5 Minute Briefing

What is a flutter – and how to fix it

Sit back and enjoy discovering, in five minutes, a subject you thought you knew, but maybe not as well as you will in 300 seconds time…

Flutter is countered using a mass balance often mounted in the horn of a light aircraft rudder

Control surface flutter is the violent and very rapid oscillation of an aileron, rudder, or elevator. Tab flutter is a similar oscillation of any hinged trim or servo tab and may occur without flutter of the control itself.

What can be the result?

If flutter happens to either a control surface or a tab it may potentially cause the surface or tab to break away.

A bad case of control surface flutter could also destabilise or overstress that part of the structure the control is attached to, thus causing that to break away as well. In the same way, a bad case of tab flutter can cause the control surface to which it is attached to flutter and fail.

A more moderate degree of control surface flutter, insufficient to cause the control to separate, can still damage the linkages that operate the surface as they struggle to make the pilot end of the linkage respond to the very rapid oscillations of the control surface. Because yokes, control columns and rudder bars are substantial items, their mass gives them inertia which makes them unwilling to respond to violent oscillations so the connecting linkages can quickly become worn, fatigued or even overstressed.

All this is clearly bad news. In the words of the famous aerodynamicist Theodore von Karman "Some fear flutter because they do not understand it, others because they do."

What causes flutter?

The oscillations are cased by an interaction between aerodynamic forces on one hand and structural, mechanical and inertia-related forces on the other.

A common manifestation of flutter is what happens when the wind blows through an open window fitted with a Venetian blind, the vanes of which are open or partially open. The structurally weak and floppy curved vanes, having aerofoil-like properties, develop lift in the draught through the window and start to distort. If the distortion then reduces their angle of attack, the vanes return towards their original shape, the lift and distortion develops again and an oscillation is set up. This can cause a most annoying rattle as the vanes thrash about. The cure is normally to close the blind or close the window.

If an aircraft experiences any form of flutter, the cure is to reduce airspeed as quickly as possible. In engineering terms the airflow is the 'forcing function'. Less airflow means less 'forcing function' giving the structural, mechanical and inertia elements a chance to damp the motion. However, from first symptoms to structural failure may well be just a few seconds which gives the pilot no time to reduce speed making a simple

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'suck it and see' approach to flutter flight test inappropriate.

How do designers guard against flutter?

There are mathematical tools to forecast whether flutter is likely to occur inside a given flight envelope of a new or modified aircraft. These are normally combined with 'ground resonance tests' of the airframe as a preliminary to carrying out flight tests with the aim of demonstrating that the aircraft is actually free of flutter issues inside the certificated speed envelope.

However, experience suggests mistakes can still occur. I have lost two close test pilot friends to flutter (Nomad/tailplane and Tucano/stores carriage) as well as knowing others who have fallen victim (Victor/tail and Venom/tailplane). The most recent accident involved the loss of the prototype Grob SPn aircraft last November. I have not yet seen it reported whether the mistake was in the maths, the ground testing or the speed envelope briefed or flown. Whatever the detail turns out to be, I doubt it will be the last example of a flutter-related accident.

My first flutter incident was one of 'rudder buzz' during a routine production flight test involving a supersonic dive in a Hunter. The noise and vibration seemed to me an excellent simulation of somebody firing a Bren gun just beneath my feet. The fix (routinely applied if this known Hunter tendency happened) was to add a small right angled strip to the trailing edge of the rudder to change its aerodynamic trim characteristics by just the small amount needed to prevent any oscillation getting under way.

On another occasion we boobed and flew four new underwing twin store carriers on a Harrier without first considering whether the quite large aluminium fairings – added to reduce carrier drag – might suffer undesirable effects. They did and, following the most intense but momentary burst of vibration, they departed without affecting the aircraft.

Twin Harriers were also affected by flutter, but single seaters escaped the problem

More flutter – in a Harrier

Another example of flutter I was involved in affected the two-seat Harrier tailplane where the tips flapped vertically during an approach when immersed in the high speed efflux from the engine. This did not happen with the same tailplane on the single seat aircraft and was probably due to the new longer fuselage structure of the two-seater. The fix for this was to insert simple tubes partially filled with lead shot inside the tailplane tips which acted as dampers and helped to change the natural frequency of the tailplane.

Controlling the problem in light aircraft

For control surface flutter to happen the airflow must be able to move the surface – as is the case with most GA aircraft. It is less likely to happen if the surface has mass balances fitted so that the cg of the control is on the hinge axis.

So far as certificated general aviation aircraft are concerned, flutter should not happen unless there are defects in the particular aircraft. Worn actuating linkages (allowing some free play of the control surface when the cockpit control is held fixed) could allow the control the freedom necessary to start an oscillation. Similarly, if a trim tab actuating cable was to break leaving the tab free, that could be worse news than just the loss of the trimmer function. To guard against this, modern certification requirements call for duplication of such cables. Finally, if the bolts holding a mass balance horn come loose and allow it to fall off then that surface could subsequently flutter. Yet more reasons to do good pre-flight checks ■

Next month:

Brian Lecomber has five minutes to explain the Aresti sequence diagrams used by aerobatic pilots

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