Tampere Wear Center Research equipment

Wear testing

- Pin-on-disk/Ball-on-disk, Crushing pin-on-disk, Uniaxial crusher, Dual pivoted jaw crusher, Impeller-tumbler, High-speed slurry-pot type erosion tester, Erosion tester, Slurry erosion-corrosion tester, Cavitation erosion tester, High velocity particle impactor, Ball-on-block, Hammer mill, Block-on-ring, Rubber wheel abrasion testers

Tribology and machine elements test rigs

- Test rigs for journal, thrust, and rolling bearings, FZG, Twin-disc test rig, Mini traction machine, Fretting wear and fatigue test rigs, Vibration Testing
Tampere Wear Center

- Concentrates on both scientific and practical aspects of wear and tribology
- Strengthens research in the field of wear and tribology of materials
- Special expertise areas heavy abrasion, impact wear, fretting and tribology of machine elements, such as gears, bearings, brakes, seals, and frictional joints
Wear testing

Pin-on-disk/Ball-on-disk
Crushing pin-on-disk
Uniaxial crusher
Dual pivoted jaw crusher
Impeller-tumbler
High-speed slurry-pot type erosion tester
Erosion tester

Slurry erosion-corrosion tester
Cavitation erosion tester
High velocity particle impactor
Ball-on-block
Hammer mill
Block-on-ring
Rubber wheel abrasion testers
CETR UMT-2 Pin/Ball-on-disk

Commercial Pin-on-disk / Ball-on-disk equipment; fulfills ASTM G99 –95a standard

Elevated-Temperature Chamber:
• Temperature: -20-350°C
• Revolve disk speed: 0.1 - 1000 rpm
• Max. disk size: 70 mm
• Standard specimens:
  • Pins: Diameter of 6.35 and 10 mm
  • Balls: Diameter of 6.35 and 9.5 mm
• Humidity/Gases Chamber (no controls)
• Possibility to use lubricants
• Humidity control: 5-95%RH

High-Temperature Chamber:
• Temperature up to 1000°C
• Revolve disk speed: 0.1 - 1000 rpm
• Max. disc size: 50 mm
• Standard specimens:
  • Pins: Diameter of 6.35 and 10 mm
  • Balls: Diameter of 6.35 and 9.5 mm
Crushing Pin-on-disk

- Pin is repeatedly pressed against the gravel bed and the disk with a pneumatic cylinder (200-500N)
- Pin does not come into direct contact with the disk at any time → wear of the components due to abrasive ploughing and cutting on the pin and disk surfaces
- During the test, the abrasive size decreases at different rates, depending on the pin-disk combination.
- Simulates cone or jaw crusher

**Specimen:**
- Diameter of 36 mm
- Height of 35 mm
- Flat area 1000 mm²

**Disk:**
- Diameter of 160 mm
- Thickness of 2-155 mm
- Rotating velocity control
Uniaxial Crusher

- The equipment crushes the abrasive uniaxially between two specimens with a high pressure
- Controlled amount of the abrasive
- Simulates a mineral crusher
- Specimen: area of 1000mm², height of 35 mm and diameter of 36 mm
- Impacts with the hydraulic cylinder:
  - 6 bar (max) 86 kN
  - 5 bar 69 kN
  - 4 bar 53 kN
  - 3 bar 39 kN
  - 2 bar 23 kN
Dual pivoted jaw crusher

- Laboratory scale jaw crusher for studying the mechanisms of abrasive wear during mineral crushing
- Key design features:
  - control of jaw movement without changing the test geometry, enabling accurate control of the compression-sliding ratio
  - versatile instrumentation for monitoring the wear processes, including piezoelectric force sensors, high speed video systems, etc.
- Test outcomes
  - wear of both jaw specimen
  - work in Fz and Fy directions
  - feed size reduction to product
- Specimen
  - jaw plate size 75*25*10 mm
  - abrasive particle size 6-14 mm
Movement of jaws with 5°+5° jaw angles

- **0° frame setup**
  - $\Delta Y = 0.3 \text{ mm}$
  - $\Delta Z = 3.0 \text{ mm}$

- **45° frame setup**
  - $\Delta Y = 3.23 \text{ mm}$
  - $\Delta Z = 3.27 \text{ mm}$

- **90° frame setup**
  - $\Delta Y = 24.0 \text{ mm}$
  - $\Delta Z = 4.98 \text{ mm}$

(high speed video = 20 times slower)

Impeller-Tumbler Impact-Abrasive Wear Tester

- Simulates wear in mineral handling applications, such as earth moving machinery and impactor plants.
- During the test, an impeller with three samples (75*25*10 mm) rotates inside a rotating tumbler filled with gravel.
- Impeller rotating speed up to 700 rpm, tumbler rotating speed up to 120 rpm
- Variables: sample angle, gravel size distribution, type, and amount
- One sample is the reference → changes in mineral composition controllable
High-speed slurry-pot type erosion tester

- Testing of wear resistant materials in high stress erosive or abrasive wear conditions
  - slurry pumps, mining applications, dredging, loader buckets, containers, etc.
- Testing of mineral abrasiveness in a slurry or in dry conditions
- Key design features:
  - high rotation speed: up to 2000 rpm (20 m/s in the sample tip)
  - large abrasive size: 0-10 mm
  - suitable for testing of metal bars or plates, thick and thin coatings, elastomers, and hybrid materials
  - possibility to edge protection
  - flow conditions vary in 4 sample levels → requires sample rotation
  - variable sample sizes and shapes
Slurry erosion-corrosion system

- Possible to determinate slurry erosion with or without corrosion
- Potentiostat for corrosion measurements
Erosion tester

Wear testing of materials and coatings at room temperature with centrifugal accelerator

- Impact angle: 15°, 30°, 45°, 60°, or 90°
- Impact velocity: 0-80 m/s
- Abrasive typically quartz
- Abrasive size: up to 1 mm
- Sample size: 20*15 mm, thickness 5 mm
- Samples quantity: up to 15 samples
High velocity particle impactor (HVPI)

- Developed for the model verification and to identify the basic mechanisms influencing the impact wear and failure behavior of materials
- Key design features:
  - various angles and impact energies; projectile speed: 30…200 m/s
  - suitable for various materials: metals, coatings, elastomers, hybrids, ...
  - projectiles: metallic or ceramic ball bearing balls, cylinders, bullets, and rocks
  - video recording: high speed camera NAC MEMRECAM up to 80 000 fps or LaVision StrainMaster 3D DIC systems (high and low rate)
  - cooling setup: temperatures down to -80°C can be reached; cooling with nitrogen gas, impact happens in ambient air
Ball-On-Block Impact Wear Testing Device

• Ball-on-block is a high-energy impact wear testing device that produces repeatedly high-energy impacts to the surface of the specimen

• Impacts are created by shooting a ball to the specimen using a pneumatic cylinder

• Simulates wear on a SAG-mill

• Ball:
  • mass 8 kg and diameter 125 mm
  • Impact velocity 8-12 m/s ($E_k = 256 \text{ J} - 576 \text{ J}$)
  • material for example tempering steel

• Specimen:
  • size 200x200x75 mm or 200x200x50 mm
  • various materials tested such as steels, rubbers, metal matrix composites, hard metals
Hammer-mill

- Two rotating hammers
- The abrasive is fed between the hammer and the specimen from a container through a feeder tube
- Hammers:
  - Speed: 5.1-9.0 m/s
  - Impact energy: 21.9-66.9
  - Typical speed 7 m/s and impact energy 50 J
- Specimen:
  - 80mm x 80mm – 250mm x 250mm
  - Thickness 15-45mm
Test Method for Cavitation Erosion Using Vibratory Apparatus

• Standard test ASTM G32-10
• Vibra-Cell VCX-500 ultrasonic processor
  • Allows process control and monitoring from 1°C to 100°C

<table>
<thead>
<tr>
<th>Test parameters</th>
<th></th>
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<tbody>
<tr>
<td>Frequency</td>
<td>20 kHz</td>
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<tr>
<td>Amplitude</td>
<td>50 μm</td>
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<tr>
<td>Distance to sample</td>
<td>0.6±0.1 mm</td>
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<tr>
<td>Water temperature</td>
<td>25±1 °C</td>
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<tr>
<td>Tip diameter</td>
<td>13 mm</td>
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Replacable Ti-6Al-4V tip for cavitation testing.
Surface fatigue wear

- Attached to Servohydraulic Instron mechanical testing machine
- Holder moves after every step
- Intender ball, cylinder or spike
- Area covered: 15 x 15 mm
Other wear testing equipment

- Dry Sand Rubber Wheel Abrasion Testing Device
- Slurry Abrasion Testing Device
- Block-on-Ring
Tribology and machine elements test rigs

Journal bearing test rig
Thrust bearing test rig
Gears and lubricants (FZG) test device
Large-scale, full power bevel gear test rig – 2 MW closed loop
Rolling bearing test rig
High pressure twin-disc test rig

Fretting wear and fatigue test rig – complete contact, bolted joint
Fretting friction, wear and cracking test rig – flat-on-flat contact
Tribometer -PCS -MTM2

Advanced vibration and noise instruments

Basic tribology equipment
- Viscometer
- Microscopes
- Surface profilers
- Pin-on-disc test device
Journal bearing test rig

Test targets – evaluation of bearing performance
- friction, power loss
- failure modes, life
- lubricants, lubrication condition
- temperatures, fluid film pressures
- bearing materials and configurations

Specifications:
- sliding speed 0.05 … 16 m/s
- projected pressure 0 … 15 MPa
- oil temperature, pressure and flow controls
- shaft misalignment control
- no support bearings
- automated operation and sequences
Thrust bearing test rig

Test targets: evaluation of thrust bearing performance
- friction and power loss
- load capacity
- bearing materials and configurations
- failure modes

Specifications:
- rotating speed 0 – 2000 rpm
- external lubrication unit with oil filtering and temperature, flow and pressure control
FZG Gear test rig

Test targets: testing gear contact and lubrication properties
- friction and power loss
- durability testing
- failure mechanisms, pitting, scuffing
- vibration and noise diagnostics
- on-line particle measurements

Specifications:
- closed loop type rig
- loading torque 0 ... 1000 Nm
- rotating speed 0 ... 3000 rpm
- external lubrication unit with oil filtering and temperature, flow and pressure control
Large scale gears tests

Large-scale, full power bevel gear test bench – 2 MW closed loop
Collaboration of ATA Gears and TAU Tribology and Machine Elements
Power transmission test rig

Test targets: performance and durability tests of different power transmission components
- lubrication condition
- failure mechanisms
- prototype testing
- vibration and noise diagnostics

Specifications:
- generator brake type rig
- isolated concrete foundation
- machine rail floor allows installation changes
- noise isolated test room
- max. power transmission 100 kW
- rotating speed 0 ... 2400 rpm

Versatile measurement possibilities
Roller bearing test rig

Test targets: evaluation of roller bearing performance
- friction and power loss
- lubricants, lubrication condition

Specifications
- bearing outer diameter 90 mm
- normal and axial loading
- oil (bath) temperature control or
- external lubrication unit with oil filtering and temperature, flow and pressure control
Twin-Disc test rig

**Test targets:** gear and rolling/sliding contact testing
- contact friction
- fatigue durability
- lubrication condition

**Specifications:**
- adjustable elliptical rolling/sliding contact
- contact pressure 0 ... 3.0 GPa
- static and dynamic loading
- disc grinding transversal
- automated operation and sequence
- advanced instrumentation
Complete contact fretting test rig

Test targets: fretting in complete contacts (i.e. 'sharp-ended' flat-on-flat type contacts)
- fretting and plain fatigue S-N curves
- fretting wear

Specifications:
- large contact 2000 mm²
- loading frequency 0 … 50 Hz
- nominal contact pressure 0 … 200 MPa
- fully reversing or fluctuating bending loading
- automated operation (unoccupied testing)
Flat-on-flat fretting test rig

Test targets: Fretting experimentation with annular flat-on-flat contact
- fretting induced friction
- fretting induced wear and cracking

Specifications:
- large contact 314 mm²
- loading frequency: 40 Hz
- nominal contact pressure: 5…100 MPa
- tangential displacement amplitude: 5…60 µm
- automated operation
The mini traction machine (MTM) instrument is used to simulate the tribological contacts under lubricated and unlubricated conditions. Fully automated traction mapping under different rolling and sliding speeds is performed with different loads and temperatures. Additional features provide the anti-wear additive film growth measurement, simulation of soft contact, wear measurement and reciprocating friction.

A normal test is performed by placing a small sample of fluid in the oil pot, and then running a test consisted of series of loads, speeds slide/roll ratios, temperatures and film thickness measurement intervals. These tests can be set by the user or by running the custom programs available on the instrument software.

**Specifications:**
- Load: 0 - 75 N
- Contact Pressure: 0 - 1.25 GPa (standard specimens) / Up to 3.1 GPa with alternative specimens
- Speeds: –4 m/s to 4 m/s
- Temperature Range: Ambient to 150°C (below ambient with oil cooler)
Vibration Testing

- Vibration equipment for monitoring, diagnostics and testing
- Industrial and laboratory applications

- LMS system for machinery vibration and modal testing
- IMC data acquisition systems
- B&K and LDS shakers
- Versatile sensors for different purposes
- Strain gage equipment, wireless
- Acoustic emission vibration and sound equipment
- Versatile analysis software
Contacts

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