better, faster durability tests

nCode's Accelerated Testing software addresses the need for reduced development times, while retaining the realism of proving ground durability tests

HBM-nCode
Tel: +1 248 350 8300
Email: jon.aldred@ncode.com
Web: www.hbm.com/ncode

nCode's Accelerated Testing software has been a hit among test engineers since its launch in 2007. The module, part of the GlyphWorks graphical test data processing software, addresses the need for shortened development times, while retaining the realism of proving ground durability tests. The result is reduced time and cost, with greater confidence in test results.

Accelerated testing methodologies apply to both the time and frequency domains. The goal of laboratory tests performed on structural and ancillary components is to replicate the same failure mechanisms seen in customer use. Because this could take months using real loading profiles, engineers develop representative loading cycles to run through the rigs quickly, yet deliver realistic damage and failure modes.

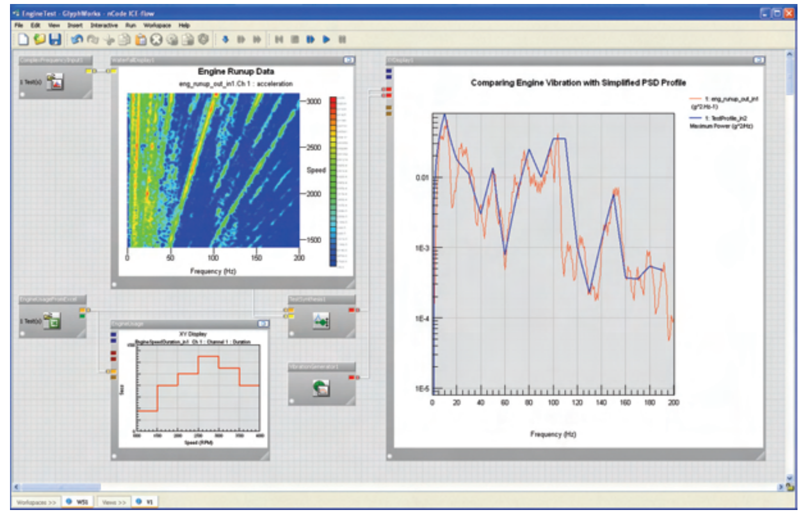
In the time domain, load signals collected from the test track are fed into test rigs. A large proportion of the raw data, however, causes little or no damage to the test component. In these cases, fatigue editing is the solution. nCode's GlyphWorks software scans through the acquired channels and deletes the non-damaging parts of the load signal. It then joins the remaining parts of the signal to ensure these 'joins' are physically re-playable on a rig. The test signal contains the same damage content as the measured signal, in as little as 10% of the replication time.

The Accelerated Testing module in GlyphWorks, however, is focused on the frequency domain. Most smaller structural, ancillary, and electronic components are tested using electrodynamic shakers. Test engineers typically apply a vibration test spectrum to ensure that resonant conditions are generated. Commonly, a power spectral density (PSD) of acceleration defining this spectrum is used. And even though vibration test rigs have become more sophisticated, as multi-axis shakers replace sequential single-axis machines, the challenge is still to use a PSD representative of the real-world environment. The test is only as good as its specification.

Defining the right PSD is particularly challenging when simulating a wide range of operating conditions. In the automotive industry, these include road surfaces that excite different suspension frequencies, differing engine speed usage profiles, or a combination of both.

Engineers apply simple approximations to develop a PSD. One approach is to calculate an outer maximum envelope based on all the separate acceleration PSDs for each measured channel. The PSD is then scaled (using greater accelerations) to make the test run more quickly. This pragmatic approach has its drawbacks. Enveloping PSDs does not take into account the duration of each damage "event", and increasing amplitudes can inadvertently exceed realistic levels and introduce unrepresentative failure modes.

LEFT: Many components are signed-off with tests on electrodynamic shakers, but which test to use? (Image courtesy of LDS Test and Measurement.)



LEFT: A waterfall plot of engine vibration is combined with expected usage to create a representative vibration test

GlyphWorks' Accelerated Testing module helps overcome the weaknesses inherent in these widely used approximations. It also combines academic research and military standards, such as NATO draft AECTP 200 and the French MoD GAM-EG13. nCode's Accelerated Testing can convert large amounts of real measured data into a single test specification.

A key part of the process is the "fatigue damage spectrum" – the relative damage caused in a system at each frequency. It is derived using an approach analogous to the shock response spectrum. Unlike a conventional enveloping approach, the fatigue damage spectrum allows for the length of time or number of repeats of an event. It can then be used to generate an equivalent PSD or swept sine signal to use in simulation tests, which can be run with a shorter test time.

Major automotive testing laboratories are seeing great productivity benefits from this approach. Chrysler's Dr Yung-Li Lee, a senior specialist in the stress lab and durability department, says, "We have seen real-time savings in performing random vibration tests by using GlyphWorks' Accelerated Testing, and now look forward to promoting the method internally and in our supplier base."

In the latest release of GlyphWorks, new capabilities have been added to address a wider range of vibration tests. In addition to PSD and swept sine tests, it is now possible to define test specifications for sine dwell and sine on random tests. Sine dwell tests specify the number of cycles to apply at a defined set of frequencies and are often used for exciting one or more known resonances.

A sine on random test profile combines fixed sine tones with a broadband PSD profile, and is commonly used for rotating machinery and powertrain applications. But how well does your sine on random test compare with actual vehicle usage?

GlyphWorks can analyze measured engine run-up data to create a waterfall plot of vibration level across a frequency range against engine speed. A waterfall of fatigue damage spectra can then be calculated, one spectra for each engine speed. This fatigue damage information is combined with a usage table of the expected time spent at each speed to give the total damage. A vibration test profile is then calculated according to the required length of the test. For a shorter test, the software will appropriately increase the levels. Additionally, other measured data from a variety of sources, such as time domain road-load data from the proving ground, can be combined to create an overall fatigue damage spectrum prior to calculating the required test profile. For vehicles such as motorcycles, where engine vibrations can be notable structural loads, this method of combining multiple vibration inputs into a single profile for easy comparison has great benefit.

GlyphWorks' Accelerated Testing enables a direct fatigue damage comparison of the known test specification and the overall expected powertrain or vehicle usage. As different customer usage is expected in different markets and regions, this enables an objective assessment of established sign-off tests for these applications.

So which standard should one test to? One challenge is ensuring the durability sign-off test is realistic. But further difficulties arise when different test specifications (perhaps for different customers) are applied to the same component. If the part fails one test but passes another, what next? nCode's Accelerated Testing method also allows a direct comparison between different standards, enabling better insight into the failure mechanism and potentially avoiding costly redesigns.

One automotive transmission supplier had two different test specifications for a mounting bracket: an existing swept sine test, and a proposed PSD profile. Resulting RMS vibration levels during the test were 18.1g for the swept sine and 22.8g for the PSD profile – but the original swept test was more damaging. Why was the new PSD profile less damaging, despite the higher levels?

Accelerated Testing comparison of fatigue damage spectra made the difference clear. Because of the time spent sweeping logarithmically over six different frequency ranges, the swept sine test applied many more cycles in the low frequency range, where there were known structural resonances. The fatigue damage spectra highlighted this effect. Subsequent analysis using GlyphWorks developed an alternative PSD test profile that matched the damage from the swept sine. ‹