

It's important for 914 pilots to realise that, with the engine shut down, the system normally rests with the wastegate in the potentially disastrous closed position – *Fig 1* shows that, at idle throttle settings, the control system makes a step change in its output, seeking a high airbox pressure which, in effect, closes the wastegate. It's been suggested that this is to try to keep the turbo spinning under these circumstances, despite the low exhaust airflow rate, so the turbo (and hence the engine) can accelerate more rapidly on demand, reducing so-called 'turbo lag'. Pilots must realise that if the TCU doesn't do its job and the servo doesn't open the wastegate after start-up, the engine WILL wreck itself as soon as they open the throttle to a point anywhere approaching the fully open position.

COCKPIT WARNING LAMPS

To guard against this possibility, after electrical power is applied to the TCU it conducts a 'self-check' and cycles the servo once throughout its range, causing two cockpit warning lamps to illuminate for a second or two, then extinguish. If either of the warning lamps remains illuminated or flashing after the check, a fault is indicated, which must be rectified before flight.

Some installations fit the servo in a location where it's visible to the pilot so proper operation can be observed during this self-check routine, but few pilots enjoy this luxury. Normally, it's necessary to take the cowls off or peer through access panels during the pre-flight check, to see the servo do its stuff.

WASTEGATE LEVER CHECK

During the pre-flight check, the free movement of the wastegate lever on the underside of the turbo must also be checked, because again – and it bears repeating – *IF THE WASTEGATE SHOULD STICK IN THE CLOSED POSITION FOR ANY REASON, THE PERMITTED BOOST PRESSURE CAN BE EXCEEDED AND THE ENGINE WILL MOST LIKELY BE WRECKED.*

Because the 'self-check' only takes a few seconds, the correct movement of the wastegate lever can easily be checked as part of the daily inspection. With the master switch on, but the engine stopped, open and close the throttle slowly, preferably with the help of a second pair of eyes, to check that the wastegate lever moves smoothly through its full range.

WARNING LAMP SITUATIONS

- With the engine operating, the red cockpit warning lamp will flash when the five-minute limit of running at more than 100 per cent throttle has been reached, after which the pilot must retard the throttle to less than 100 per cent throttle. This action will reset the timer to zero, but reapplication of more than 100 per cent power within the next five minutes is likely to cause damage to the engine and/or turbocharger.
- The same red warning lamp will illuminate continuously if maximum boost pressure has been exceeded.
- In the event of TCU or sensor failure, an amber warning lamp will flash – unless the failure is due to no electrical power getting to the TCU.

The warning lamps associated with the TCU are intended as alerting devices, but they aren't meant to be a substitute for a functioning manifold pressure gauge, which is essential to proper operation of the 914, regardless of whether a fixed- or variable -pitch propeller is fitted.

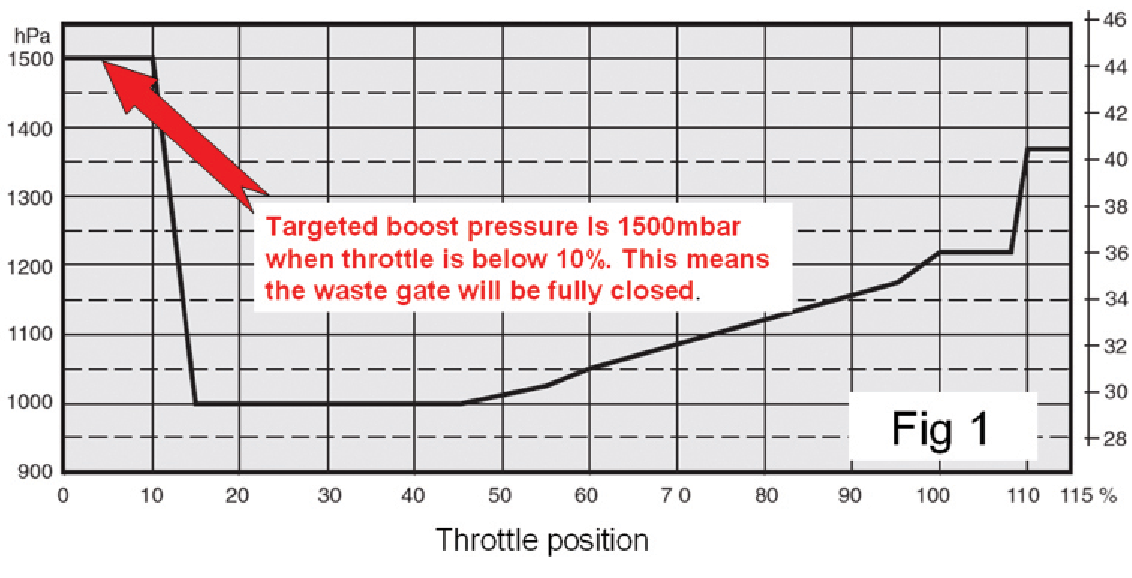
SERVO ISOLATE SWITCH

It should be clear from the above that it's normally absolutely essential that, whenever the engine is running, the wastegate control servo is fully functional, to avoid a risk of disastrous over-boost.

Despite this, controversially, Rotax recommends fitting a panel-mounted switch which allows the pilot to interrupt the electrical power to the wastegate servo. The reason for this is, in some installations, the servo / TCU combination has sometimes gone into a 'surge' or so-called 'bootstrap' condition during flight, an unstable condition causing un-commanded pulsing in engine manifold pressure and engine power.

Under these circumstances, flicking the servo isolate switch off *for less than five seconds* while well throttled back, and then switching it on again, should break the cycle – after a short regulating time, engine operation should stabilise. If the engine still doesn't stabilise, the servo should be switched off for the remainder of the flight, but in this case, it'll be essential for the pilot to observe the manifold pressure gauge and TCU warning lights, and restrict the throttle position as required, to keep the manifold pressure within limits. If at the moment the servo is switched off, the wastegate is in the open position, the engine will appear to operate normally, although depending on the altitude, full-power may not be available.

On the other hand, if the wastegate should 'freeze' in the fully closed position, the throttle will feel unusually sensitive and punchy, and normal max power may be



(Left) **Fig 1**

reached in less than half the usual throttle travel. Go above the half-way mark and the engine is likely to self-destruct, especially if a constant-speed prop is fitted, which will prevent an unusually high rpm alerting you to what's going on. Of course, if your manifold pressure is displayed on an EFIS, a warning indication triggered by the abnormally high MP may save the day.

Other things that might cause the wastegate to stick in the closed position include a broken servo cable, an internal failure of the TCU or, as mentioned previously, the wastegate itself having seized. Inadvertent shorting of TCU wiring-to-ground (eg due to chafed insulation) has also been shown to be able to cause the servo motor to run to the end of its travel, corresponding to a fully closed wastegate.

Just to be clear about it, the servo isolate switch must be in the ON position at all times during normal operations, ie the servo must be active. Perhaps confused by misleading labelling of the servo isolate switch, some unfortunate pilots have mistakenly assumed that they don't need the turbo for a simple ground run and, therefore, the 'turbo switch' (sic) can be left off. As we've seen above, with the switch in the off position, the servo won't respond to TCU input and will therefore not protect against over-boost.

Consequently, it's important that this switch be guarded against inadvertent operation and properly labelled. One of those double-action switches where you have to pull the toggle out before you can move it from one position to the other is ideal. Also, it shouldn't be grouped with other less important switches that the pilot might be inclined to ignore, assuming they were all obscure in purpose or to do with non-essential services. Choosing an unambiguous label for the switch may also help – perhaps 'servo over-boost protection, on/off' would convey the function more clearly.

Some 914-powered aircraft have been built without the servo isolate switch fitted, on the basis that, in the very unlikely event of surging problems being experienced, the servo can instead be taken offline by pulling the circuit breaker on the power feed to the TCU. The problem with this is that with the power to the TCU switched off, none of the TCU warning lights function, so the pilot won't have the benefit of the red flashing light to help warn him of having opened the throttle to the point of over-boost.

The AAIB report into a fatal accident with one 914-powered aircraft suggested that this practice may have contributed to the engine having failed in-flight – the crankshaft which was analysed at Farnborough showed the characteristic twist of a drastically over-boosted 914.

INTAKE TEMPERATURE

The temperature of the intake air is increased as it passes through the turbocharger, partly by taking heat from the hot turbocharger body but also due to the compressing of the intake air, as per Boyle's Law. At a critical fuel/air mixture temperature, detonation can occur in the combustion chambers which could damage the engine.

In the 914, to prevent this happening, the TCU will command the wastegate to open if the air in the airbox reaches a pre-determined temperature – between 72°C and 88°C, depending on engine variant. When this happens, there will be no warning lamp, you'll simply notice that advancing the throttle through the 'gate' won't result in increased manifold pressure. The resulting power loss might be an embarrassment if operating in the 'hot and high' scenarios common in Arizona and suchlike, or even if flying a fully loaded four-seater on the hottest days in the UK.

FUEL PUMP ISSUES

Unlike the 912 and 912-ULS, the 914 has no provision for a mechanical fuel pump, instead it relies on an electric fuel pump. Therefore, 914 is doubly electrically dependent, insofar that as it relies on electrical power from the aircraft's bus to not only control the turbocharger wastegate via the TCU, but also to supply fuel to the engine via the electric fuel pump. Switch off the electrical power to the 914's fuel pump and the engine will stop – instantly.

As a safeguard, the 914 is normally installed with duplicated electric pumps so that if one fails the other can be brought into play, to keep the engine running.

As with all duplicated systems, it's important that the wiring to the two pumps doesn't route through a common connector, and that the pumps are individually earthed, to prevent a single component failure potentially taking both of them offline. Some designers supply the pumps from different busses for the same reason. Pilots should be aware of how the pumps are wired so as to help them react appropriately in the event of an electrical system failure. For example, knowing whether switching off the master switch during flight, in response to 'hot wire smells' in the cockpit, would result in an engine shutdown.

If it's possible to stop the engine by switching off both the fuel pumps, again, it's a good idea not to include the fuel pump switches among groups of less important switches so, for example, there's less risk of stopping the engine when you try to flick the strobes off. If you can't switch off both electric fuel pumps without switching off the master switch, remember that this should be part of the essential mental checklist actions prior to a forced landing or uncontrolled arrival – you don't want a still-live electric fuel pump squirting fuel out of ruptured fuel lines among the wreckage.

On the subject of the fuel system, it's important that the fuel pressure gauge on the 914 is a differential pressure gauge, one arranged to display the difference in pressure between the carburettor fuel inlet pressure and the static pressure in the airbox rather than, as is usual, the difference between the fuel inlet pressure and ambient pressure, otherwise the displayed figure is of little value.

LAA TECHNICAL LEAFLET TL3.26, ELECTRICAL SYSTEMS

Space has defeated me this month so a follow-up article will discuss operator issues relating to the fuel injected 912-iS – a very interesting engine which brings the 9 series up to date with the benefits of fully mapped ECU to control fuel injection and ignition.

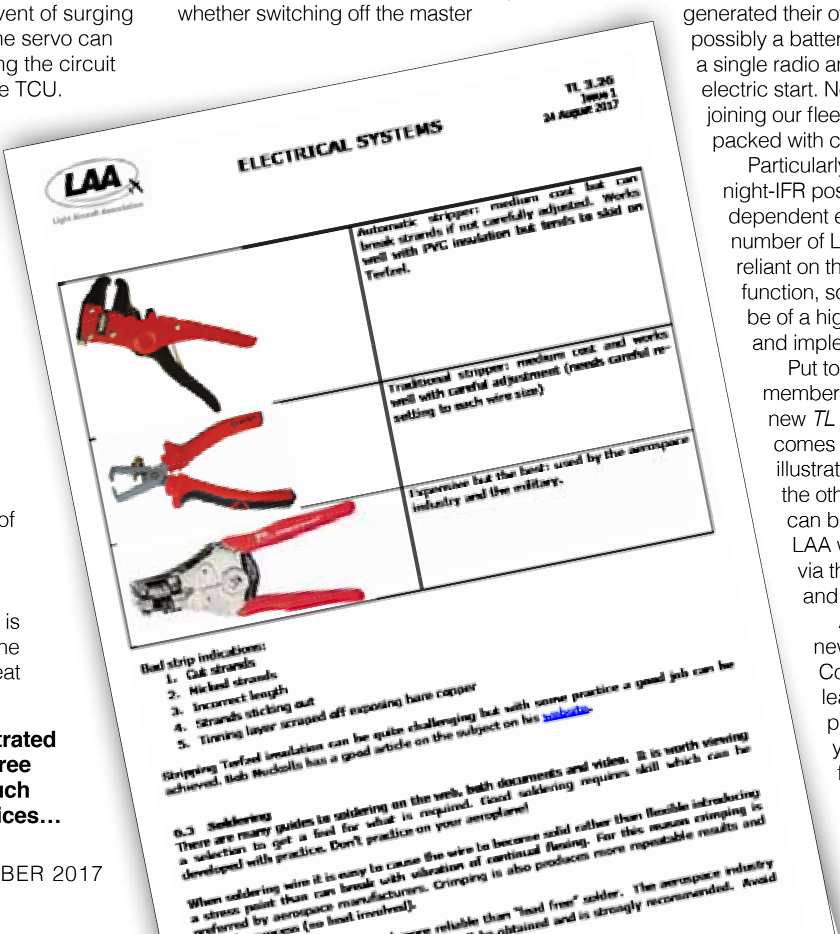
However, before signing off for the month, the above reference to 'electrically dependent engines' reminds me make mention of the new *LAA Technical Leaflet, TL3.26, Electrical Systems*, issued in August this year, which gives guidance on the design and installation of electrical systems in LAA aircraft.

It wasn't too many years ago that the majority of LAA aircraft had hardly any electrics – perhaps just a pair of magnetos which generated their own power internally, possibly a battery and alternator to operate a single radio and, for the really advanced, electric start. Nowadays, most aircraft joining our fleet are, in comparison, packed with complex electrical kit.

Particularly with the advent of night-IFR possibilities and electrically dependent engines, an increasing number of LAA machines are totally reliant on their electrics continuing to function, so the installations need to be of a high standard both of design and implementation.

Put together largely by LAA members on a voluntary basis, the new *TL* makes a very good read, comes in a new and attractive, illustrated format and, as with all the other *Technical Leaflets*, can be downloaded off the LAA website (*www.laa.uk.com*) via the 'Aircraft and Technical' and 'Data Library' tabs.

Also look out to for a new LAA Electrical Wiring Course, where you can learn the 'hands-on' skills of producing or maintaining your own wiring loom. The first course is scheduled to take place at Turweston on 2 December. ■



(Right) **The new-format, illustrated *LAA Technical Leaflets* are free to download and contain much practical info, even tool choices…**