Tribological performance – from model scale to component scale tests

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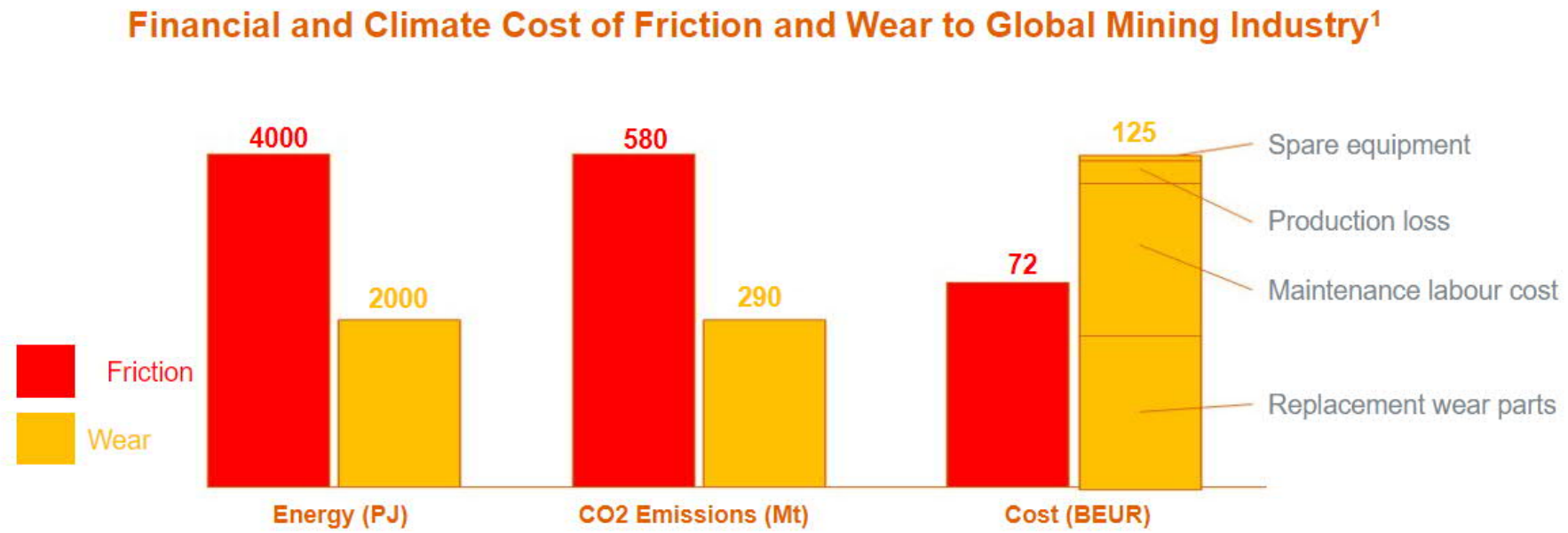
Motivation



2.7% of global emissions

50% of mining energy consumption

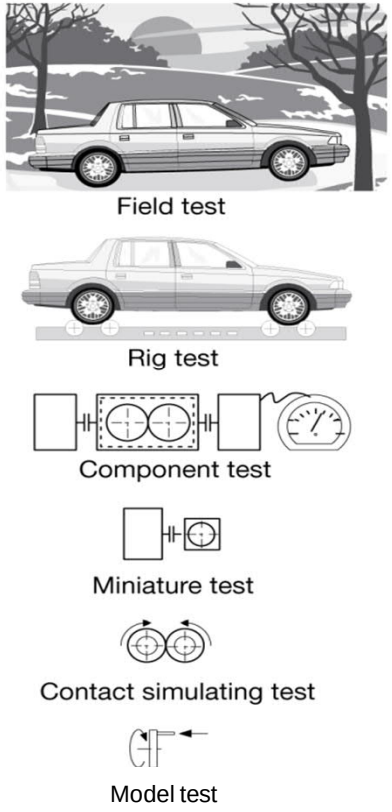
Holmberg et al, VTT (2017)

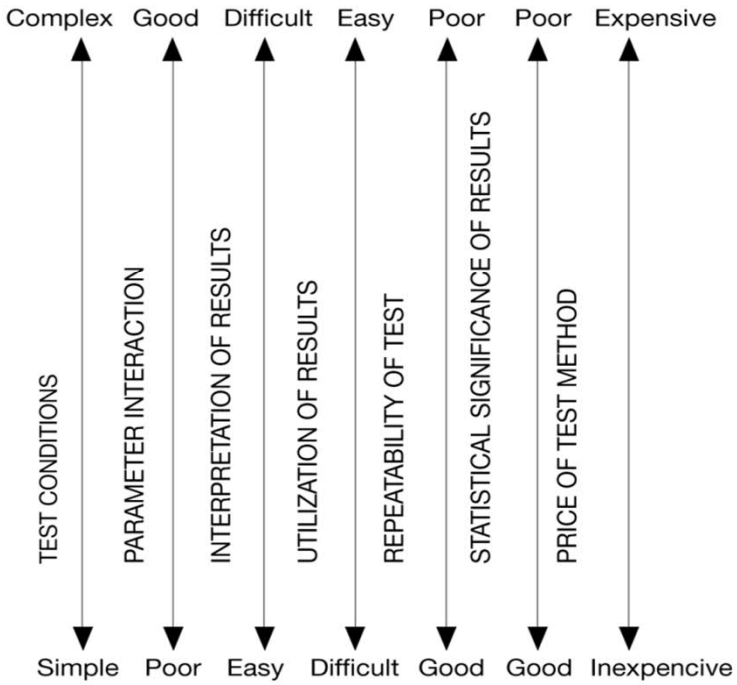
The EU has set the renewable energy target at 32 % for year 2030

The current trend is to build bigger and more powerful wind turbines with request of longer lifetime expectancy.

Image Shutterstock

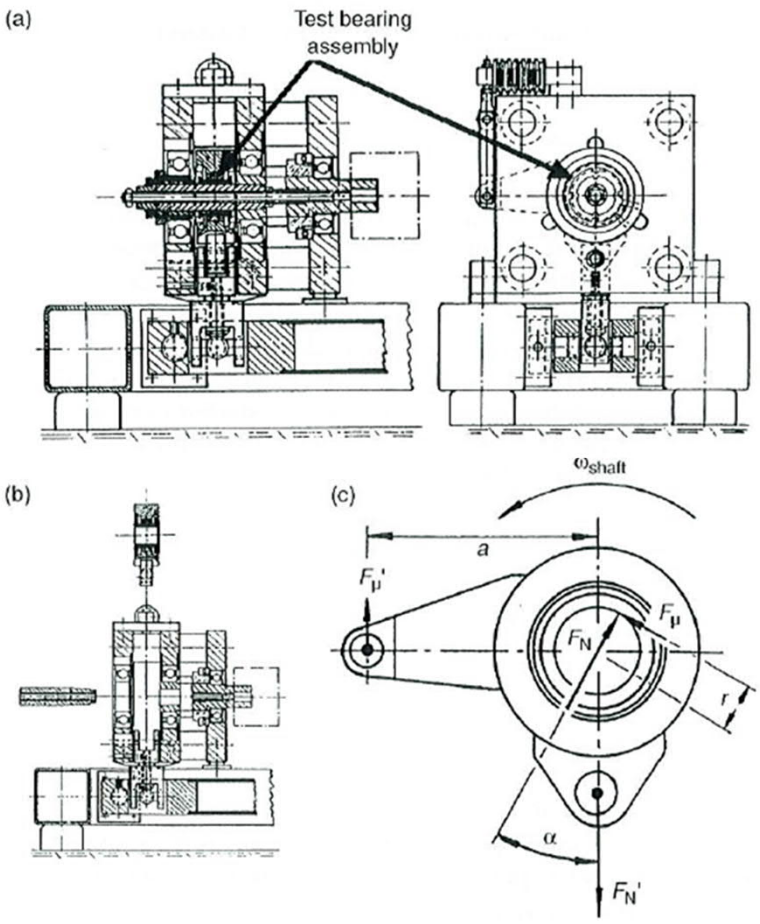
The use of novel material solutions require extensive evaluation and testing of material properties



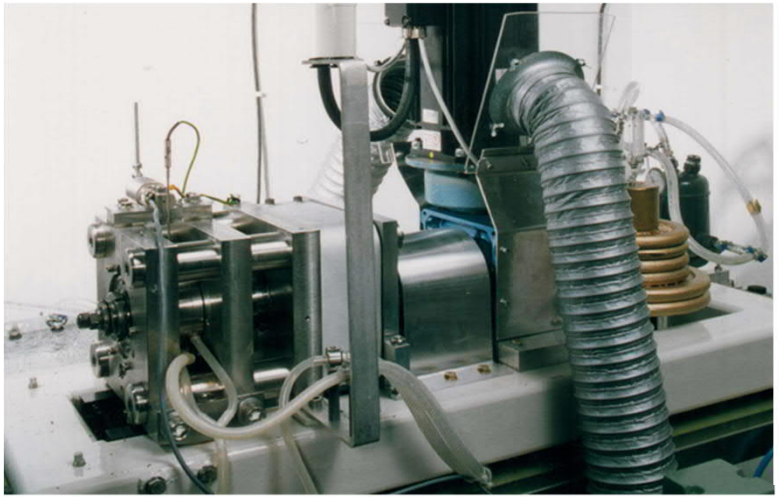


Journal bearing component tests

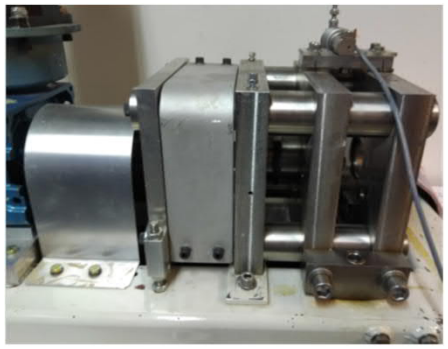
- Journal bearing component test:
  - Tests can be carried out with different material solutions and lubricants
  - Possibly the damping and stiffness of the journal bearing can be measured



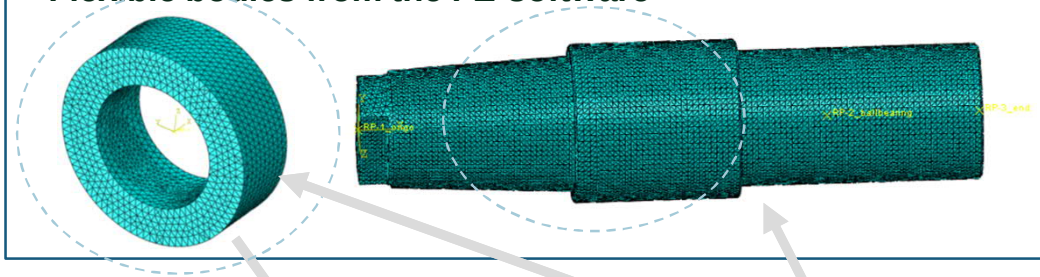
- Example of test parameters:
  - CuSn-bearing, steel shaft
  - Lubricant:
    - Synthetic industrial gear oil
  - Test parameters:
    - Speed: 35 – 330 RPM
    - Load: 0.5 – 15 kN



Modeling the journal bearing test - MBS



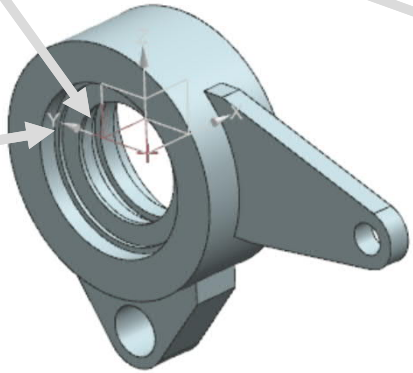
Bearing shell and Journal modelled as deformable parts
- Flexible bodies from the FE-software



Auxiliary roller bearing support (rigid)

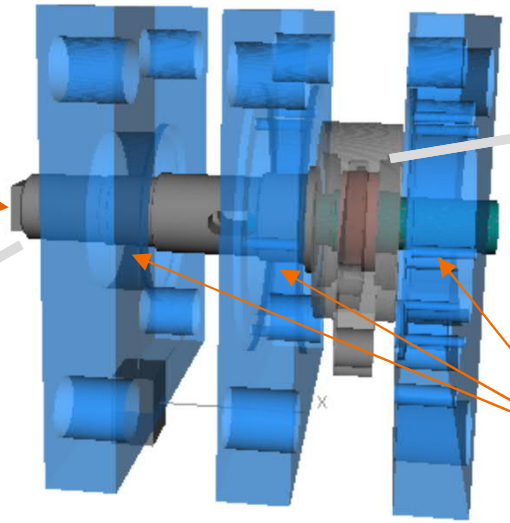
Roller bearing support (rigid)

Roller bearing support (rigid)

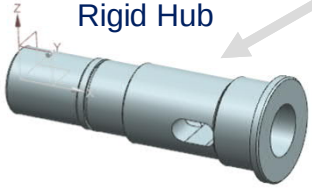


Test equipment allows different bearing geometry combinations

Excitation from (electric motor) as rotary motion



Rigid Hub

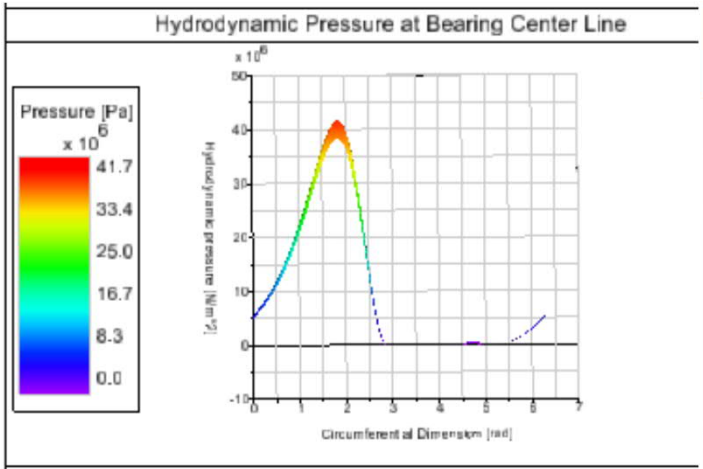


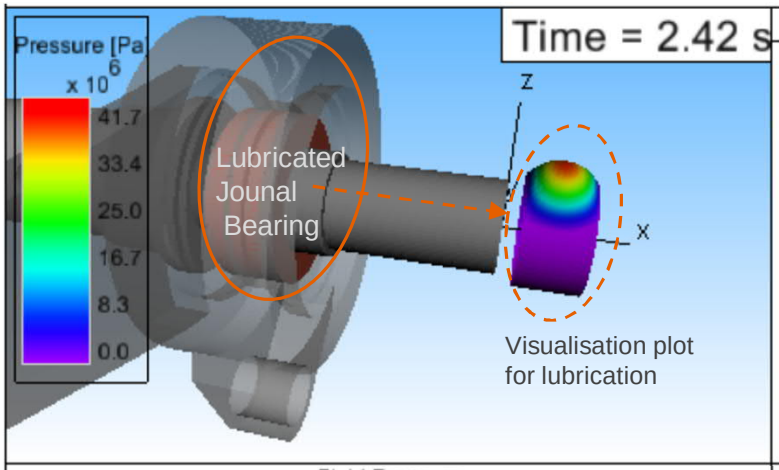
Rolling element Bearings

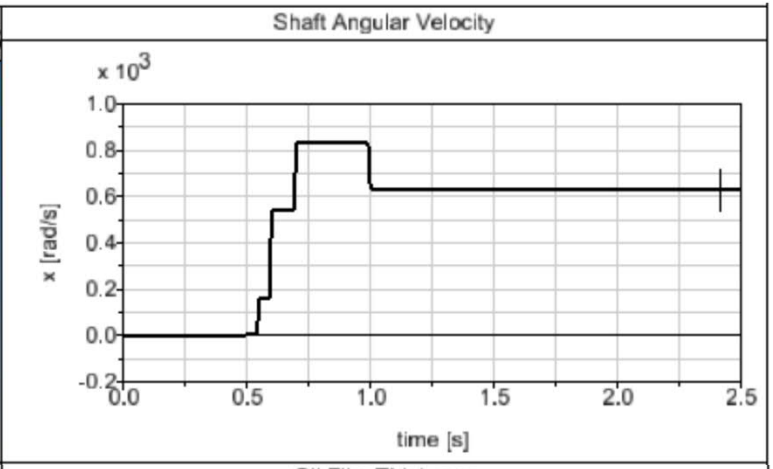
Rigid Bearing house

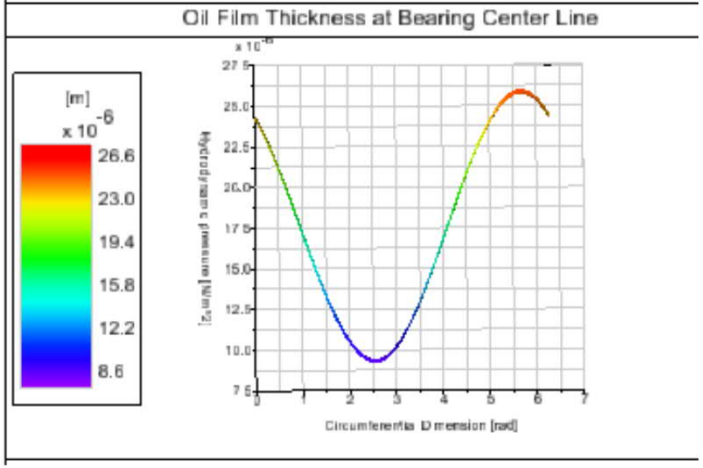
- Oil inputs
- Sensors
- Loadings

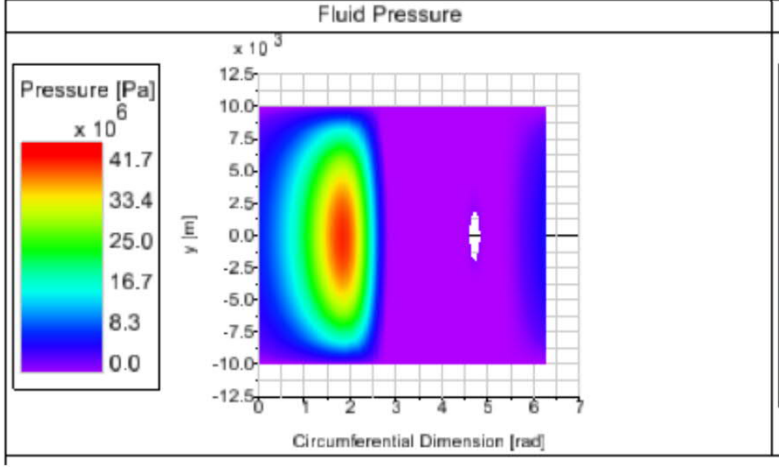
Modeling of bearing lubrication – FEM & EHD

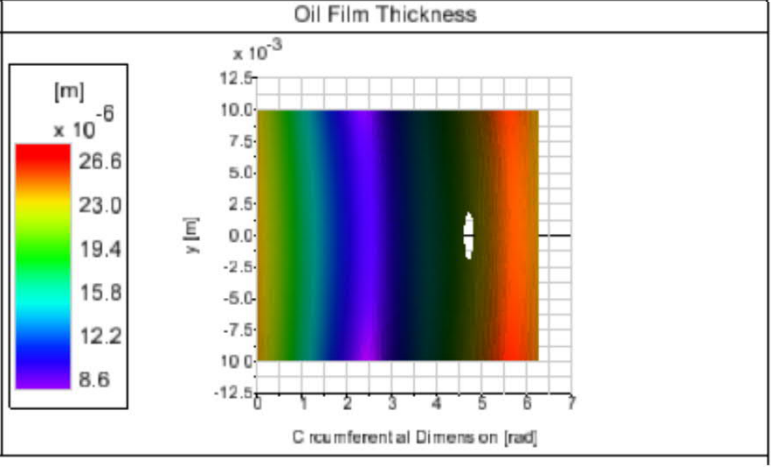








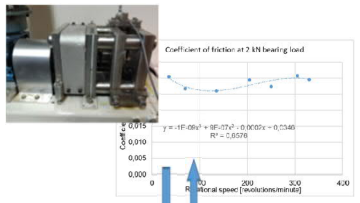




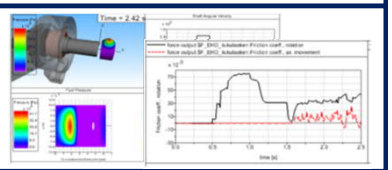
Lab-to-Field upscaling

Laboratory scale Digital Twin

Model Parametrisation



FEM+EHD modeling & simulation in lab-scale

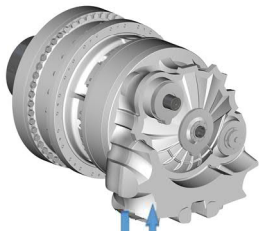


input data from pilot model to laboratory tests

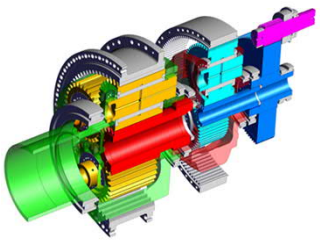
data to pilot scale model for predictions

Pilot scale

Experimental gear box



Gear box FEM+EHD modelling



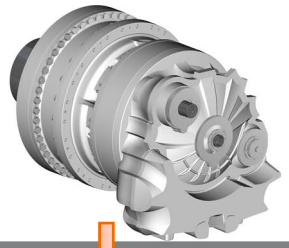
Experimental and simulation data:

- laboratory and pilot scale

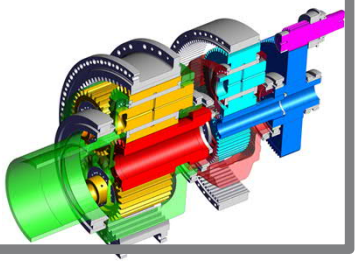
Simulation data:

- laboratory and pilot scale

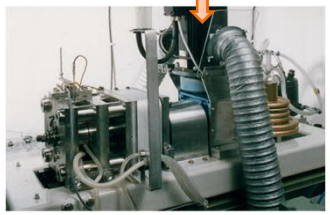
Journal bearing – Laboratory-to-Field upscaling



- Determine the operational parameters leading to BL conditions -> **HD/EHD – ML - BL transition**
- **Predict wear in boundary lubricated conditions** -> contacts within BL region causing wear
- Provide **estimates of lifetime/durability** of new material concept
- Generate the Lab-to-Field upscaling tool for **materials upscaling** based on laboratory scale and pilot scale experimental tests and modelling



Down-scaling: projection pressure, sliding speed, lubrication, temperature

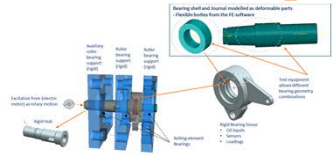


Materials: TestSet1, TestSet2

Journal bearing component tests

Down-scaling:
- contact pressure → load
- sliding speed → rpm
- temperature
- contact conditions
- surface roughness

Upscaling: Shift between lubrication regimes during operation



MBS-FEM/EHD model: Friction modelling

Block-on-ring model tests

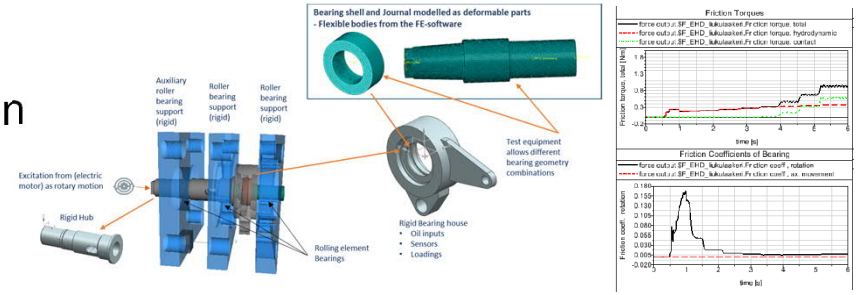
Data: wear volume for different sliding distances and loads

Upscaling: Estimation of the bearing wear performance

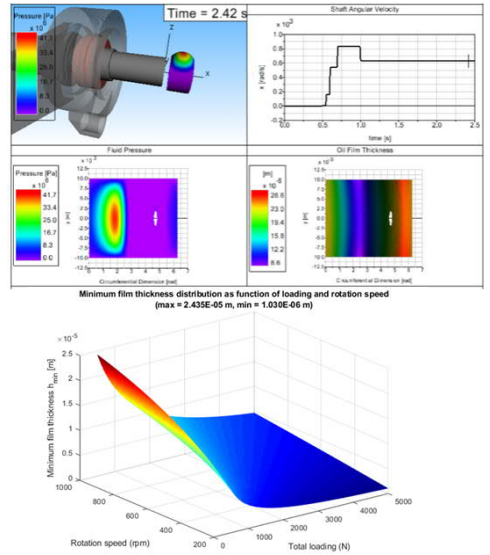
Wear model for the bearing material wear

Journal bearing - Virtual sensing concept

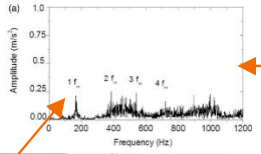
- Combining acoustic emission (AE) sensor data, friction data and simulation data to predict the lubricant film thickness (lubrication regime)
  - Monitoring lubricant film thickness, lubrication regime
  - Predicting transformation from HD/EHD to mixed lubrication and boundary lubrication regimes

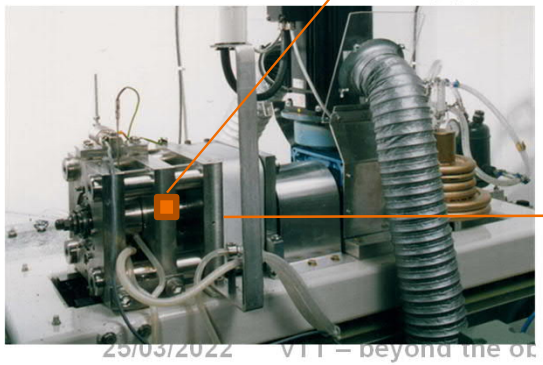


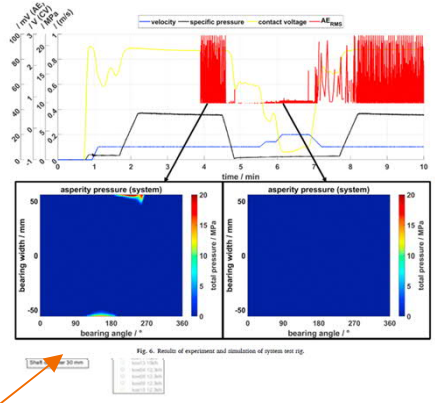
MBS/FEM – EHD/HD modeling



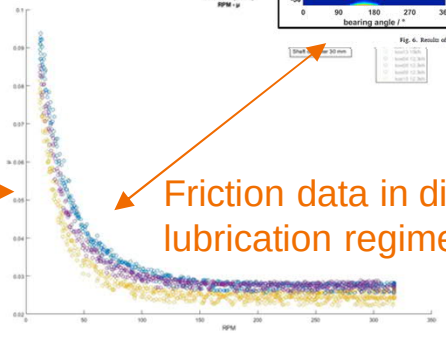
AE-sensor data in different lubrication regimes







Modeling data in different lubrication regimes



Friction data in different lubrication regimes

beyond

the obvious

Vuokko Heino