SAFETYSPOT

With Macolm McBride Airworthiness engineer

Stresses and strains

Second guessing the design engineer can lead to problems

I WAS listening to the radio on my way to work this morning – usual waffle, mostly made up, pretend jollity, you know the sort of thing. Anyway, my ears tuned in to some 14-year-old explaining how to deal with stress during an interview for a new job.

The conversation headed into the realms of psychobabble and I mentally tuned out. However, it got me thinking.

In between negotiating the roundabouts on the A43 and avoiding drivers who clearly believe there are only two positions for a throttle pedal, I considered what stress is, and why the word is used in so many contexts.

Time is a big stress item. Well, not in itself, but it helps to define a fixed point. "You've got to get this done by..." equals stress. "Any time you like," equals no stress.

In other words, you've got to have something to react against to have stress.

I looked up the definition of stress and here is what it came up with: mental, emotional, or physical strain caused by anxiety or overwork. It may cause such symptoms as raised blood pressure or depression. Blimey! So what's strain? I looked this up, "Something that causes stress."

For the purposes of the aeronautical engineer, stress could be defined as 'load per unit area' and strain could mean the amount that something moves, or deforms, in relation to this load.

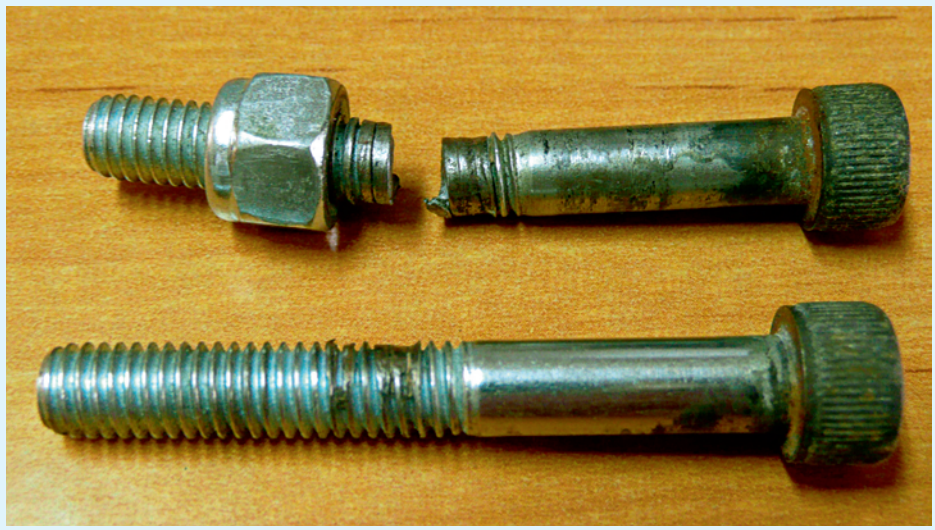
Stress divided by strain, or amount of load divided by amount of movement, equals a ratio which engineers term the 'modulus of elasticity'.

Design engineers continually work out these ratios and design attachments and fitments with the numbers in the forefront of their minds. They select appropriate bolts and, if they have done their sums right, the bit that they have designed shouldn't fail.

The point of all this is that all bolts are not the same and before you even think about changing a bolt for a different type, check it out with the designer of the aircraft.

And, if you don't know him or her, don't change the bolt type.

Wrong bolt leads to gear failure



GERRY Breen, a long-standing PFA/LAA member, has for some years operated a flying school in the Algarve. He was very upset when the undercarriage failed on his Pioneer 200 aircraft. Well, who wouldn't be?

Gerry, and I hope he won't mind me telling you this, first started his flying career as an aircraft engineering apprentice, so he knows a fair amount about the nuts and bolts of flying.

In his report he says, "On closer inspection of the (undercarriage) bolt it was found that the inner part was loose inside the fuselage. It had failed in bending and shear across the threaded portion of the bolt where the main loads had been applied."

Gerry goes on to say that the other undercarriage bolt was bent, "showing signs of imminent failure."

What it looks like has happened is that the appropriate aircraft-quality bolts have been substituted for commercial-quality cap head bolts of the wrong size.

A particularly challenging environment for a fastening is anywhere in or near the engine compartment. Continually varying temperature and vibration levels (variations in frequency and 'peak to peak' power) added to often very large load factors can present an aircraft (or engine) designer with a bit of a headache.

High-tensile bolts can be troublesome as their relative stretch is reduced, and applying the correct torque to these bolts is critical. Engineer's 'feel' is not good enough. There are a number of different ways in which a bolt can be secured, for example wire locking and Locktite are often used.

For the reasons above, it is not a good idea to 'up' the bolt specification. You might think that you're improving the assembly but, in fact, you could be inadvertently sowing the seeds of disaster.

Propeller bolts have always been troublesome, particularly bolts holding wooden propellers onto the crankshaft or gearbox drive – the reason is that you cannot apply enough torque to stretch the bolt without damaging the wood. Wire locking of bolts is essential here.

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Where's the propeller?

Gone, that's where! Wrong bolts, wrong torque and lack of inspection

HAVING been loosely involved in the early development of two-stroke power units and associated reduction drives for aeroplane use, I can bear witness to the fact that it is not a cheerful feeling when a propeller falls off the front, or, as in this next example, the back.

This pilot and his passenger were flying at about 2500ft above the beautiful Lancashire countryside en-route to an airstrip at Cockerham. The first sign of trouble was a 'rattling' sound. This was not accompanied by any vibration.

After a couple of minutes, there was a new mechanical noise followed by the abrupt stoppage of the engine. The pilot carried out a forced landing without damaging the machine, so well done to him. On inspection, he noticed that the propeller was missing.

The powerplant in question was a Jabiru 2200A and regular readers will recall that we talked about lack of damping effect with this engine in last month's Safety Spot. The propeller was subsequently found by a local farmer and sent to the AAIB for investigation.

Impossible to see with the propeller fitted, but the wire locking has broken allowing progressive slackening of the bolts, leading to failure.

As is often the case with this type of installation, a flange is bolted to the end of the crankshaft and the propeller subsequently bolted to the flange.

The bolts that failed were the ones that connected the flange to the engine. It appeared all the bolts failed, pretty much, together, although evidence from the recovered flange suggested that one of the bolts held on in one last gasp effort.

Five of the six attachment bolts were found with the propeller/flange assembly. These were sent to HT Consultants of Aldershot by the AAIB for analysis. It is Mr Tyrer from HT Consultants that we have to thank for the various pictures.

The conclusion of the tests suggested that the bolts' failure had resulted from some long-term, high-cycle fatigue mechanism fracturing the six bolts attaching the propeller flange.

Mr Tyrer's report said, "It is also considered that long-term progressive slackening of the six bolts resulted from frottage of the bolts in their relative holes and that this had been exacerbated by the use of bolts that had been threaded along their full shank lengths."

I know many of you out there will be thinking, "If it's threaded along its full length then it's a screw not a bolt." This aside, another major problem about this type of installation is its lack of inspectability.

Take a look at the picture of the wire locking, easy to see now, but impossible with the propeller fitted. So, wrong bolts, wrong torque, broken wire locking and, last but not least, lack of inspection.

Stay vigilant for any signs of cracks forming

ONE of our newer inspectors, Steve Clarehugh, has reported a weird bit of localised airframe tube cracking he found while re-covering a Rans S6. To be honest, we're all a little foxed by this strange damage so we're thinking of getting the part analysed by a metallurgist.

Take a look at the picture. It's a first for me. Steve seems to think it may have been caused by ice forming in the tube.

While we're on the subject of Rans aircraft, we have had a few more reported tailplane tube cracks. Keep your eyes open for cracking on these early microlight types.

Dave Almey, who has been a PFA/LAA inspector for over 25 years, called me last week to ask me to warn you all that cracking can happen anywhere. He has found cracks on the tailplane tube's rear attachment as well as the front – so be vigilant. Fair winds.

Frame tube crack on a Rans S6 – was it caused by ice forming within the tube, or something else?