Institute of Thermomechanics of the Academy of Sciences of the Czech Republic

LABORATORY OF SURFACE TECHNOLOGY AND DEGRADATION OF MATERIALS

2025

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Veleslavínova 71/11, Pilsen

Laboratory of Surface Technologies and Degradation of materials in Pilsen

Modern approach to materials engineering and material degradation

Our focus

- Advanced technological processes: PVD, PA CVD, chemical-heat treatment.
- Testing the resistance of materials to mechanical, corrosion and thermal stress.
- Simulation of degradation processes to increase the lifetime of materials.
- FEM simulation and material models

Why us?

Extensive laboratory and machinery equipment

We use modern laboratories and advanced technological processes for surface treatment, degradation and analysis of materials, and more.

Expertise and experience

We have extensive experience with industrial research and development in the areas of energy, engineering, automotive, and healthcare.

Individual approach to partnership

We collaborate with each partner on a tailor-made basis and bring innovative solutions to ensure maximum satisfaction when solving a specific task.

Key Industrial Partners

Doosan Škoda Power, ŠKODA JS, Techniques Surfaces Czech Republic, voestalpine High Performance Metals CZ, CENTES, NAVEL, Advanced Metal Powders, VZÚ and others

Key laboratories and equipment

Technological laboratories

- Surface Treatment and Surface Modification Laboratory
- Chemical-heat Treatment Laboratory
- Laboratory of Materials Processing by Ageing Processes
- Heat Treatment Laboratory

Materials degradation laboratories

- Macromechanical Loading Laboratory
- Corrosion Degradation Laboratory
- Laboratory of Ageing of Polymer Materials

Analytical laboratories

- Materialographic Laboratory
- Laboratory for Evaluating the Properties and Behavior of Surface Layers
- Laboratory of Microscopic Methods

FEM simulation and material models

- Development and implementation of material models
- Finite element simulations of materials response to loading processes
- Prediction materials fractures

Workplace goal

1 **development and implementation of advanced technological processes in the field of surface treatments using different technological processes PVD and PA CVD, chemical-heat treatment and heat treatment including ageing of material systems**

2 testing the resistance and predicting the behavior of material systems in degradation processes induced by corrosion and chemical action, thermal effects, macro, micro and nano mechanical stress

3 **evaluation of initiation and development stages of degradation of material systems and complex properties and behavior of surface layers of material systems, microregions of materials and bulk materials of various structures**

4 development of methodological procedures for evaluating the results of technological processes, properties and behavior of material systems with chemical-heat treatment, surface treatments and modifications, and material systems from degradation and ageing processes

5 **development of methodological procedures for setting degradation and ageing processes in correlation with operational stresses**

6 FEM simulation and material models

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Workplace activity

Areas

technological processes of PVD and PA CVD surface treatments

heat and chemical-heat treatment

degradation and ageing of materials

methodological approaches in the field of analytical methods and simulative degradation and ageing processes

FEM simulation and material models

Cooperating companies

Doosan Škoda Power s.r.o.

ŠKODA JS a.s.

Techniques Surfaces Czech Republic s.r.o.

IBZ Group s.r.o.

CENTES spol. s.r.o.

NAVEL spol. s.r.o.

Tool factory HRUBÝ s.r.o.

Jimalu s.r.o.

Gühring s.r.o.

voestalpine High Performance Metals CZ s.r.o.

MEDUNA vacuum hardening s.r.o

Advanced Metal Powders s.r.o.

LaserTherm spol. s.r.o.

Research focused on collaboration with practice

Energy

The area of turbine control elements and steam turbine blades, as well as the area of nuclear energy

Engineering

Area of production of tools, special components, heat treatment of products

Healthcare

Biocompatible and bioactive materials
Area of polymer, composite and metal materials

Automotive

Special components with corrosion, temperature and mechanical stress

Applied research

Transfer of results from pre-applied and applied research → Practice

Project activity

2016-2019

•co-solver of the project Application No. CZ.01.01.01/0.0/15_019/0004451 Thin film deposition - advanced tools and innovative technologies

2016-2022

•co-solver of the project Support of excellent research teams in priority axis no. CZ.02.1.01/0.0/15_003/0000493 Centre of Excellence for Nonlinear Dynamic Behaviour of Advanced Materials in Engineering

2017-2019

•co-solver of the project Epsilon TA CR project no. TH02010026 Development of new technologies for the production of progressive tools and components

2020-2022

•co-solver of the project Application no. CZ.01.1.02/0.0/19_262/0000161 Optimalization of selected surface treatment of heat-resisting steel for specific operational conditions

2023-2024

•co-solver of the project Proof of concept no. CZ.01.01.01/0.8/22_001/0000232 Feasibility study of ecological change of heat treatment by advanced technologies in correlation of qualitative changes of properties and ecological load

2023-2025

•co-solver of the project Application No. CZ.01.01.01/0.1/22_002/0000357 Optimization of the chemical heat treatment of special stainless steel materials with a controlled structure from the point of view of the technological operating parameters of the surface treatment and base material systems

2023-2025

•co-solver of the project Application No. CZ.01.01.01/0.1/22_002/0000358 Optimizing the production of special components from the point of view of forming technology and increasing resistance by surface treatments to the operating conditions of thermal and chemical loads

Technological processes HC490

low voltage reactive arc evaporation in vacuum

- according to the choice of material and structure properties of the cathode
- *according to the choice of process parameters*

surface treatments mainly based on Ti, Cr, Zr, Co nitrides:

binary nitrides TiN, CrN, ZrN, HfN, TaN, WN, VN, CoN, MoN...
ternary nitrides TiAlN, TiSiN, CrAlN,CrSiN, TiNb, ZrNb....
quarternary nitrides TiAlSiN, CrAlSiN...
quinary nitrides TiAlNiSiN, CrAlNiSiN...

chemical elements used to create surface treatments

Ti, Cr, Zr, Co, Mo, W, Ta, Hf, V, Al, Si, Nb, Ni, Cu, Ag

magnetron reactive sputtering in vacuum

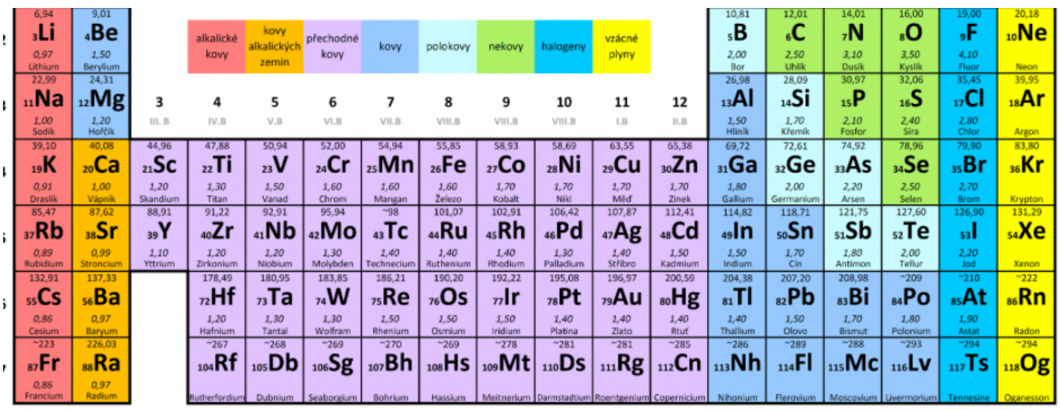
chemical elements used to create surface treatments:

Ti, Cr, Zr, Co, Al, Si, Cu, Ni

chemical heat treatment of surfaces

plasma chemical reactions in gas and thin film deposition

ion implantation into the surface of materials



Technological processes

Application directions

- increase in surface hardness
- improved friction resistance
- improved heat resistance
- improved corrosion resistance
- improved chemical resistance
- increased resistance to abrasion and erosion
- increased resistance to local fatigue
- achieving biocompatibility, bioactivity

Optimization of technological processes

- temperature
- working pressure
- partial pressures of working and reactive gases
- acceleration bias on deposited objects
- current at the cathodes
- controlled electromagnetic field or permanent magnetic field
- process time in relation to other process parameters
- power load target
- and many other factors

Selection and optimization of surface treatments for selected applications

Special materials for applications with high temperature and chemical loads

1.4841	CSN 42 2951
1.4828	1.4852
1.4826	1.4980

Special materials for the automotive industry

1.4571
1.4541

Special bearing materials

1.3505
1.3520

Special materials for energy

T552	1.4913
T671	1.4923
MLX17	1.4922

Heat and chemical-heat treatment

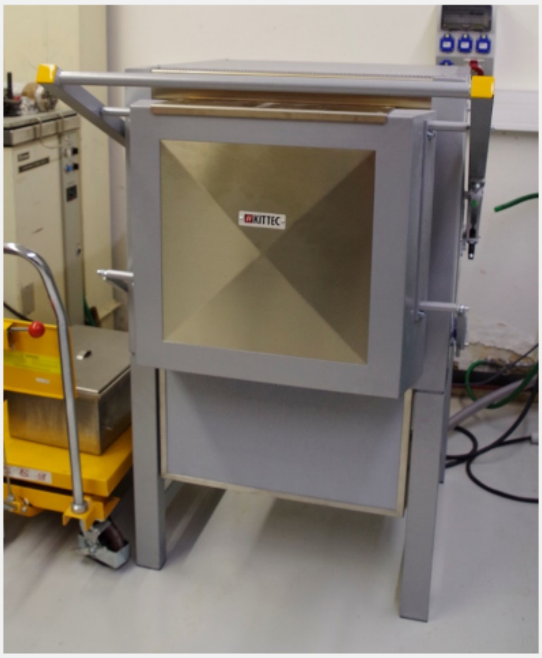
Application directions

- increase in surface hardness
- improved friction resistance
- improved heat resistance
- improved corrosion resistance
- improved chemical resistance
- increased resistance to abrasion and erosion
- increased resistance to local fatigue

Optimization of heat treatment to achieve

different structure properties of products

entry into technological processes of surface treatments due to their optimization



Equipment

- Annealing furnace
- Annealing and hardening furnace
- Circular furnace
- Tube furnace
- Muffle furnace
- Liquid nitrogen and argon

Processes

Nitriding
Cementation
Carbonitriding
Nitrocementation
Boriding
Annealing
Hardening
Temperature Ageing

Macromechanical testing

Methods of loading

Static loading – tension, compression, bending and torsion
Cyclic overloading
Low-cycle and high-cycle fatigue loading – tension, compression, torsion and bend
Mechanical loading in a temperature chamber and with induction heating
Mechanical loading at room temperature
Mechanical loading in liquids

Application directions

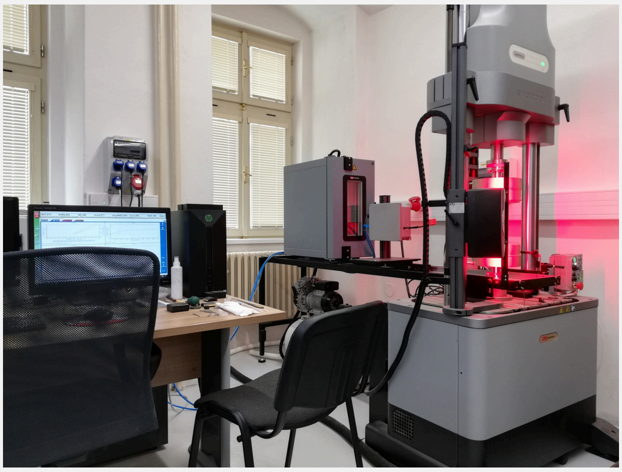
verification of resistance to static loads
verification of resistance to oscillating loads

Application

· Influence of surface treatments (PVD-ARC, magnetron, CHHT)
Influence of heat treatment
· Influence of degradation processes- corrosion, temperature load
· Effect of ageing of polymers and composites – temperature, humidity and radiation

Machine

Epuls



Polymer and composite materials

Ageing evaluation

· Temperature ageing
· Ageing due to humidity
· Evaluation of relaxation under pressure
· Evaluation of materials in the automotive, marine and railway industries
· Evaluation of materials in the field of cable insulation
· Evaluation of sealing elements
· Evaluation of materials for bio applications

Ageing testing

Various combinations

- sun radiation
- influence of defined humidity or showering
- influence of temperature by heating and beyond sun radiation

Approximation of real conditions
long-term effects of combined influences on polymer ageing

Monitoring the effect of sun radiation:
For selected polymer materials
For selected composite materials
For surface treatments
- realized by technological processes

Other equipment

Drying rooms

Water baths

Corrosion resistance testing

Corrosion simulation

· exposure to humidity
· influence of humidity level
· exposure to salt fog
· water spray or saline spray tests
· temperature effect

Testing in chambers with defined conditions

- saline
- selected acids (boric, oxalic, sulphuric,..)
- at room temperature
- at elevated temperature

Evaluation of corrosion initiation, corrosion development and analysis of corrosion protection possibilities

Devices

- Corrosion chamber
- Cyclic voltametry
- Salt and acid baths
- Laboratory scales

Evaluation of mechanical properties and behavior of surface layers, surface layer – basic material systems and material microregions

Measurement methods

- Static measurements in different modes
- Scratch measurements in different modes

Evaluation

· Evaluation of hardness characteristics
· Evaluation of elastic-plastic behavior
· Evaluation of brittle fracture properties
· Evaluation of adhesive-cohesive behavior of systems surface treatment – basic material
· Evaluation of local fatigue properties
· Evaluation of friction properties and wear

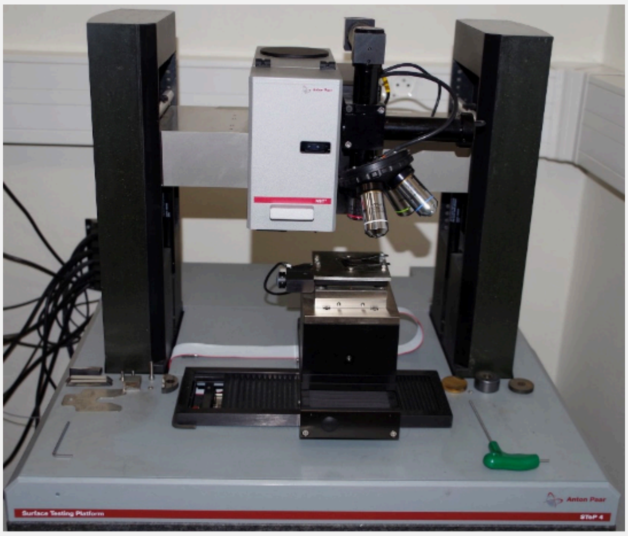
Devices

nanoscratch tester

macroscratch tester

Ernst hardness tester

Epuls



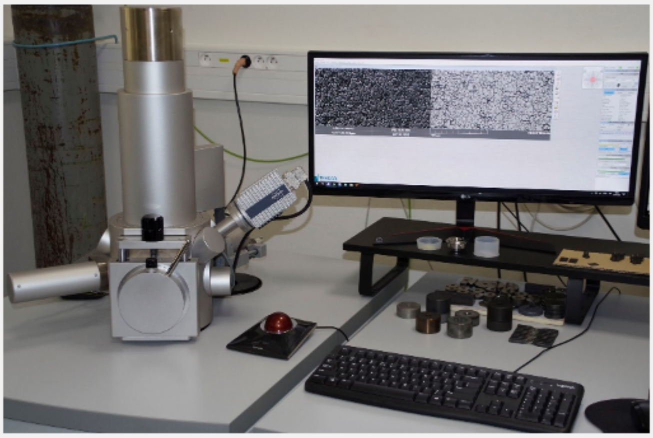
Application

· Evaluation of surface treatments from technological equipment with feedback
· Evaluation of chemical and heat treated surfaces with feedback
· Evaluation of changes after various heat treatments
· Evaluation of changes after corrosion exposure
· Evaluation of changes after long-term temperature exposure
· Evaluation of step changes after various ageing processes – temperature, humidity, radiation
· Evaluation in small locations

Evaluation of surface morphology and fractures, structure, phase and chemical composition

Evaluation

- Evaluation of morphology, structure, phase and chemical composition of basic bulk materials.
- Evaluation of materials after various heat treatments
- Evaluation after various chemical-heat treatment of surfaces
- Evaluation after various technological processes of deposition from HC490
- Evaluation after long-term temperature exposure
- Evaluation after various corrosion and chemical tests
- Evaluation after various ageing processes
- Evaluation of failures and fractures after mechanical load tests
  - Static
  - Quasi-static
  - Fatigue
- Evaluation after all types of indentation tests



Devices

- Scanning electron microscope and EDX microprobe
- Light materialography microscope
- Digital microscopy
- X-ray fluorescence

Other equipment

Materialography

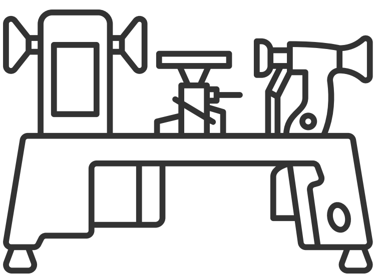
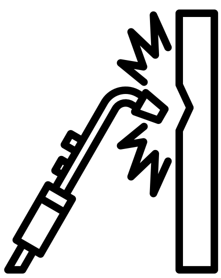
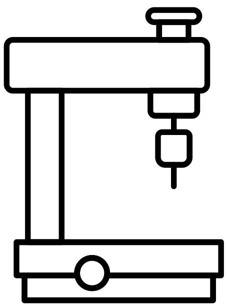
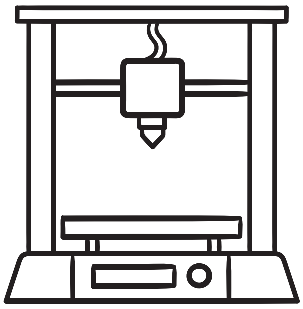
- Grinder/polisher
- Cutter
- Various etchings

Laboratory

- 3D printer
- Calotest

Workshop

- Blasting device
- Lathe
- Milling machine
- Drill
- Grinder
- Welding machine
- Hydraulic press

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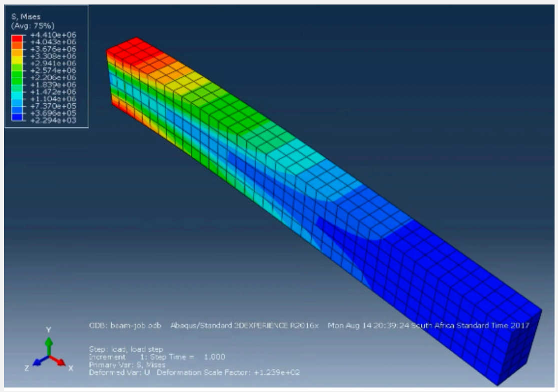
FEM simulation and material models

1) development and implementation of material models
2) finite element simulations of the response of materials to loading processes
3) prediction of material failure

The central topic of the research is the development of constitutive models of materials. In particular, these are elasto-plastic material models and models respecting the degradation of materials under the influence of loading and the surrounding environment. The designed material models are subsequently implemented in finite element software, which allows to simulate various behavior of materials. The performed numerical analyses focus both on the prediction of material failure and on the simulation of the response of materials during mechanical or thermal loading.



Software

Abaqus

Application

Automotive industry
Mechanical engineering industry
Construction industry
Aerospace industry

Material models

General properties (density, damping, thermal expansion)
Elastic properties (linear, nonlinear, viscoelasticity)
Inelastic properties (plasticity, rubbers, betas..)
Thermal properties
Acoustic properties
Hydrostatic fluid properties
Equations of motion
Volume diffusion properties
Electrical properties
Fluid flow properties
Combined properties