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Evaluating self-lubricating materials for large scale bearings functioning under seawater conditions

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Laboratory Soete

Tribology and Fatigue

Application

- Civil engineering : moving parts
- Ships & deck applications
- Locks, gates, drawbridges
- Mooring systems
- Hydropower

What makes these applications special

- Water lubricated
- Small amplitude
- Small velocity
- Corrosive/ underwater
- Permanent loading

Typical materials

Bulk polymer materials

- Cheap
- Low strength
- Low PV value

Bronze materials

- Base material + solid lubricant
- High strength
- Friction μ ≈ 0.2
- Use of lead (lead bronze / lubricant)
- Adhesive wear / fretting wear

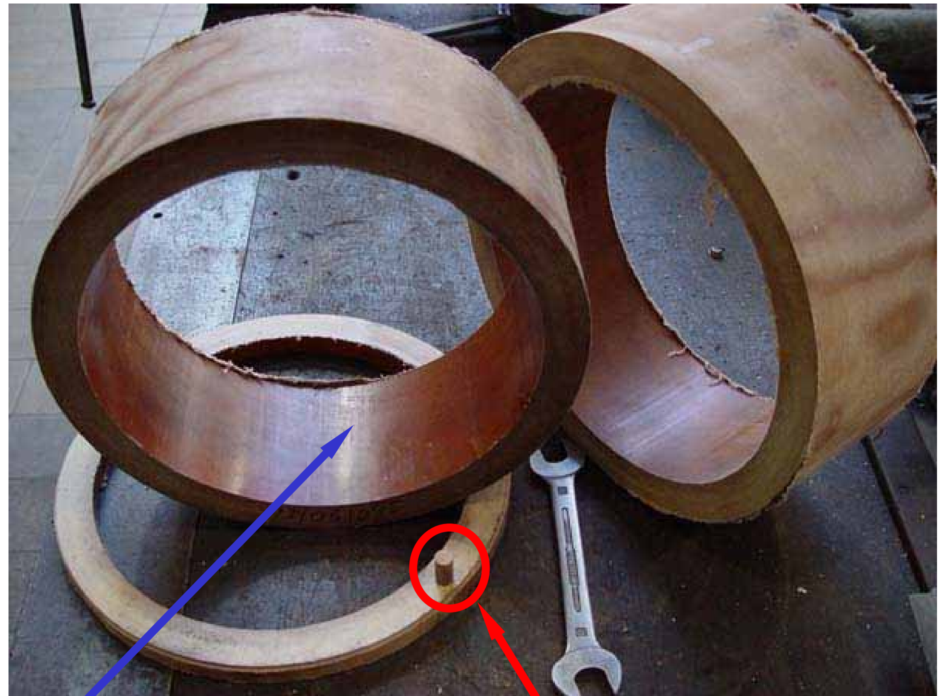
Composite materials

- Fibres : increased strength
- Solid lubricant PTFE
- Friction μ ≈ 0,1
- PV limit

Large scale testing

SCALE DEPENDENT:

- Distribution of solid lubricant
- Contact pressure & distribution
  - Edge effect
  - Non-uniform pressure
- Behaviour of wear particles
- Effect of (small) stroke



Typical application

Ø 300 mm

Typical small scale test

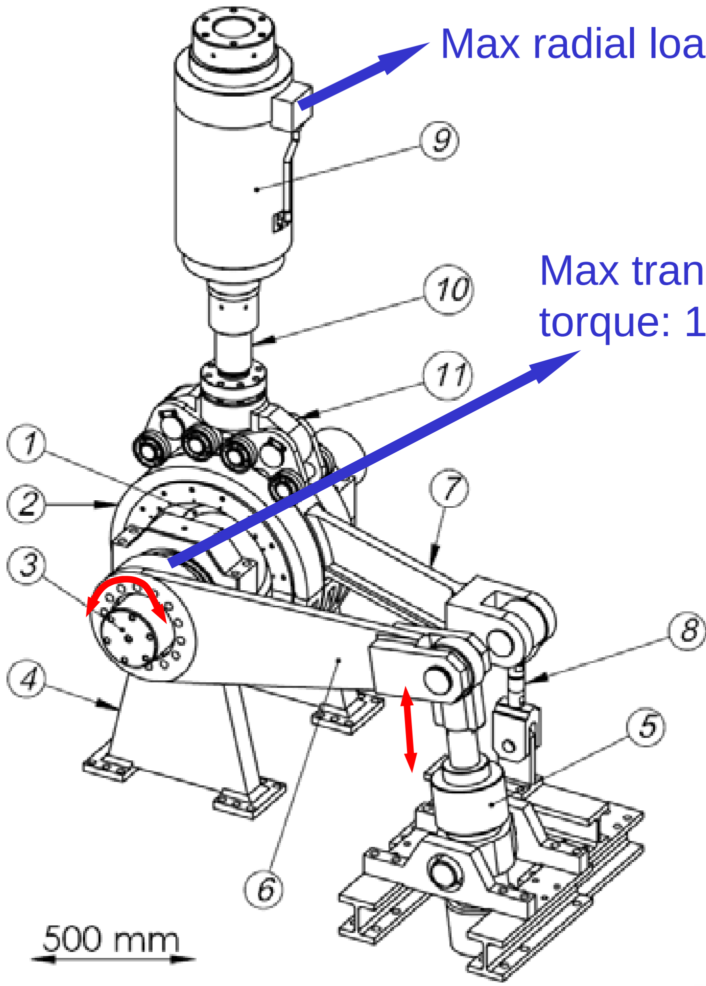
Ø 8 mm

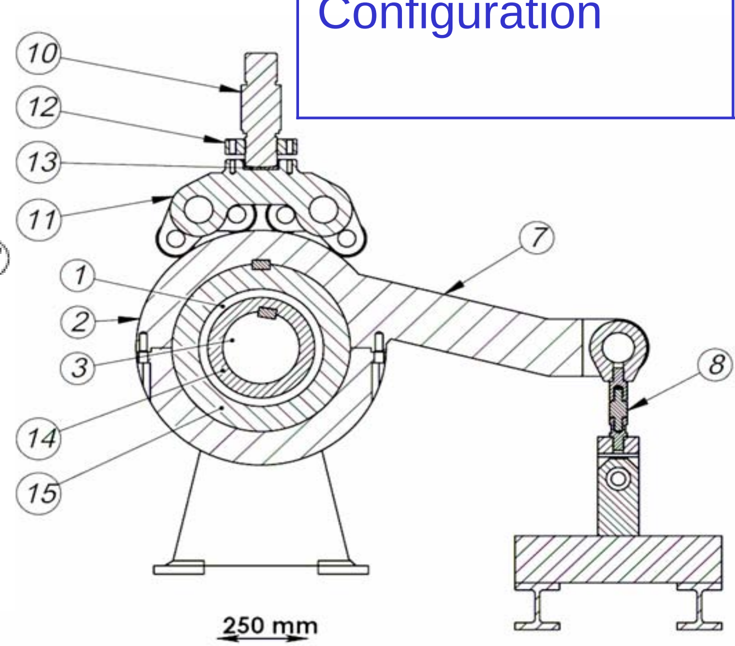
Test setup

- ➢ Radially loaded bearing
- ➢ Load introduced by carriage (8 wheels)
- ➢ Shaft of bearing: oscillating movement
- ➢ Side flanges + seals: water lubrication

- ❑ Measured signals
  - ✓ Friction torque
  - ✓ Bulk temperature countersurface
  - ✓ Vertical displacement of bearing (wear)
- ❑ Controlled
  - ✓ Drive piston displacement
  - ✓ Radial load

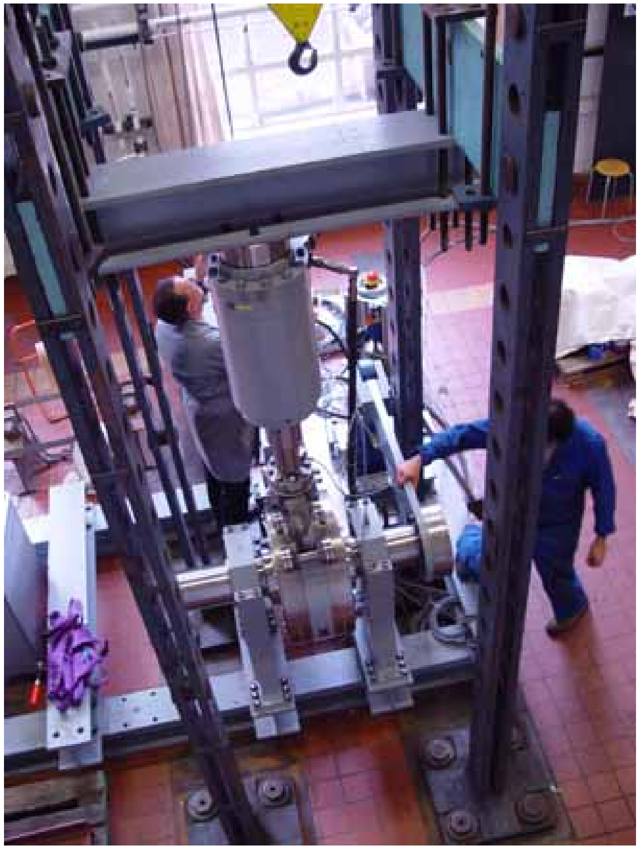
Test setup





Radial load	1350 kN
Max bearing size	Ø 400 mm, Length 300 mm
Max rotation	+/-15°
Max torque	100 kNm
Configuration	Moving shaft Moving bearing

Test setup

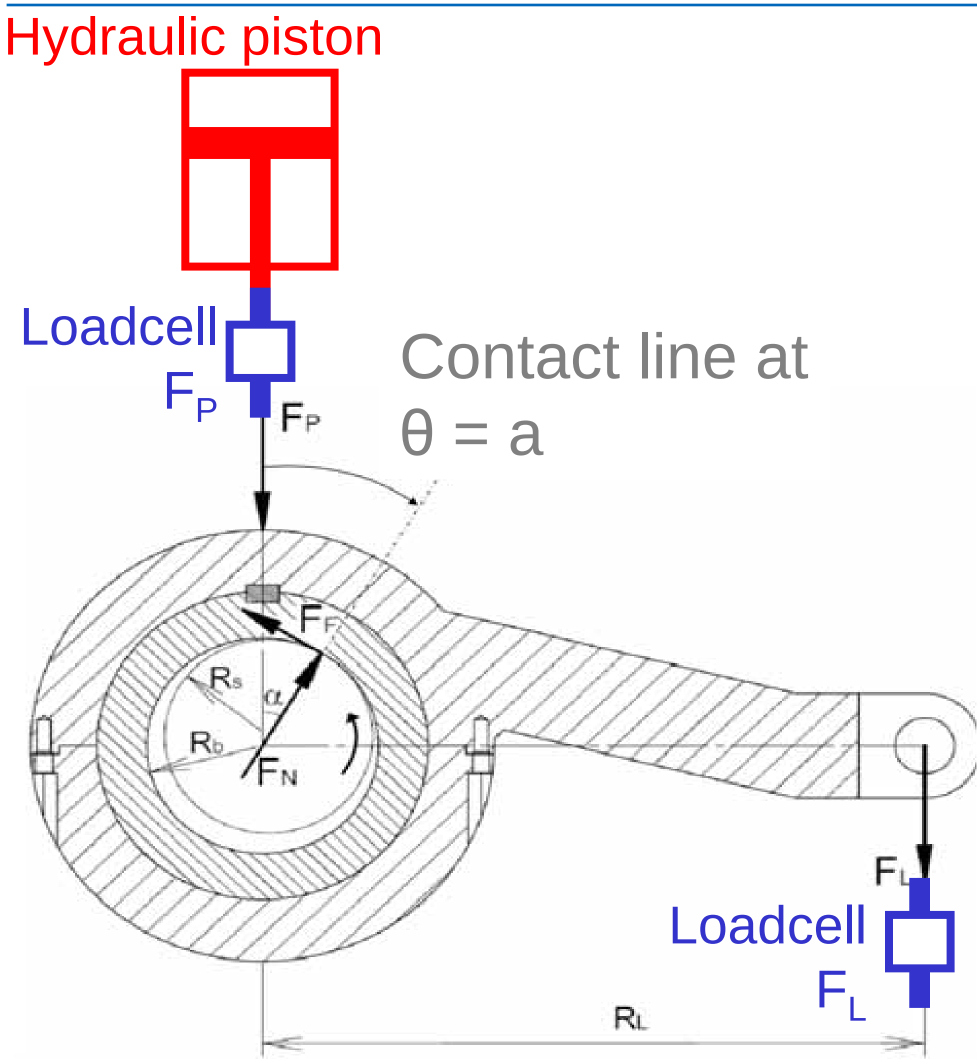


Specimens

Bearing material
Back-up ring

Countersurface
Temperature sensor

Calculation of the COF



Sliding

$$\mu = \frac{F_F}{F_N} = \tan\alpha = \frac{1}{\sqrt{\frac{1}{\sin^2\alpha} \quad 1}}$$

$$\sin\alpha = \frac{R_L}{R_B}\frac{F_L}{F_P + F_L}$$

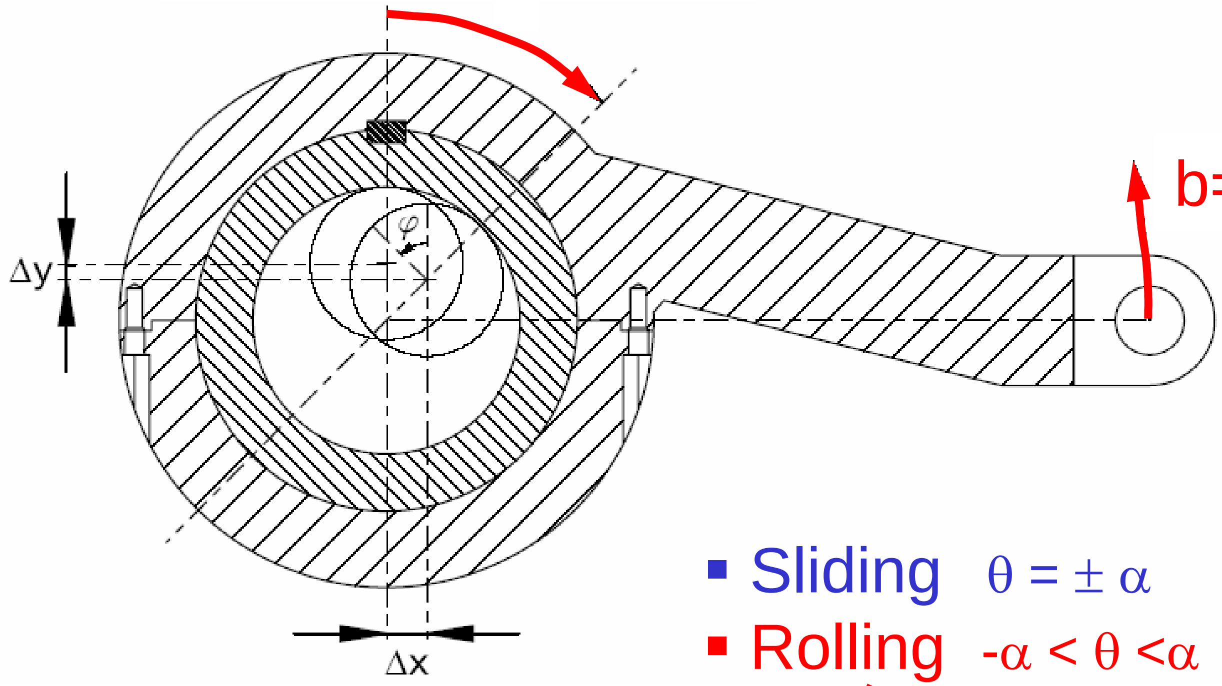
$$\mu = \frac{1}{\sqrt{\left(\frac{R_b}{R_L}\right)^2\left(\frac{F_P + F_L}{F_L}\right)^2 - 1}} = \tan\alpha$$

R_L, R_b: known geometrical values

Oscillating movement

At velocity reversal: ROLLING

θ: position contact line



$$\varphi = \theta \cdot \frac{(R_s - R_b)}{R_s}$$

$$\Delta y = (R_b - R_s)\cdot(1-\cos\theta)$$

$$\Delta x = \underbrace{(R_b - R_s)}_{\text{Bearing clearance}}\cdot \sin\theta$$

Bearing clearance

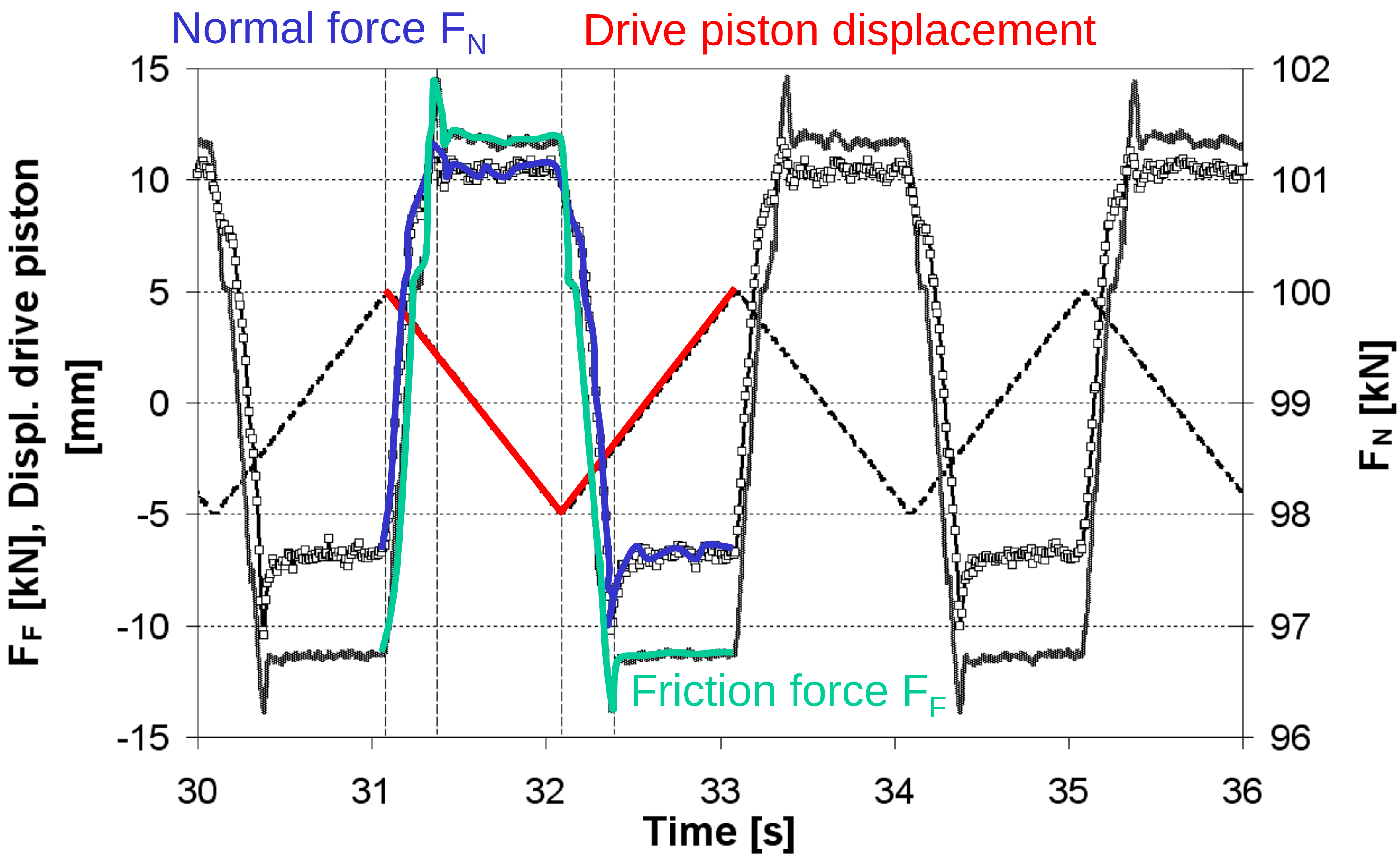
- Sliding $\theta = \pm\alpha$
- Rolling $-\alpha < \theta < \alpha$

Shaft rotation during rolling: $\varphi_{2\alpha} = 2\alpha \cdot \frac{(R_s - R_b)}{R_s} = 2\alpha \frac{\text{clearance}}{\text{diameter}}$

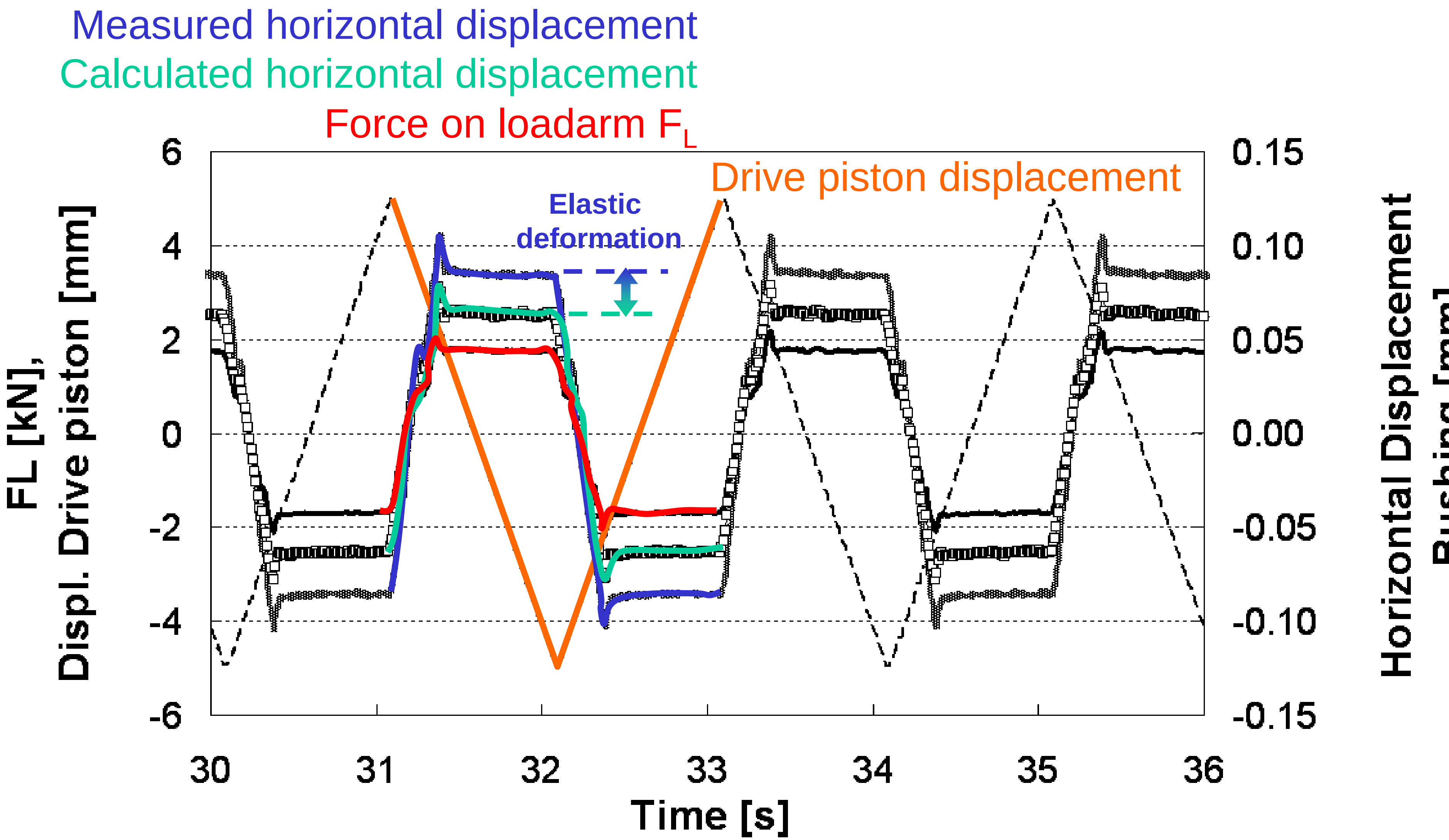
Materials and test conditions

Normal load:	100 kN (compression)
Contact Pressure:	2.8 MPa
Velocity bearing:	10 mm/s
Sliding stroke:	10 mm
Friction material:	Filament wound composite material Polyester fibres Phenolic resin and PTFE (solid lubricant) $\rightarrow \varnothing$ 300 mm x 120 mm
Counterspecimen:	Steel S355J2G3 $\rightarrow$ surface roughness: 0.2 µm < R_a < 0.3 µm
Bearing clearance:	1.1 mm

Test results



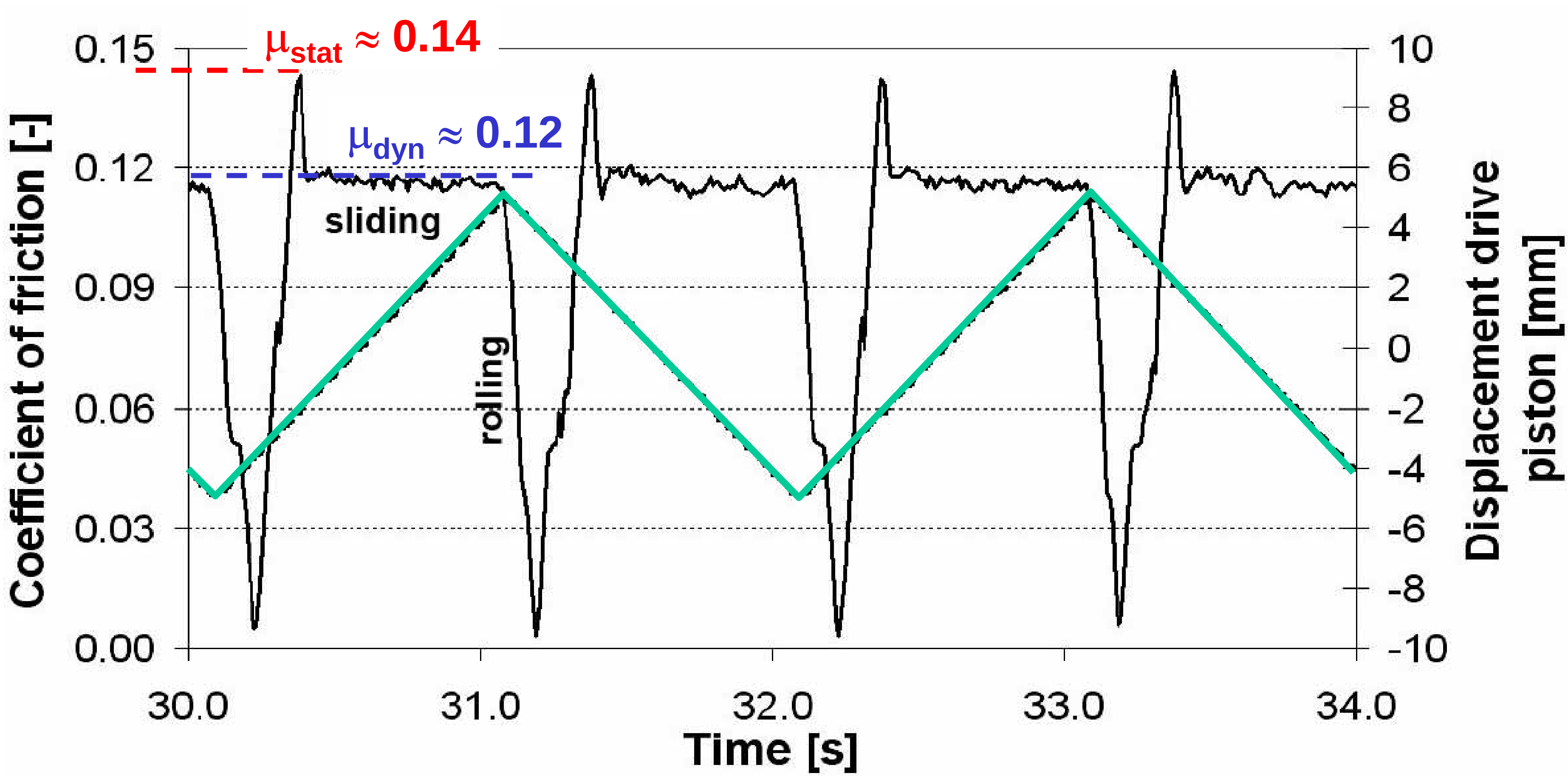
Test results



Test results

Coefficient of friction

Drive piston displacement



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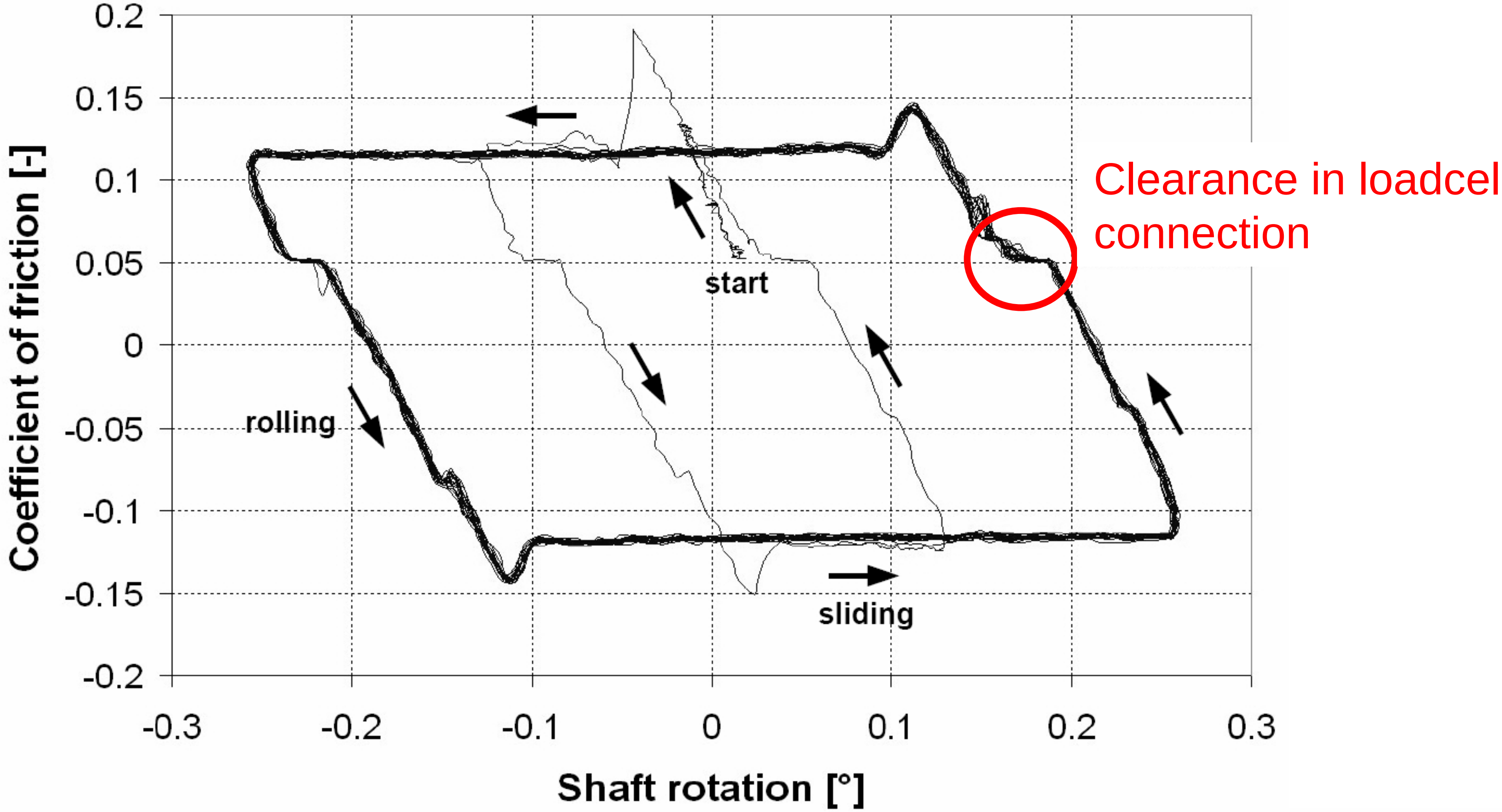
Test results

Coefficient of friction – shaft rotation



Conclusions

✓ Test apparatus developed for

→ Large scale testing(heavy loading conditions)

→ Evaluation of friction and wear behaviour of journal bearings

→ Dry and wet (seawater) operating conditions

✓ First tests show

→ COF can be calculated from the measured F_P and F_L

→ Measured values of COF correspond to manufacturers values

→ Elastic deformation should be taken into account for the calculation of the rolling angle