"A Practical Understanding of Phase, Time Waveforms and Resonance"

Presented By: Steve Buscarello, President & CEO, Update International, Inc.
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Course Description

Standard vibration analysis can too often focus solely on Frequency Analysis while ignoring the valuable and unique perspectives offered through other forms of analysis, such as: Phase, Time Domain and Resonance Analysis. Many vibration courses will barely touch on these topics, despite the fact that they are extremely useful and helpful in understanding what is actually happening within a machine—and what the best solution will be. This workshop will highlight these areas from a practical perspective, and help to emphasize and enforce the importance and potential uses of these techniques for any analyst no matter their level or years of experience.

Each topic will be explored using demonstrations and simulations while highlighting some of the insights offered through the signal processing issues that impact the effectiveness of these methods relative to any and all instruments. The Ultimate Goals of this workshop is to try to remove both the common misconceptions found in these forms of analysis, and help to emphasize the relative importance of these analyses when combined with pure Spectral Analysis

Course Outline

Phase

1) Obtaining the data
   a) Absolute Phase
   b) Relative Phase
2) Signal processing issues
   a) Why is phase sometimes hard to get?
   b) What system measurement parameters can change the end phase accuracy.
3) Relative relationship rules
   a) Basic rules relating vibration phenomena to their effects on phase relationships.
4) Use in understanding root cause
   a) What does the phase tell me is the problem?
   b) What does this tell me more than just the FFT Spectrum?
5) Practical tests/procedures
   a) Proving Resonance
   b) Determining Appropriate Mitigation
   c) When to Detune or Addressing the Source

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Time Waveform Analysis

1) Setup and obtaining the data
   a) Relationship between Length of Reading and FFT Resolution
   b) Effect of Nyquist Frequency on Time WAVEFORM
      i) **Close the book on Common Misconceptions for Nyquist Frequency**
2) Signal processing issues
   a) Too short of a Reading
      i) Potential hide issues such as Beats or Low Frequency Phenomena
      ii) Doesn't capture all Periodic Events
      iii) Missed events such as Transients
   b) Signal Clipping
      i) Amplitude seems lower than it is in reality
      ii) Poor ability to discern frequencies present.
   c) Too small Sampling Frequency
      i) Aliasing Present (High Frequencies appear as lower Frequencies)
      ii) Amplitude Accuracy Issues
      iii) Shape Accuracy Issues
      iv) Phase Accuracy
      v) NOTE: Higher Sampling RATE is better for all of the above Approximate Equations
      vi) If a frequency is not given shape accuracy, it will appear as multiple frequencies on an FFT.
3) Can perform Impact Analysis
   a) FFTs will see a single Impact as stimulating Many frequencies
   b) A Waveform will show a single/simple Impact as a base/ring frequency and an exponential decay
      i) Waveforms can be used to determine the Frequency of an Occurrence,
      ii) The Q factor and Resonance relationships of that Impact
      iii) Determine the Effects of the Natural Frequencies of the system and approximate locations
4) Fault determination
   a) Determine Base Characteristics such as Beats
   b) See if natural frequencies are likely present
   c) Time Waveform is the basis for Phase, Frequency, and Resonance Measurements
   d) Can "HEAR" a Fault

Resonance

1) What is it?
   a) Resonance is the phenomena present in ALL Objects that when stimulated will vibrate at this frequency.
      i) Pendulums, Swings, Tuning Forks, Glass breaking from Sound, etc.…
   b) Not all Resonance is Bad
      i) Some machines have tuned dampers that with a resonant at a specific frequency will remove all vibration at higher frequencies
   c) Creates Nodes and Antinodes of Vibration
      i) Nodes – Points of little to No Vibration
      ii) Antinodes – Points of high Vibration

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2) Tests and methods for proof of its impacts
    a) Resonance Run up and Coast down Test
        i) Determine if resonance is present in the speed change during the operation of the machine from on to off and vice versa
            (1) Very accurate for Frequencies in this range
            (2) Resonances in this region are Crucial to be aware of
    b) Frequency Response Function (FRF)
        i) Find frequencies and strengths of resonances based on response to a known added force across the Frequency Spectrum
        ii) Useful in finding Transfer functions and other mathematical representations of the system
        iii) Important for systems that are under constant control systems
    c) Bump Test
        i) Similar to FRF but done without a known force input
        ii) Can be done with the machine on or off
        iii) Shows frequencies across the spectrum for possible resonances
    d) 10 Point Plot
        i) Determine the locations of Nodes and Antinodes
        ii) Can prove resonance is occurring
        iii) Used for determine the best and most effective places to add braces of masses to change the resonance
        iv) Shows how the resonance will affect harmonics
        v) Shows the Mode Shape from the resonance
    e) Phase Relationships
        i) Some phase relationships can be used to show resonance
        ii) Resonance can be proved if Phase shifts 180° as the frequency changes.
3) Obtaining the data
    a) Find locations of Resonances
    b) Determine their relative impact on vibration
    c) Resonance can only be an issue if some force caused it to be
        i) Resonance cannot create vibration by itself
    d) Determine Q Factors between resonances to determine approximate effects on frequencies
4) Resonance Issues
    a) Phase is often hard to get good accuracy for
    b) Everything will always have some resonances and they may or may not have a negative impact
    c) Not always easy to change location of resonance
    d) From a Mathematical Standpoint, it is the only form of vibration that has theoretically unlimited energy, and if present will always destroy a machine eventually.

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