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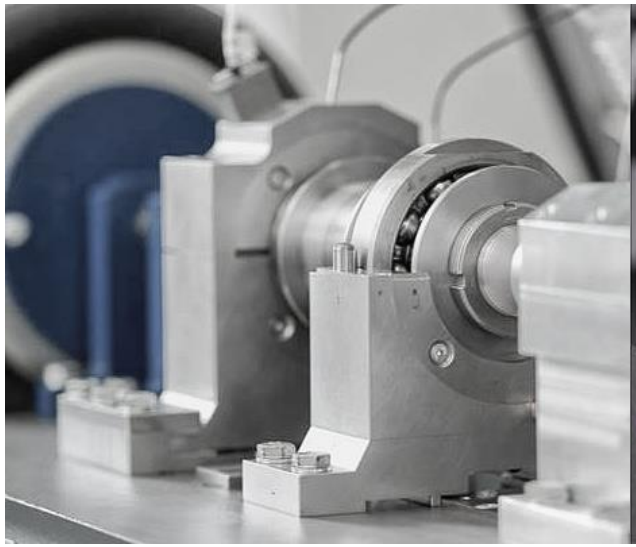
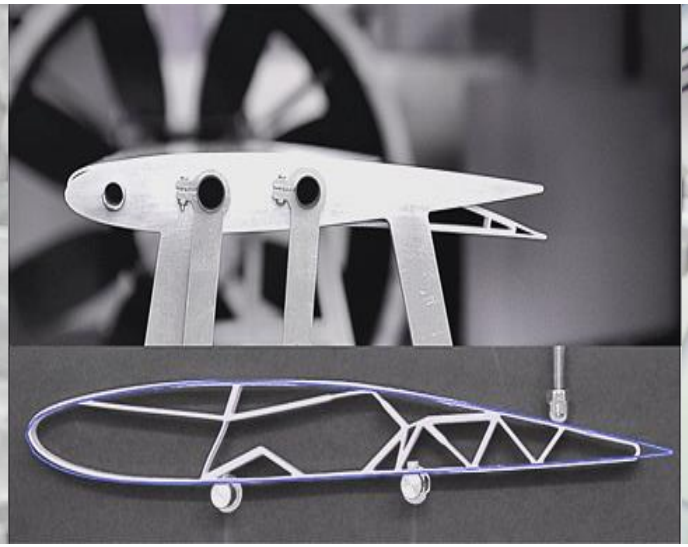
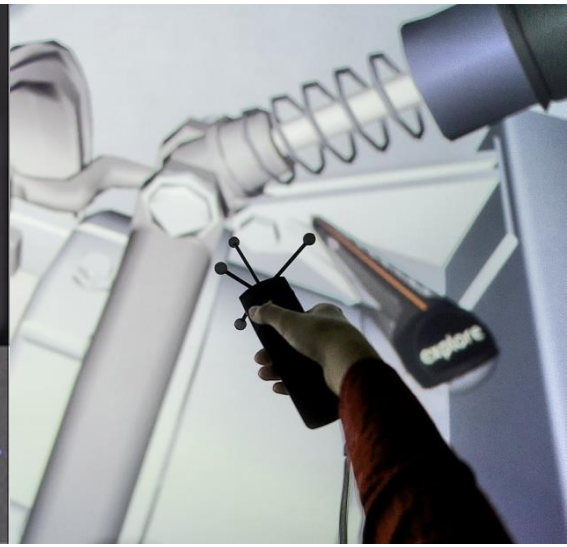
Friction Losses of Cylindrical Roller Bearings Due to Axially Oscillating Shafts

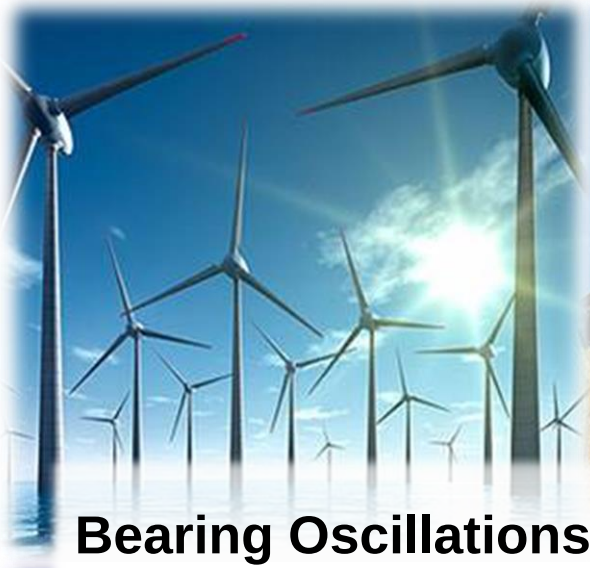
Andreas Meinel, Stephan Tremmel



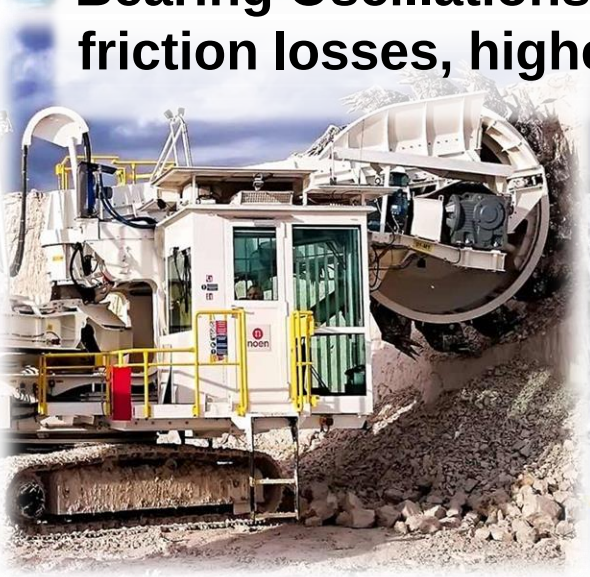




Motivation



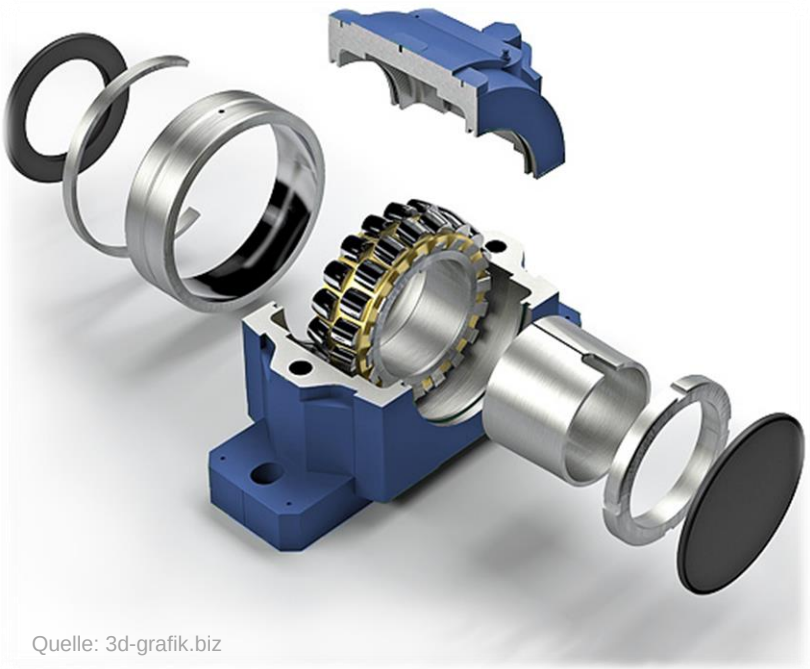
Bearing Oscillations occur in many applications and can cause friction losses, higher temperatures and lubricant degradation!



Quellen: energie-xxl.de, traktorpool.de, faz.de, noen.cz, technology.risiinfo.com, rdoequipment.com

Outline

? How do axial shaft oscillations affect friction losses in cylindrical roller bearings and how is this contingent on oscillation frequency and amplitude, rotational speed or radial load?

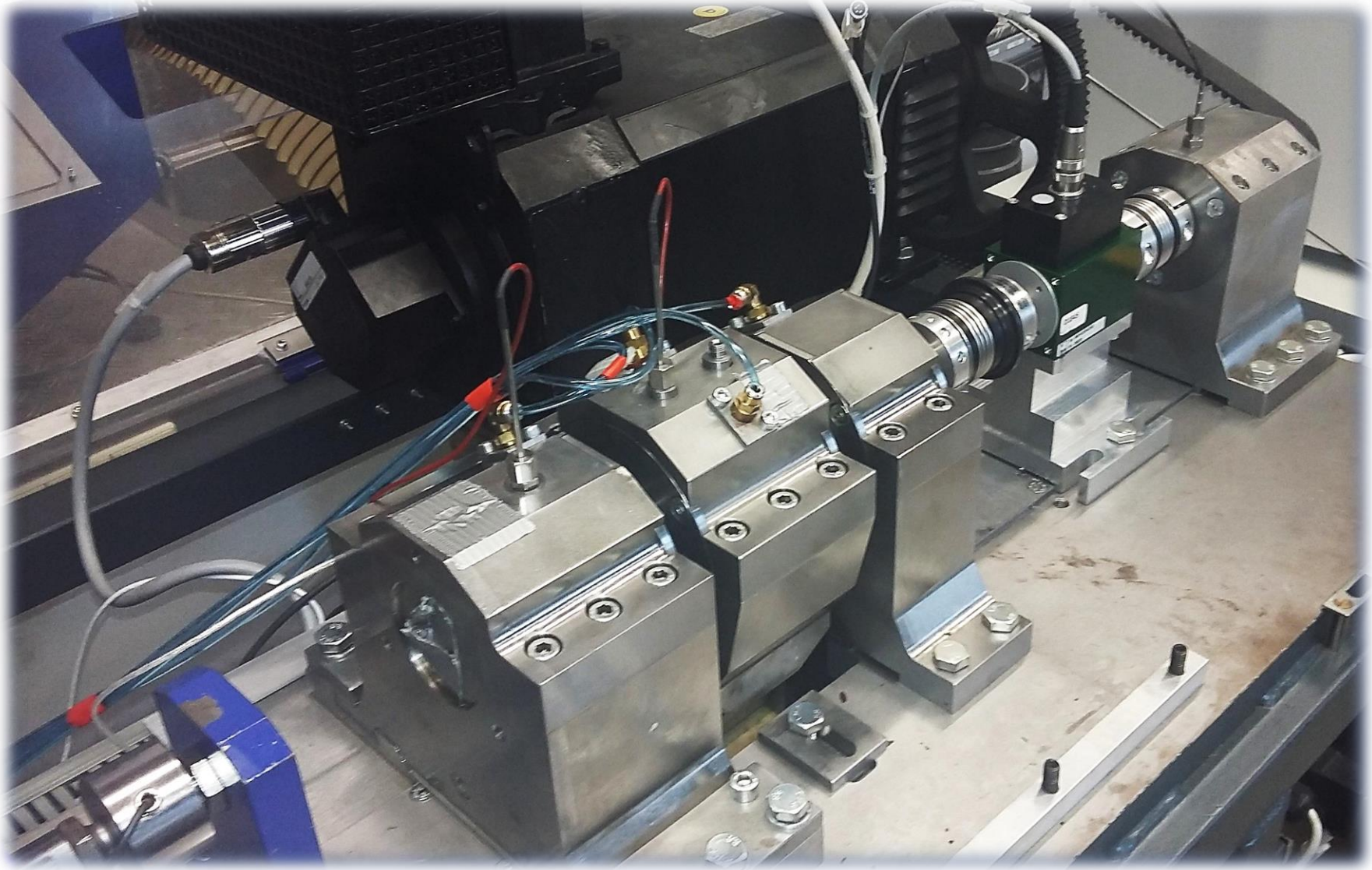


Quelle: 3d-grafik.biz

- Bearing Test Rigs
  - Bearing Friction Test Rig
  - Oscillation Test Rig
- Experimental Procedure
  - Test Parameters
  - Method of Analysis
- Results
  - Axial Friction Forces
  - Power Losses
- Summary and Conclusions

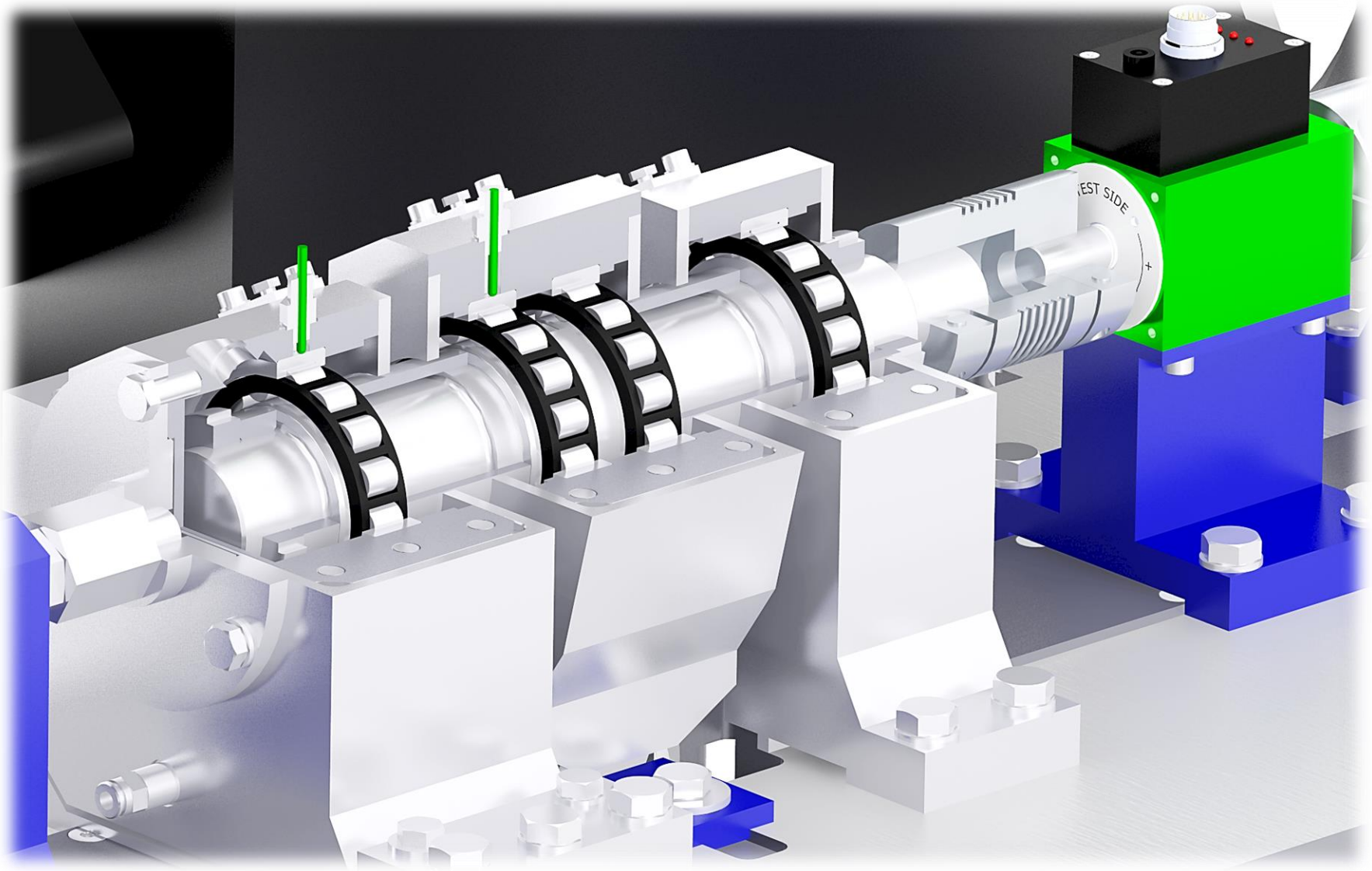
Bearing Friction Test Rig

Overview



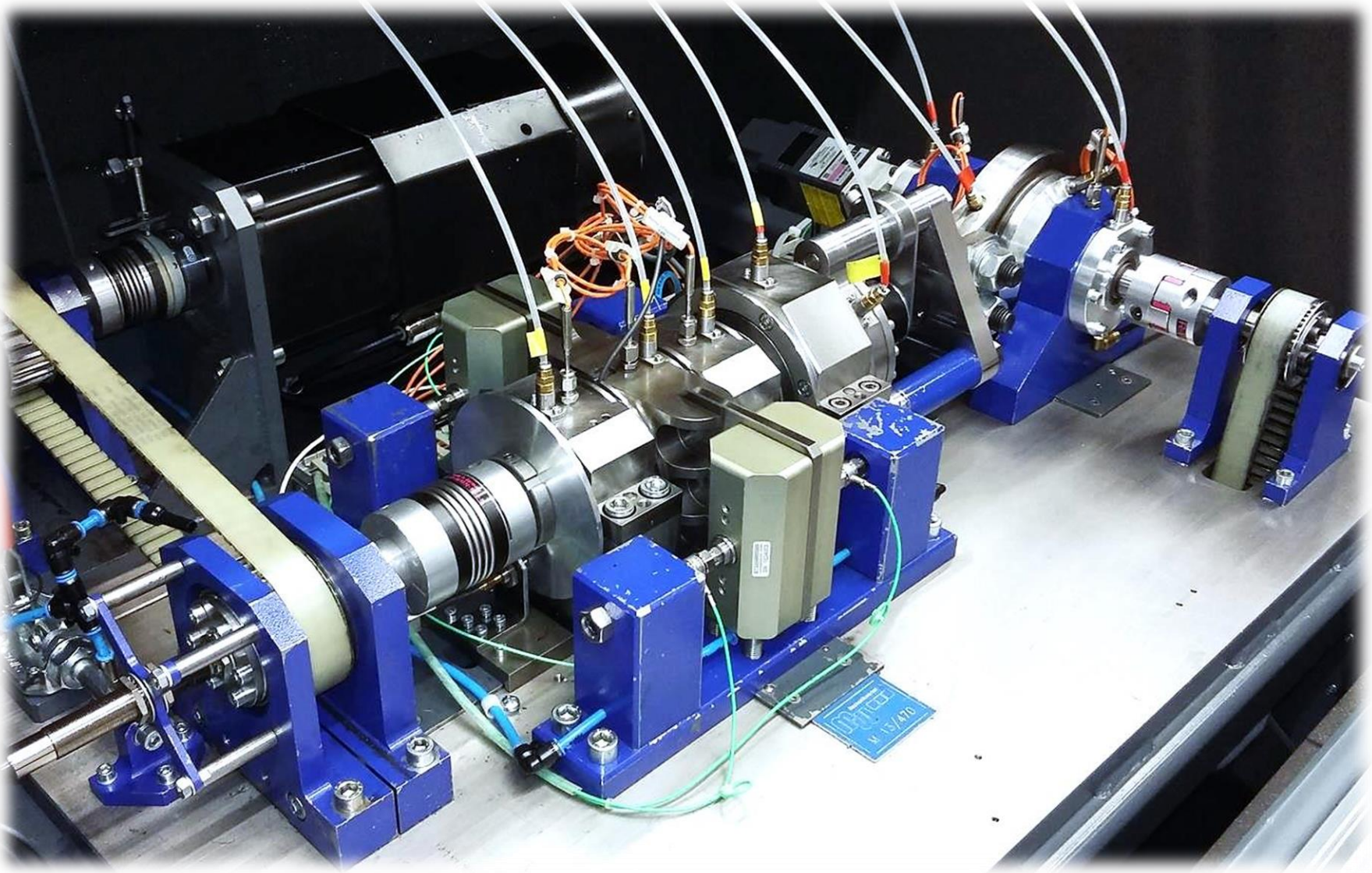
Bearing Friction Test Rig

Cross Section of the Test Bearing Unit



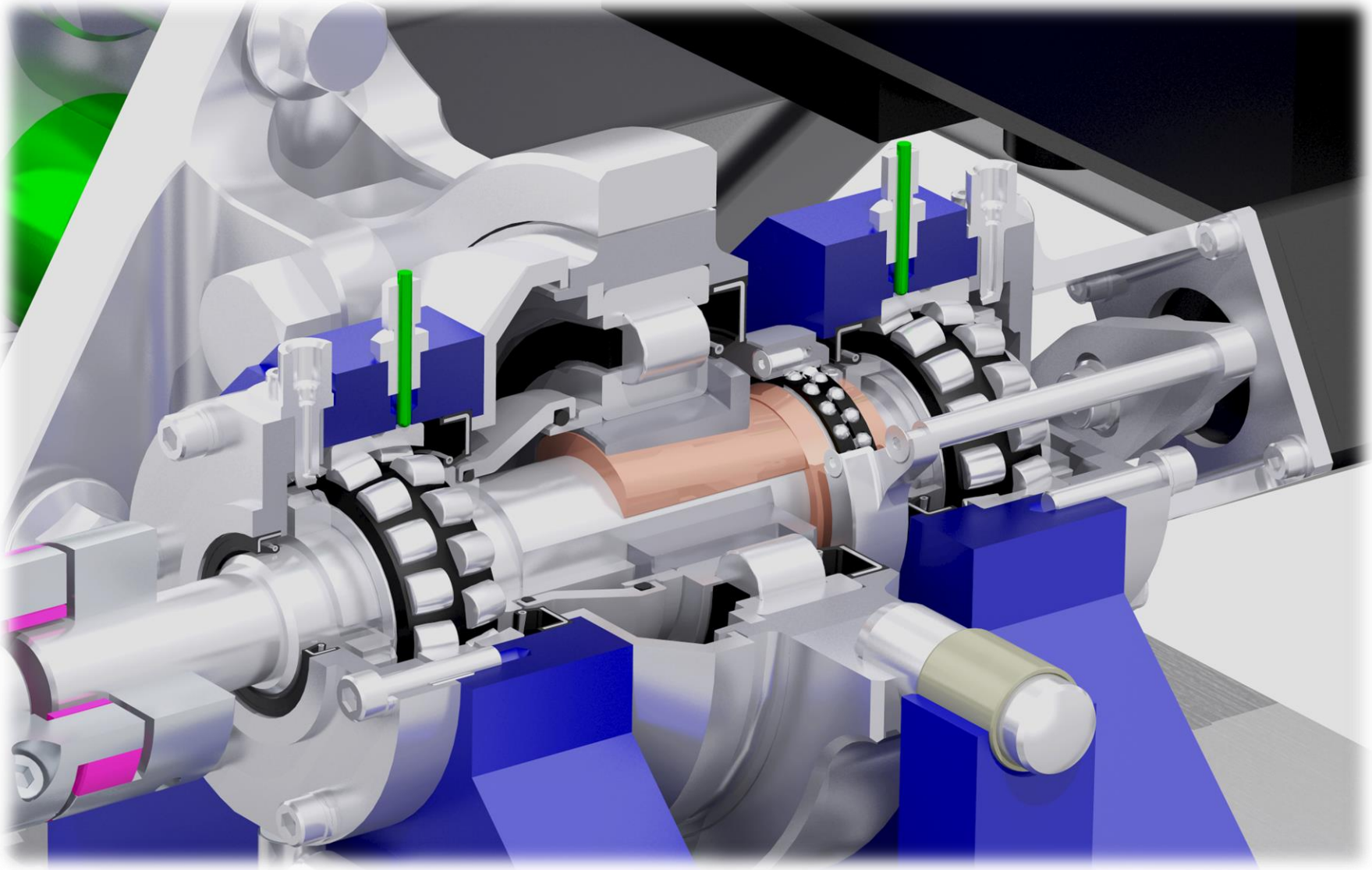
Oscillation Test Rig

Overview



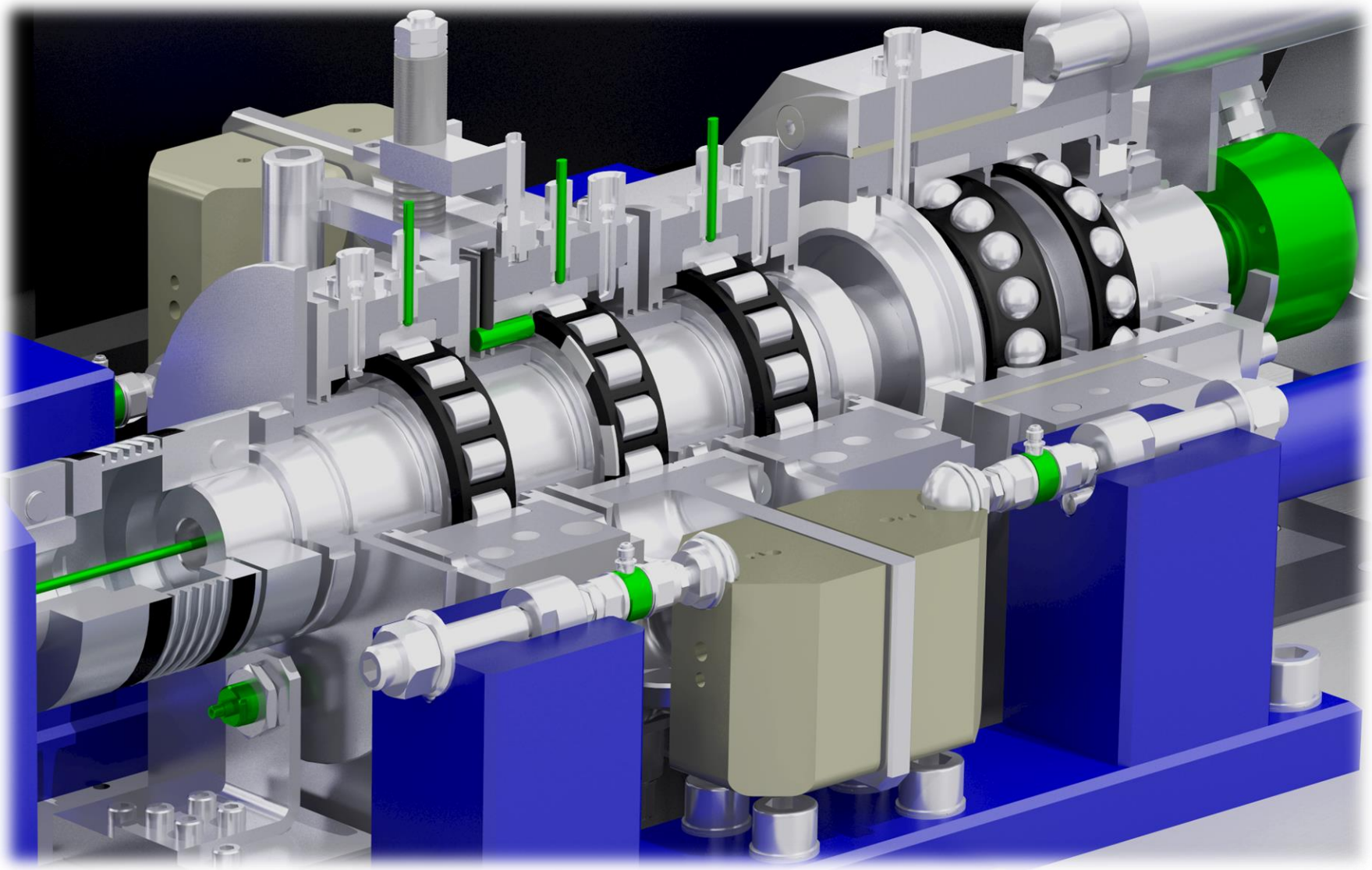
Oscillation Test Rig

Cross Section of the Eccentric



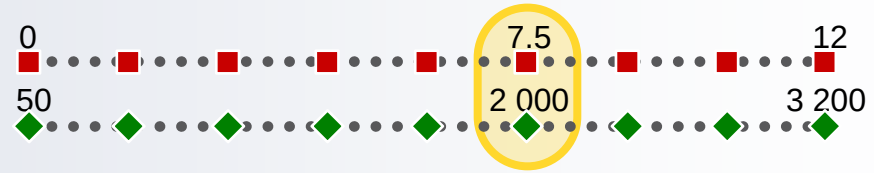
Oscillation Test Rig

Cross Section of the Test Bearing Unit



Experimental Procedure

Test Parameters and Method of Analysis



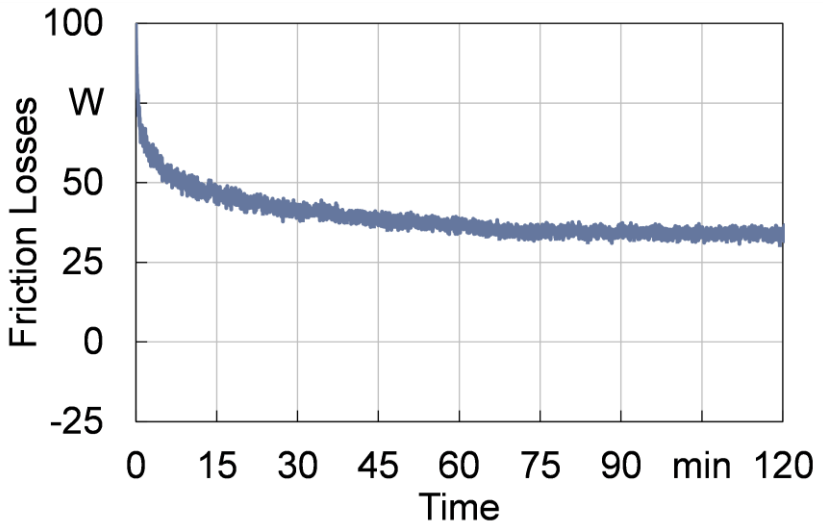
Bearing friction moment M_{rot}

$$M_{rot}(t) = \frac{1}{4} M_{total}(t)$$

Friction losses due to rotations P_{rot}

$$P_{rot}(t) = 2 \cdot \pi \cdot n \cdot M_{rot}$$

$$P_{rot} = P_{rot}(t = 120\,\text{min})$$



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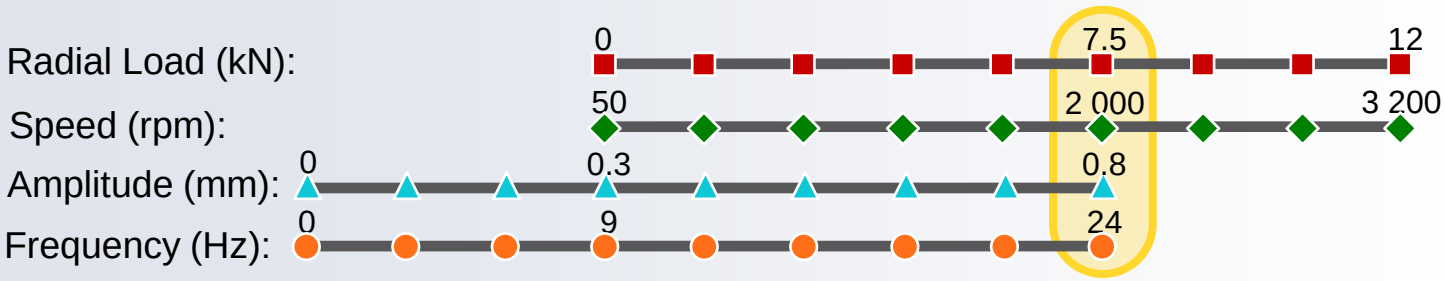
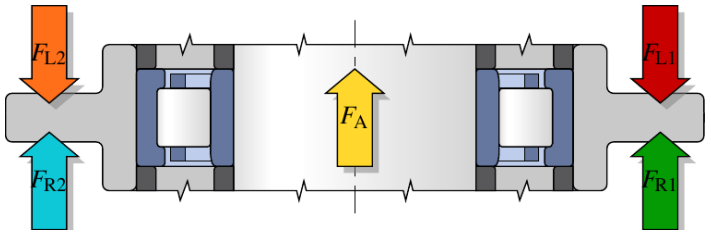
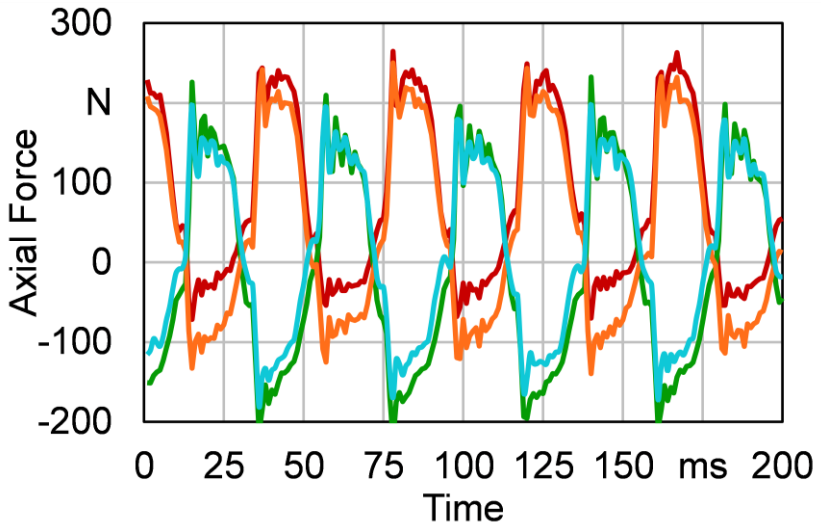


Axial friction force F_A

$$F_A(t) = F_{L1}(t) + F_{L2}(t) - F_{R1}(t) - F_{R2}(t)$$

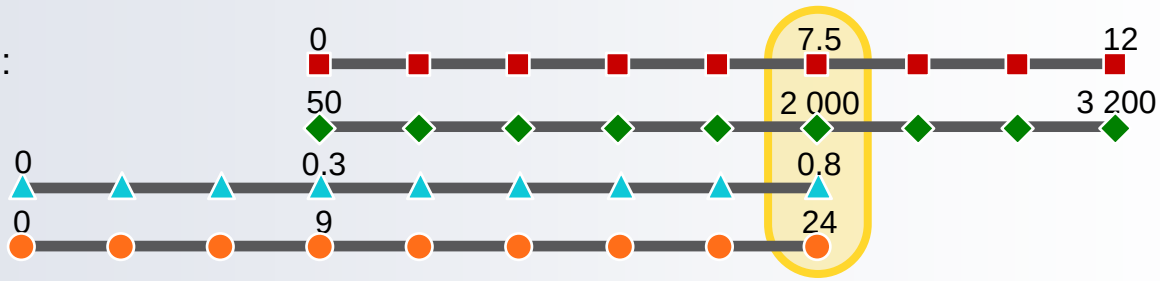
$$F_A = \frac{1}{t_s}\int_0^{t_s} \left|F_A(t)\right| \, \mathrm{d}t$$





Experimental Procedure

Test Parameters and Method of Analysis



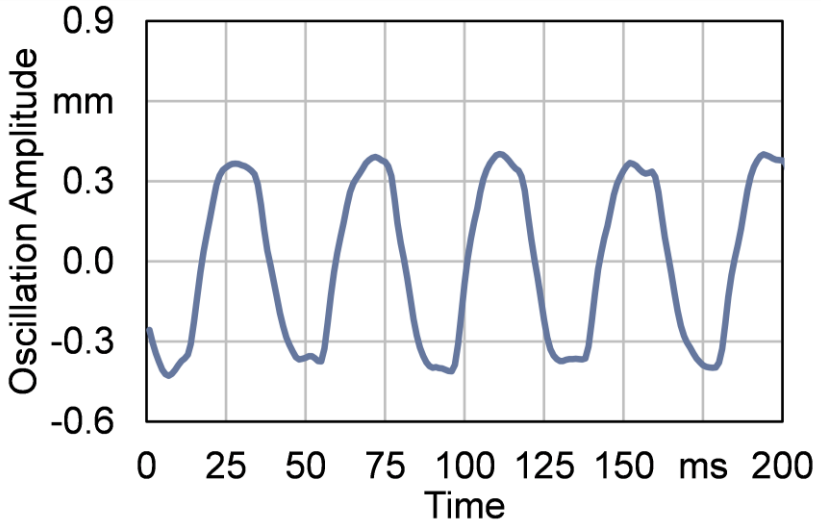
Axial friction force F_A

$$F_A(t) = F_{L1}(t) + F_{L2}(t) - F_{R1}(t) - F_{R2}(t)$$

$$F_A = \frac{1}{t_s}\int_0^{t_s} \left|F_A(t)\right| \mathrm{d}t$$

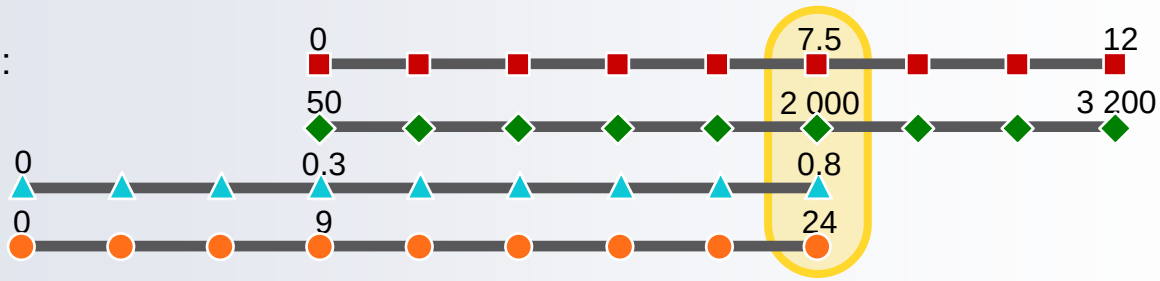
Oscillation velocity v_{osc}

$$v_{osc}(t) = \frac{\mathrm{d}s_{osc}(t)}{\mathrm{d}t}$$



Experimental Procedure

Test Parameters and Method of Analysis



Axial friction force F_A

$$F_A(t) = F_{L1}(t) + F_{L2}(t) - F_{R1}(t) - F_{R2}(t)$$

$$F_A = \frac{1}{t_s}\int_0^{t_s} \left|F_A(t)\right| \, \mathrm{d}t$$

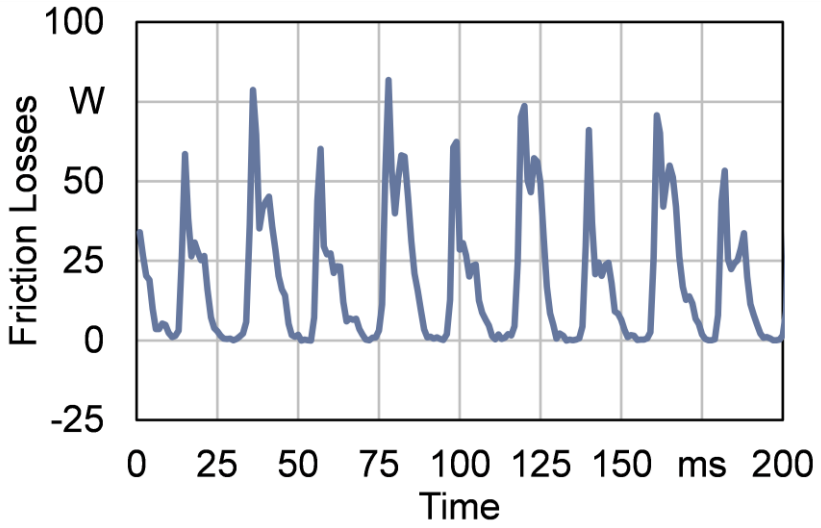
Oscillation velocity v_{osc}

$$v_{osc}(t) = \frac{\mathrm{d}s_{osc}(t)}{\mathrm{d}t}$$

Friction losses due to oscillations P_{osc}

$$P_{osc}(t) = \left|v_{osc}(t) \cdot F_A(t)\right|$$

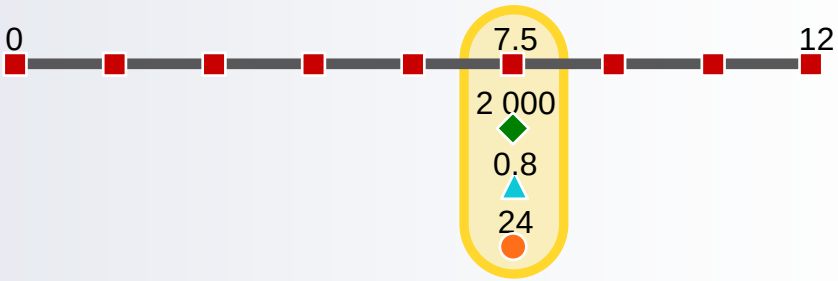
$$P_{osc} = \frac{1}{t_s}\int_0^{t_s} P_{osc}(t) \, \mathrm{d}t$$

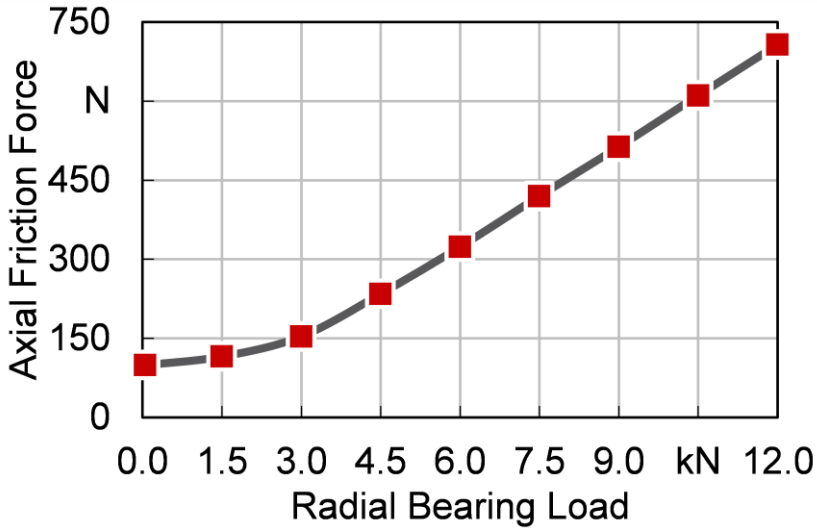


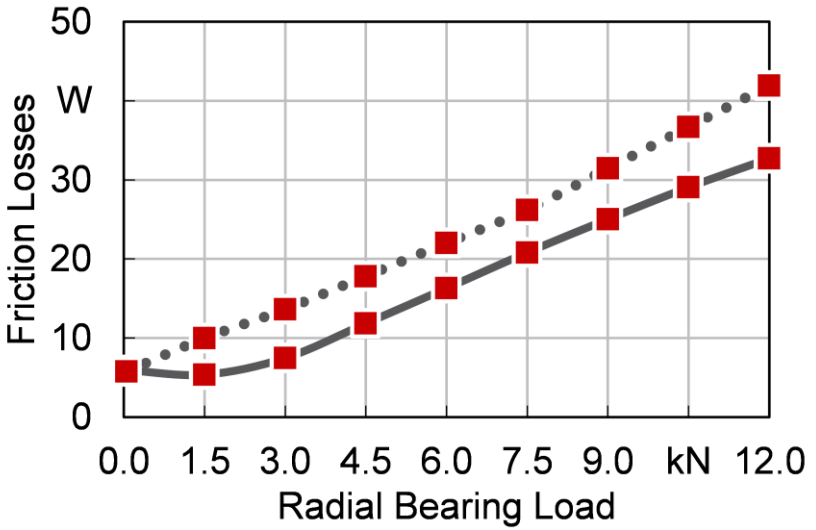
Results

Variation of Radial Load

Radial Load (kN):
Speed (rpm):
Amplitude (mm):
Frequency (Hz):







- Axial friction forces are linearly amplified with increased radial loads.
- Axial shaft oscillations cause significant additional friction losses.

Results

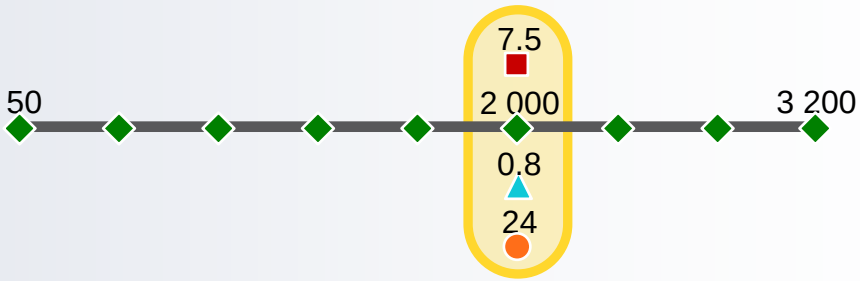
Variation of Rotational Speed

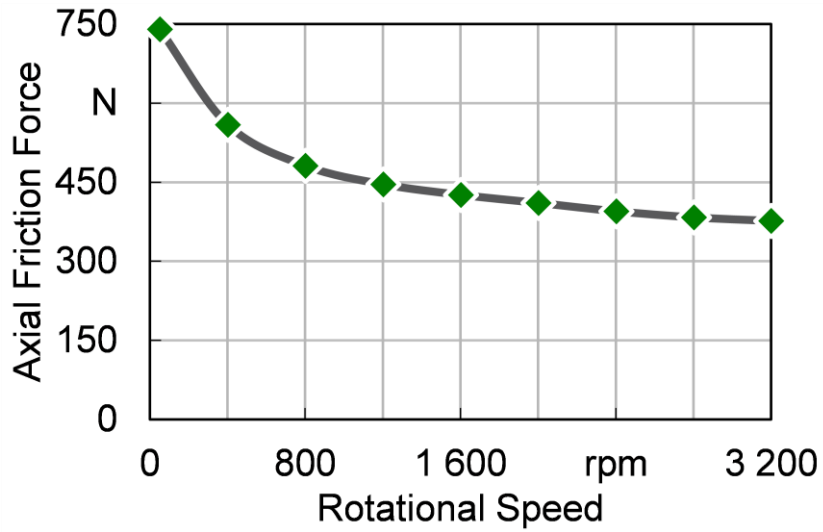
Radial Load (kN):

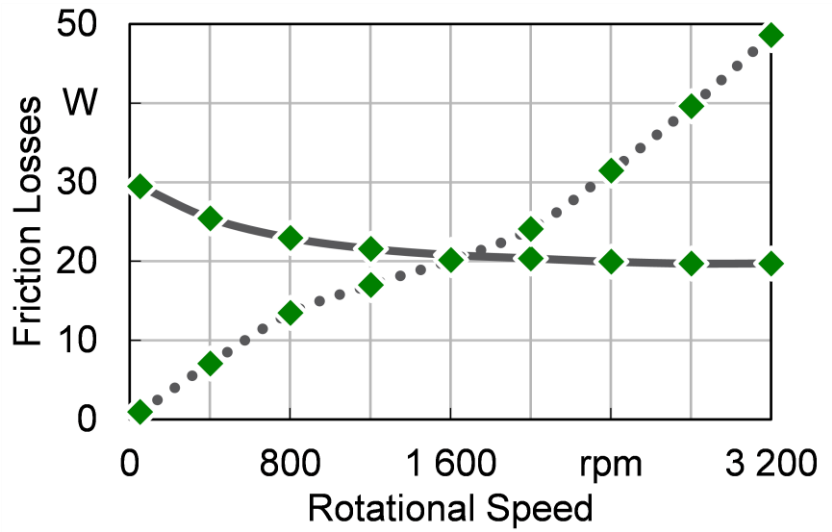
Speed (rpm):

Amplitude (mm):

Frequency (Hz):







- Faster rotational speeds lower the axial friction forces.
- Oscillations exhibit the greatest impact on friction losses at low to moderate speeds.

Results

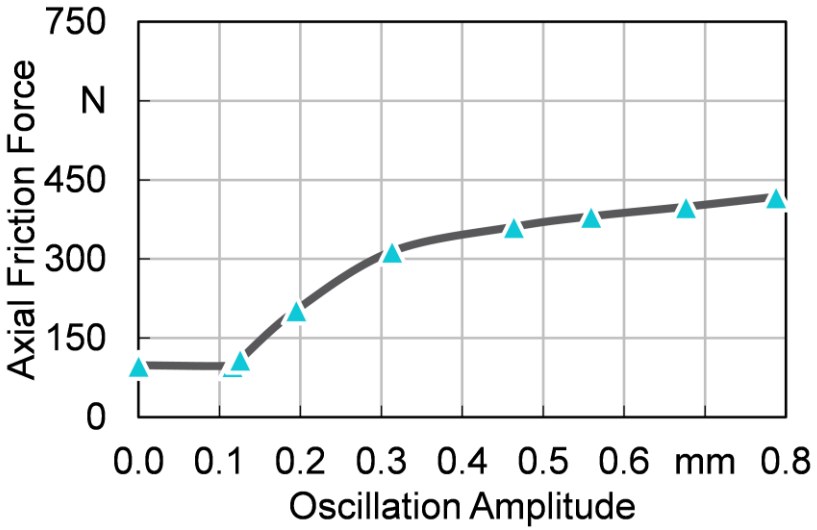
Variation of Oscillation Amplitude

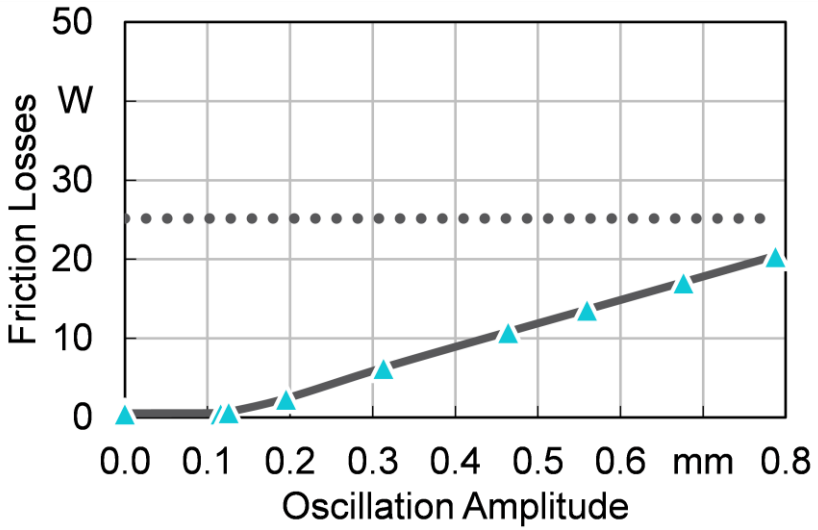
Radial Load (kN):

Speed (rpm):

Amplitude (mm):

Frequency (Hz):





- The axial forces approach a maximum value for higher amplitudes.
- Low amplitudes have no significant impact on axial forces and friction losses.

Results

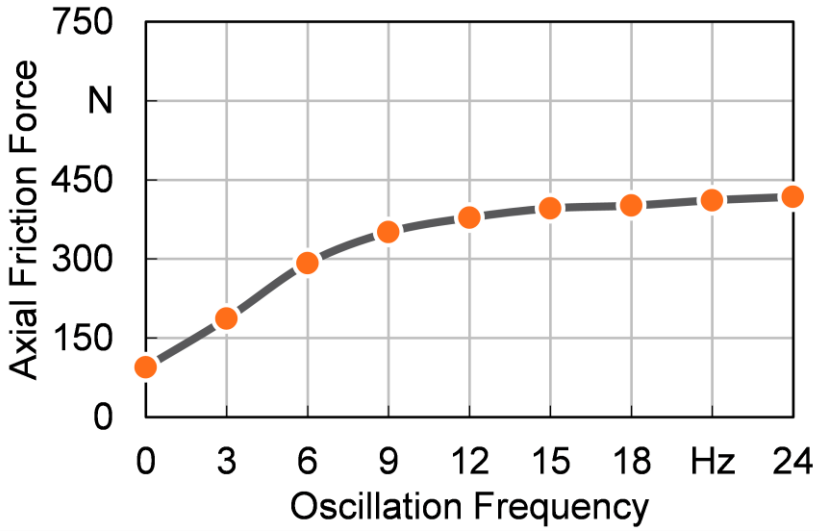
Variation of Oscillation Frequency

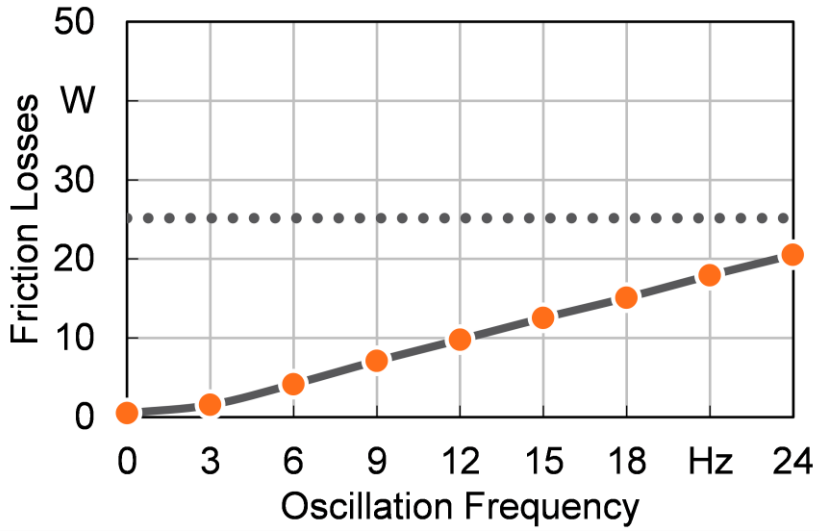
Radial Load (kN): 7.5

Speed (rpm): 2 000

Amplitude (mm): 0.8

Frequency (Hz): 0 9 24





- The axial forces approach a maximum value for higher frequencies.
- The friction losses increase with faster oscillation velocities.

Summary and Conclusions

?

How do axial shaft oscillations affect friction losses in cylindrical roller bearings and how is this contingent on oscillation frequency and amplitude, rotational speed or radial load?

- Oscillation amplitudes need to exceed a certain threshold to cause significant friction losses.
- The axial forces approach a maximum value for higher amplitudes and frequencies.
- Axial forces and friction losses are amplified with increased radial loads.
- The friction losses increase linearly with the oscillation velocity.
- Oscillations have the gravest effect at low rotational speeds.
- Axial oscillations can generate very significant power losses and temperature increases.

Thank you for your attention!
Any questions?