

Department of Materials and Metallurgy (DMM)

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The Research Infrastructure Centre of the Faculty of Natural Sciences and Engineering (NTF) offers research equipment of NTF that is also located at the Department of Materials and Metallurgy.

Department of Materials and Metallurgy

Aškerčeva cesta 12

Lepi pot 11

SI-1000 Ljubljana

Tel: +386 1 470 45 00

Fax: +386 1 470 45 60

E-pošta: info@ntf.uni-lj.si

Equipment

ELOTEST M2 V3+

University of *Ljubljana*,

Faculty of *Natural Sciences and Engineering*



Research equipment is co(financed) by the Slovenian Research Agency.

Responsible person:

- prof. Milan Bizjak, DrSc
- Chair of Engineering materials
- Tel: 01 200 04 21
- E-mail: milan.bizjak@omm.ntf.uni-lj.si

Namembnost opreme:

- NDT eddy current discovers changes in materials such as: cracks, cavities and other errors.

Access to equipment:

- The equipment is available on **Lepi pot 11 Street**, by agreement with the operator or with the head of the laboratory.

Price for equipment use:

- Skilled user: 12,55 €/hour

Simple thermal analysis+

Responsible person:



- assoc. prof. Jožef Medved, DrSc
- Chair for Metallurgical Processing Technique
- Tel: +386 1 200 04 23, +386 1 200 04 48
- jozef.medved@omm.ntf.uni-lj.si

Purpose of equipment:

- Cooling of the metal and alloy was monitored by means of an ETA (simple thermal analysis). Curing is accompanied by the release of heat, which is reflected in the cooling curve as a change in cooling rate. The characteristic points indicate the formation of individual phases of the microstructure. The analysis is suitable for determining the state of the melt in the manufacture and laboratories.

Application of industrial measurements+

Responsible person:

- assoc. prof. dr. Peter Fajfar
- Chair of Materials Forming
- Tel: +386 1 2000 451
- E-mail: peter.fajfar@omm.ntf.uni-lj.si

Purpose of equipment:

- We perform measurements of technological parameters of technologies for transformation of metals (rolling, forging, extrusion, etc.).



Calorimeter 200 C+
University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE

Research equipment is (co)financed by the Slovenian Research Agency.

Responsible person:

- prof. Borut Kosec, DrSc
- Chair of Heat Engineering, Lepi pot 11
- Tel: 01 200 04 10
- E-mail: borut.kosec@omm.ntf.uni-lj.si

Purpose of equipment:

- Determining gross calorific values of solid and liquid samples. Validation according to standards DIN 51900, ISO 1928, ASTM D240, ASTM D4809, ASTM D5865, ASTM D1989, ASTM D5468, ASTM E711.

Access to equipment:

- The equipment is available by agreement with the operator or with the head of the laboratory **on Lepi pot 11 street, 2nd floor, room 219**. Contact person: Marija Ribič Berdajs (marija.ribic@omm.ntf.uni-lj.si).

Price for equipment use:

- Skilled user: 18,12 €/hour
- Non-skilled user: 43,88 €/hour



Measurements of contact temperatures+

Responsible person:

- assoc. prof. dr. Milan Terčelj
- Chair of Materials Forming
- Tel: +386 1 4704 506, +386 1 2000 434, +386 1 4250 316
- E-mail: milan.tercelj@omm.ntf.uni-lj.si

Purpose of equipment:

- This method is used to measure the temperature of hot forming tools and other machine parts. Enables temperature measurements up to 00:15 mm from the surface with high response thermocouples.

Device for preparing of samples for TEM analysis – Gatan pips 609+

Responsible person:

- prof. dr. Boštjan Markoli
- Chair of Metallography
- Tel: +386 1 470 46 14, +386 1 470 45 34
- E-mail: bostjan.markoli@omm.ntf.uni-lj.si

Purpose of equipment:

- This device is intended for the preparation of samples for transmission electron microscopy (TEM) and the analysis and interpretation of TEM images and diffraction roentgenograms.

Device for rapid solidification processes+

Responsible person:

- prof. dr. Milan Bizjak
- Chair of Engineering Materials

- Tel: +386 1 200 04 21, +386 1 200 04 30
- E-mail: milan.bizjak@omm.ntf.uni-lj.si

Purpose of equipment:

- The device is capable of producing thin (below 100 μ m) and narrow (2-3 mm) strips of different metals and alloys from the melt by cooling speeds 105 to 106 K / s. In this way, the hardened alloy has a chemical composition, microstructure and properties that differ significantly from those conventionally made from metallic materials. Some materials are also made for research institutions from abroad (sources of energy, materials, shape memory).





Nevron networks for analysis of impacts and prediction processes+

Responsible person:

- assoc. prof. dr. Milan Terčelj
- Chair of Materials Forming
- Tel: +386 1 4704 506, +386 1 2000 434, +386 1 4250 316
- E-mail: milan.tercelj@omm.ntf.uni-lj.si

Purpose of equipment:

- Effective mainly in cases where the effects of parameters on a certain grandeur very complex (complex), but there is enough database. Has successfully been used to analyse the effects of chemical composition on surface cracking during the transformation of materials, optimising the mechanical properties of materials, forecasting processes, wear, etc.

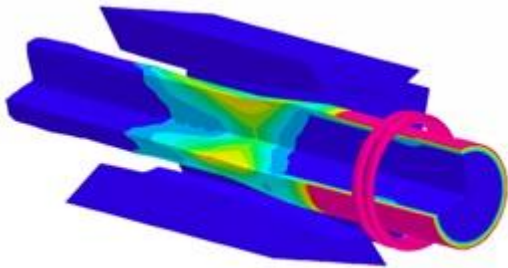
Numerical analysis of materials and processes+

Responsible person:

- prof. dr. Tomaž Rodič
- Chair of Materials Forming
- Tel: +386 1 200 04 40, +386 1 200 04 44
- E-mail: tomaz.rodic@omm.ntf.uni-lj.si

Purpose of equipment:

- Computer predictions of the stress-deformation temperature and electromagnetic fields using finite element method.



Microscope Olympus BX61 for characterization of macro and microstructures+

University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.

Responsible person:

- prof. Primož Mrvar, DrSc
- Chair of Foundry, Lepi pot 11
- Tel: 01 2000 447
- E-mail: primoz.mrvar@omm.ntf.uni-lj.si

Purpose of equipment:

• In this laboratory, we can characterise macro and microstructures, mainly of castings and other parts. The laboratory is equipped with a powerful system for image analysis (Materials research lab, producer Analysis). The system allows for macroscopic investigation of casting defects like: shrinkage and gas porosity, cracks, inclusions, etc., as well as microscopic investigations and analyses in light and dark field, in polarised light and with interferential contrast. The laboratory is equipped with the following Olympus instruments: Instrument for macro images, Stereo microscope, Metallographic microscope

Access to equipment:

• The equipment is available upon agreement on **Lepi pot 11, ground floor, room 9**; access time is dependent on equipment use. Reservation and information: tomaz.martincic@omm.ntf.uni-lj.si.

Price of equipment use:

- skilled user: 33,26 €/hour
- non skilled user: 69,51 €/hour

Computer programme Thermo-calc software+



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE



University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.

Responsible person:

- prof. Jožef Medved, DrSc
- Chair for Metallurgical Processing Technique
- Tel: +386 1 2000 423, +386 1 2000 448
- E-mail: jozef.medved@omm.ntf.uni-lj.si

Purpose of equipment:

- Thermo-calc software is meant for calculation of phase diagrams and thermodynamic properties with different databases for all types of metal materials and alloys.

Access of equipment:

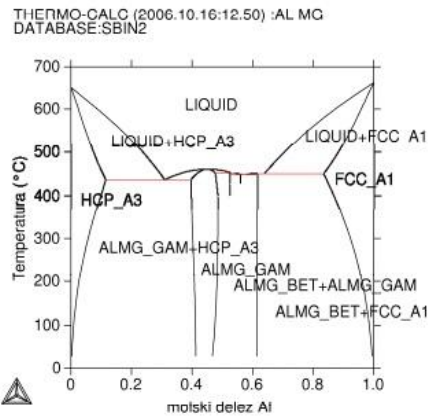
- Chair for Metallurgical Processing Technique, *Lepi pot 11, office 5B*, 1000 Ljubljana

Price for equipment use:

- Skilled user: 1.13 €/hour
- Non-skilled user: 36.76 €/hour



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REPUBLIKE SLOVENIJE



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Scanning electron microscope with EDS, JSM 5610+

University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE



Responsible person:

- assist. prof. Aleš Nagode, DrSc
- Chair of Engineering Materials
- E-mail: ales.nagode@omm.ntf.uni-lj.si

Purpose of equipment:

- Surface analysis,
- Morphology,
- Phase and chemical composition (EDS)
- SEM JEOL-5610 is intended for the surface analysis of solids in vacuo 10⁻⁵ to 10⁻⁶ mbar. It is equipped with an energy dispersive X-ray spectrometer that allows for a qualitative and quantitative chemical microanalysis, a sensor for back scattered electrons (enable phase analysis) and a sensor for secondary electrons (indicates a relief surface and thereby detects the microstructure of the analysed material). It is used in the development and testing of materials, supporting technologies, analysis of injuries and forensic research.

Access of equipment:

- The equipment is available by agreement with the operator or with the head of the laboratory.

Price for equipment use :

- Skilled user: 17,73 €/hour
- Non-skilled user: 58,68 €/hour



Simulator of thermomechanical metallurgical states GLEEBLE 1500D+

University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE

Responsible person:

- prof. Peter Fajfar, DrSc
- Chair of Materials Forming
- Tel: +386 1 4704 500
- E-mail: peter.fajfar@omm.ntf.uni-lj.si

Purpose of equipment:

• Simulator of thermomechanical metallurgical states enables the following investigations of materials: tensile test, compression test, flow curves, activation energy, microstructure development during hot forming, high temperature fatigue testing, solidification simulation, welding simulation, heat treatment, multistage forming test, wear testing.

Access of equipment:

• The equipment is available upon agreement with the responsible person of the equipment. Access time depends on equipment use. It's located at **Lepi pot 11-13**, Ljubljana.

Price for equipment use:

- Skilled user: 28.33 €/hour
- Non-skilled user: 45.20 €/hour



Simultaneous thermal analysis, STA 449 Jupiter+
University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.

Responsible person:

- prof. Jožef Medved, DrSc
- Chair for Metallurgical Processing Technique
- Tel: +386 1 2000 425, +386 1 2000 448
- E-mail: jozef.medved@ntf.uni-lj.si

Purpose of equipment:

• Simultaneous thermal analysis (STA) is a method of thermal analysis that makes it possible to investigate a variety of samples by two or three thermal-analytical methods. Usually those are thermogravimetry (TG), differential thermal analysis (DTA) and differential scanning calorimetry (DSC). Simultaneously, the investigation can be done on processes based on energy difference (absorbing and relaxing heat under reaction) and investigation of mass change (oxidation, degradation, etc.). STA measurement is a complex measurement that is recommended for determining the physical – chemical properties of materials, especially new ones. Simultaneously, the modelling of technological processes can be done. STA analysis makes it possible to determine characteristic temperatures (melting point, boiling point, allotropic modifications, etc.), thermal effect (melting / solidification enthalpy, combustion heat, etc.), specific heat C_p , loss or increment of mass, etc.

Access of equipment:

• Chair for Metallurgical Processing Technique, **Lepi pot 11, laboratory 5A**, 1000 Ljubljana. Available upon agreement.

Price for equipment use:

- Skilled user: 33,84 €/hour
- Non-skilled user: 59,61 €/hour



Differential scanning calorimetry DSC 404 F3 Pegasus® (Netzsch, Germany)+

University of *Ljubljana*,

Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.

Responsible person:

- prof. Jožef Medved, DrSc
- Chair for Metallurgical Processing Technique
- Tel: +386 1 2000 425, +386 1 2000 448
- E-mail: jozef.medved@ntf.uni-lj.si

Purpose of equipment:

• The device enables measurements with differential scanning calorimetry, which is used to determine the thermodynamic properties of materials (metals, ceramics, etc.), such as: characteristic temperatures, enthalpies, specific heat, etc. This is the latest instrument from the above-mentioned manufacturer, namely the DSC 404 F3 Pegasus®, a high-temperature differential scanning calorimeter designed to accurately determine the specific heat of high-performance materials at high temperatures. It allows several different types of furnaces (silver, copper, steel, platinum, SiC, rhodium and graphite), on which the temperature range of the investigation (-150–2000 °C) also depends. We currently have a steel furnace that allows measurement temperatures from -100 °C to 1000 °C. As you can see from the temperature ranges, the instrument allows cooling with liquid nitrogen using the cooling system CC 300.

Access of equipment:

- Chair for Metallurgical Processing Technique, *Lepi pot 11, laboratory 5A*, 1000 Ljubljana. Available upon agreement.

Price for equipment use:

- Skilled user: €/hour
- Non-skilled user: €/hour



Differential scanning calorimetry DSC 204 F1 Phoenix® (Netzsch, Germany)+

University of *Ljubljana*,

Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.



Responsible person:

- prof. Jožef Medved, DrSc
- Chair for Metallurgical Processing Technique
- Tel: +386 1 2000 425, +386 1 2000 448
- E-mail: jozef.medved@ntf.uni-lj.si

Purpose of equipment:

• The instrument enables measurements with differential scanning calorimetry, which is used to determine the thermodynamic properties of materials (metals, ceramics, etc.), such as: characteristic temperatures, enthalpies, specific heat, etc. The DSC 204 F1 Phoenix® has a unique concept in which all essential operating components are integrated into the device itself. The calorimeter is used in the temperature range from -180 °C to 700 °C. As can be seen from the temperature ranges, the instrument can be cooled with liquid nitrogen, using the cooling system CC 300.

Access of equipment:

- Chair for Metallurgical Processing Technique, **Lepi pot 11, laboratory 5A**, 1000 Ljubljana. Available upon agreement.

Price for equipment use:

- Skilled user: €/hour
- Non-skilled user: €/hour



Light microscope Zeiss, Axio Imager A1m+

University of **Ljubljana**,

Faculty of **Natural Sciences and Engineering**



Research equipment is (co)financed by the Slovenian Research Agency.



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE

Responsible person:

- prof. Boštjan Markoli, DrSc
- Chair of Metallography
- Tel: +386 1 470 46 14
- E-mail: bostjan.markoli@omm.ntf.uni-lj.si

Purpose of equipment:

- Light microscope enables observation of the microstructure of properly prepared metallographic samples of different materials. The microscope enables imaging of samples using different examination modes like bright field, dark field, differential interference contrast and polarised light. The light microscope is equipped with a digital camera AxioCam ICc 3 (3.3 million pixels) and AxioVision software for image analysis (grain size, phase fractions, etc.).

Access to equipment:

- Equipment is available on **Aškerčeva 12 street, 1st floor, soba 127**, upon agreement.

Price for equipment use:

- Skilled user: 34,41 €/hour
- Non-skilled user: 68,82 €/hour



Optical microscopes Reichert+

Responsible person:

- prof. dr. Boštjan Markoli
- Chair of Metallography
- Tel: +386 1 470 46 14, +386 1 470 45 34
- E-mail: bostjan.markoli@omm.ntf.uni-lj.si

Purpose of equipment:

- Optical microscopes enable research and characterisation of metal surface materials.

Universal tensile testing machine – Zwick z250+

Responsible person:

- prof. dr. Milan Bizjak
- Chair of Engineering Materials
- Tel: +386 1 200 04 21
- E-mail: milan.bizjak@omm.ntf.uni-lj.si

Purpose of equipment:

- The tensile machine, with a work area of up to 250 kN, in addition to the standard equipment is supplemented by a stove that provides testing at a hot temperature of up to 700 °C. Triple temperature control in the oven allows the execution of complex measurements such as the determination of Superplastic properties of metallic materials.





Vacuum induction casting furnace+

University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.



Responsible person:

- dr. Primož Mrvar, DrSc
- Chair of foundry
- Tel: +386 1 2000 447
- E-mail: primoz.mrvar@omm.ntf.uni-lj.si
- prof. Jožef Medved, DrSc
- Chair of Metallurgical Processing Technique
- Tel: +386 1 2000 423
- E-mail: jozef.medved@omm.ntf.uni-lj.si

Purpose of equipment:

• All processes including preparation, melting, pouring and cooling are made in a vacuum or in a controlled atmosphere.

• Specifications:

- Power: max 45 kW
- Frequency: 1 – 5 kHz
- Vacuum: 10 – 3 mbar
- Volume: 2.5 L
- Max. temperature: 2000 °C
- The furnace is suitable for making and elevation and casting of different materials.
- With the new experimental computer regulated furnace, we can perform:
 - Gravity casting in permanent moulds,
 - Gravity casting in unique forms made from different fireproof materials,
 - Centrifugal casting in shells (investment casting) and permanent moulds.
 - The furnace can be used for directional solidification.

Access of equipment:

• The equipment is available upon agreement on **Lepi pot 11 street, ground floor**; access time is dependent on equipment use. Reservation and information: tomaz.martincic@omm.ntf.uni-lj.si

Price for equipment use:

- Skilled user: 124,34€/uro
- Non-skilled user: 139,26 €/uro



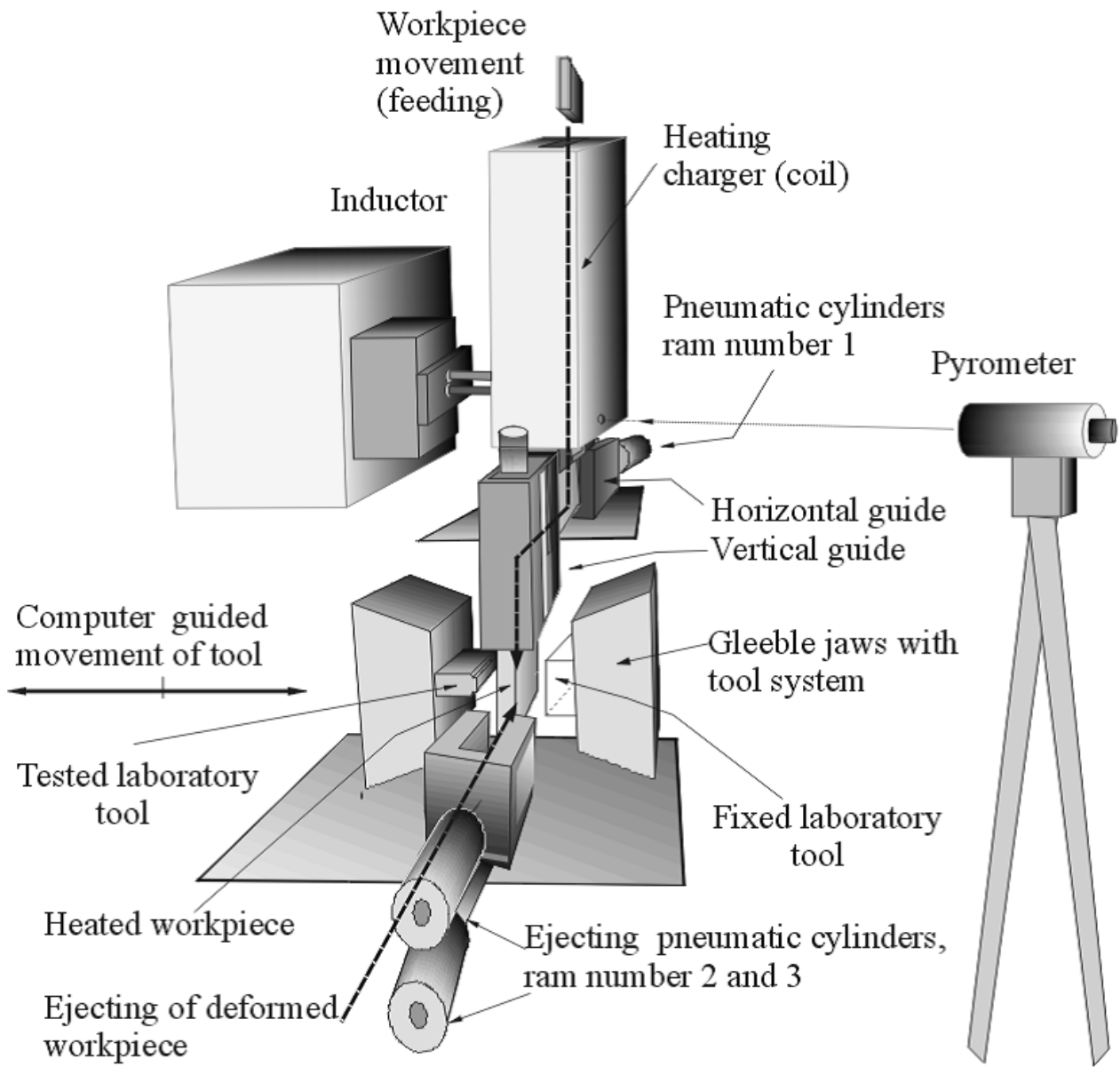
High temperature determination of wear resistance+

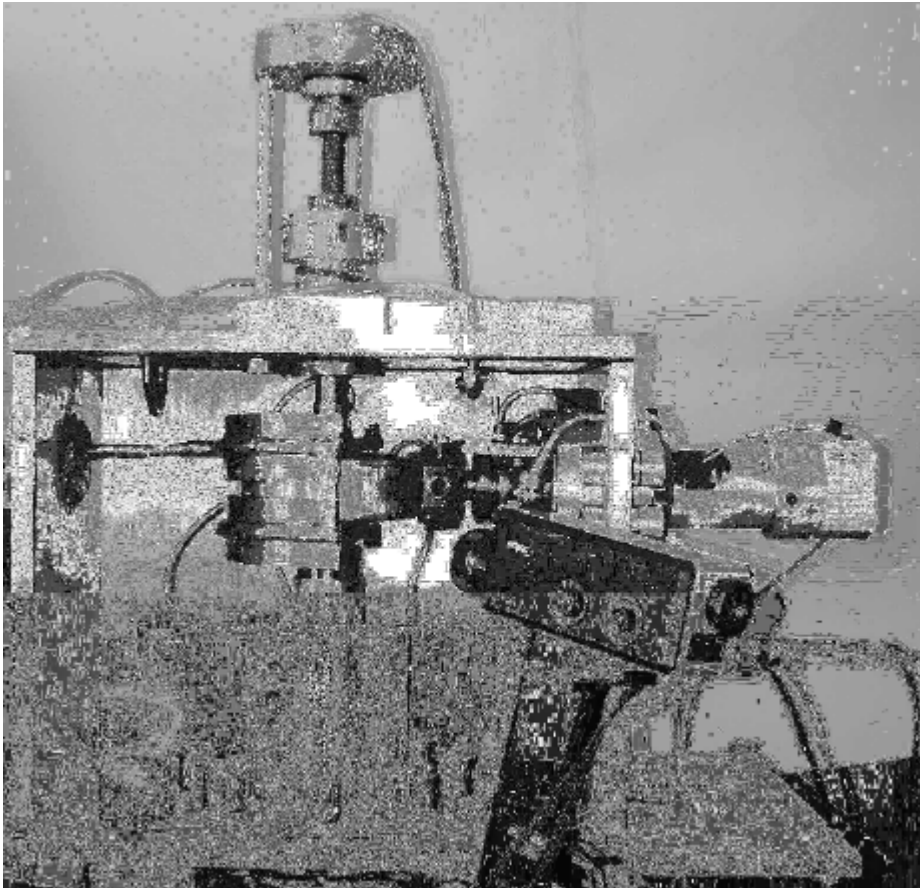
Responsible person:

- assoc. prof. dr. Milan Terčelj
- Chair of Materials Forming
- Tel: +386 1 4704 506, +386 1 2000 434, +386 1 4250 316
- E-mail: milan.tercelj@omm.ntf.uni-lj.si

Devices for testing wear:

- Long sliding lengths (tribological pair of hard test / Soft antibody)
Short sliding lengths (forging).





Scanning electron microscope Jeol JSM-7600F+
University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE

Research equipment is (co)financed by the Slovenian Research Agency.

Responsible person:

- prof. Boštjan Markoli, DrSc
- Chair of Metallography
- Tel: +386 1 4704614
- E-mail: bostjan.markoli@omm.ntf.uni-lj.si

Purpose of equipment:

• Scanning electron microscope (SEM) enables imaging and microanalysis of different materials. Lateral resolution when using SE is 1.0 nm at 15kV. The microscope enables magnifications from 25 to 1,000,000 times. It can work with acceleration voltages from 0.1 to 30 kV. The scanning electron microscope is equipped with several different detectors:

- SE, LEI Detector (secondary electrons)
- BE Detector (backscattered electrons)
- INCA Oxford 350 EDS SDD (EDS micro-chemical analysis)
- INCA Wave 500 spectrometer (WDS micro-chemical analysis)
- XENOS XeDraw 2 (e-lithography)
- EBSD, Channel 5, Oxford Instruments (system for determination of crystallographic orientation)
- r-filter for combining SE in BE signals

Access to equipment:

• Equipment is available at [Jožef Stefan Institute, Jamova 39 street](#), upon agreement.

Cena za delo:

- Skilled user: 34,41 EUR/hour
- Non-skilled user: 68,82 EUR/hour



Thermal Constant Analyser Instrument Hot Disk TPS 2200+

University of *Ljubljana*,

Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.

Responsible person:

- prof. Borut Kosec, DrSc
- Chair of Heat Engineering, Lepi pot 11
- Tel: 01 200 04 10
- E-mail: borut.kosec@omm.ntf.uni-lj.si

Purpose of equipment:

• Determining calorific values of metal materials, polymers, ceramics, composites, thin layers, fluids, with high precision of measurements and repeatability of results in the temperature range -50 °C to +750 °C.

Access to equipment:

• The equipment is available on [Lepi pot 11 street](#), upon agreement with the operator or with head of the laboratory. Terminate reservation:

marija.ribic@omm.ntf.uni-lj.si

Price for the equipment use:

- Skilled user: 198,22 €/hour
- Non-skilled user: 228,17 €/hour



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Scanning electron microscope FEG-SEM Thermofischer Scientific Quattro S (Thermofischer Scientific, USA)+

University of *Ljubljana*,

Faculty of *Natural Sciences and Engineering*



Research Equipment is (co)funded by the Slovenian Research Agency.



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE

Responsible person:

- assist. prof. Aleš Nagode, DrSc
- Chair of Engineering materials
- Tel: 01 200 04 33
- E-mail: ales.nagode@ntf.uni-lj.si

Purpose of equipment:

FEG SEM is equipped for imaging with secondary electrons (SEI), backscatter electrons (BEI) and transmission electrons (STEM). It also possesses detector for (micro)chemical analysis (EDXS), cooling stage (to -60 °C) and heating stage (to 1000 °C) for in situ dynamic testing:

- (re)crystallisation and phase transformations;
 - oxidation, catalysis;
 - growth of materials;
 - hydration, dehydration and determining of contact angle.
- Quattro S enables nano characterisation of:
- metals & alloys, magnetic in super magnetic materials;
 - ceramic materials, composites and polymer materials;
 - thin layers;
 - minerals;
 - soft materials: polymers, textiles, filterv, gels and tissues.

Access to equipment:

Equipment is located at the **Chair of Engineering materials, Lepi pot 11, groundfloor, nd is available upon agreement.**

The price for the use of the research equipment:

- **216,63 €** – base price (it is calculated every time in dependency of the way the analysis is performed and also of the used carrier)



Compact Vacuum Arc Melting System SP-MSM208 (MTI Corporation, USA)+
University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



Research equipment is (co)financed by the Slovenian Research Agency.



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE

Responsible person:

- prof. Boštjan Markoli, DrSc
- Chair of Metallography
- Tel: +386 1 4704614
- E-mail: bostjan.markoli@ntf.uni-lj.si

Purpose of equipment:

- The arc melting system is designed for melting up to 10 g of metallic materials with a melting point up to tungsten (above 3000 °C) under a tiny positive or low vacuum atmosphere (usually Ar). In addition, the system is equipped with a copper mould for vacuum suction casting of rods with a diameter of 6 mm.

Access to equipment:

- Equipment is available at the Department of Geology. The equipment is available by arrangement with the operators or the equipment administrator

Cena za delo:

- Skilled user: 32,29 EUR/hour
- Non-skilled user: 58,53 EUR/hour



T-RDI Stream Pro Flow meter+

University of *Ljubljana*,
Faculty of *Natural Sciences and Engineering*



JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE

search equipment is (co)financed by the Slovenian Research Agency.

Responsible person:

- prof. dr. Mihael Brenčič

Department of Applied Geology

- Tel: +386 1 4704523
- Email: mihael.brencic@ntf.uni-lj.si

Purpose of equipment:

- The equipment is intended for measuring flows in watercourses.

Access to equipment:

- Equipment is available at the Department of Geology. The equipment is available by arrangement with the operators or the equipment administrator.
- Not possible to rent equipment without trained NTF operators..

Čena za delo:

- Skilled user: EUR/hour
- Non-skilled user: EUR/hour

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