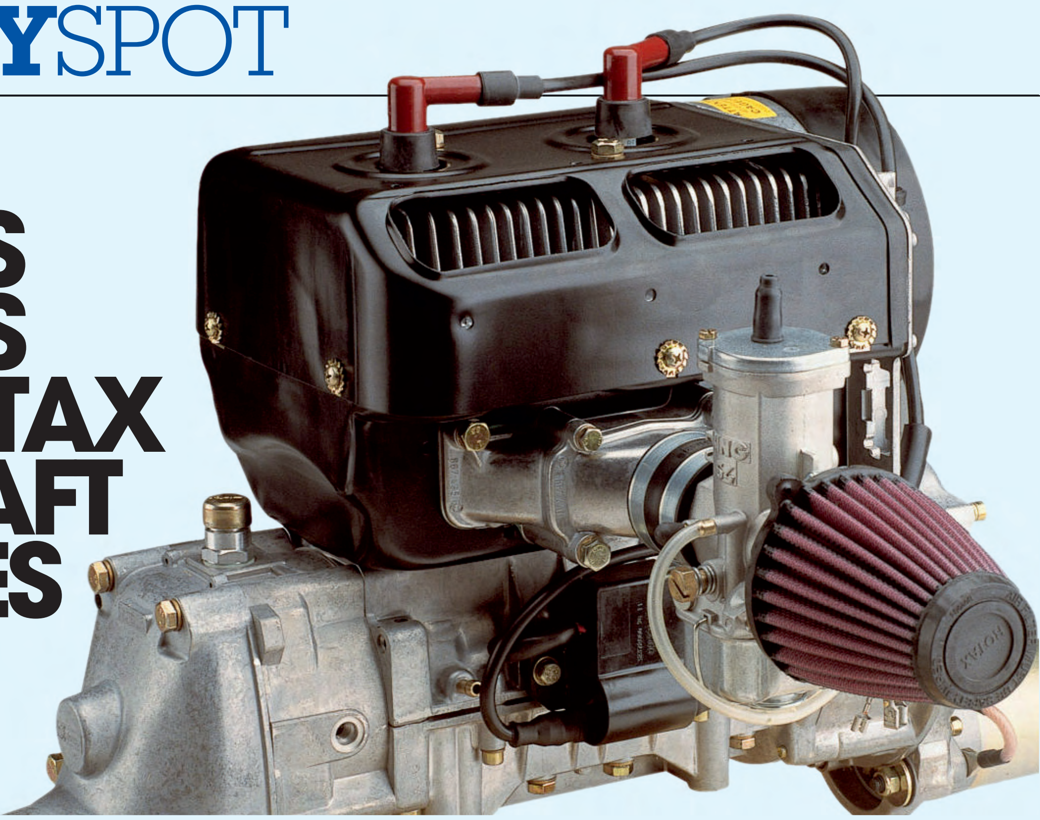
SAFETYSPOT

AVGAS AND ITS EFFECTS ON ROTAX AIRCRAFT ENGINES



Contamination affects different areas of this versatile engine

HERE we are again, the time when I push the curtains aside and allow you, dear member, a brief glimpse into Malc's world. It's a busy place, and there is always lots going on.

I say this because I'm a bit frazzled by efforts at the recent Aero Expo and somewhat daunted by the rather large catching-up period that always seems to be required after such an event. There's a pile of Permit applications big enough to make an igloo... perhaps I could construct one in my lunch hour and escape all this.

Last month's Safety Spot caused a bit of a stir and a few of you wrote and called to let me know that I didn't know what I was talking about when it comes to vapour pressure and Rotax slipper clutches, very different things I'm sure you would agree, but joined by my discussion about Mogas v Avgas.

I read my article again and I agree that bits of it were a somewhat difficult to follow; the slipper clutch photo only showed the top of the assembly and was therefore a bit misleading.

Let me say this about the (very gentle) criticism(s) laid at my door. I do tend to assume a fair amount of knowledge viz matters physical, I do this because I know that readers are not members of the general public... amongst whom the idea that it is important to understand the workings behind well, almost anything, is an anathema. Readers are members of the Light Aircraft Association, to whom the joys and challenges of getting airborne are continually under deliberation!

'When Skydrive says Rotax engines don't like avgas, we'd be foolish not to listen'

That said, if there's something 'not quite right' or needs a 'bit of expanding', then please feel free to give me a nudge about it. So, what about slipper clutches?

Those of us who have had the privilege of watching the development of Rotax engines' involvement in various airsports could not fail to be fans of these versatile mechanical devices. It is my opinion that, regardless of the hype from various airframe manufacturers, engine availability leads the way in aircraft design.

When microlight/minimum aircraft first started appearing on our shores there were many, mostly two-stroke, engine types fitted. Within the UK microlight market a clear leader emerged, and no, it wasn't a Rotax. The engine of choice at this time was a Japanese engine, or rather series of engines, made by Fuji Heavy Industries. These engines were marketed originally in the UK by Nicklow Engineering, who were based at Silverstone racing circuit.

It didn't take long for Rotax to see the potential, and their first engine specifically designed for this market, the 447cc twin-cylinder two-stroke, 'swept the board'.

As always of course there were a number of reasons for the success of this little powerplant, perhaps, one of the biggest being that Fuji pulled out of the UK microlight marketplace due to concerns about product liability.

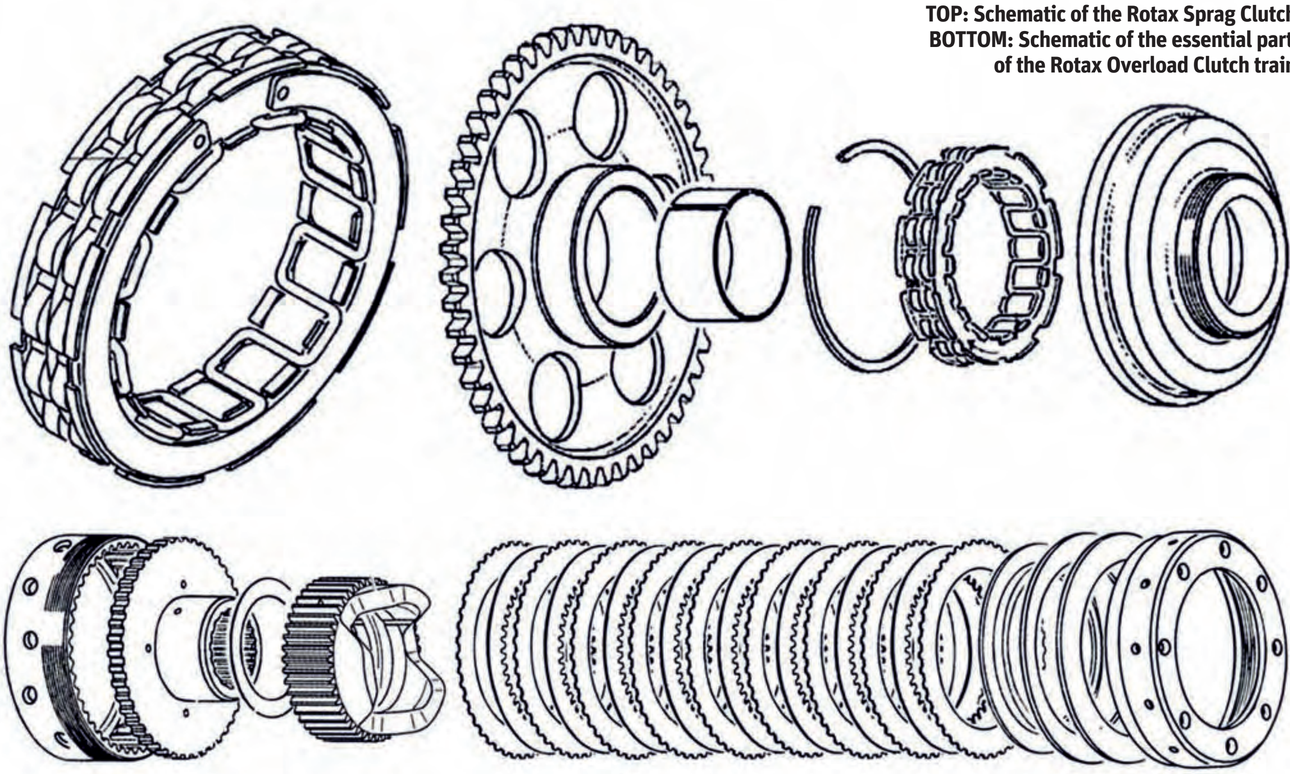
There were, of course other selling points; the integral gearbox (previous engines used belt drives) being at the front, and, of course, excellent 'product support' could (and can still) be counted on from the UK's Rotax distributer, Skydrive. This has been a big selling feature.

Why am I 'bashing on' about this? Well, when the UK boss of Skydrive says Rotax engines don't like avgas we'd be foolish not to listen.

Back to specifics. In last month's Safety Spot I showed a picture demonstrating lead contamination in a slipper clutch from a Rotax 912. A number of chaps have questioned this by

PHOTO Conrad Beale

The clutch plates on this Rotax Overload Clutch – one of three 'clutches' on the engine – are completely full of lead based deposit. If this device was needed it probably wouldn't work.



**TOP: Schematic of the Rotax Sprag Clutch.
BOTTOM: Schematic of the essential parts of the Rotax Overload Clutch train.**

'Large amounts of gunge will stop this device working properly'

PHOTO Conrad Beale

It can be seen that this piston's operation has been severely compromised by the lead compounds formed in this engine. The top piston ring is completely stuck in its groove.

saying that the picture wasn't a slipper clutch and 'so what', a bit of contamination. They had a point because, during the editing process, half the picture was missed out and the picture focussed on the 'Dog Clutch' part of the assembly. I also agree that the contamination as shown isn't that important.

This build-up of lead gunge looks to be the result of deposition due to acceleration forces aggregating lead compounds around the rim of the overload clutch, to use the correct name for this device. I've got a better picture of an overload clutch, which shows that acceleration isn't the only force at work on the molecular lead compounds here; take a look.

Just to clear this clutch confusion up a bit, let me explain what the various clutches do on the 9-series Rotax. You may not have come across this engine and wonder what all the fuss is about.

The first clutch in the system is less of a clutch and more of a device! Termed the 'Sprag Clutch', it is really a series of many small sprung cams that run inside a housing. The cams allow movement of the housing in one direction only, a bit like a ratchet, and is used to mechanically isolate the starter motor, in effect doing the job of the Bendix drive you might be more familiar with. Large amounts of gunge will stop this device working properly which could result in difficult starting or even starter motor damage.

The second clutch (also really a device) goes by the name 'Dog Clutch'. This device provides torsional cushioning by forcing a 'dog' up an inclined plane against an axial spring. This device is operating all the time the engine is running but is particularly important at idle rpm; the dog clutch helps to flatten out the internal load peaks in the drive train.

The third clutch really is a clutch but, just to completely confuse you, it's designed never to have to do anything. Before you throw the magazine across the floor, let me explain.

Take a look at the exploded diagram of the whole assembly, the engineers amongst you will note that there is no mechanism for releasing the clutch, that's because this is an overload clutch, sometimes misnamed (in my opinion) slipper clutch. This is the clutch, which is set to a very high pre-load, and breaks any connection between the propeller and the engine in the event of a propeller strike.

In other words this clutch prevents loads imparted through the propeller damaging the crankshaft.

MOGAS, THE FLIP SIDE

SO, on the previous pages, we looked at how avgas can leave deposits on the Rotax clutch, but that's not the end of the potential problems.

Let's have a closer look at the vapour pressure problems associated with mogas in fuel systems fitted to aircraft.

In the last Safety Spot, I mentioned the fact that as pressure drops, for example as the aircraft climbs, there is more likelihood that the liquid fuel will reach its vapour pressure and change into its gaseous form... in other words, reach its boiling point.

If this happens in a fuel line, the system, which is designed to manage liquids, will fail, and the engine will stop. I've had a few people ask me about this over the last few weeks so I feel duty bound to expand the explanation a little.

In the world as we understand it, we soon get used to the various states in which matter can exist – solids, liquids and gasses. In science speak, we tend to call these states 'phases'. Most substances can be forced or moved around these phases by varying the local environment, ie varying the temperature or pressure.

'It is essential fuel systems take into account temperature and pressure effects'

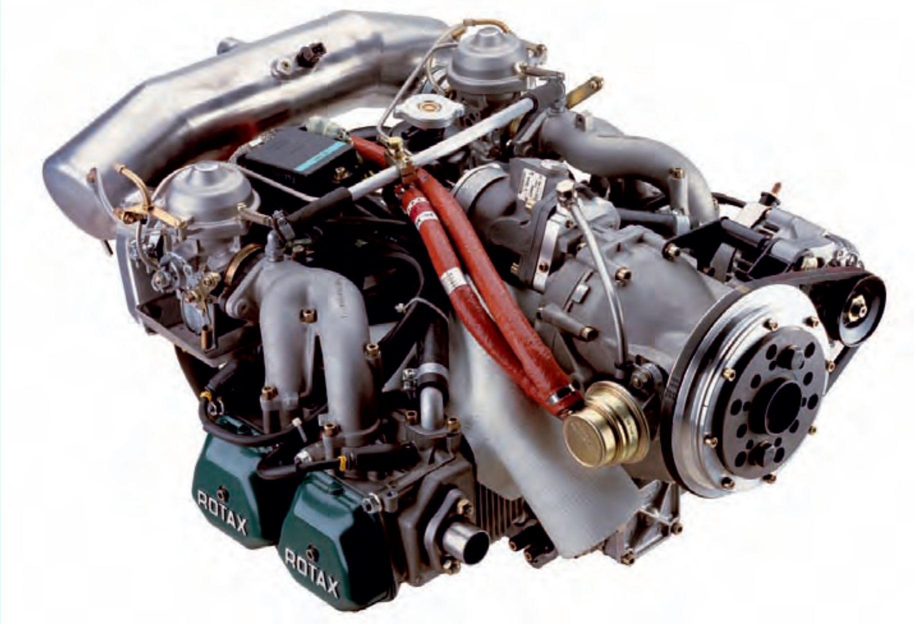


PHOTO Rotax

It is vital fuel lines are fire-proofed and routed away from hot areas of the engine bay, as shown above.

To see what effect these Ts and Ps have on materials I have drawn an imaginary 'phase diagram' (below) which you may like to study.

The important line on this graphical representation is between TP and CP, above this line equals fluid, below equals vapour. It can be clearly seen that increases in temperature will push a substance 'through the line' into vapour; in effect a liquid will boil when the saturated vapour pressure (to use the correct name) equals the external pressure. It is essential that fuel system design takes into account temperature and pressure effects.

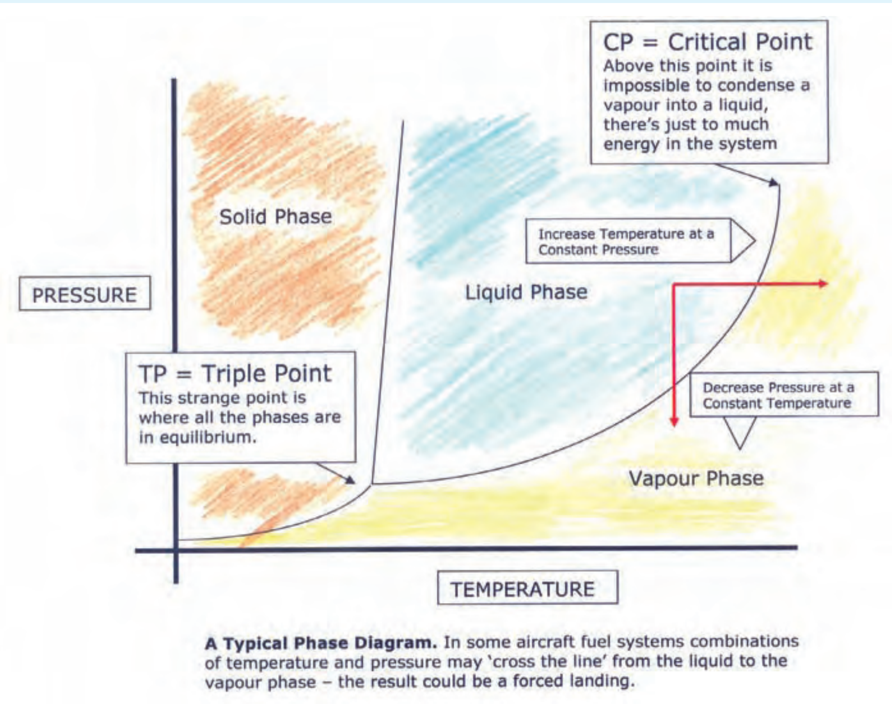
This is especially critical with aircraft using mogas because the saturated vapour pressure is lower in mogas than avgas. In other words, mogas is far more likely to have a problem associated with vapour locks in the fuel system.

The two critical areas for vapour formation are where the fuel lines are routed in the area of the engine (because of increases in local temperature) and entry ports to the fuel pumps, because of local pressure drops caused by fuel being 'sucked' into the pump.

Another area of concern in fuel systems is where there is any local disturbance in the line that may cause a pressure drop.

See the picture below of a badly attached fuel line I found just last week whilst visiting an aircraft for another reason. Apart from the fact that the tie wrap used to secure this fuel pipe was definitely restricting fuel flow there would also be a venturi effect dropping pressure locally, if the vapour bubbles produced reach the fuel pump then the pump will stop working and the engine may stop.

I hope that clears up any confusion that I may have generated. As I have said before (many times now) please feel free to put your threepenny-worth in. Safety Spot is only as good as the items you supply!



Malcolm's Typical Phase Diagram to show how matter changes its state with varying Ts & Ps.

PHOTO Malcolm McBride

This kinked fuel pipe will act as a flow reducer and the local pressure drop may start vapour formation. See text above.

With Malcolm McBride
Airworthiness Engineer

VPM M16 TANDEM TRAINER: MAST CRACKS UPDATE

Back in April, Safety Spot featured an item about cracking that had been found on the masts of a couple of machines in the UK. One of our inspectors who specialises in gyroplanes, Roger Savage, sent some great pictures showing cracks that had developed in this critical area of the airframe.

Unfortunately, due to space issues, one of these pictures wasn't printed at the size required to see the crack. I've asked the Editor to include it again because it shows very well how difficult it can be sometimes to spot cracks. This crack is lurking alongside a weld.

Our concern about these mast cracks was shared by the UK CAA and, since the Safety Spot article, a Mandatory Permit Directive (MPD) has been issued requiring a thorough inspection of VPM masts.

You can download a copy of this MPD if you want to read what the actual requirements are from the LAA or CAA websites. Look for MPD 2009 - 004 'Airframe Structure Inspection'.

Since the Safety Spot feature on this subject, I have received yet another report of a mast crack on a VPM gyroplane.

This crack was actually very difficult to see and so the inspecting engineer, gyroplane guru Tony Melody, used a dye penetrant to show the extent of the cracking. As you can see from the photograph, the crack extends symmetrically around both sides of the mast and has reduced the strength of this component considerably.

'The inspecting engineer used a dye penetrant to show the extent of the crack'

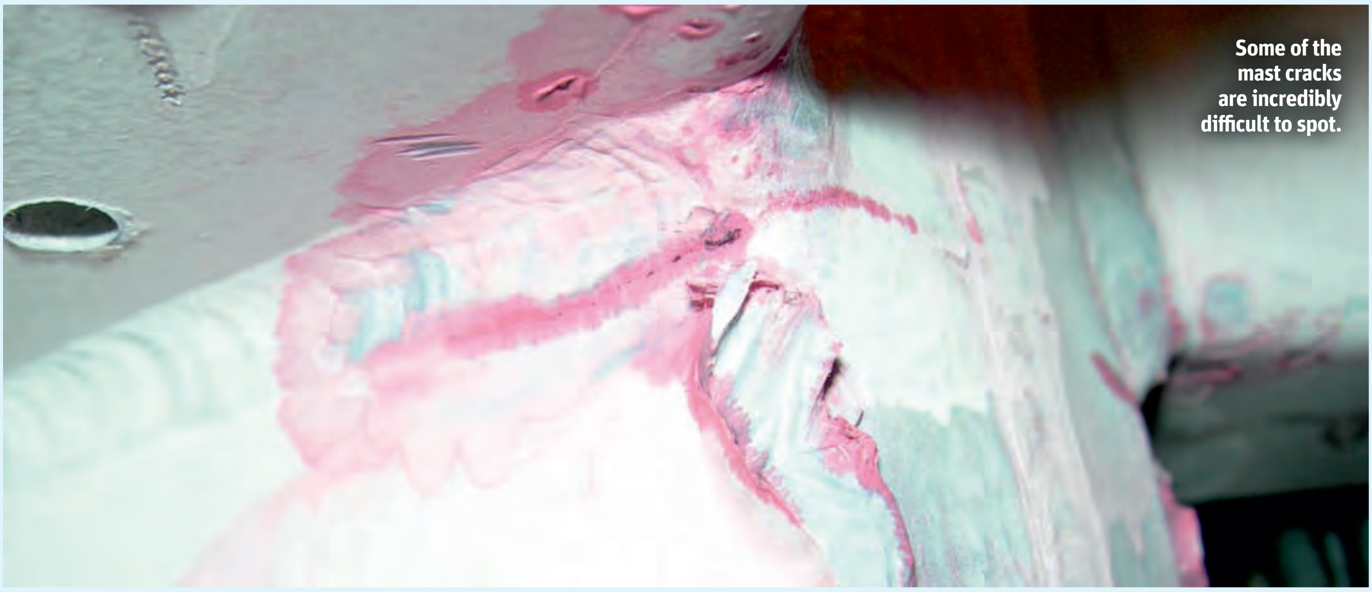
One of the features in the design of very small aircraft is that most of the structure should be considered primary structure – if a component within the primary structure fails, then the structure itself will probably fail.

This failure, should it occur in flight, would almost certainly lead to the loss of the aircraft.

So, with this sobering thought, what was my next job? Oh yes, where are those igloo plans.

Fair Winds.

VPM mast cracks have led to a Mandatory Permit Directive.



Some of the mast cracks are incredibly difficult to spot.