Strain Analysis for determining fan fatigue life

Ensuring life of a generator set radiator fan
Agenda

- Company Overview – Cummins Power Generation
- Generator Structure Overview
- Instrumentation and Measurement
- nCode Analysis
- Conclusion
Company: Cummins Inc.

- 2013 Revenue: $17.3 billion
- Headquarter in Columbus, IN.
Cummins Power Generation – Applied Technology

- Cummins Power generation – Generator sets, Alternators and transfer switches
- The Applied Technology group is a multi-speciality group catering the acoustics, structural analysis, experimental mechanics, thermal and fluid test needs of the company.

**Capability:**
- Material and Component properties
- Experimental Stress Analysis
- Force, Load, Strain, Displacement Measurement
- Fatigue testing and analysis
- Vibration/Shaker Table Testing
Generator Set Architecture

- Typical Diesel engine based genset
- Test focus on the radiator fan, part of the genset cooling system.
- Becomes imperative to study dynamics of the fan
Instrumentation and Measurement

1. Finite element analysis
2. Strain Gaged Fan
3. Completing Wheatstone bridge
4. Wiring to slip ring
5. Wiring from slip ring/test cell setup to data acquisition system
6. Data Acquisition System
7. Testing in Operating Condition

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Livonia, MI (USA)

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Fan strain Project – Scope

- Analysis to identify life of a centrifugal fan based on strains during operation.
- Goal would be to ensure life of radiator fans.

Fan strain analysis – Project Flow

- Finite element analysis
- Instrumentation
- Fan Dynamics
- Order Analysis
- Material selection for fatigue
- Fatigue result post-processing
Using nCode GlyphWorks for Fan strain analysis

- Some tools for data quality check

  **Data Quality check**

  **Drift Detection analysis**

  **High Frequency filtering**

  **Spike Detection analysis**
Rainflow Comparison – Before and After spike Detection

- Some of the Glyphs used for data quality analysis include
  i. Drift Detection
  ii. Spike Detection
  iii. Butterworth Filter

A comparison has been made in the below image to depict how noise can be eliminated/picked out for data quality analysis.

- Clear indication of change in the number of cycles in the legend
- This indicates elimination of noisy signals
Dynamic Analysis - Fan Strain

Order Analysis/ Joint Time Frequency Analysis

Strain data Spectrum analysis

Resonances

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Strain Amplitudes</th>
<th>Operating Conditions</th>
<th>Test Conditions</th>
<th>Excitation Order</th>
<th>Engine Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>306.6 Hz</td>
<td>160.1 micro-inch/inch</td>
<td>Start stop</td>
<td>Fan 4th</td>
<td>1192 RPM</td>
<td></td>
</tr>
<tr>
<td>119.3 Hz</td>
<td>32.9 micro-inch/inch</td>
<td>No Load Sweep</td>
<td>Fan 10th</td>
<td>1589 RPM</td>
<td></td>
</tr>
<tr>
<td>137.4 Hz</td>
<td>152.7 micro-inch/inch</td>
<td>Loaded Sweep</td>
<td>Fan 12th</td>
<td>1785 RPM</td>
<td></td>
</tr>
</tbody>
</table>
Fatigue Analysis - Fan Strain (I)

- Statistical analysis on fatigue results.
- Data extracted via ‘Statistics/Datavaluesdisplay’ glyph.
- Helps in comparison of alternating/mean strains in the data and hence shows the safety factors after excel analysis.

Sample nCode process.

Mean strains

Alternating strains

Reserve factors
Fatigue Analysis - Fan Strain (II)

- Fatigue analysis template

  - The strain life glyph gives the liberty to input lab generated material properties

  - Multiple locations with different stress concentration factors, material properties, surface finishes can be analyzed at once

  - Back calculation analysis helps in understanding the fatigue life considering the service life of the component
Advantages of using GlyphWorks:

- Good technical support/prompt support
- Great collection of webinars
- Great visualization
- Scripting options / pre-made glyphs saves a lot of time
- Back calculation capabilities helps quantify various test surfaces for life.
Thank you!

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