Accelerated Test Time@RPM

Phil Korth
• Harley-Davidson Motor Company celebrating it’s 115th Anniversary produces cruiser and touring motorcycles and offers a complete line of Harley-Davidson motorcycle parts, accessories, riding gear and apparel, and general merchandise. For more information, visit Harley-Davidson’s Web site at www.harley-davidson.com.
Challenge/project scope – Why Do We Need Accelerated Test Time@RPM

- Proving Grounds provide various duty cycles to generate vibration profiles
- Duty Cycles at the proving ground are typically correlated to road roughness
- Duty Cycles at the proving ground have powertrain excitation but typically don’t represent customer usage Time@RPM
- Electrodynamic shaker testing covers combined road & powertrain excitation
- Accelerated Test Time@RPM is needed to provide the correct overall customer correlated vibration profile for an electro-dynamic shaker
How does an Accelerated Test Time@RPM Glyph Work?

• Glyph edits accelerometer data into RPM binned time histories based on Time@RPM Duty Cycle
• Glyph creates Frequency Damage Spectrum (FDS) for each RPM time history
• FDS Summation is weighted by Time@RPM Duty Cycle
• The calculated FDS is used to generate the Time@RPM based vibration profile
How does the H-D Accelerated Test Time@RPM Glyph Work?

- **Glyph has 3 sections**
  - Section 1 - TAL Data Check
  - Section 2 - Creates FDS based on TAL
  - Section 3 - Creates PSD based on combined RPM FDS’s

- **Glyph Requires**
  - Acceleration Channel in units of g
  - An RPM Channel that encompasses full RPM band
    - Engine Runup
    - Sport type course that sweeps full RPM range
  - Time at level csv file
Section 1 - TAL Data Check

- Acceleration & RPM Channel
- Time at Level
Section 2 – FDS from TAL

Instructions for this tab of this Glyph.

- Load a time history into the TH Input Glyph.
- The time history must contain an RPM channel and at least one acceleration channel.
- Acceleration channels MUST have units of "g", not "g/s".
- Strain and other non-acceleration channels may be loaded, they will be ignored.
- Load a usage file (.csv file with rpm and customer usage table) into the TAL MC Input glyph. If the field data does not have data in a certain rpm band, you will need to adjust settings in the AccelTestParam Glyph, to either ignore this or cause error.
- Adjust the parameters in the AccelTestParam Glyph.
- Run the Glyph.
- The display below will show the FDS spectrums for all channels.
- The SRS, FDS and Raw PSD spectrums will automatically be loaded into the Histogram inputs on the next tab.
Section 2 – Where The Magic Happens Inside a SuperGlyph FDS & SRS calculation

- Engine Sweep data is extracted for individual RPM ranges
- A repeat count is calculated based on time duration of extracted data and weighted by the time@level requirement
- The repeat count is fed to the SRS to calculate the FDS for the RPM range
- FDS damage results are tabulated for all RPM ranges
Section 3 – PSD from RPM FDS

Instructions Tab 3

Instructions for this Tab of this Glyph

The FDS, SRS and Raw PSD histograms, from the previous tab should automatically load into the Histogram Inputs on this tab. So, the process on the previous tab needs to be run, before running this tab.

Adjust the test duration and the Test Synthesis Q to the TestSynParam glyph. If you would like to reduce the amplitude of the accelerated test, set the Test Synthesis Q to a higher value than what was used for the Field Data SRS.

Review the Studio Display, showing SRS vs ERS and Raw PSD vs Accel Test PSD.

Export the Studio Display, for all channels, for documentation of the analysis parameters.

The Accelerated Test PSD is automatically output in a csv format and can also be copied from the Accel test PSD Data display and pasted into Excel.
Proving the Accelerated Test Time@RPM Glyph Works

- Utilize a duty cycle (Duty Cycle A) and calculate relative damage from a specimen strain time history response
- Run the Time@RPM Glyph on the specimen being excited by an RPM sweep
  - Utilize Duty Cycle A to create a Time@RPM CSV profile
  - Generate a PSD vibration profile
  - Run profile on a shaker
  - Collect strain response data from the test specimen
  - Calculate relative damage
- Run Accelerated Test Glyph on time history accelerometer data from Duty Cycle A
  - Generate a PSD vibration profile
  - Run profile on a shaker
  - Collect strain response data from the test specimen
  - Calculate relative damage
- Compare relative damage of all 3 strain responses
### Duty Cycle A Relative Damage

#### Duty Cycle A

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Event Damage</th>
<th>Time Seconds</th>
<th>DC Repeats</th>
<th>DC Damage</th>
<th>% Damage</th>
<th>Unedited Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>2.60E+00</td>
<td>290</td>
<td>1738</td>
<td>4.51E+03</td>
<td>32.34%</td>
<td>504020</td>
</tr>
<tr>
<td>Interstate</td>
<td>1.92E+00</td>
<td>152</td>
<td>2319</td>
<td>4.45E+03</td>
<td>31.88%</td>
<td>352488</td>
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<tr>
<td>Country1</td>
<td>1.00E+00</td>
<td>103</td>
<td>1738</td>
<td>1.74E+03</td>
<td>12.47%</td>
<td>179014</td>
</tr>
<tr>
<td>Country2</td>
<td>8.85E-01</td>
<td>104</td>
<td>3478</td>
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<td>107030</td>
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<tr>
<td><strong>Total Damage</strong></td>
<td><strong>1.40E+04</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>1598784</strong></td>
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444.1 hours
Duty Cycle A Time@RPM
Run the Time@RPM Accelerated Test Glyph and Generate a Vibration Profile
Run the Time@RPM Vibration Profile on Virtual Shaker
Run Accelerated Test Glyph on Duty Cycle Based Time Histories and Generate a Vibration Profile
Run the Duty Cycle Accelerated Vibration Profile on Virtual Shaker
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<tr>
<td><strong>Time@RPM Acc Test</strong></td>
<td>1.70E+01</td>
<td>240</td>
<td>720</td>
<td>1.23E+04</td>
<td>100.00%</td>
<td>48 hours</td>
</tr>
<tr>
<td><strong>Duty Cycle Accelerated Test</strong></td>
<td>1.97E+01</td>
<td>240</td>
<td>720</td>
<td>1.42E+04</td>
<td>100.00%</td>
<td>48 hours</td>
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- Damage comparisons are all very close
- What accounts for difference between accelerated test methods?
FDS Comparison Duty Cycle vs Time@RPM

- **FDS Compare**

- **FDS Damage Factor vs FRF**

  - Road input region largest damage difference
  - Attributes to differences between accelerated test methods
Summary

- Reviewed an Accelerated Test Time@RPM glyph

- Using the Accelerated Test Time@RPM allows for the generation of a vibration profile correlated to time@RPM usage

- Using a generic duty cycle, strain damage correlation was demonstrated for an Accelerated Test Time@RPM vibration profile vs a duty cycle based time history response vs a duty cycle based Accelerated Test vibration profile
Thank You!

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