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EXPONENTIAL CYCLIC TESTING – A NEW METHOD OF ASSESSING FLIGHT STRUCTURES

Abstract

This paper presents a new method of testing for the strength of flight vehicle components and materials, giving a result closer to the flight environment and requiring only one specimen.

Traditionally, the strength of say a fin and its attachment to a rocket or aircraft body could be tested in two ways. Firstly, in a static test, a load is slowly increased, and the force versus deflection curve measured. While the presence of nonlinearity indicates the onset of yield, the working of rivets and material damage are not revealed.

To overcome these limitations, a fatigue test is often applied, using many cycles at each of several amplitudes. One specimen can be tested at only one load level, so this requires several test specimens and long machine times.

The new method described here applies reversed loads whose amplitude increases exponentially. This method was applied to a sample fuselage joint (12 inch diameter, 32 bolts) for the Ausroc 2.5 sounding rocket (see www.asri.org.au). It was tested at the University of NSW mechanical engineering laboratory in Sydney, Australia.

This test combines and improves on the best features of static and cyclic tests, It is a good representation of some real flight cases - increasing oscillations, such as pitch oscillations in a rocket, control system instability, or flutter. In practice, displacement measurements are taken at several places to separate deflections in the test rig, metal components eg fin and fuselage, bolted or riveted joint etc.

Traditional acceptance criteria can be applied reliably. Firstly, 'no damage at limit load' by examining that loop, a video of the test, and perhaps the specimen after that cycle. 'No failure at ultimate load' is plainly visible.

Quantitatively, the effective stiffness at any amplitude can be estimated by linearizing the appropriate loop. The effective damping or coefficient of restoration can also be estimated by integrating for the fraction of applied energy which is returned within the displacement reversal. Thus, linearized stiffness and damping coefficients can be extracted, as functions of amplitude, for use in modelling of control systems and aeroelasticity. This has been done for the Ausroc 2.5 joint, all from one test.

This method can be applied to a component such as a wing, a fin, a control surface, or rocket fuselage joint. It can also be applied to a test specimen such as a bolted or riveted joint, or a new material.

Other advantages of the exponential cyclic test include the ability to screen many samples (eg prototype materials or joints) in a short time. Only one specimen of each type needed, and it combines the best of static and cyclic testing. It is significant that no limit load needs to be specified in advance (as long as the first cycle is below damage level) due the scalable nature of exponential laws; thus any two test results can be compared.