AXIAL VIBRATION FOR A SYNCHRONOUS MOTOR, GEARBOX, COMPRESSOR TRAIN
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Problem Statement

- Synchronous Motor (20KW), Gearbox, Inlet compressor
- Train installed 2007 with 2mm axial vibration mainly on the motor (low speed) side.
- Amplitude @ 2 mm with a frequency of 2.8 Hz (170/min). Gearbox running noisily.
Mathematical Model

FLEX. COUPLING

MOTOR     LS CPLG      GB  HS CPLG   COMPR
Rotor 1
Damped Freq=74.8049 RPM
Log Dec=4.4464

Rotor 2
Damped Freq=74.8049 RPM
Log Dec=4.4464

Rotor 3
Damped Freq=74.8049 RPM
Log Dec=4.4464

Rotor 4
Damped Freq=74.8049 RPM
Log Dec=4.4464

Courtesy of Jason Kaplan, ROMAC/University of Virginia.
Assumptions

• Gear mesh is infinite rigid relative to other axial springs in the system and gear mesh damping effect is neglected
• The compressor rotor is axially stationary as the thrust bearing stiffness is much higher when compared to coupling axial stiffness
• The coupling stiffness non-linearity is ignored at low load
• The thrust Bearing is infinite rigid and its damping effect ignored
Calculation Results

- M-motor = 12000kg
- K-ls-cplg-axial = 1.7E6 N/M
- M-gb = 3500 kg
- K-hs-cplg-axial = 2.4E6 N/M
- Ncrit1-axial = 1.4 Hz (85 CPM)

- The axial oscillation frequency is 2.8 Hz.
- The rotor oscillates at 2X Ncrit1-axial and is visible to the observer.
Discussion

- API Standards do not discuss axial critical speeds
- The coupling axial gap is a variable dimension due to ambient temperature and rotor thermal condition changes.
- Axial resonances are rarely observed events. The Author is aware of only a few known cases (<5)
- There is little literature or research available on this subject.
- It is common belief if the axial alignment and thrust bearing clearances are set properly excitation forces will not be large enough to excite the axial natural frequency
Solution

• Motor magnetic center recheck with no change made

• Limited end float coupling installed. The vibration amplitude was reduced but not eliminated

• Extreme high axial alignment target was implemented with original disc pack coupling. Axial oscillation issue solved.
Conclusion & Recommendation

• The train experienced axial vibration at 2X of the train 1st axial natural frequency. Bull gear and pinion relative displacement was observed and calculated.
• Excitation force came from misalignment and motor magnetic centering force.
• The motor is not designed to run off magnetic center. The motor centering force is believed to be around 100-200 lbf/1000 HP.
• The motor centering force is believed to be non-linear to the axial displacement.
• The motor centering force coupled with misalignment was sufficient to trigger the observed axial oscillation.
• High axial vibration was resolved by better alignment.
• The study concluded axial vibration thresholds exist. They depend on axial excitation forces and axial mass-elastic property.
• More research in this directions is necessary to improve coupling design requirements and alignment criteria.
Lessons Learned

• Compressor trains with very low axial stiffness coupling tend to have low frequency axial oscillations.

• High alignment targets can reduce the excitation force. The process can be time consuming and misalignment change with ambient condition.

• Damping effect is low in the discussed motor compressor train which makes this simplified simulation valid and relates well with what was observed.

• Running at 2X axial natural frequency can cause axial vibration and LCF at coupling and gearbox. This can be a significant reliability issue.

• Precaution shall be given to coupling design to increase the lowest axial critical speed frequency.