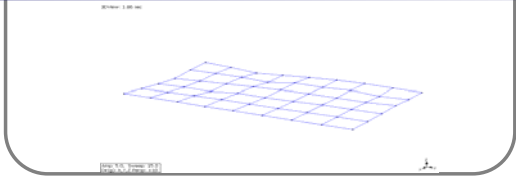


Structural Resonance

Presentation by Chad Wilcox



Agenda – Structural Resonance

- Definition
- Consequences
- Identification
- Control

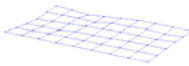
What is Resonance?



857 cpm

Forcing Frequency = Natural Frequency

870 cpm



Forcing Frequency

- Forcing Frequency
 - External force imposed onto structural system
 - i.e. – shaft speed, component frequencies (BPF, GMF, belt frequencies, electrical), etc.
 - Direct forces AND nearby forces

Natural Frequency



- Natural Frequency (ω_n)
 - Fixed system property based on a systems' mass (m) and stiffness (k)
 - A system will have an infinite number of natural frequencies
 - Dominant Frequencies
 - Range of Interest

$$\omega_n = \sqrt{\frac{k}{m}}$$

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What is Resonance?



Forcing Frequency = Natural Frequency

- *CONDITION* in which a response is amplified.
- Resonance is not a force

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Consequences of Resonance



- Damaging
- Unsafe
- Camouflages other problems

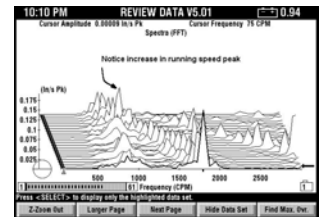


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Identification – Basic Methods



- High Amplitudes
- Broken welds, bolts, etc.
 - Strobe light is a useful tool
- Cascade Plots

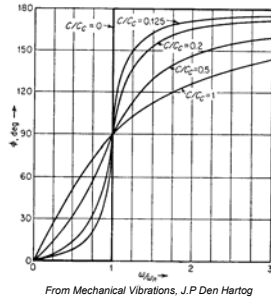


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Identification – Basic Methods



- Phase shift

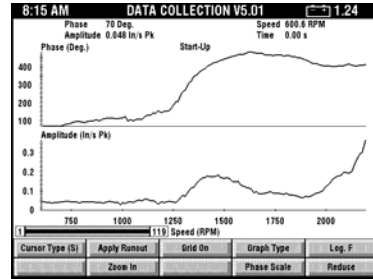


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Identification – Basic Methods



- Bode Plots

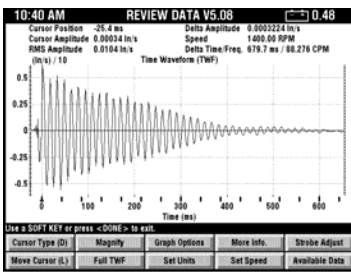


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Identification – Basic Methods



- Bump Tests

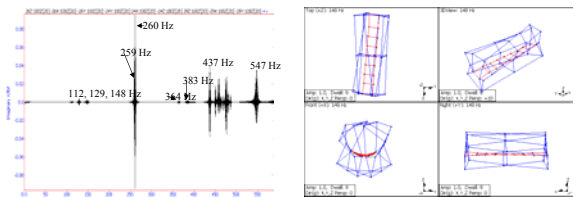


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Identification



- Modal Analysis
 - Identifies system properties
 - Frequencies, shapes, damping characteristics
 - Impact / Shaker Testing

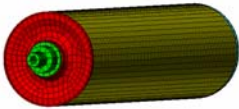


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Identification



- Modal Analysis
 - Finite Element Models



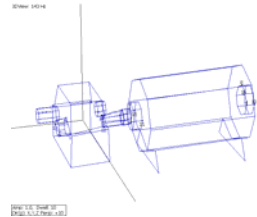
Model: 6 of 12
Frequency: 94.422 cycles/s
Maximum Value: Not Available
Minimum Value: Not Available

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Identification



- Operating Deflection Shape (ODS)
 - Identifies operating conditions



Model: 10 of 14
Max: 1.11E-04

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Controlling Resonance



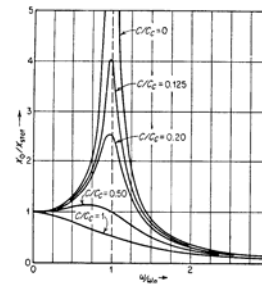
- Reduce forcing amplitude
- Avoid forcing a system at a natural frequency
 - Forcing Frequency (Rotational Speed)
 - Natural Frequency (Mass and Stiffness)

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Controlling Resonance



- Increase system damping



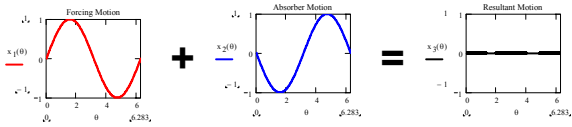
From Mechanical Vibrations,
J.P. Den Hartog

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Controlling Resonance



- Vibration absorption
 - Tuned mass, Active mass

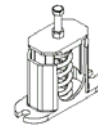


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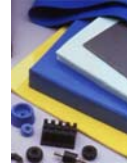
Controlling Resonance



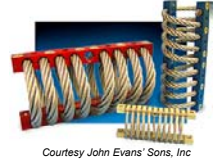
- Isolate resonant component
 - Springs, pads, pneumatic, suspending components



Courtesy Greenheck



Courtesy EAR
Specialty Composites



Courtesy John Evans' Sons, Inc

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Conclusion



- Define
 - Forcing Frequency = Natural Frequency*
- Effects
 - Damaging, Unsafe, Camouflages other problems*
- Testing Methods
 - Basic, Modal or ODS*
- Managing Resonance
 - Forcing, mass, stiffness, damping, absorber, isolation*

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