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BB3 Structural Vibration Problem Resolved Using Analytical Methods

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Installation

• 3 stage BB3 type

• Water injection service (1200 GPM @ 2650 ft)

• Driven through gearbox by natural-gas engine

• 3560 to 6000 RPM continuous operating speed range
Problem

Vibration Performance

- High bearing housing and casing vibrations showed after the pumps were relocated and put into a new service (Ran fine in previous life)

- Same problem with 3 identical units
- Horizontal vibration (~0.6 in/sec) at or above 5200 RPM
- Not able to reach full speed (6000 RPM)
Root Cause Analysis
Structural Resonance – Impact Testing

Impact tests show a horizontal structural resonance at approximately 85 Hz (5100 cpm) on pump inboard and outboard end.
Root Cause Analysis

Pump Lateral Rotordynamics

• High speed operation. (6000 RPM)
• Heavy coupling. (~100 lbs total)
• Long shaft span at drive end.
• Nearest seal is eye of suction impeller.
Root Cause Analysis

Overhung mode critical speed (~4700 RPM)

Low damping

Large coupling orbit
Root Cause Analysis

Recommendations

- Replace coupling
- Lateral stability improved
Root Cause Analysis

Support Structure Modal FEA

Not every seam welded

Uncertain hold-down locations
Root Cause Analysis

Support Structure Modal FEA

Horizontal pump mode
84Hz [5040 cpm]

Mode shape offers clues to detuning
Root Cause Analysis

Recommendations

Add gussets / struts

Box the pedestals

Predicts increase in natural frequency
136 Hz [8160 cpm]
Implementation

Bracing added to all four pedestals (as piping allowed)
Implementation

Drive-end pedestals also 'Boxed' to reduce twisting
Implementation

Coupling Changes

- Original – 48 lbs (pump-side)
- Profiled – 36 lbs (pump-side)
- Field Balanced

- Entirely new 13 lbs (pump-side)
Results

• Reduced Vibration
  – Original  0.60 in/sec  @ 5200 RPM
  – Added Struts  0.28 in/sec  @ 5800 RPM
  – Changed Coupling  0.19 in/sec  @ 6100 RPM

• Ability to run through entire operating speed range
Lessons Learned

• Avoid unnecessarily heavy couplings.
• Open communication facilitates root cause analysis.
• Fix problems when found, as found.
• Relocating equipment and/or changing services – including speed range – can result in vibration issues.