



Kulumine ja kulumiskindlus (triboloogia)

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Inseneriteaduskond, TTÜ

Sisu:

- Sissejuhatus
- Võimalused
- Labor ja seadmed
- Näidisprojekt



1. Sissejuhatus:

Triboloogia on teadusharu, mis käsitleb detailide hõõrdumist, määrimist ja kulumist.

Kulumine on hõõrdumisega kaasnev tahke keha pinna järkjärguline purunemine ja sealt materjali eraldumine või pinna jäävdeformatsioonina ilmnev keha mõõtmete järkjärguline muutumine.

Kulumise tagajärjel tekib **kulum**, mida iseloomustatakse sobivais pikkus-, massi- või mahuühikutes.

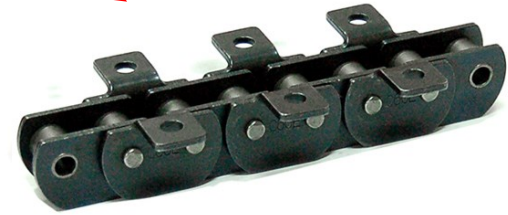
Järeldus:

kui on **koormus** ja **liikumine** -> siis tekib **kulumine**
->siis pöörduge **www.ttu.ee/tribo**



Tootja: A

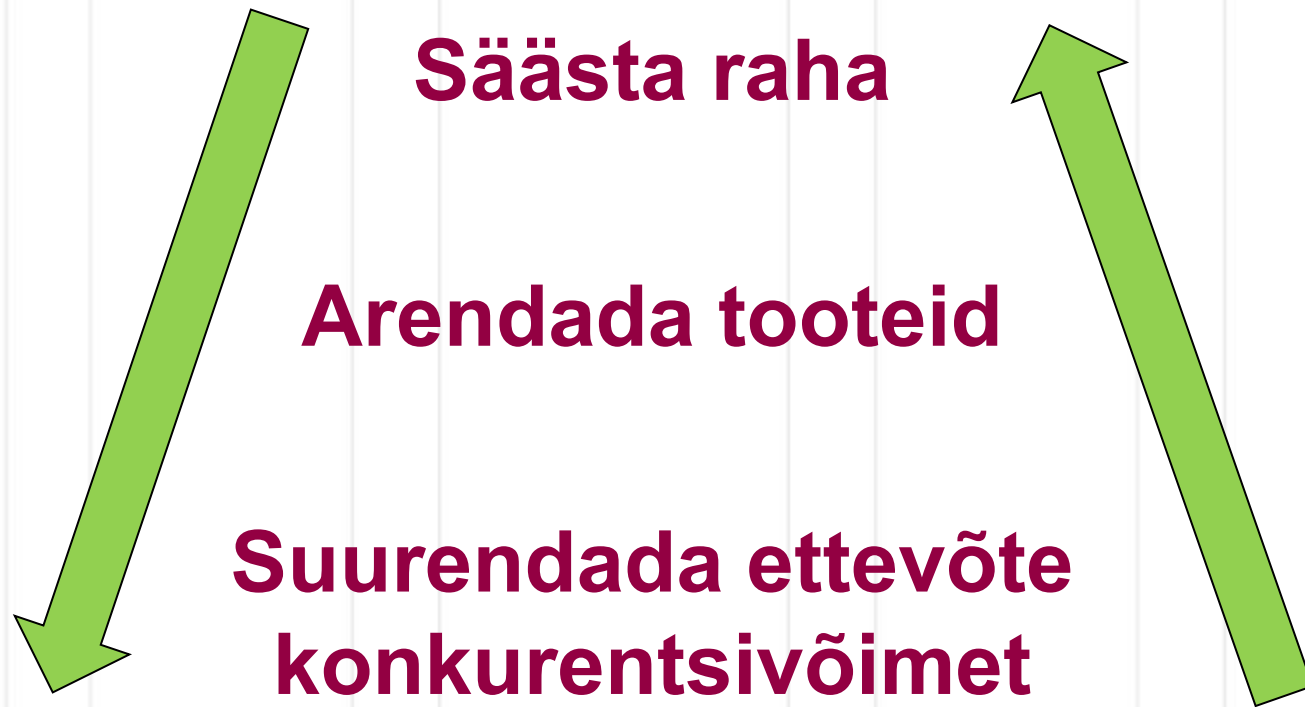
Hind: 10 EUR/jm



Tootja: B

Hind: 50 EUR/jm

Meie eesmärgid



2. Meie kompetentsid:

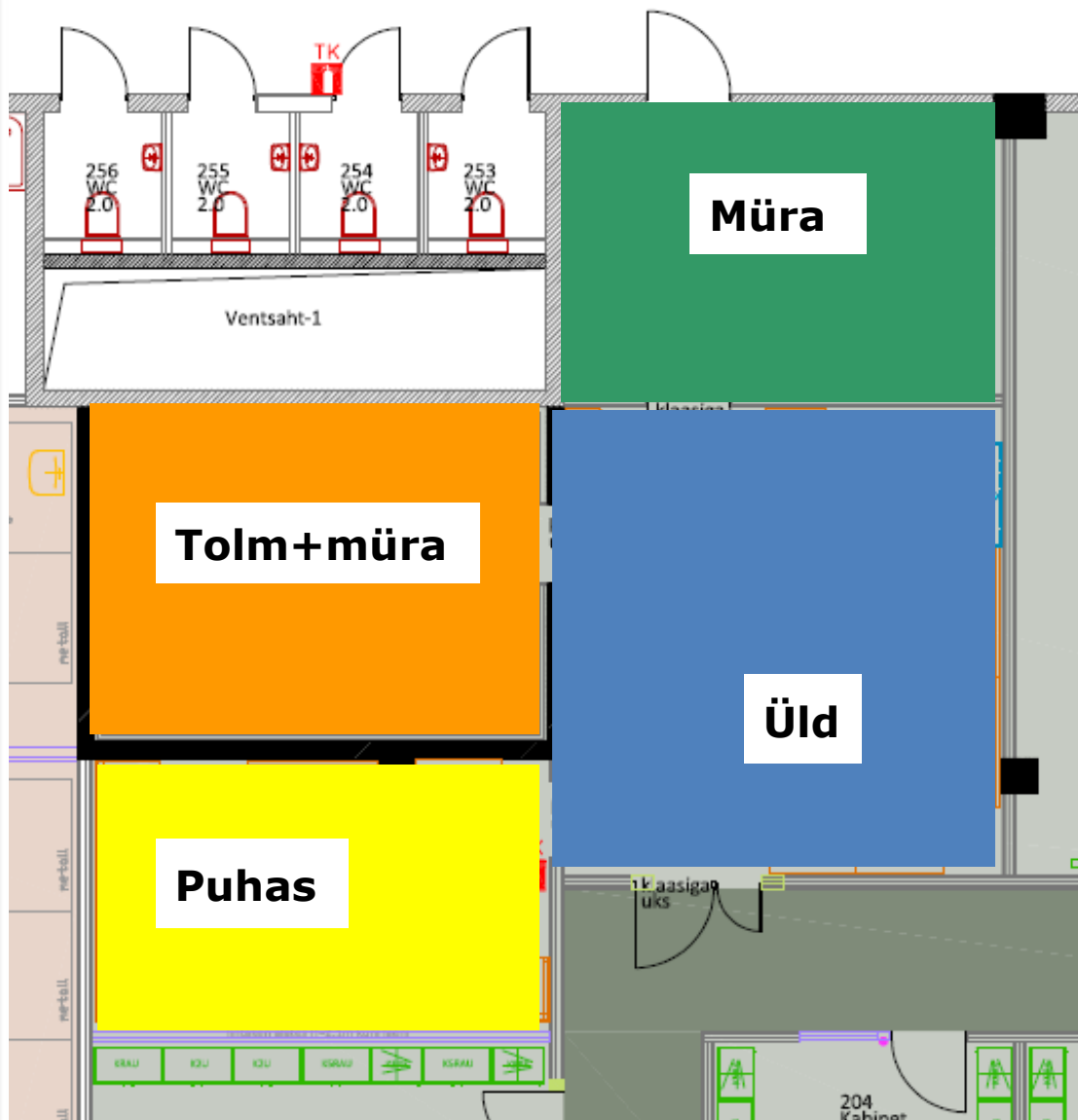
Kulumise põhilised eriliigid



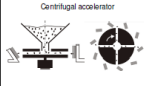
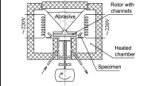
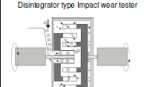
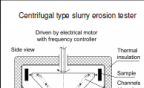
On võimalik katsetada meie laboris!!!

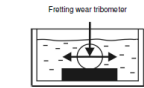
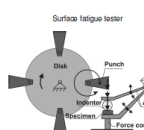
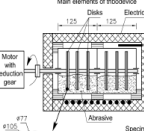
[Bhushan, ed. Modern tribology handbook. CRC press, 2000]

3. Laboriruumid ja seadmed:

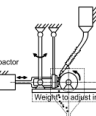


WEAR TESTING FACILITIES AT TALLINN UNIVERSITY OF TECHNOLOGY

Type of wear	Scheme or image	Description / Parameters	Applicable standard
Abrasive erosion (AEW) ► At room temperature ► At high temperature 20 – 650 °C (possible to make with inert gas as well)	 	Impact angle 15-90° Impact velocity 0-60 m/s Abrasive size 0.05-1.00 mm 15 / 20 samples at once (room temperature / high temperature tester)	GOST 23201-78 ASTM G76-07 BS EN 60587:2007
Abrasive impact wear (AIW)		First collision velocity 40-125 m/s, second max 200 m/s Abrasive size up to 7 mm 14-14 samples at once	For specific custom conditions
Slurry erosion (SEW)	 	Impact velocity: 3-35 (usually 20 m/s) Abrasive particle concentration: up to 60 wt. % Typical abrasive – sand 50 µm (forming stable slurry). Slurry is impacting the samples and then moving along the cylinder formed by samples (impact angle is close to zero). Typical duration – 24 hours 30-35 samples at once	ASTM G75-07 G73-04

Type of wear	Scheme or image	Description / Parameters	Applicable standard
Fretting wear Wazeu SVT500 with air bearings		Ball-on-Fat and Pin-on-Fat geometries Liquid media available Ball / pin: ø6 – 10 mm Stroke ± 2.0 mm Frequency 0.1 – 40 Hz Temperature 20 – 150°C Normal force 0 – 500 N Dead weight loading	ASTM D4170-97 G133-05 D5706 D5707 DIN 51834-1 51834-2
Surface fatigue wear (SPW)		The energy of the impact depends on the weight of the punch and the velocity (3-500 m/s). Frequency of impacts 12-100 Hz Diameter of the indenter 5-20 mm One sample test	ASTM D2794-93 D1170-03
Abrasion-oxidation		Velocity 0-0.1 m/s Temperature 20 – 900 °C Pressure expressed by abrasive 200-400 Nm ² Possible testing in two abrasives at once; 18-18 samples at once.	For specific custom conditions

Type of wear	Scheme or image	Description / Parameters	Applicable standard
Block-on-Ring Abrasion testing machine for natural stones and concrete tiles CONTROLS model 48-D0471		Electronic control of disk speed, Auto shut-off at selected number of revolutions, Disk wheel thickness – 70 mm Abrasive – white corundum sand FEPA grit size 80. Calibration – Bouillon's marble	EN 1338, 1339, 1340 Contact: Mergel Rosenberg mer@tribo.ee
Block-on-Ring ► Sliding wear (without abrasive) ► Abrasion (with abrasive) ► With abrasive slurry	  	Disk: ø228.6 mm (steel) ø228.6 or 80.0 mm (rubber). Excitation of abrasive slurry is available. Velocity 0.1-15 m/s Force 1-250 N One sample test	ASTM G99-04 B611-85 G105-02 G137-97 G77-05e1
Sliding wear with or without abrasive	 	Block (1-10)(15-25)(25-90) mm Ball ø 3 mm Temperature 20 – 450 °C (in Block-on-Ring scheme) Normal force 0 – 200 N Dead-weight loading Speed 30 – 700 rpm One sample test	ASTM G99-04 G105-02 G137-97 G77-05e1 ASTM G132-96 G99-05

Type of wear	Scheme or image	Description / Parameters	Applicable standard
Sliding wear with or without abrasive (fine abrasive)		Normal force depends on size of ball Ball 15 – 30 mm Speed 20 – 500 rpm Typical abrasive – diamond paste 1 µm One sample test	KaloMax method
Slurry abrasive wear		Continuous sample movement in slurry pot Unidirectional Max 8 samples at once Monitoring of forces (vertical, horizontal)	For specific custom conditions
Abrasive wear with impacts and adjustable inertia value		Low, medium and high stress abrasion with impacting Disk: Ø80 mm (steel, composite or ceramic) Velocity 0.1-3.0 m/s Force 10-250 N Impact energy 0-19 J Frequency 0-65 Hz Abrasive max 1 mm Inertia max 200 kg One sample test	For specific custom conditions like drill bits, etc
TABER ROTARY ABRASER 350G (type 5135)	 	Two abrasive wheels are abrading material sample and X-shaped abrasion pattern is formed. Load 250-1000 g Different types of wheels (or sandpaper strips) with different abrasive particle size are possible (selected according to material to be tested)	EN 14323:2004 EN 439-2 ISO 4586-2 DIN 53759-4:2005 DIN 68861-2 Contact: Jaan Kars jaan.kars@tribo.ee

Type of wear	Scheme or image	Description / Parameters	Applicable standard
	  	Continuous sliding mode. Spiral and butterfly tracks are also possible. Fretting mode.	Ball-on-Fat and Pin-on-Fat geometries Ball ø 3, ø 10 mm Normal force 0.1 – 200 N Servo-controlled loading with spring suspension. ASTM G132-96 G99-05 ASTM D4170-97 G133-05 D5706 D5707 DIN 51834-1 51834-2 ASTM E98-82 D4172
Sliding and fretting wear by Universal tribometer UMT2 (from CETR now Bruker)		Four-Ball method: Balls 0.5 (12.7mm) Torque 0.1-226 N m Load max 200 N	ASTM D2096 D2098 D2793 D4172 D5183
Four-Ball method for oil testing		Balls 0.5 (12.7mm) Torque max 25 N m Rotational frequency 100-3000 rpm Load max 10000 N	ASTM D2096 D2098 D2793 D4172 D5183

AUXILIARY EQUIPMENT:

Scales: A&D GR-202 (±0.01 mg); Mettler Toledo ME204 (±0.1 mg)

Optical microscopes: Zeiss AXIOVERT 25; Zeiss Discovery V20 both equipped with camera and software (Laboratory of Mechanical Testing and Metrology)

Scanning Electron Microscope: Hitachi TM-1000 equipped with EDS module; others are available on request.

Profilers: 2D Mahr Perthometer PGK120 (Contact, Non-contact); 3D Bruker ContourGT-K0+ (Non-contact)

Cutting and polishing equipment: from Struers and Böhler in "Laboratory of Mechanical Testing and Metrology".

Marking and engraving: various types

Contact details:

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Tallinn University of Technology: www.ttu.ee

School of Engineering (new title since 01/01/2017),

Department of Mechanical and Industrial Engineering (new title since 01/01/2017),

Research Laboratory of Tribology and Materials Testing:

Ehitajate tee 5, 19086 Tallinn, Estonia

<https://www.ttu.ee/tribo/departments/mechanical-and-industrial-engineering/services/tribology-testing/>

or (direct link)

www.ttu.ee/tribo

Näidisseade 1: CETR/Bruker UMT-2 universaalne arvutiga kontrollitav tribomeeter

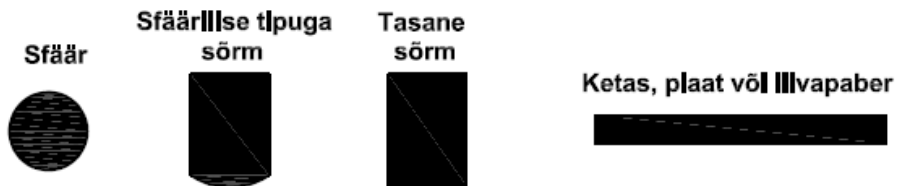


Võimalused: adhesioon, abrasiiv, väsimus, korrosioonmehaaniline kulumine

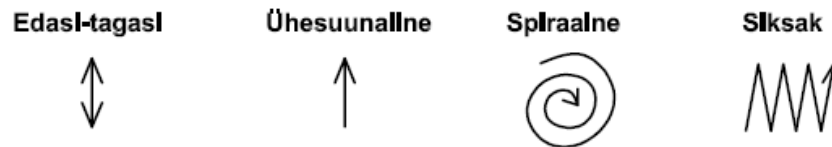
CETR/Bruker
UMT-2

20-1000 °C

Katsekehad:



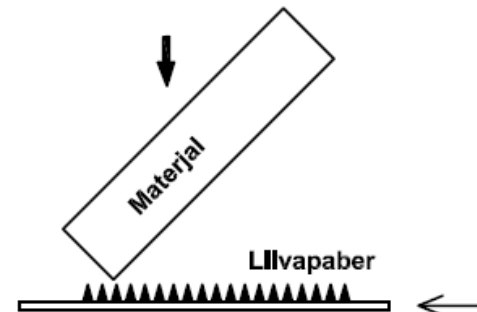
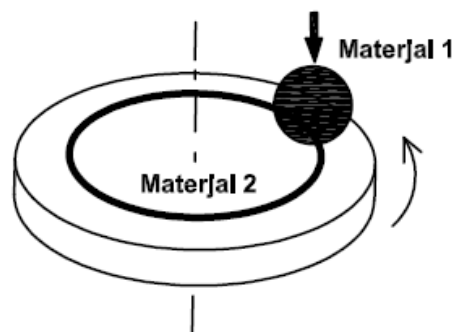
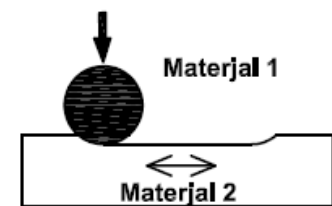
Liigutused:



Kontrollitav: koormus, hõõrdejõud, pöördemoment, temperatuur, niiskus

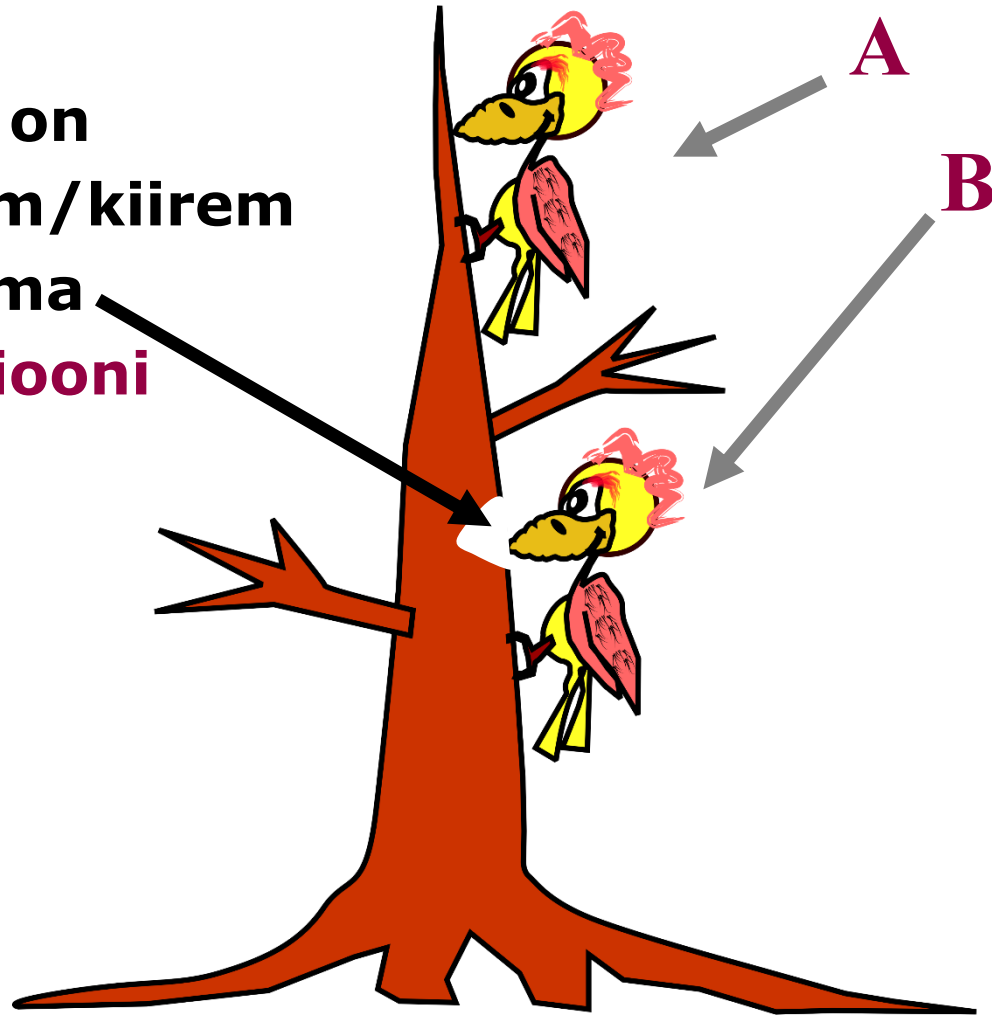
Võimalused: kuivalt / vedelikuga (määrdeainega)

Tüüpilised:

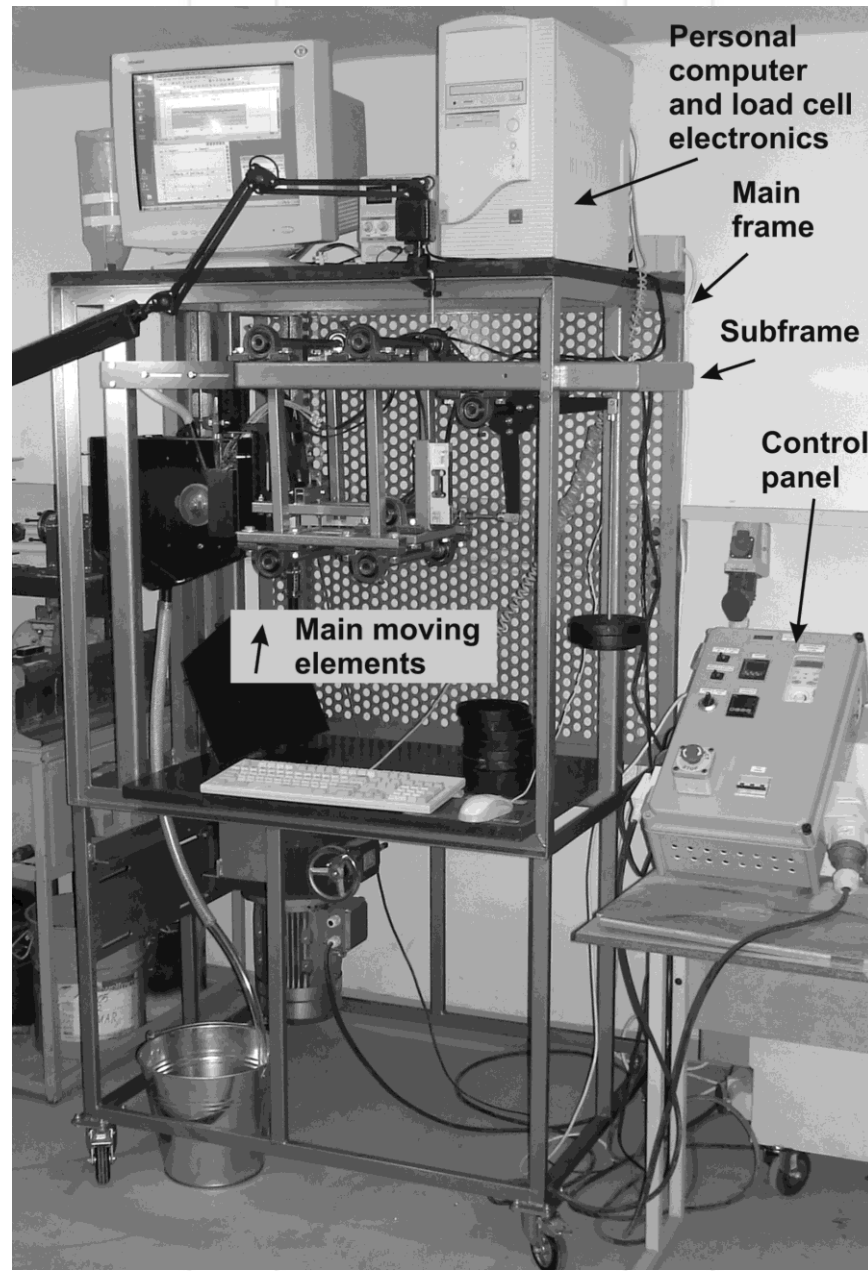


Kumb on nutikam?

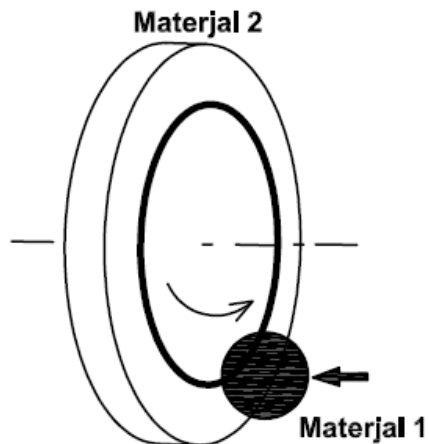
Kahju on
suurem/kiirem
suurema
inertsiooni
tõttu



Näidisseade 2: Löök-abrasiivne seade reguleeritava inertsiooniga (patenteeritud)



**1. Variant. Liughõõrdumine.
Reguleeritava inertsiooniga.**



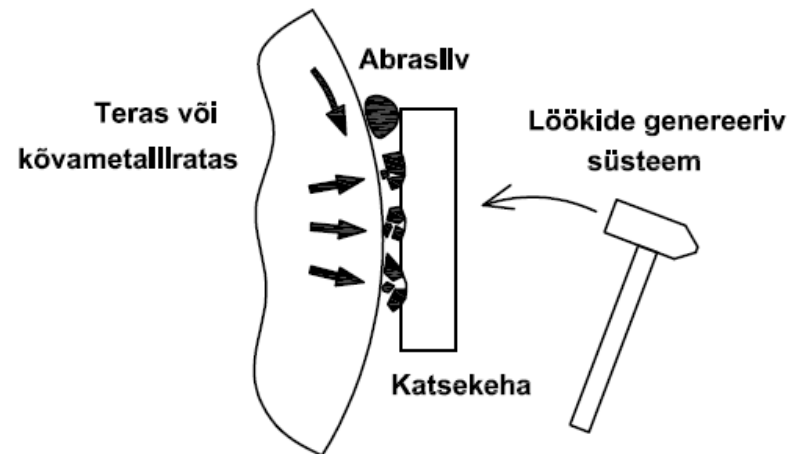
Kasutusvaldkond:
Templid

**2. Variant. Abrasiivne.
Temp: -7 kuni +450°C
Hõõrdejõu mõõtmisega.**



Kasutusvaldkond:
**Konveierid,
mullaharimise
riistad,
eriprotsessid**

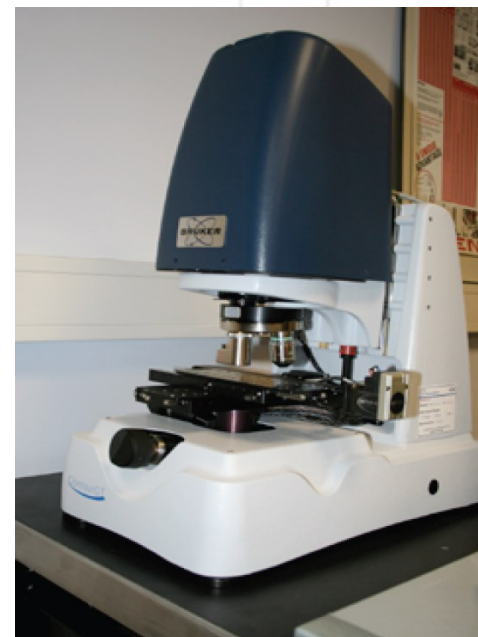
**3. Variant.
Löök-abrasiivne.**



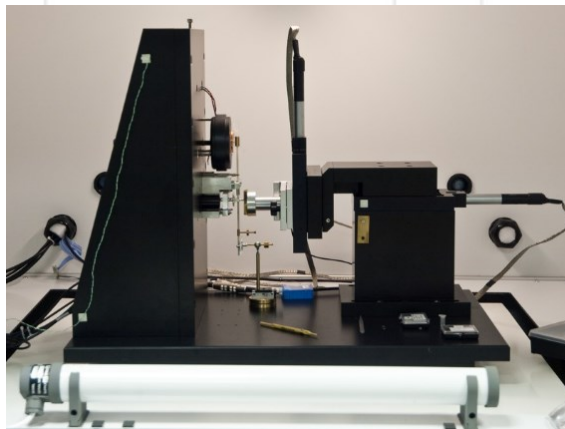
Kasutusvaldkond:
**purustid, puurid,
asfalti lõikemasinad,
läbinduskombainid.**

**Seadmed katsekehade
Ettevalmistamiseks ja
karakteriseerimiseks**

**Mikroskoobid, tarkvarad
piltide analüüsimiseks, 2D
kontaktne ja 3-D optiline
profilomeeter**



**Seadmed tugevuse (tõmbe, surve, painde),
kõvaduse (nano, micro, macro) ja
löögisitkuse määramiseks.**



**Seadmed keemilise analüüsi määramiseks
(s.h. ka ülitäpne O, N, H, C, S)**



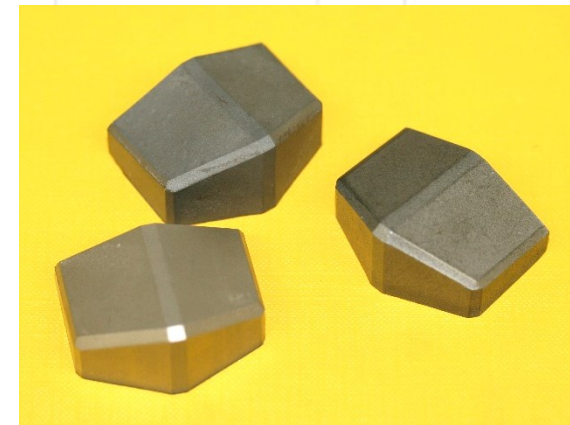
4. Näidisprojekt:

NeTTUN: New Technologies for Tunnelling and Underground Works (Euroopa Liidu teaduse 7. raamprogramm; FP7 2007-2013; leping 280712).



**Kuluvosade kasutusaja
pikendamine**

**-> sai valmistatud
umbes 20 erinevad
materjale
+patenditaotlus**



www.nettun.org



Tänan kuulamast!

Küsimused?

www.ttu.ee/tribo