With Malcolm McBride
Airworthiness Engineer

THROTTLE SPRING SAGA

More views and experiences with throttles that spring to full on... or off. Which do you recommend? A Kingsland provides a 12-year detective mystery

A typical Rotax 912 installation. The twin carburettors have a spring bias to default to fully-open should the throttle cable break. The problem is the springs can cause the throttle to open unintentionally *(Photo: Brian Hope)*

When I was a lad, nobody talked about jet streams, at least if they did, I never heard about it. Mind you, I was always posted to the technical classes at school which, as you may know, didn't include geography in the syllabus. Apparently, according to the BBC at any rate, we can blame all our weather 'ills' on the misbehaviour of the jet stream. This naughty section of our upper atmosphere is far too south for its (or perhaps our) own good.

I'm not sure that the weather is really different this summer than at any time in my past; the British and the weather have always had a fickle relationship, which makes life for the aviator here pretty interesting – that's one of the many great things about living here in the UK and, of course, one of the reasons I'm going to the Med for my holiday!

Before I get into this month's airworthiness items, I must thank all the members that took the time to let me know their thoughts on what has become known, rightly or wrongly, as the 'Rotax throttle spring issue'. For those who didn't manage to catch last month's 'Safety Spot', I must explain that, in the June issue, I discussed three incidents where the behaviour of the engine, after a failure of the throttle control, had a bearing on the outcome for the aircraft and crew. In brief, I discussed two unrelated incidents where the initial failure of the throttle system was caused by the mechanical failure of the throttle cable or its attachment; I also described an incident where an accident was caused because the pilot was distracted and failed to complete the pre-start checks properly; a secondary feature of this incident was the 'bias to open' arrangement of the throttle system.

The reason why I cast doubt over the discussion being entitled the 'Rotax throttle spring issue' earlier is that, in the three incidents alluded to, a Rotax engine featured in only one of them. If you haven't seen the June edition of 'Safety Spot' incidentally, all the 'Safety Spot' pages can be downloaded from the LAA's website... just click on 'Safety' where you will find a link to 'Safety Spot'.

LAA Inspector Peter Whitehead, who is also the Chief Engineer at Shropshire Light Aviation based at Sleap, writes:

Dear Malcolm
Your article on Rotax engine throttles being biased to full throttle was very timely as, just a few days earlier, I had had an alarming experience with the very same.

The local aero club, for whom we carry out maintenance, has recently bought a Tecnam P2002JF with a Rotax 912 fitted. This, incidentally, is a certified aircraft. After a maintenance check I was carrying out the ground runs, after which I returned the aircraft to the aeroclub hangar. I am still getting to grips with this machine and almost every time I jump into it to bring it in for maintenance I discover another little foible.

This time, as I arrived at the hangar with idle power, I thought the throttle lever was a tad stiff and decided to check the friction device. As I released the friction the throttle lever immediately went to full power. WOW! It was a good job I had my feet on the brakes, as I would have discovered a quick way to put an aircraft into a hangar.

I am an experienced pilot/engineer and jump into a variety of aircraft to carry out ground runs on a daily basis so I am very wary of the peculiarities of various types, but what if a low-hour student or PPL had done the same? The results don't bear thinking about.

I am with you on this one, a throttle bias spring should tend to move the throttle lever on the carburettor to full power in the event of cable failure but not override the inherent friction of the whole throttle control.

Pete's experience was scary but the aircraft he was moving had toe brakes. What about an aircraft with no brakes? Another response, this time from Staffordshire-based LAA flyer, Graham Elvis

Hi Malcolm
Your article about the merits or otherwise of 'spring to open' control was very interesting and prompted some thoughts:

1 The solid core system that failed had a beautifully designed gripper but suffered from the fact that a single fracture was catastrophic (no warning).

2 The 'Teleflex' cable may be a high quality product but there is no way of knowing if the core/end attachment is about to fail (again, no warning).

3 I agree with you that the 'crushing washer' method is crude but, at least with a multi-strand core, the strands tend to fracture one at a time so should be picked up by inspection. On my Rotax installation I have added a nipple to each cable with a 1mm space from the existing anchor. In the event of the anchor slipping the backup nipple holds and the failure is obvious at inspection.

4 I cannot see how any single control device can be made perfectly reliable – a single failure will result in loss of control. Duplicate controls will withstand a single failure but must indicate that failure in some way otherwise you are back to square one (increased TBF but no warning before failure).

5 On balance I think I support the Rotax philosophy – engine going to full chat at start-up is less likely to be fatal than engine going to idle at altitude (say, mid-Channel?).

Thanks Graham for your thoughts; LAA Inspector, Dave Bonsall, comments that he likes to see a washer between the mixture cable and the bronze mixture control arm, he explains, 'I've seen this piano wire inner core wear into the bronze and become loose, as it does so it stops the mixture from reaching full rich. This sounds sensible to me.

And Peter Jeffcote, a Warwickshire-based member who describes himself as a 'Jodel jockey', recounted an incident that occurred whilst he was a student pilot:

Hi Malcolm
Re your articles on throttle springs, while I was learning to fly years ago, I was on my second ever solo cross-country. I was flying the club's Cessna from Coventry to Silverstone, then Sywell. As I flew over Silverstone I did a circle to look at the track, and opened the throttle to gain a bit of speed, but nothing happened. I carefully moved the throttle control forward and back to no effect.

At this point it took me a couple of minutes to convince myself that this was serious and it was happening to me! Knowing the make-up of the carburettor, and that it might snap shut at any moment, I had a careful look at Silverstone for straight bits but there weren't any. I called Turweston and explained the position but they suggested I go on to Cranfield.

I couldn't go on to Sywell, as I would have to cross over part of Northampton, so Cranfield it was. I spoke to Cranfield and declared an emergency; they cleared the circuit for me. As I was travelling along the revs were slowly dropping, so I had to trim back to hold height, but that made me go slower and the revs were still dropping, a kind of juggling act.

I arrived over Cranfield at circuit height, did a quick circle to have a look and do a standard circuit (I hadn't been there before). An instructor suggested I adjusted the mixture to control the revs, but engine control was too coarse, and it was upsetting my landing so I shut down and glided in. I did a normal landing and turned off at the first intersection, great.

My point in all this is that if the throttle had a spring to close it, it would have dropped me in a field somewhere between Coventry and Silverstone. As it was I had plenty of time to firstly convince myself there was a real emergency, and secondly to make plans and act on them.

Pete went on to explain that the reason for the throttle failure was that a fitter, on a previous check, hadn't made the connection correctly; the aircraft was fixed at Cranfield and he got home OK.

Primarily, I think that this issue has highlighted three points. One, it is vital that a regular pre-start routine is developed and carried out… but a throttle system that biases towards full throttle is not a good idea as it could cause an unintentional opening that may cause problems. Two, there are three basic ways a throttle can behave if the control cable should fail; either it would go to full throttle, not move (i.e. stay at the same rev setting), or default to a closed (or idle) position. Of these three options, the responses I received suggest that you equally like the 'go to full' or 'stay the same' options, but none of you liked the 'default to closed' option very much and under no circumstances, in the view of the responders, should the carburettor spring be able to overcome the normal friction in the throttle system. I completely agree with the latter comments, as you already know!

Pete's story highlights the fact that there is a potential fourth option when thinking about throttle behaviour, the slowly changing situation. I thought that the idea of trimming further and further aft as the engine rpm reduced as the throttle vibrated slowly closed a rather scary one personally. I am reminded of the futility (and dangers) of trying to stretch a glide in a sailplane, often thinking that you 'might just make it'. You can all too easily end up low and slow and having to make the best of the limited choices you have remaining towards the end of the glide should you end up having to perform an out-field landing.

To broaden out the lessons learnt from these three events, I think that we are reminded once again of the importance of learning (and performing) checks at critical points during a flight. We should perhaps, with our engineering hats on, also be reminded of the need to think of the component both in its role as a component and its role and effects within a system. We shall be supporting the AAIB with their recommendations that throttle levers must not be able to creep (or, for that matter, spring) to an open position when throttle friction is removed.

ENGINE MOUNTING-BOLT FAILURE ON AUSTER KINGSLAND

I can almost hear you thinking, 'What on earth is an Auster Kingsland?' Well, I'll be honest, ➠

Here is a photo of G-AJIT flying over Sheffield some 12 years ago, I hope that you agree with me that this is a fine-looking aircraft. Actually, Andy tells me that this was a memorable flight as he was a passenger. His newly-qualified 17-year-old daughter, Kirsty, was at the controls! This photo, for the anoraks out there, was taken from Mike Watts' Chipmunk, both aircraft having taken off from Netherthorpe. G-AJIT is now back in the air after the engine mount bolt failure and, by all accounts, flying well *(Photo: Andy Kay)*

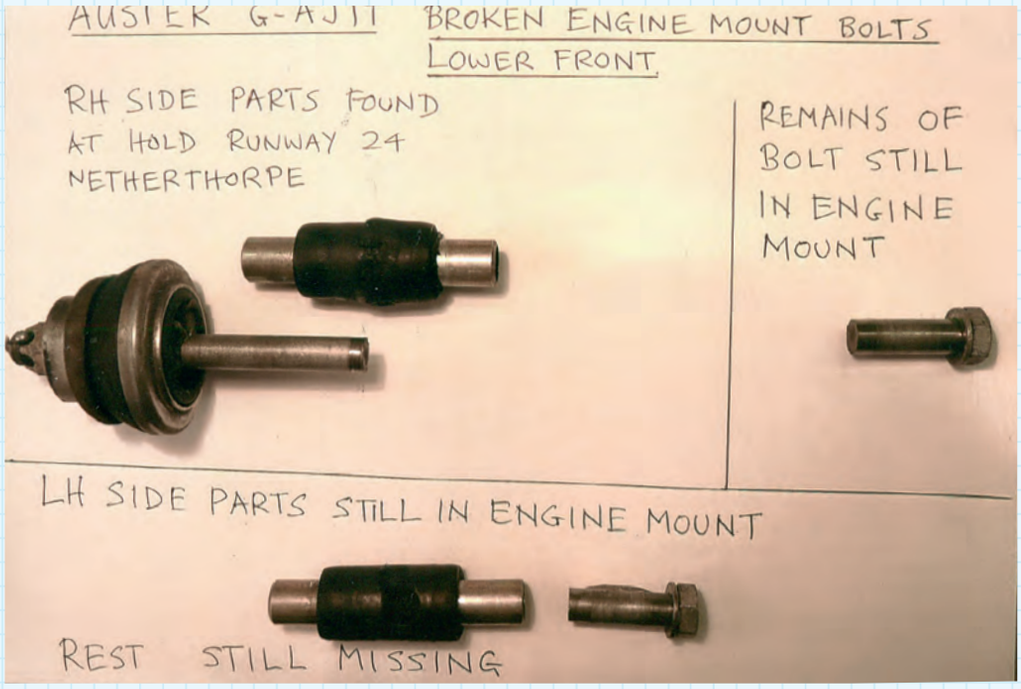
SAFETYSPOT

I had to do quite a bit of delving within the LAA's archives to find out as this aircraft joined the LAA Fleet quite some time ago.

Gajit, as this aircraft has become affectionately known by the flying group that now own her, started life as an Auster 5J1 Autocrat at the Rearsby factory in 1947 and ended up as a 'Kingsland' after an extensive rebuild, which began in the early 1980s. The complete rebuild included a considerable number of fairly major modifications, hence the reason for its individual name. We've a fair number of Austers on our books since the type transferred from a Certificate of Airworthiness machine to being allowed to operate on a Permit to Fly; I counted over 100 listed on our database. It has been said that there are as many types of Auster as there are individual machines but, whilst this is a bit of an exaggeration, it's not far short of the mark... I counted 19 separate types and I wouldn't be surprised to discover more!

Gajit joined us back in the early 1990s because she no longer qualified for 'Certified' status due tothe aforementioned Mods. Firstly, her wings were changed to a one- off type which first started life on an AOP 6 (Terrier), the Fowler flap, as fitted to the Terrier, was removed and replaced by the simple split flat of the Auster Autocrat. The cockpit fuel tank was removed and Cessna 150 tanks built into the wings. Other changes included the wheels, which were replaced with Scott units similar to the Piper Pawnee... the toe brakes, fitted to the left-hand rudder pedal assembly also came from a 150. The biggest change, excluding the wing, was front of firewall; most of the 5Js were fitted with the Cirrus Minor in-line inverted four, but the rebuilder decided on the venerable Continental O-200 flat-four and used the engine mounting from a Taylorcraft F19. The exhaust system and cowlings came off a Cessna 150 and the entire electrical system was copied from the Taylorcraft.

The result of these changes was a fine-looking and, from all accounts, great to fly, two-seater aircraft. Even though it was a bit of a 'bitser', it was well



Here is a picture by Joe of the engine mount parts that a local flying instructor found beside the runway at *Gajit's* base airfield, Netherthorpe, plus those remaining on the aircraft. It is likely that the left-hand lower engine mount had failed at some time in the past, this has probably led to the subsequent failure of the lower right *(Photo: Joe Cudby)*

Here is a picture of the likely cause of the bolt failure; note that the stud is protruding through the encasement into the rubber. The effect of this would have been to seriously reduce the damping effect of the rubber mount which may have led to the early failure of the bolt due to fatigue *(Photo: Suzie Quinn)*

This is a closer look at the left-hand lower engine mount bush, you can see clearly how the incorrectly fitted stud has damaged the rubber *(Photo: Suzie Quinn)*

This is a classic picture of a sequential fatigue failure in bending. This is the fracture face of the lower left-hand engine mount bolt that remained with the aircraft after its failure. It is likely that this bolt initially failed at a point around the 5 o'clock position. Note the distance between the beach marks increases as they are created from lower right to upper left in this shot, this is due to the steadily increasing point loading as the bolt failed. The final failure zone (about 11 o'clock) covers about 20% of the surface and would have occurred quite rapidly *(Photo: Richard Greene)*

I have to say that I absolutely love this photograph of the fracture face of the lower right hand engine mount bolt. It is impossible to say exactly what's going on here but the picture shouts out 'I'm turning' quite loudly. I think that this is a bending failure due to fatigue. I can see six general 'fronts' where the applied load appears to have been pure bending until, that is, the failure reaches about half the radius, and then the load begins rotating. If you have any thoughts about this please feel free to let me hear them, I'm all ears when it comes to fractography *(Photo: Richard Greene)*

deserved of an LAA Permit. Oh, and if you're wondering why the name 'Kingsland', well, that's simple, the original builder, PFA Inspector 'Jock' Kay was also a director of a company called Kingsland Aviation Ltd based in, yes, you've guessed it, Kingsland, Herefordshire. I spoke to his son, Andy, who completed the aircraft after his Dad's passing. He explained that his Dad found the fuselage lying in the hangar at Shoreham and offered the proprietors of Southern Air a 'few quid' for it… the rest is history.

I received a CAA Occurrence report which made interesting reading. It began: "Tuesday 03 April, 2012. Parts of engine mount found at hold, Runway 24 (Netherthorpe). AC inspected having been in hangar since evening of Sunday 01 April. Both lower front engine mount bolts had fractured approx 1in from the bolt head; only these parts remained in the engine mount.'

I spoke to the author of the report, LAAer Joe Cudby, on the telephone a few days later and we agreed that this double bolt failure seemed odd. Joe is an engineer himself who, although now retired, knows a thing or two about material fractures; he specialises in ceramics so he took the broken parts to a pal at Sheffield University for his thoughts on the mode of failure. Once Joe, and his colleague, Richard Green, had sorted out the probable sequence of this failure, he wrote it up in the form of a report and sent it to us here at LAA HQ. I couldn't ask for more.

I spoke to LAAer Suzie Quinn, one of the aircraft's co-owners, and she explained, "My partner and I went flying in *Gajit* and we didn't notice anything odd, bearing in mind the engine mounting bolts had probably broken before this flight. We were originally going to the Breighton fly-in but, because Joe was booked to fly the aircraft later in the afternoon, we decided on just having a local jolly. My partner, Mike, was the handling pilot."

Suzie continued, "When we'd finished our flight we put the aircraft back in the hangar, but, it wasn't until the next day that Joe actually turned up for his sortie… somebody had made a date mistake on the booking form. Anyway, when he got there, he found a package by the aircraft containing the broken bolts and a note from one of the local flying instructors explaining that he had found the bolts lying 'in the grass' next to the runway."

Hats off to the instructor for taking the trouble to stop his aircraft and retrieve these bolts, he could very well have saved a life.

I took a look at the aircraft's history to see whether there was anything in the aircraft's past that could explain why these bolts could have become overloaded and failed, and guess what, I came across an AAIB report detailing a nose-over event that had occurred in August 2000. Thinking that I had struck gold dust, I read:

'Whilst concentrating on several factors, such as avoidance of a drain which ran parallel to the runway, marker boards and a helicopter hovering close by, the pilot did not see a LITAS approach aid light unit at the side of the taxiway, near the holding point of Runway 36.

'The aircraft impacted the light unit with its left main wheel, which caused the aircraft to tip onto its nose. The propeller struck the ground and the engine stopped instantly… subsequent engineering inspection ascertained that the engine's crankshaft was cracked in four places.'

I checked with the LAA Inspector who oversaw the engine rebuild and he explained that the engine was overhauled completely and was effectively zero timed, a new propeller was sourced and fitted but, as far as he could remember, the engine mounting bolts were not changed. He explained that it would be normal practice to check these bolts for straightness and any other sign of distress but, if they were OK, they would have been reused.

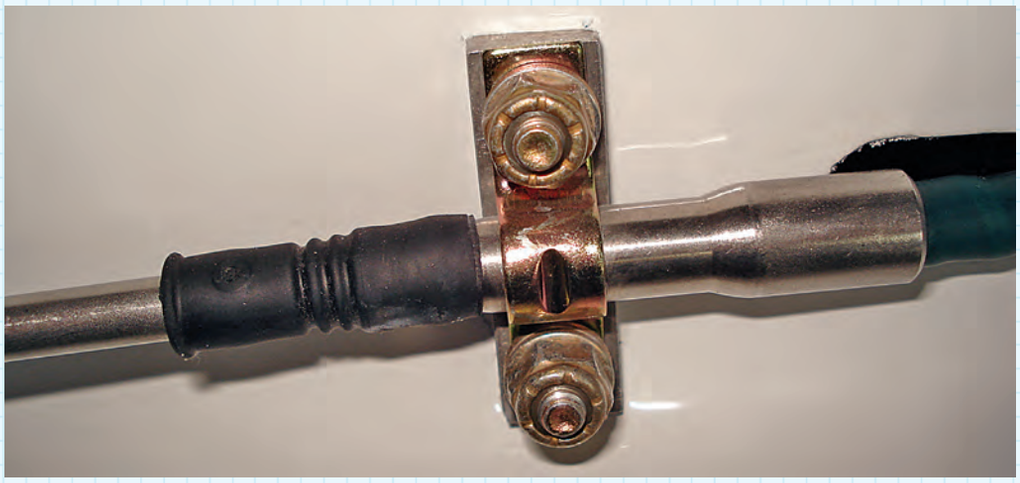
Joe checked the aircraft's logbook and noted that, since the engine rebuild, the aircraft had completed over 800 hours. I started to doubt whether the previous nose-over could be to blame for the subsequent failure. Certainly, during a nose-over, one would expect both the lower engine mounting bolt to be equally loaded and this might be seen in the symmetrical nature of the bolt failures; in other words, both bolts failed at exactly the same distance from the bolt heads (if you remember, about 1in from the head). Against this as a precursor to failure, has to be the number of in-service hours flown since the incident; surely, if the bolts had been damaged in the nose-over 12 years before, they would have failed before now?

Then Joe sent me his report, which included pictures taken

by the Sheffield metallurgist, Richard Green, himself and Suzie. You can see from the selection I have included what looks to have happened. At some time in the past an electrical earth has been attached to the engine mount lug; you can see that the attaching stud has been screwed right into the area normally occupied by the rubber engine mount jamming it fairly solidly. I think that this has effectively stopped this engine mount from working correctly and this, in turn, has lead to a fatigue failure of the left-hand lower bolt. Once this bolt had failed, the load into the remaining three fixings would have been increased. What happened next is, naturally, an educated guess, but I think that the right-hand lower bolt was probably a little loose and could have been rotating under some loading conditions.

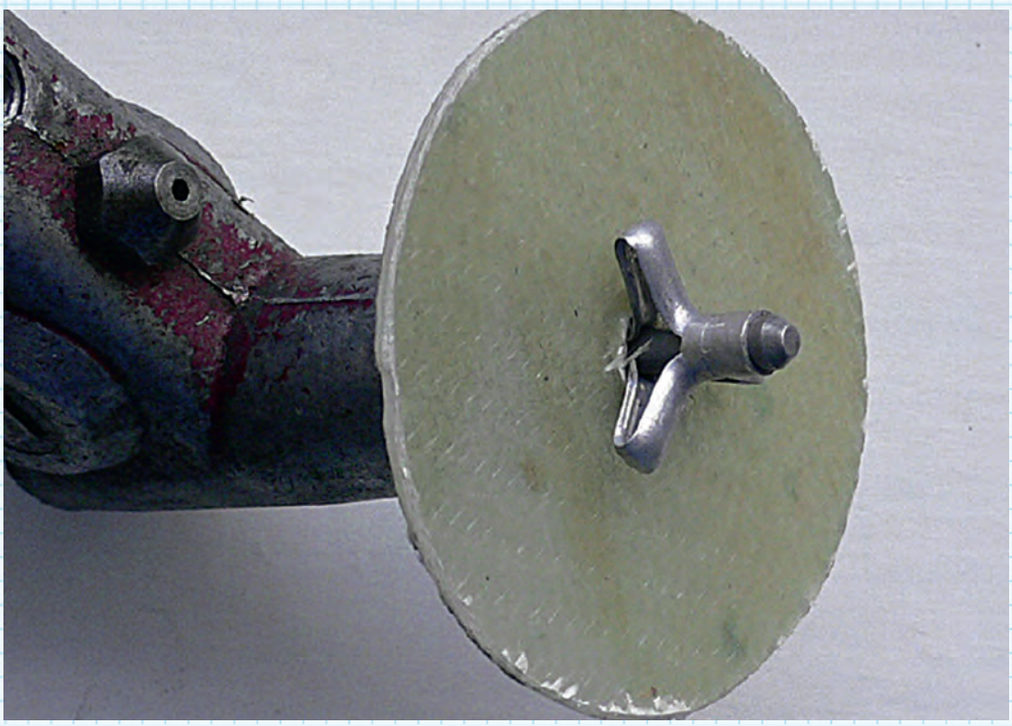
Take a look at the fracture face picture; this shows that the bolt has been overloaded in bending at different points in the circumference of the bolt. Hence the view that the applied load or the bolt could have been rotating; loads through rubber can exhibit strange effects, but I think that it's more likely that the rotation came through the bolt occasionally changing its radial orientation.

So, what lessons can be learnt from this serious failure report? Well, I suppose I should reiterate the fact that without the efforts of the instructor who found the remains of the engine mount and, probably more importantly,



The picture above has featured in 'Safety Spot' before and, before you go completely mad looking for the problem (well, this is 'Safety Spot'!) let me explain that there isn't anything wrong with the Teleflex clamp shown in this picture. Note that the clamp is bolted through the fibreglass structure firmly and that the indent in the outer clamp is fitting snugly in the recess in the cable's outer sleeve. This is the rear attachment of the rudder operating Teleflex (push-pull) cable. Fittings in fibreglass need continual inspection because the slightest looseness will cause a premature catastrophic failure. Previously, we have had problems caused when the indent wasn't properly located in the outer sleeves recess and, with a Teleflex cable, if the clamp fails in any way then its operation is lost. *(Photo: Roger Lewis)*

Pictured above is a rudder cable clamp failure as found by LAA Inspector Roger Lewis. The use of Rivnuts in this sort of application is a definite no-no and should really have been spotted during previous inspections. Roger applied a small load to the clamp and felt a little movement... so he applied a fraction more... *(Photo: Roger Lewis)*



It is notoriously difficult to make a mechanical connection between a fastener and a composite structure. Roger explained that the front rudder cable connection is riveted because of reduced access in the Jabiru airframe; I questioned the sense in this as I know that compressive forces caused as a blind rivet is formed can cause local material failure and delamination. Roger sent me this picture of TLR rivet which is designed to increase the surface area of the rivet in the rear surface; you can see from this picture that this increase in clamping surface area claimed is actually an illusion. Certainly the rivet is unlikely to pull-through as there is a lot of material folded but, because of the small clamping surface area, it is very likely to come loose if oscillatory loads are applied. *(Photo: Roger Lewis)*

took the trouble to identify the origin, the engine's attachment may have completely failed. I'm not completely convinced that the nose-over in 2000 didn't have a part to play; the moment arm between the striking point (at the bottom/front of the engine) and the lower mounts is fairly considerable and it is possible that the lower bolts were overloaded without showing obvious signs. An overload in any material will change the materials future fatigue characteristics.

What about lessons for the inspection of engines and their mountings? We looked earlier, when discussing the throttle bias issue, about looking at components first, as individual items, and then, as part of a system. The rubber mount on this aircraft had clearly been compromised for some time and, although it may have looked OK from the outside, clearly wasn't working. I bet that, with the cowling removed, this would have been apparent if enough load had been applied to it during a close inspection. Also, what about the earth stud? An easy thing to miss but probably the prime cause for this unusual failure.

Happily, the aircraft has been fixed and is now back in the air, where it should be. Remember, during your 'cowlings-off' you may not see something starting to fail by just looking. You may need to apply an appropriate load to the item and see how it behaves.

RUDDER-CONTROL FAILURE ON JABIRU SPL

I'm getting a serious case of dèjá vu, in fact, I think that I have a double dose and it's making me feel quite wobbly. Let me explain. I'm going on my holidays tomorrow; I know, I know, I don't deserve it. Anyway, you can imagine that this edition of 'Safety Spot' is a bit of a last minute affair but, just as I was about to finish it off with a few nice comments, I remembered that we've had another incident where a primary control has been compromised because an attachment has failed and, for safety's sake, I should share the tale with you. Last year was just the same, another last minute important airworthiness item; this involved a cracked rotor hub if I remember correctly. That's the first dose of dèjá vu.

The second dose comes in the form of a question… haven't we heard about this before? I checked back in my records and, well yes, back in 2009, August to be precise, we had a couple of failures involving Jabiru Teleflex attachments, which led to a control system failure. If I remember correctly this event led to the issue of a couple of bulletins, now, where did I put those pictures?

I received an application for a Permit Renewal from LAA Inspector and Jabiru expert Roger Lewis. On page three of the application form, where the inspector records any significant work done, Roger had added, 'Flying Control Anchor Point – Incorrect fitting has worked loose over time and, after a small force was applied, the fitting came away.'

I thought I had better check this out so I gave Roger a call. "I'll tell you what," explained Roger, "this fellow had a close call as I don't think this fitting would have lasted long in service!" Roger sent me a picture of the failed components with a letter, I will let him explain.

Dear Malcolm

I recently did a Permit renewal inspection on a two-seater Jabiru SPL. I noticed that there was some play between the rudder cable and the rear anchor point, which was not there the last time I inspected the aircraft and, to cut a long story short, the play was due to inappropriate hardware used to fix the anchor point to the fuselage during the build. This error had been missed during the annual inspections as the offending items were well hidden in the fuselage.

I have enclosed a picture for your information. The builder used a threaded fastener that was 'push fitted' from the outside and held with resin flock. Over a period of time, the fasteners have worked themselves loose resulting in the play that could be seen during inspection. The significance of the play, which was minimised by a filler, became apparent once the area was cleaned off and the anchor point removed.

The lessons that the owner and I have learnt include:

1 Any play between any flying control cable and the anchor point is unacceptable and must be investigated. There is no redundancy so inspections should be frequent and thorough.

2 Owners should be aware that anchor points can loosen through fair wear and tear. What is secure one day may not be secure the next.

3 Failure of an anchor point will invariable lead to loss of control.

I agree with Roger completely and I have included the picture with an explanation as to the reasons for this failure. I mentioned earlier, when discussing the best method for seeking out possible problems in the engine compartment that, by applying a sensible load to an item during an inspection, you may see a looseness or weakness. This is exactly what Roger has done during this inspection, so very well done to him.

You can see that this attachment has been held on using Rivnuts, which are essentially a tubular, counter-bored and threaded-alloy rivet. They're great for attaching tertiary items where access, especially from behind, is difficult, but they're certainly not designed to hold primary structures or controls together and are not featured in the Jabiru Build Manual, so this was an unauthorised change.

Roger explained that the forward control attachment is attached using special 'TLR' rivets which are specially designed to fix to fibreglass. I hadn't heard of these and Roger kindly sent me a picture showing how they work. I hope that you can see, by studying the picture that the bearing surface at the blind side is pretty small even though the actual arms are long. I'm not convinced that these rivets would be any better at holding something solid than a normal Cherry Lock. Anyway, Roger's point that anchor points can loosen through 'fair wear and tear' is a really good one; it's well known that it's difficult to connect anything to fibreglass, that's why we carry out regular inspections after all.

Fair winds! ■

LAA ENGINEERING SCALE OF CHARGES

LAA Project Registration	
Kit Built Aircraft	£300
Plans Built Aircraft	£50
Issue of a Permit to Test Fly	
Non-LAA approved design only	£40
Initial Permit issue	
Up to 390kg	£320
391 - 499kg	£425
500kg and above	£565
Three seats and above	£630
Permit renewal	
Up to 390kg	£105
391 - 499kg	£140
500kg and above	£190
Three seats and above	£210
Modification application	
Prototype modification	£45
Repeat modification	£22.50
Transfer	
(from CofA to Permit or CAA Permit to LAA Permit)	
Up to 499kg	£135
500 kg and above	£250
Three seats and above	£350
Four-seat aircraft	
Manufacturer's/agent's type acceptance fee	£2,000
Project registration royalty	£50
Category change	
Group A to microlight	£135
Microlight to Group A	£135
Change of G-Registration fee	
Issue of Permit Documents following G-Reg change	£45
Replacement Documents	
Lost, stolen etc (fee is per document)	£20

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