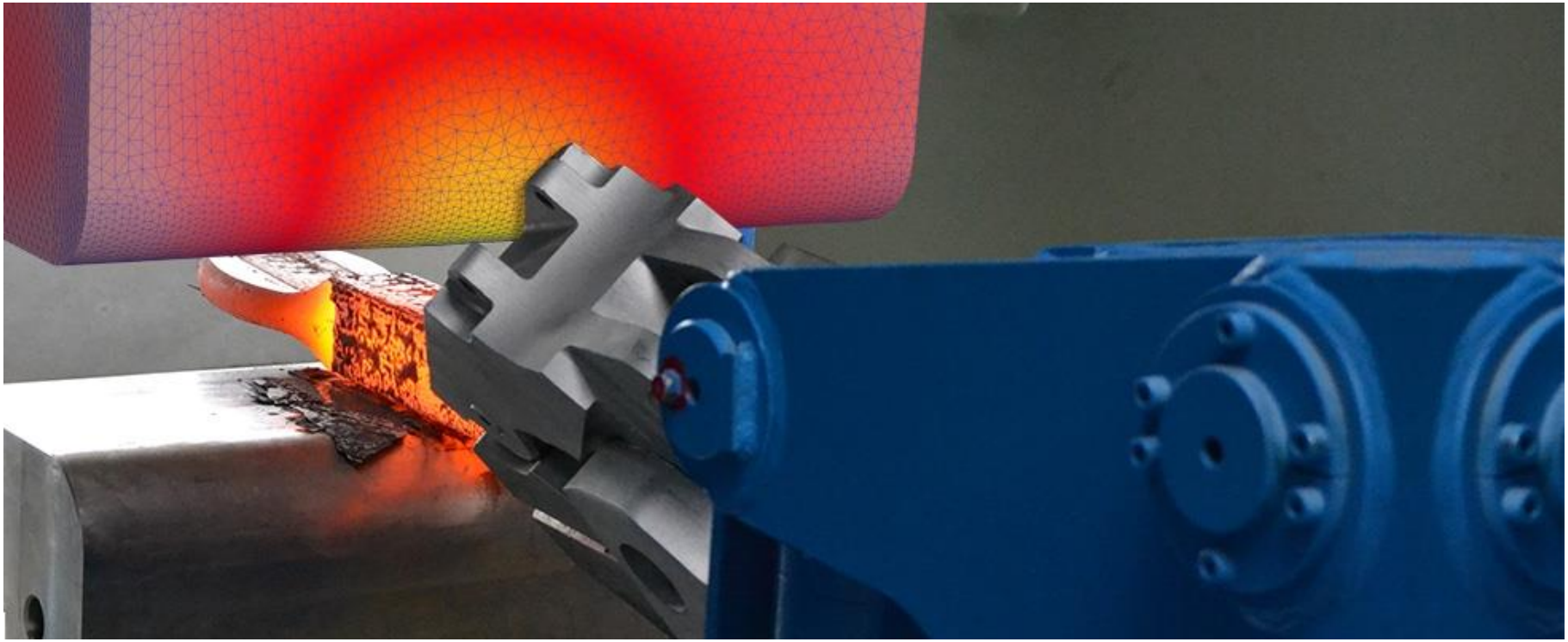
COMTES FHT a.s.

R&D in metals

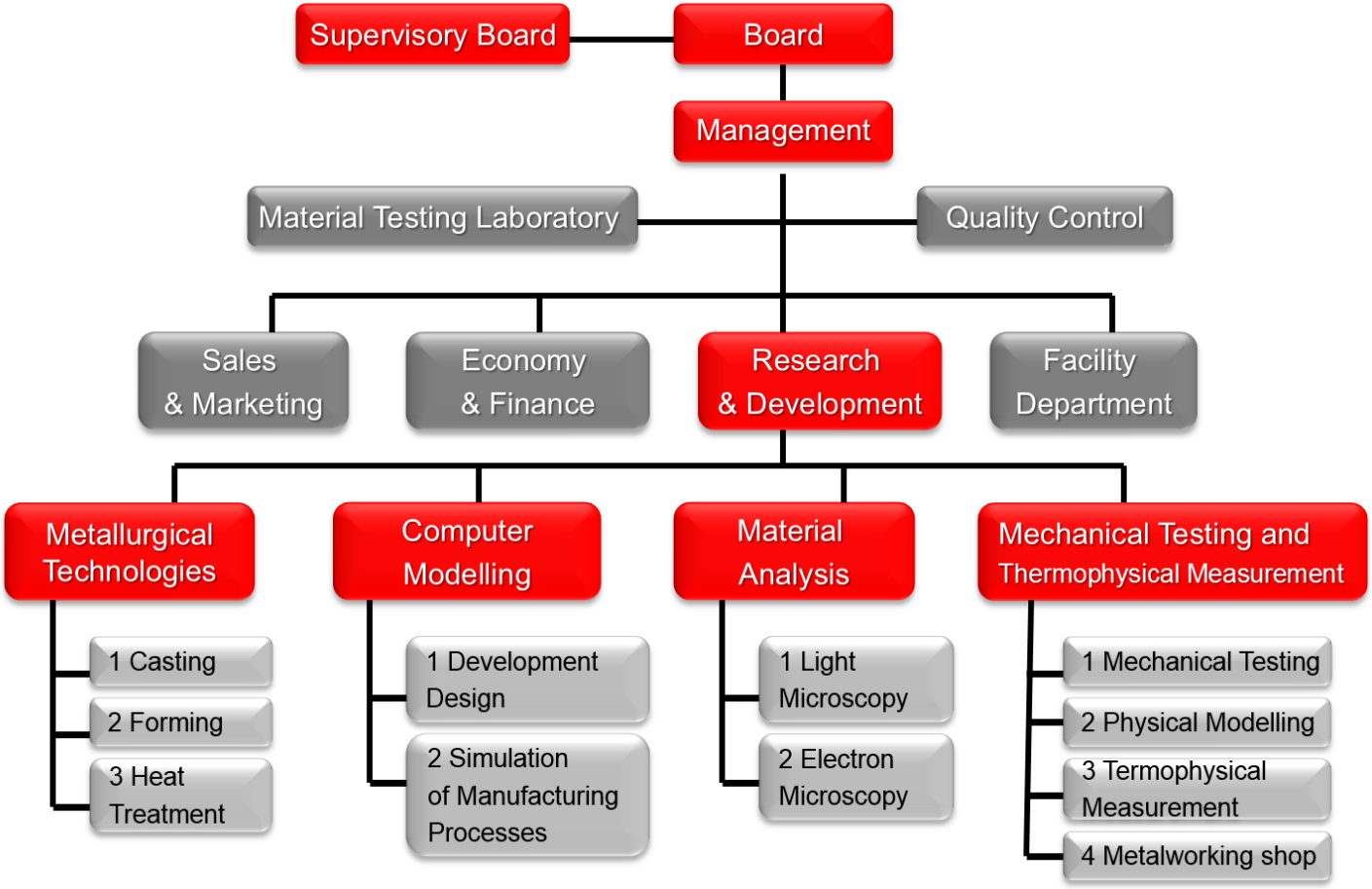


Facility in Dobřany

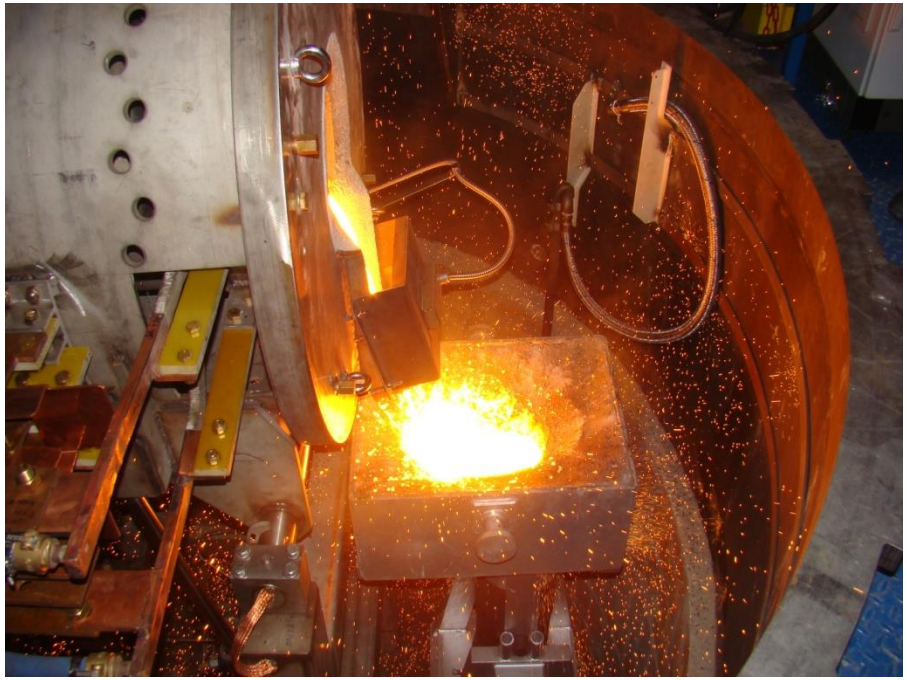
Activities

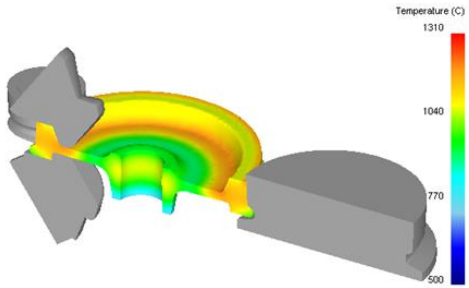
- Development of technologies
- Materials research
- Measurement and testing
- Consultancy and training

Organigram

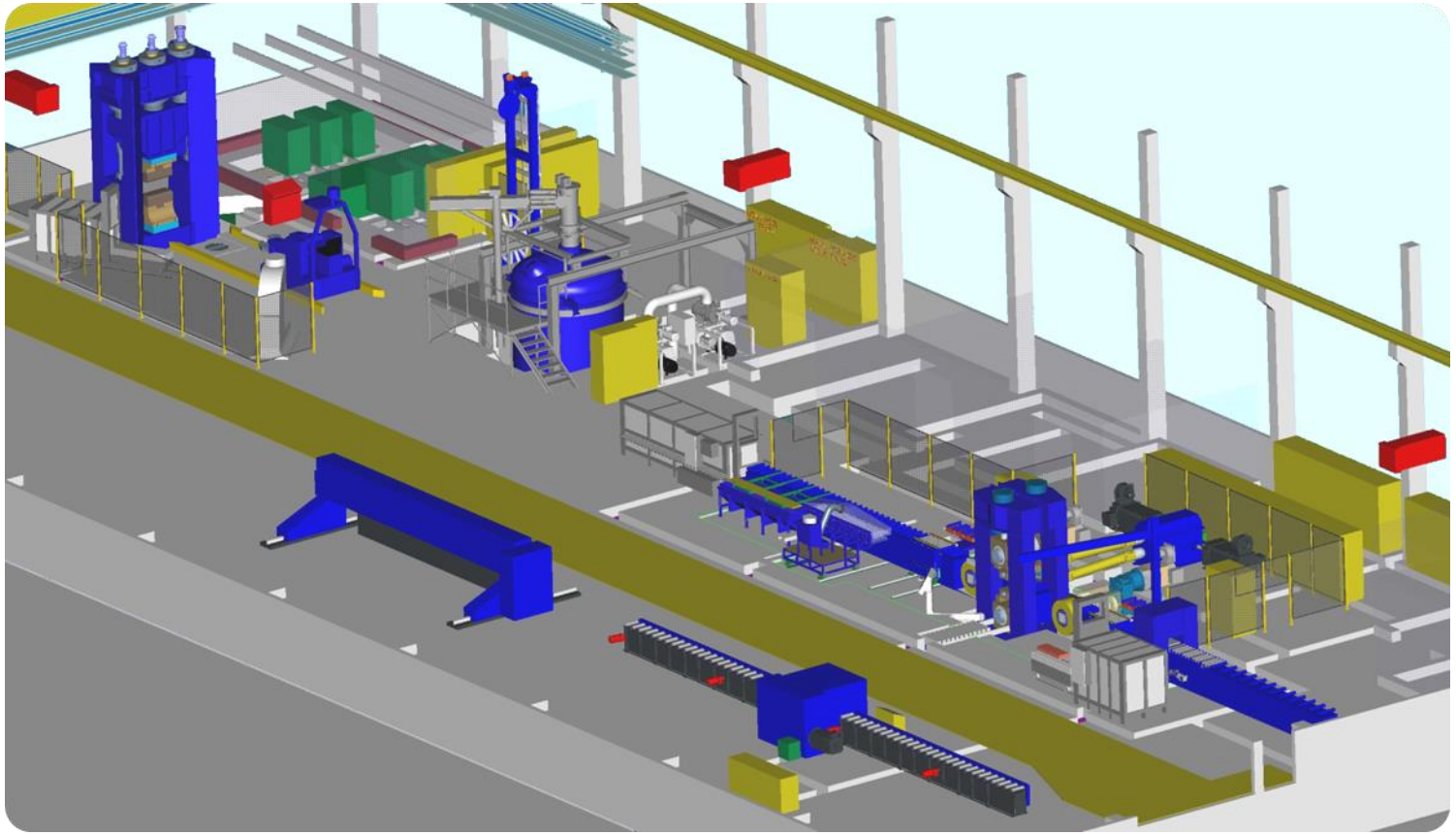

Supervisory Board
Board
Management
Material Testing Laboratory
Quality Control
Sales & Marketing
Economy & Finance
Research & Development
Facility Department
Metallurgical Technologies
1 Casting
2 Forming
3 Heat Treatment
Computer Modelling
1 Development Design
2 Simulation of Manufacturing Processes
Material Analysis
1 Light Microscopy
2 Electron Microscopy
Mechanical Testing and Thermophysical Measurement
1 Mechanical Testing
2 Physical Modelling
3 Termophysical Measurement
4 Metalworking shop

Overview of departments





Metallurgical Technologies



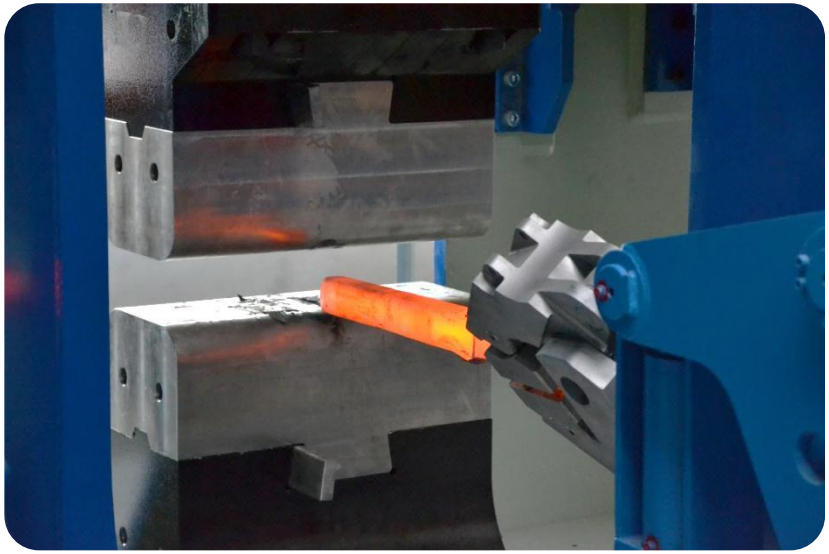
Metallurgical Technologies

- Melting and casting of ingots and castings up to 500 kg (steel, Ni based superalloys, Al alloys etc.)
- Vacuum melting and alloying

Metallurgical Technologies

- Forging of ingots up to 1 t, forging of small specimens, prototyping
- Open and closed die forging
- Program forging (automatic open die forging)

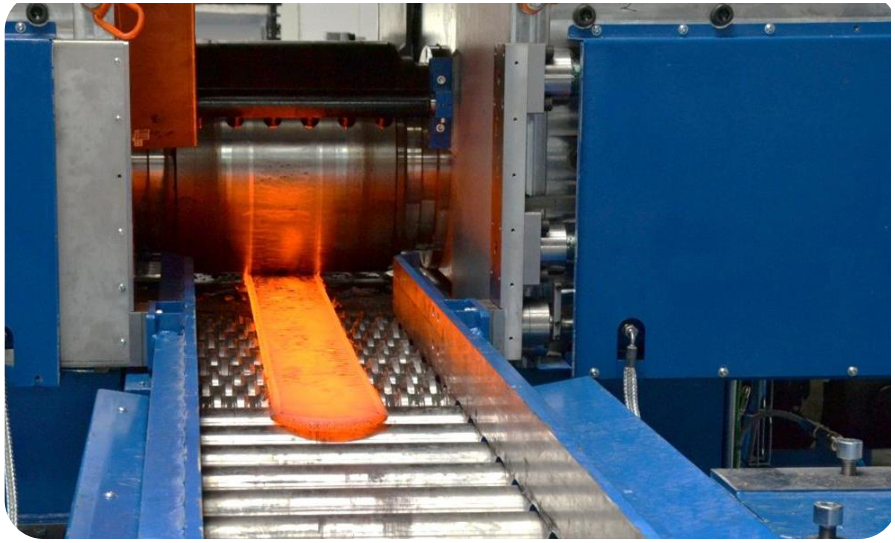
Max. force	2 500 t
Working area	800 x 800 mm
Max. stroke	500 mm
Max. opening	900 mm



Forging press 2,500 t

Metallurgical Technologies

- Hot and cold rolling of sheets down to 0,5 mm on reversible rolling mill (both two-high and four-high configurations can be used)
- Thermo-mechanical rolling
- Rolling of tailored rolled blanks

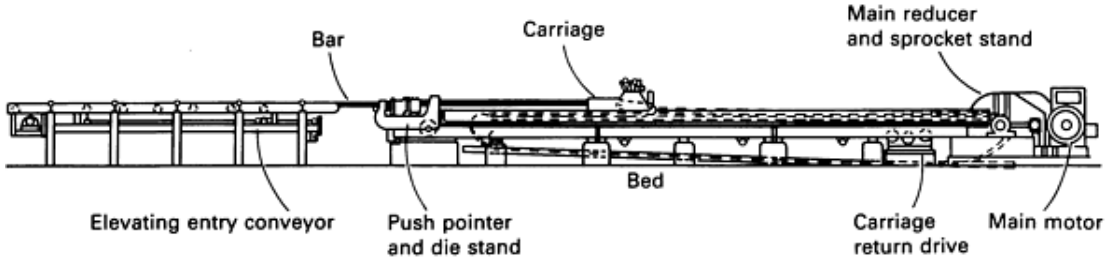


Two high mill
Hot rolling
- Max. input height 100 mm
- Max. temperature 1250 °C
- Rolling down to 4 mm

Four high mill
Cold rolling
- Max. reduction 10%
- Rolling down to 0,5 mm

Metallurgical Technologies

- Drawing of wires and tubes (from approx. 30 to 0,2 mm)



Draw bench for
diameters 30-6 mm

Precise drawing line for
diameters 15-0.2 mm

Universal straigthening
line for wires and tubes

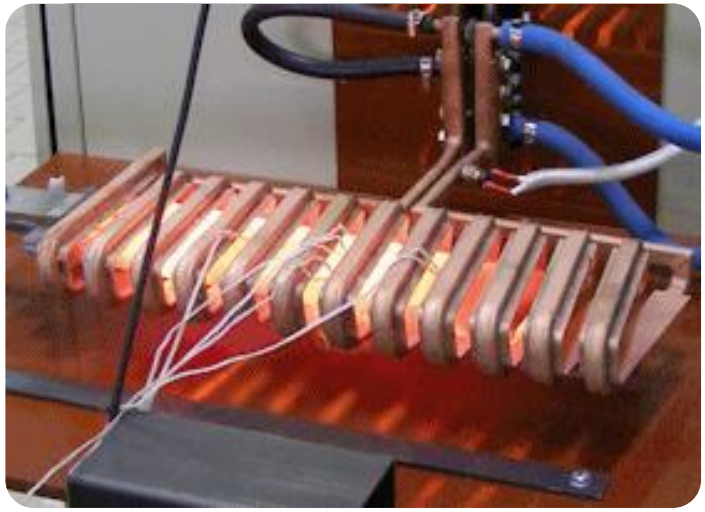
Metallurgical Technologies

- Conventional and vacuum hardening
- Cryogenic treatment
- Thermo-chemical treatment (nitriding, case hardening, boronizing)

Heat chamber of the SCHMETZ vacuum hardening furnace

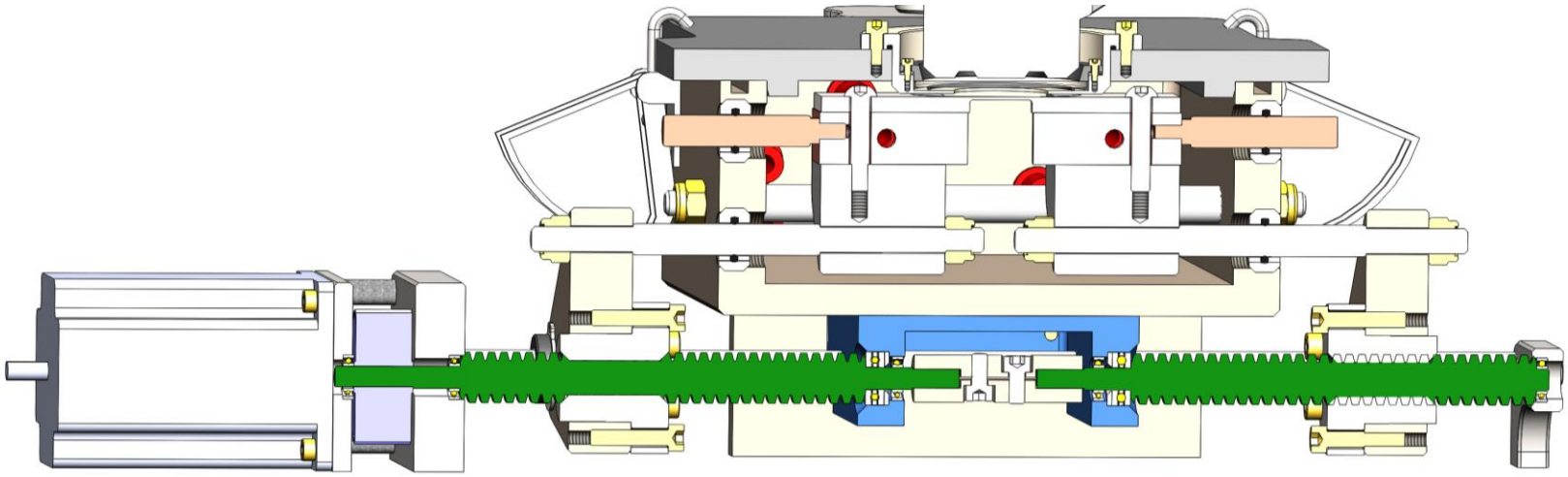
Metallurgical Technologies

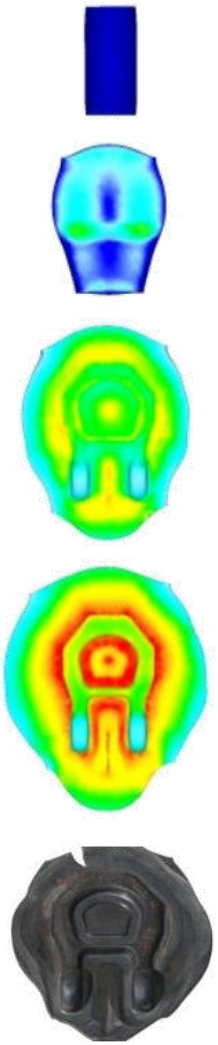
- Development of induction heat treatment procedures
- Incl. calculations and manufacturing of inductors

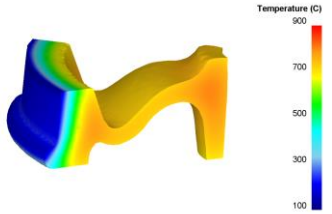


Examples: application of
induction heat treatment

Computer Modelling

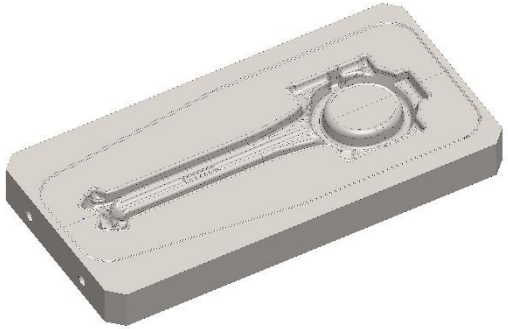




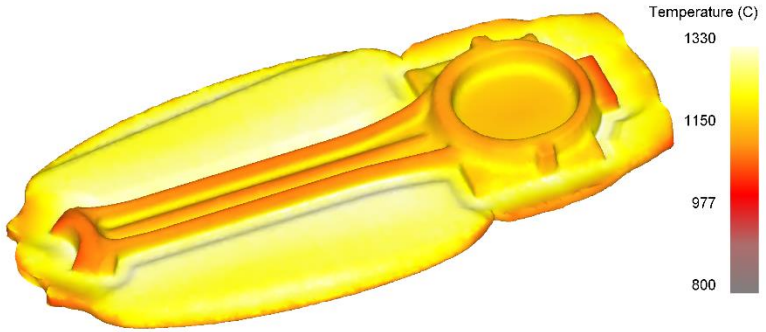


Computer Modelling

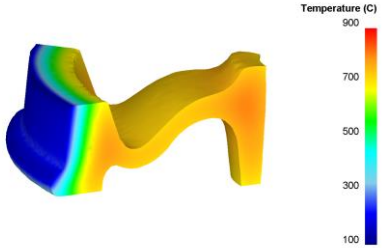
Development Design



Simulation of Manufacturing Processes



Development Design



- **Design** development
- **Design** optimization, material optimization
- **Design** lifetime extension
- **Design** of forging and heat treatment fixtures
- **Design** of special tools and jigs
- **Design** of laboratory samples and tools

DS CATIA

DS SolidWorks

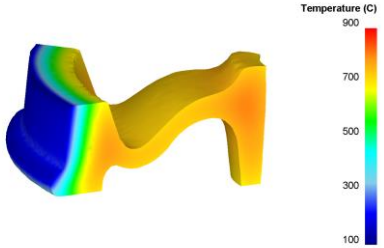
MSC Software

fe-safe

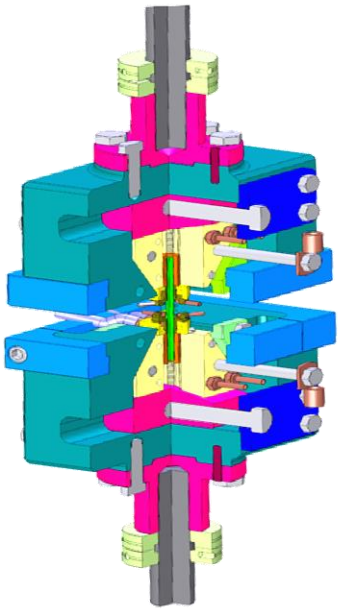
SOLID EDGE

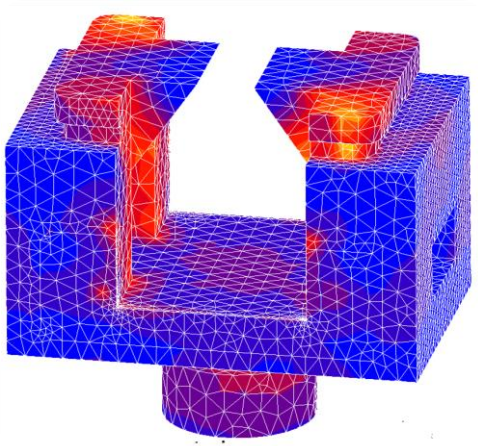
DS ABAQUS

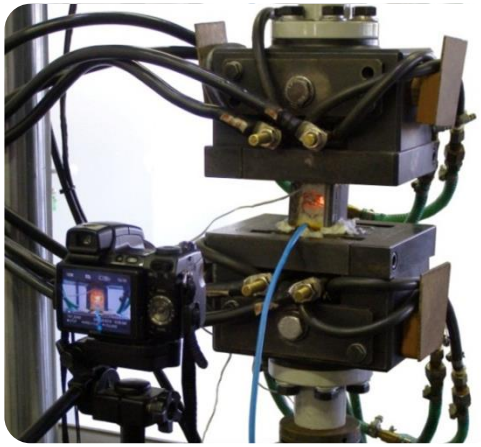
Development Design



Grips for the thermo-mechanical simulator

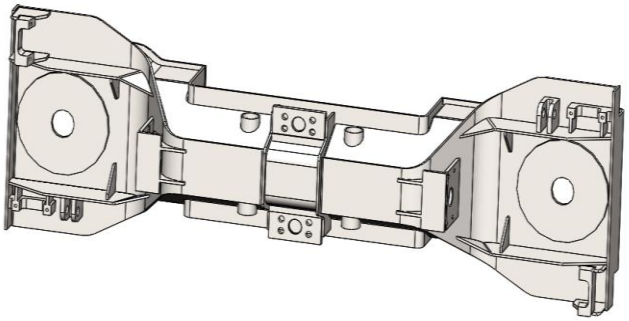




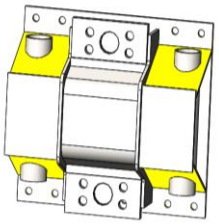


CAD model → FEM simulation → Testing machine

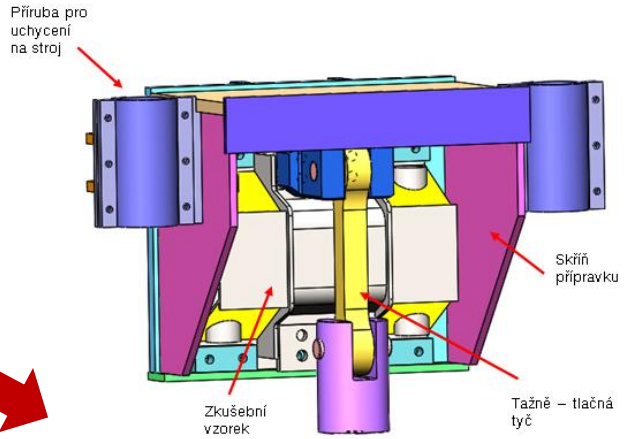
Fixtures for Testing



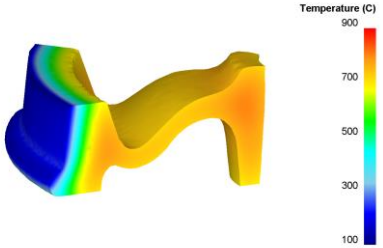
Design part to be tested



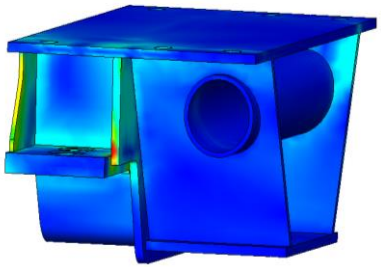
Sample

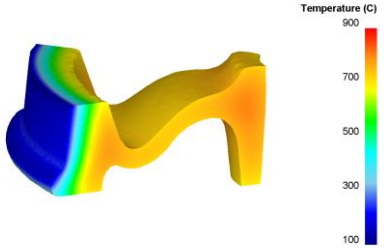


Design of fixture



Measurement – crack initiation





Simulation of Manufacturing Processes

- **Material data preparation** for numerical simulation
  - Measurement (mechanical and thermal properties) and evaluation
  - Thermo-mechanical properties calculation based on chemical composition

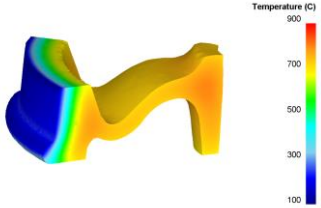
- **Design and optimization of processes**
  - Forging, rolling, stamping
  - Hydroforming,.....
  - Heat treatment, thermomechanical processing, hardenning
  - Induction heating

DEFORM™
Design Environment for FORMing

AUTOFORM
Forming Reality

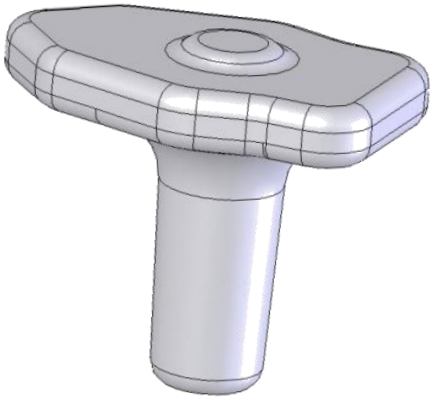
ABAQUS

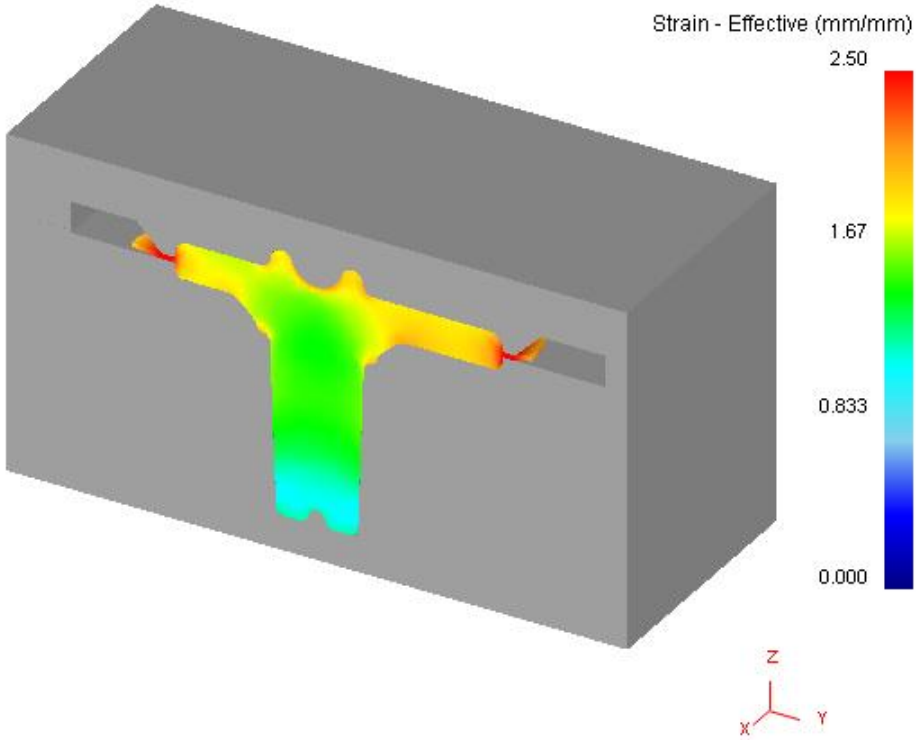
JMatPro
PRACTICAL SOFTWARE FOR MATERIALS PROPERTIES

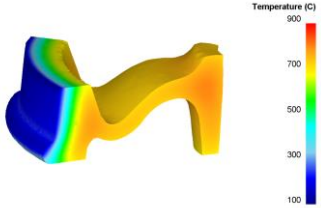


Closed-die forging simulation

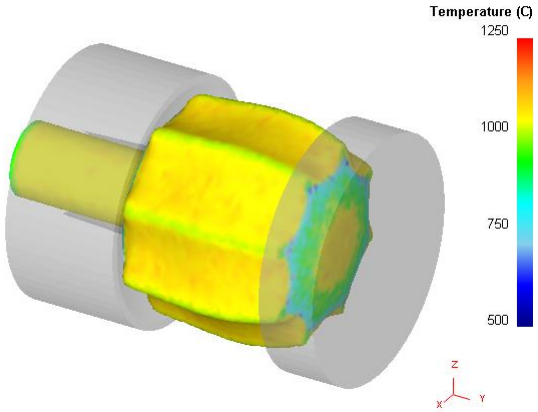
- Forging process design
- Material flow analysis
- Calculation of strain level
- Temperature analysis
- Analysis of lap formation
- Die cavity filling

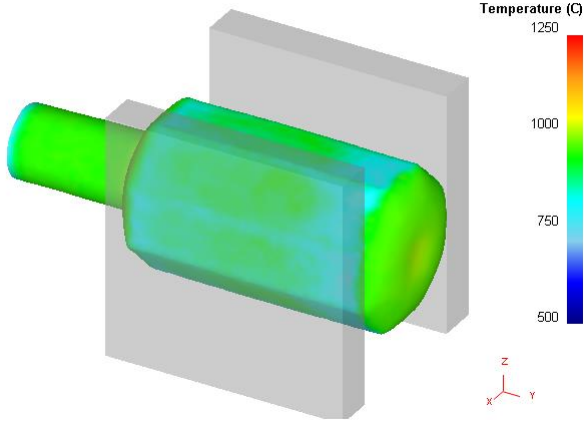




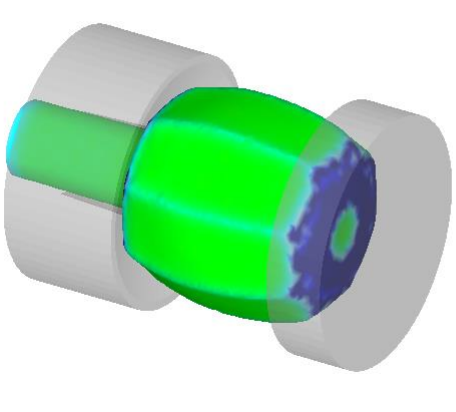


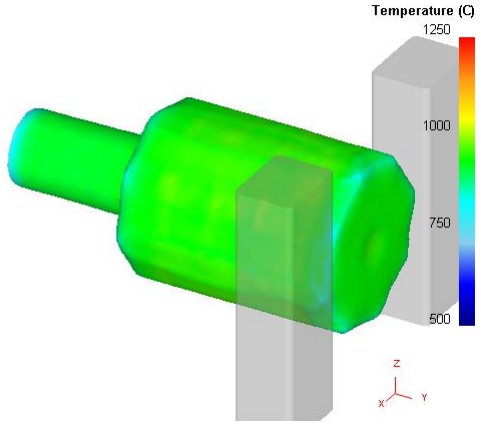
Open-die forging simulation

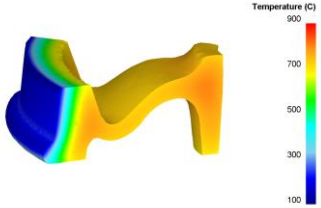




Analysis of material flow within
segregation cone region and along the ingot axis

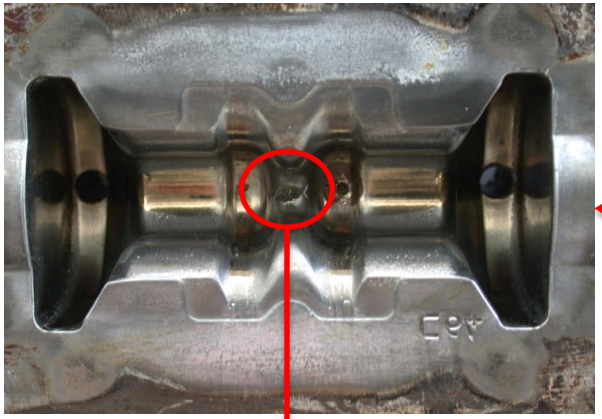


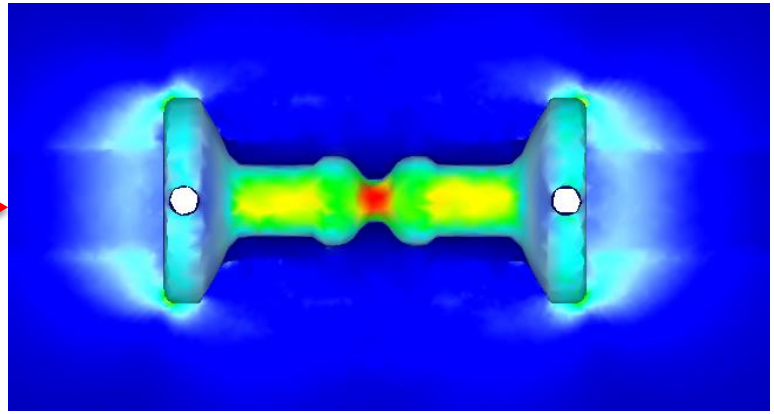




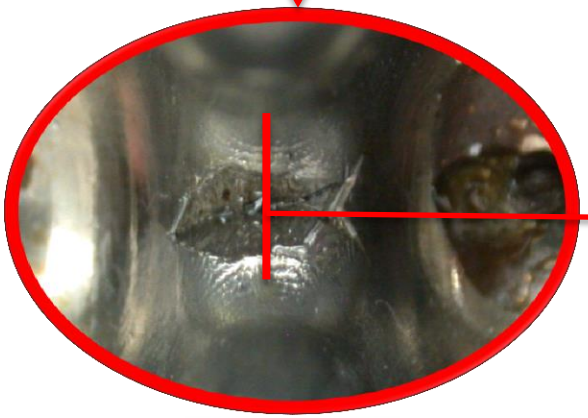
Closed die stress and life-time evaluation

- Stress state in the die

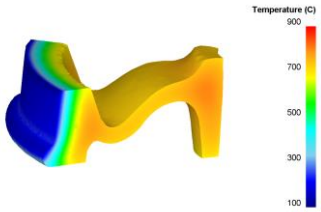




Stress state in the die

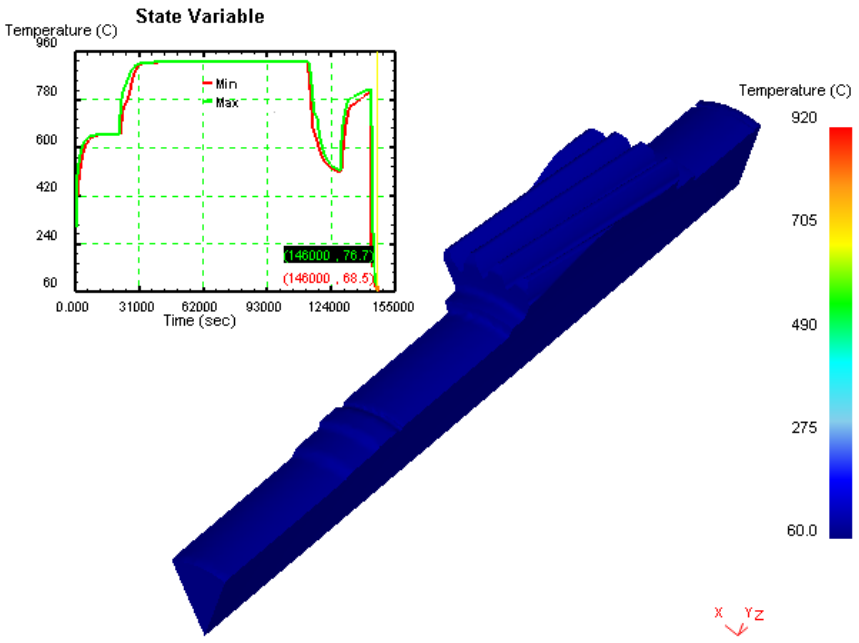


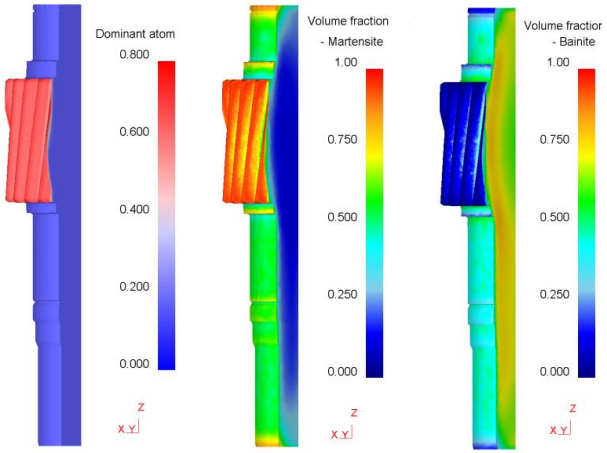
Crack



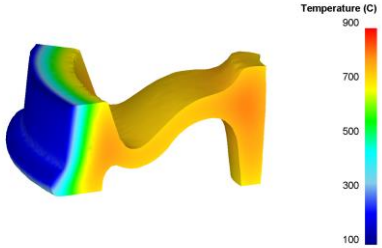
Simulation of heat treatment

- Case hardening of gear shafts



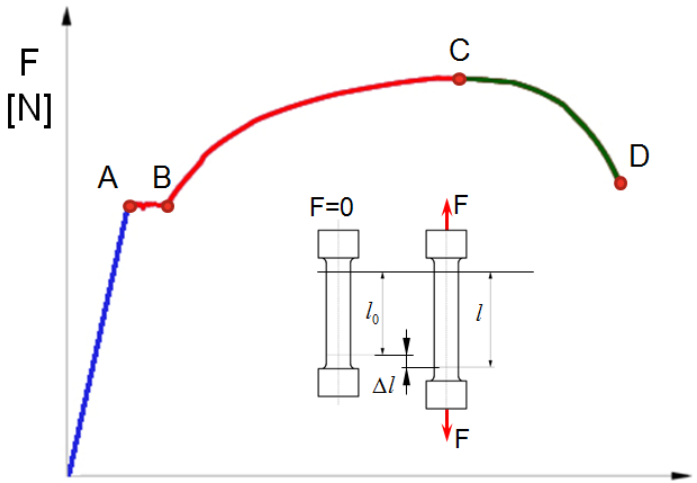


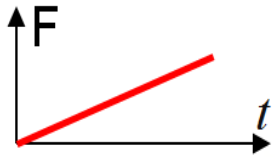
Calculation of carbon diffusion and subsequent phase transformations

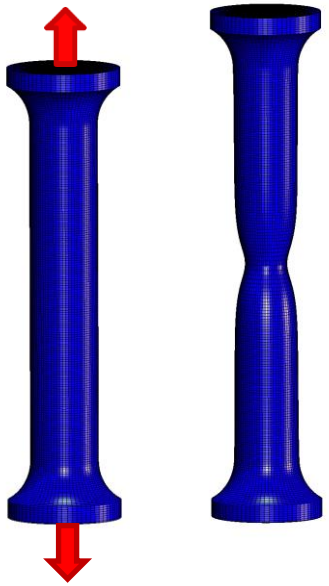


Materials data for basic material models

- Basic materials data evaluation

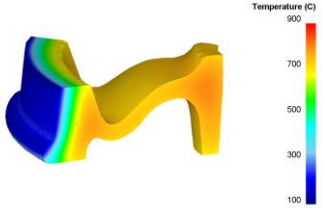






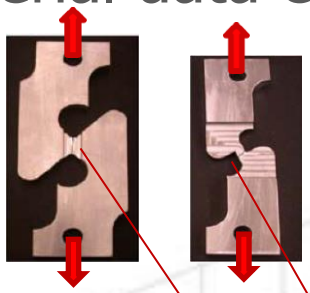
Hooke's law : E, μ

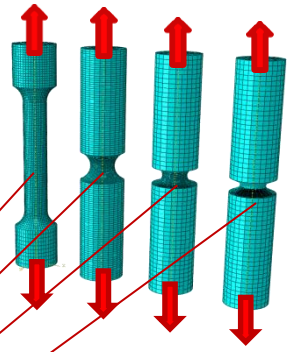
Plastic deformation: isotropic, kinematic, cyclic plasticity, creep, ….

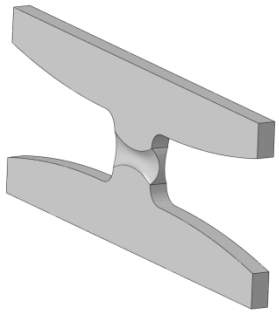


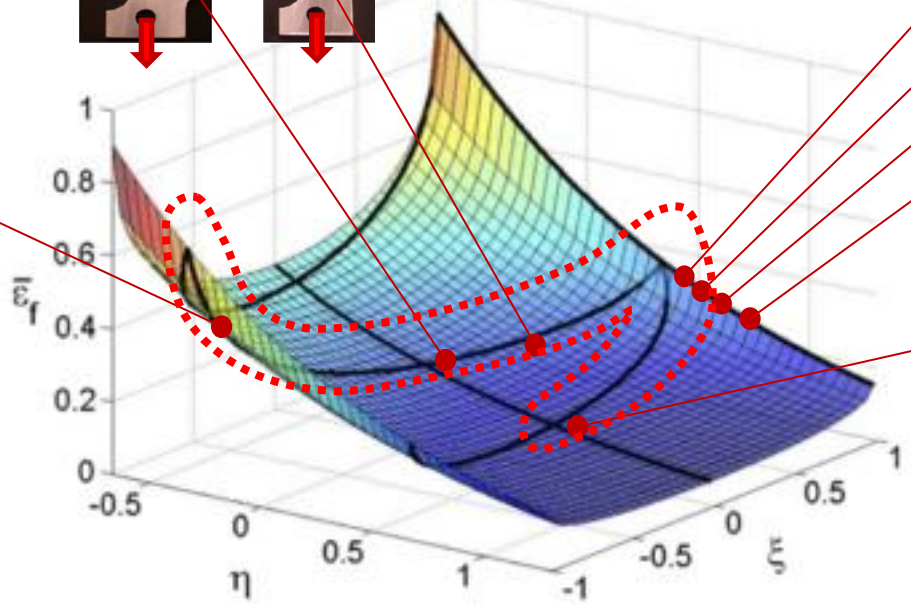
Material data for advanced material models

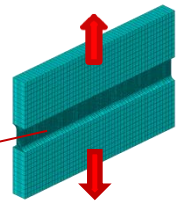
- Advanced material data evaluation – fracture locus

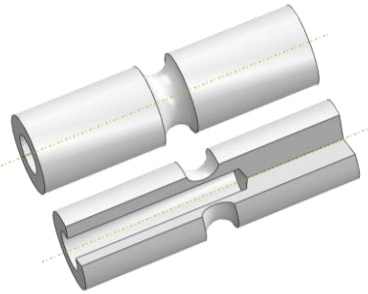




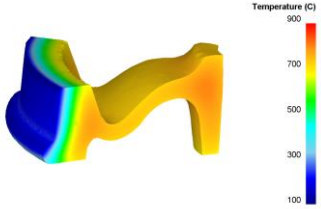




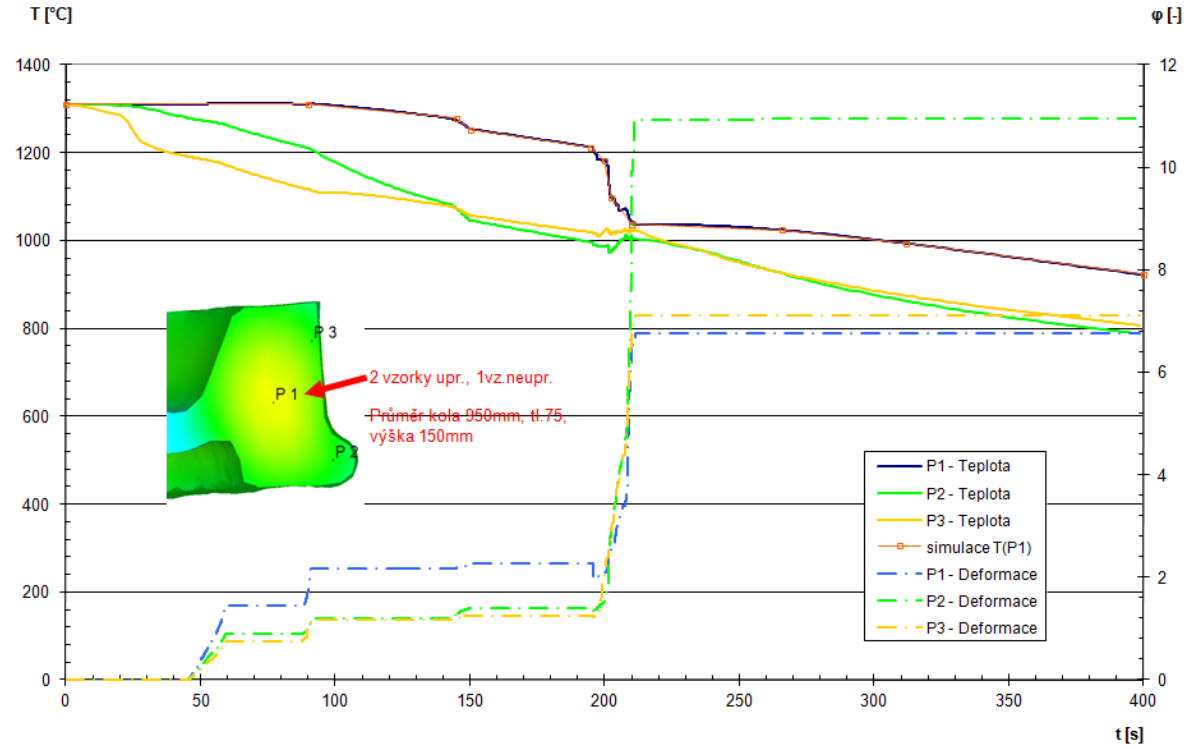


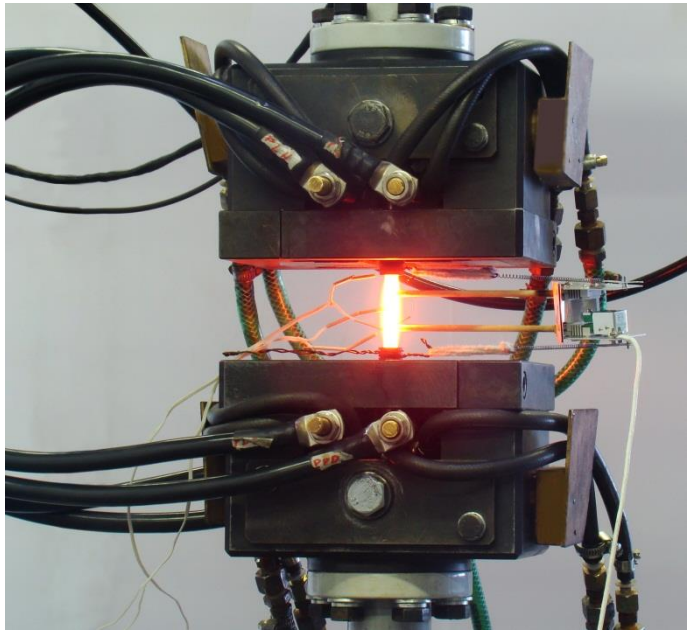


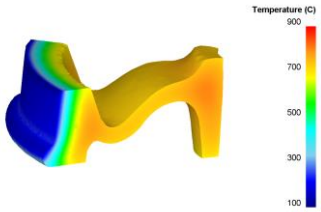
Complex simulation (FEM + physical model)



- Modelling of microstructure in defined points (P1, P2, P3) using a combination of numerical and physical simulations

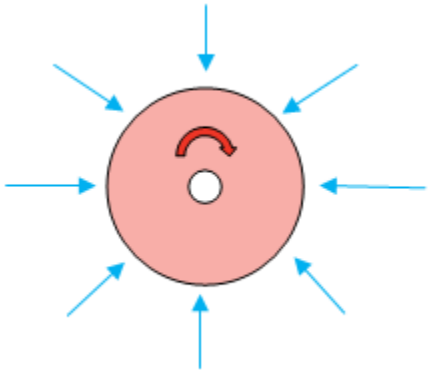






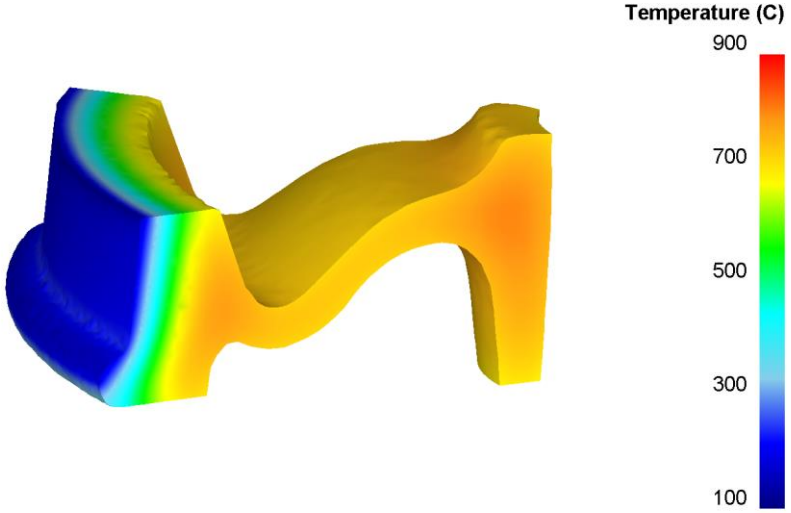
Cooling of railway wheel

- Simulation of the railway wheel cooling using experimentally derived boundary conditions
- Determined heat transfer coefficient (HTC)



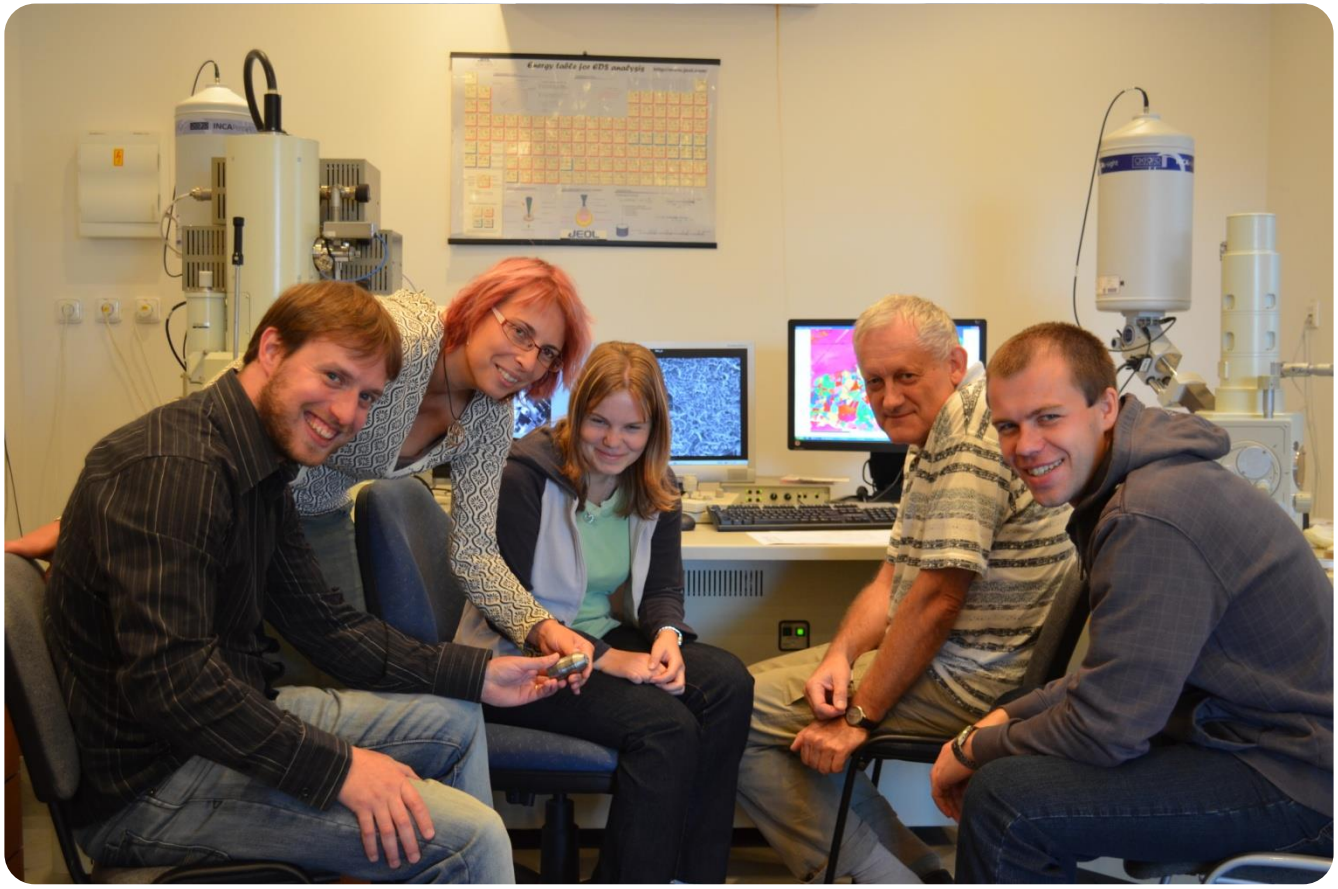
cooling wheel basic chart

Experimental measurement



Temperature decrease from 900 ° C to 480 ° C per 2.5 min

Materials Analyses

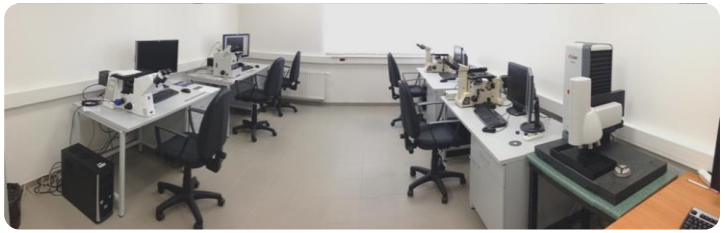


Materials Analyses

- Services
  - Evaluation of microstructures (ferrous and non-ferrous metals)
  - Phase analysis, identification and measurement of volume fraction
  - Evaluation of porosity in alloys
  - Chemical composition measurement by means of EDX (point, line, area mapping)
  - Fractography
  - Hardness measurements (in the laboratory, outside the laboratory)
  - Measurement of the layer thickness
  - Failure analysis, case studies

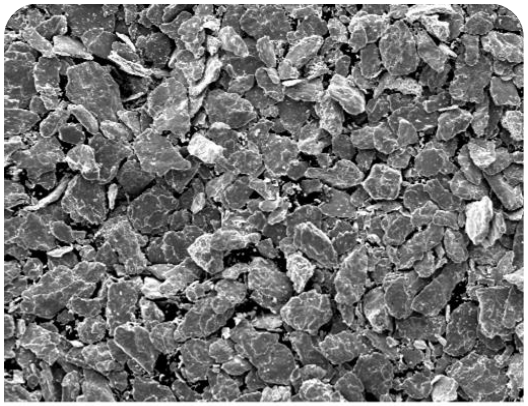
Materials Analyses

- Equipment
  - 4 optic microscopes (Nikon and Carl Zeiss)
  - 2 scanning electron microscopes (Jeol with EDX and EBSD)
  - Preparation of metallographic samples with modern equipment (Struers, Buehler)

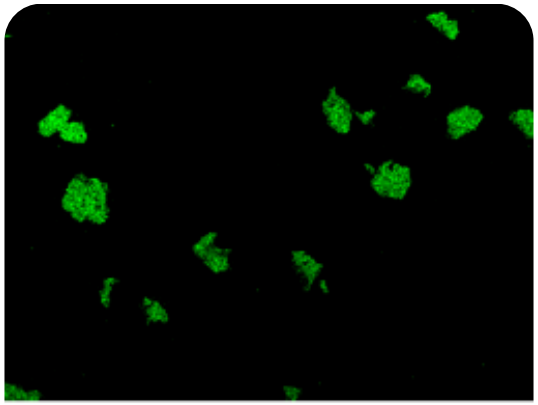


Materials Analyses

- Scanning electron microscopy

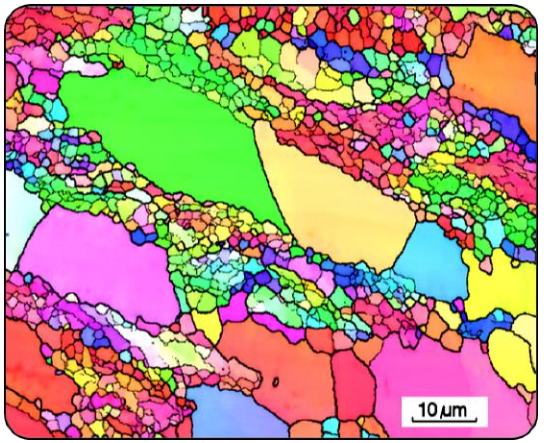


Electron Image 1



Cr Ka1

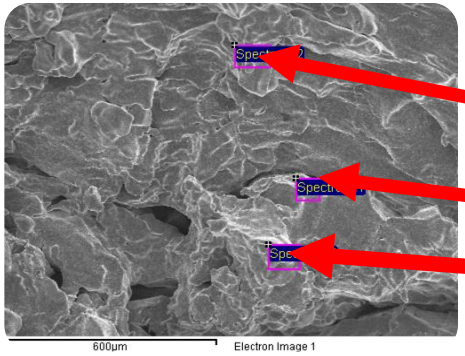
EDX map - distribution of chromium in the powder material



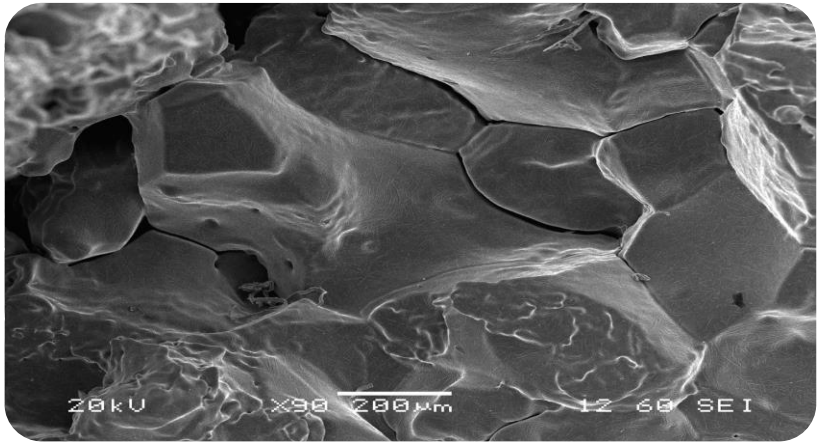
EBSD Analysis of non-uniform recrystallization process

Materials Analyses

- Fraktography



Spektrum	S [%]	Cr [%]	Fe [%]
1		9.65	90.35
2	1.98	9.43	88.58
3		9.01	90.99



Materials Analyses

- Instrumented nanoindentor – NanoTest Vantage

  - Measuring of elastic and plastic properties of materials on the nano-scale.
  - Load range: from 10 μN to 500 mN (resolution 3 nN)
  - Experiments:
    - Depth versus load hysteresis
    - Multiple load cycle with increasing load
    - Creep test
  - Hardness and modulus mapping
  - Acoustic shield and temperature controlled chamber for low thermal drift.
  - Both ISO 14577 and ASTM 2546 compliant

Materials Analyses

- Accredited tests

No	Description	Identification
1	Metallographic determination of non-metallic inclusions	ČSN ISO 4967, DIN 50602 ASTM E 45
2	Grain size determination	ČSN EN ISO 643 ASTM E 112
3	Microscopic observations thickness	ČSN EN ISO 3887- čl. 4.2
4	Rating metallographic structure of cast iron	ČSN EN ISO 945
5	Determination of the proportion of surface phase image analysis	ASTM E 1245
6	Rating micro / macro structure	ČSN EN 1321
7	Vickers hardness	ČSN EN ISO 6507-1
8	Rockwell hardness test	ČSN EN ISO 6508-1
9	Front steel hardenability test	ČSN EN ISO 642

Materials Analyses

- On site metallography

Portable digital microscope **Keyence VHX-5000 + Movipol 5 = <u>documentation of microstructure on your facillites anywhere in the world</u>**

+

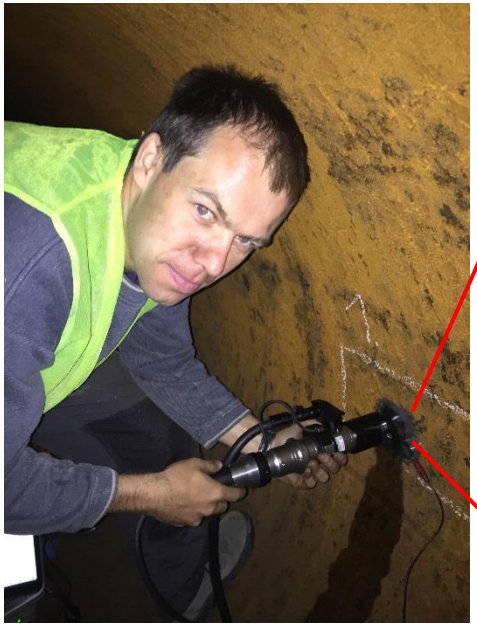
Portable hardness testers
(accredited tests)

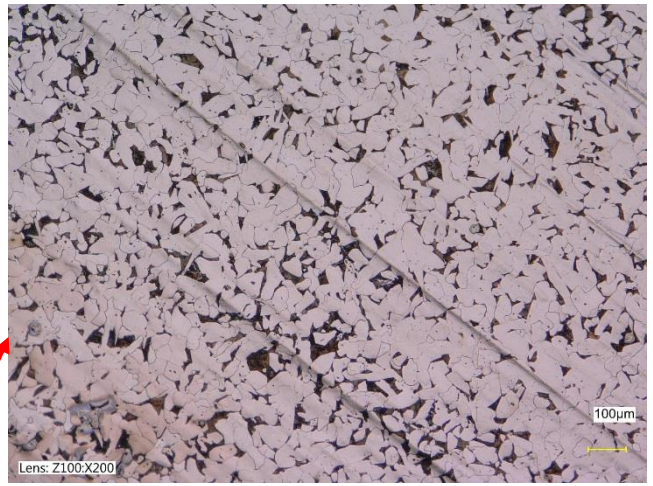
- dynaTESTOR M495 – UCI testing – Vickers hardness
- M295 – Leeb principle – conversion to HB, HV, HRC available

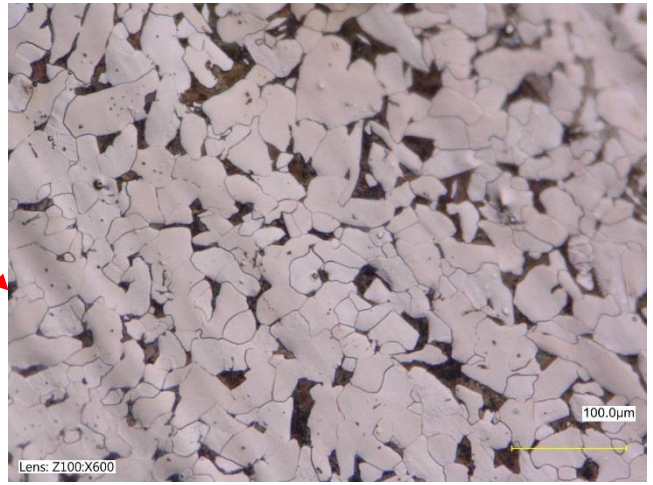
Keyence microscope
- High Dynamic Range (HDR) images
- bright field & dark field,
- one zoom lens with magnification from 100x to 1000x

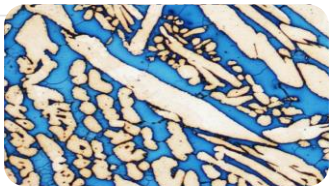
Materials Analyses

- On site metallography







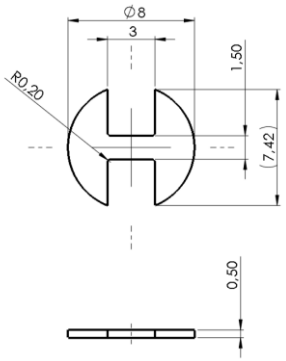


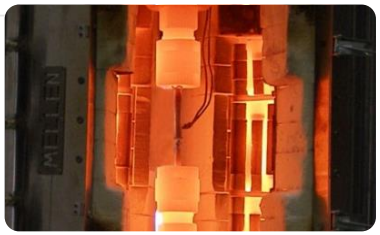
Materials Analyses + Mechanical Testing

- Special device for samples extraction

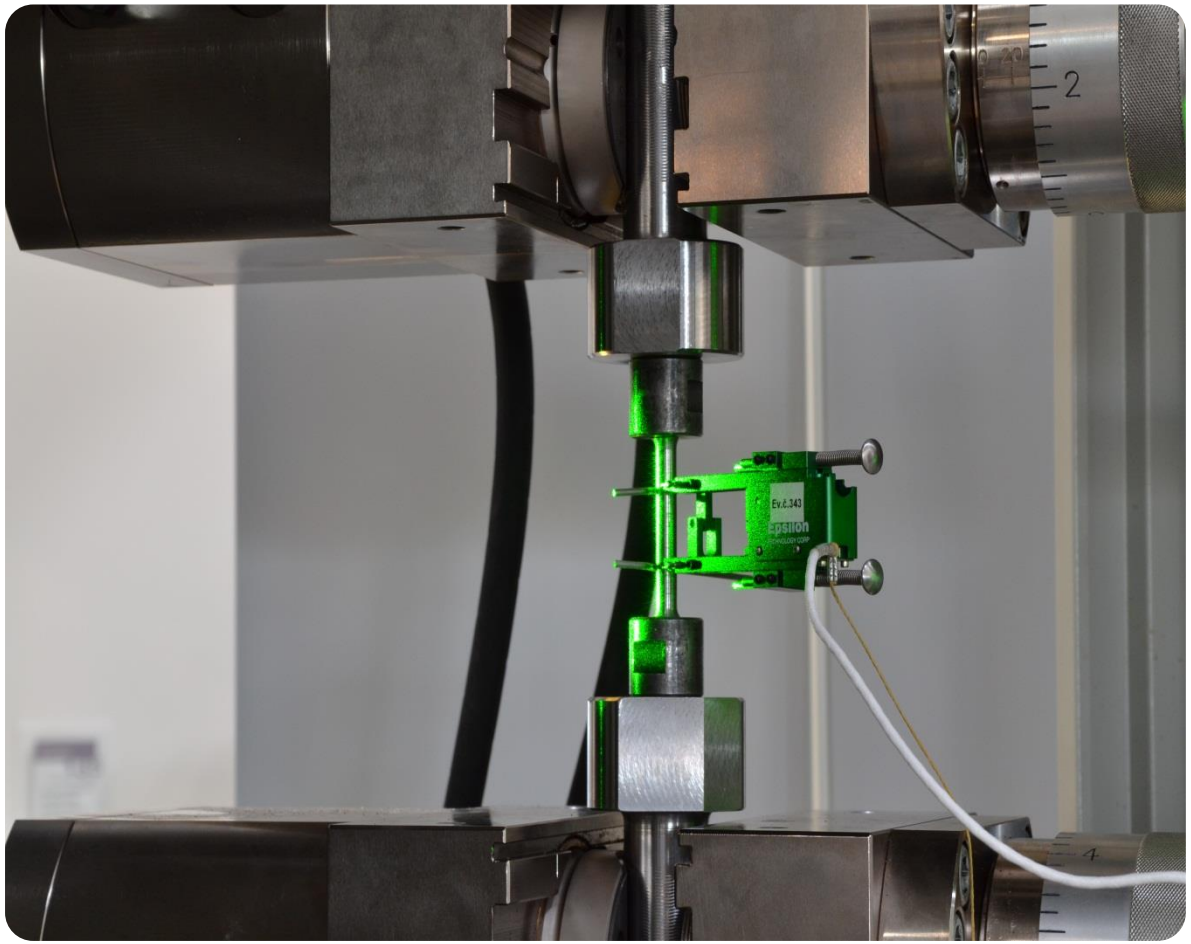
  (Electric Discharge Sampling Equipment)

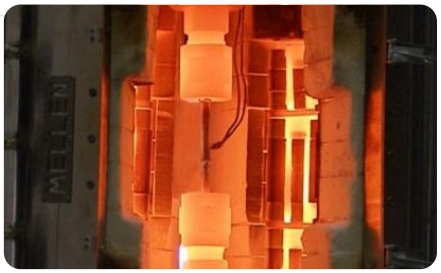
  - „Non-destructive" extraction of samples from components in use
  - Extracted sample is further analyzed
  - Mechanical testing (Small Punch Test, Micro-Tensile Test)
  - Hardness measurement
  - Chemical composition determination
  - Microstructure analysis
  - Residual life determination





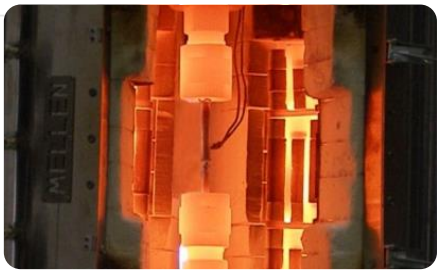
Mechanical Testing & Thermo-physical Measurements





Mechanical Testing

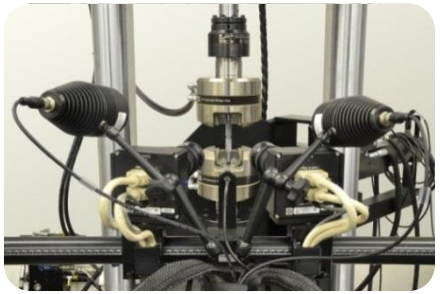
- Accredited tests (tensile tests, instrumented Charpy tests, hardness)
- Static and dynamic tests (tensile, compression, bend) up to velocity 25m/s, dynamic testing of Young's modulus
- Wide testing temperature range (-200°C to 1400°C)
- High- and low-cycle fatigue tests (Manson-Coffin and Wöhler curve)
- Short-time creep tests
- Miniature-sample testing
- Torsion and biaxial testing
- Transition temperature determination
- Fracture toughness tests
  - J-R curves
  - Master curves
  - Fatigue crack growth rate, threshold value
- Component testing
- Non-standard tests per customer request

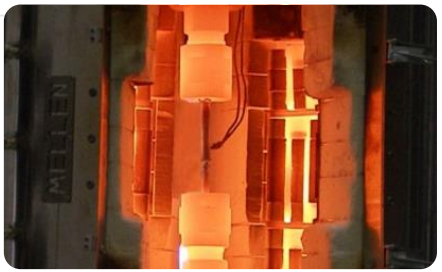


Mechanical Testing

- Optical strain measurement systems
  - ARAMIS, video-extensometer, laser-extensometer, high-speed camera
  - Contactless measurements with data acquisition
  - Precise deformation measurements
  - Available even for dynamic testing

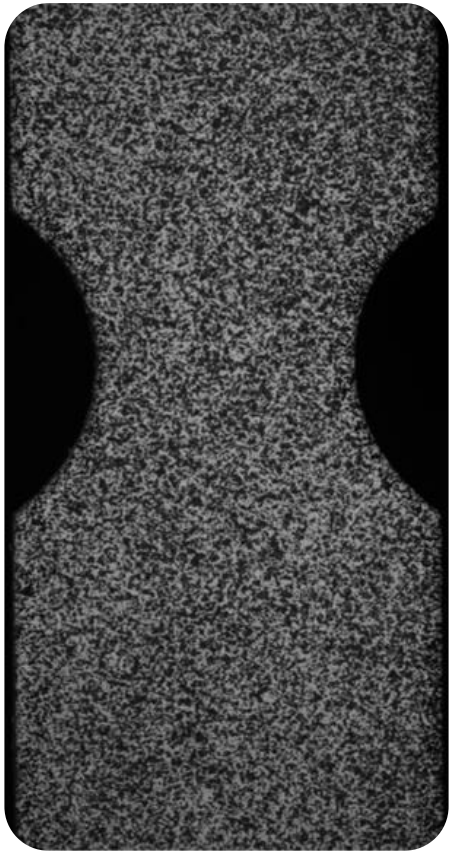
- System ARAMIS
  - Digital Image Correlation (DIC)
    - Optical measurement method
    - Measurement of surface deformation
    - 2D (1 camera) or 3D (2 cameras) measurement
    - Video-extensometer
    - True Stress-True Strain diagram measurements
    - Flowing Limit Curve (FLC, FLD)

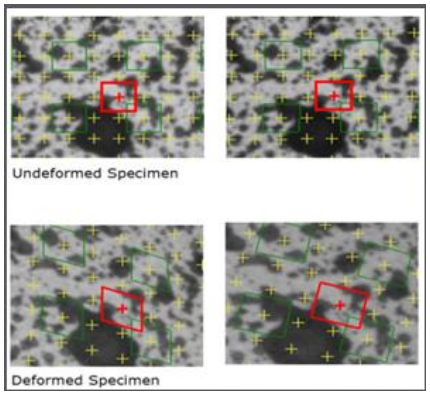


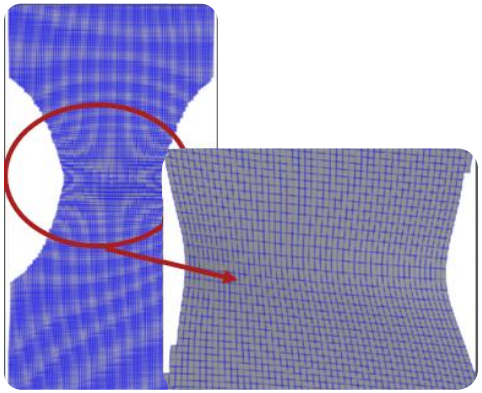


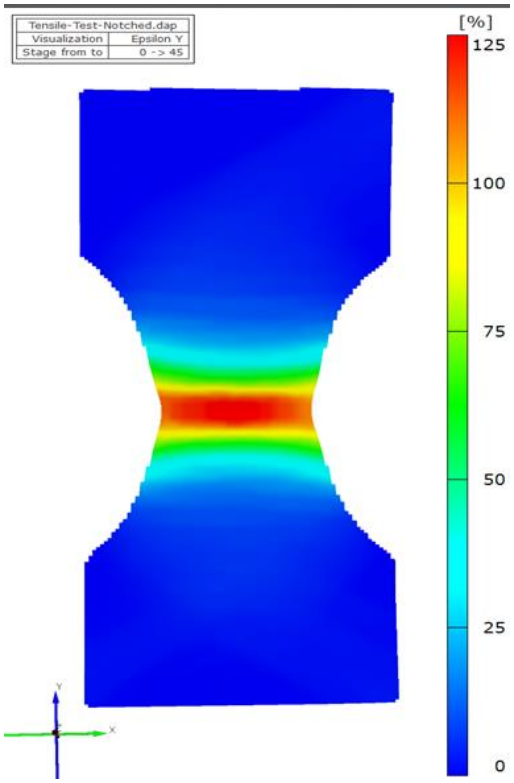
Mechanical Testing

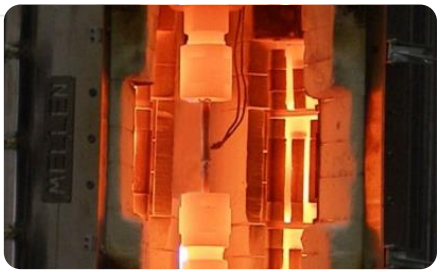
- ARAMIS – Digital Image Correlation





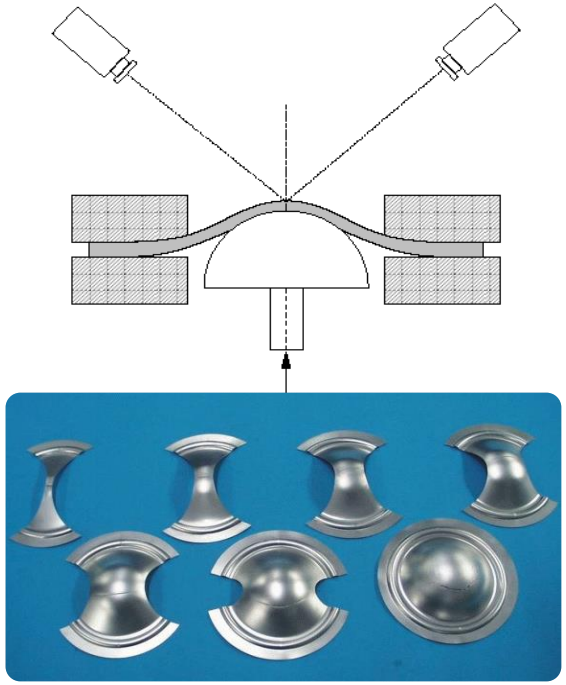


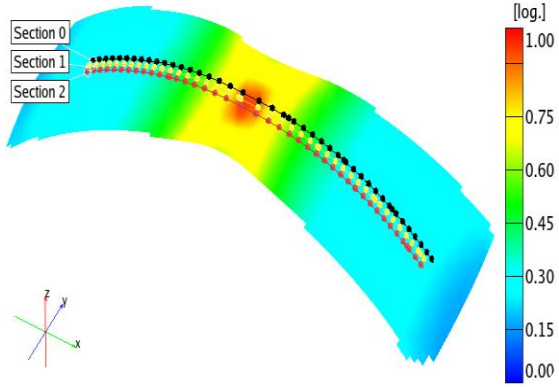


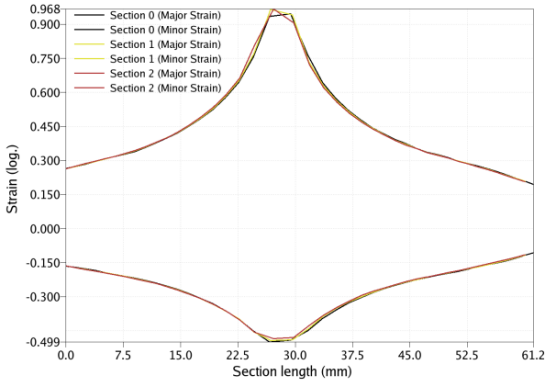


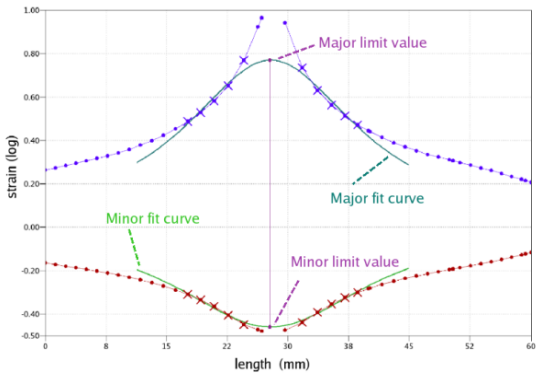
Mechanical Testing

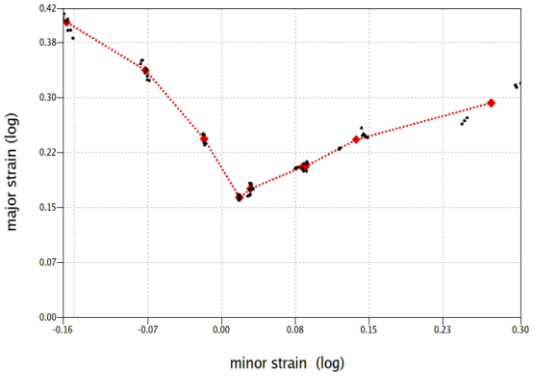
- ARAMIS – FLC diagrams (flowing limit curves)

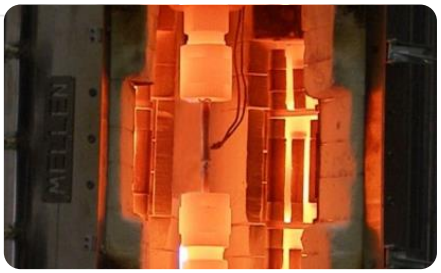








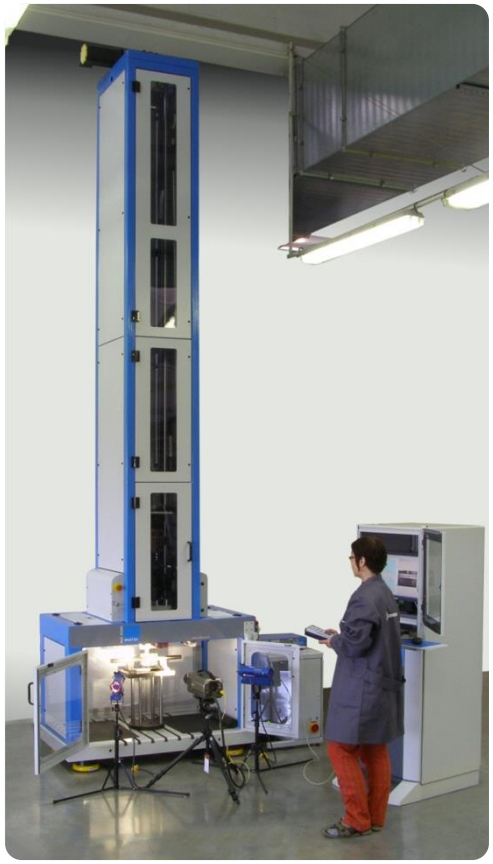




Mechanical Testing

- Dynamic tests
  - Impact tester IMATEK IM10T-30HV

Drop height	50 mm to 3000 mm
Drop weight	8 kg to 100 kg
Velocity range	1,0 m/s to 25 m/s
Energy range	2,5 J to 3000 J
Temperature range	-70 °C to +200 °C



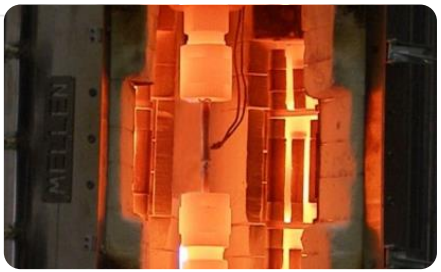
High-speed camera Phantom v710 1 Mpx

- Full resolution 1250x1080px at 7 500 fps
- Lower resolution 128x8px at 680 000 fps

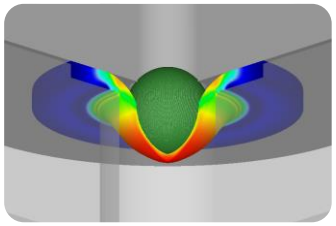
Possible tests

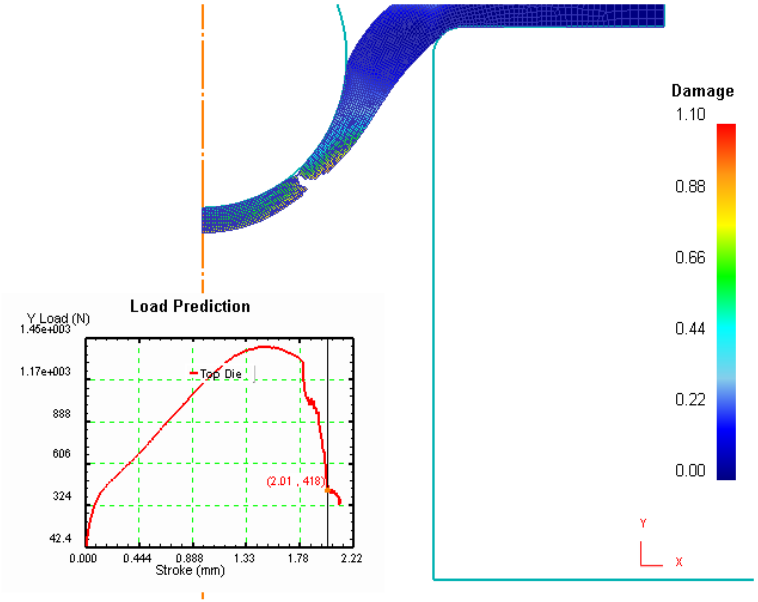
- tensile, compression, 3-point bending…
- dynamic testing of components

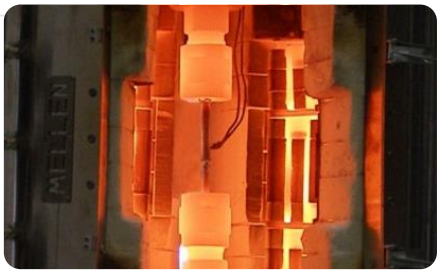
Mechanical Testing



- Testing of miniature samples – Small Punch test (SPT)
  - Specimens – disc D=8mm, t=0,5mm
  - Measurement of stress-strain behavior
  - Determination of tensile properties
  - Measurement of transition temp.
  - Estimation of fracture toughness

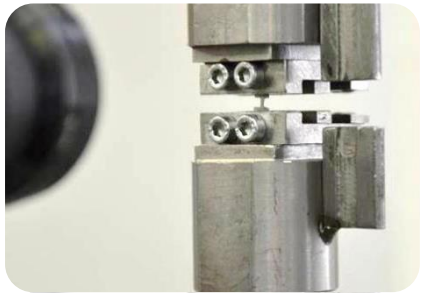


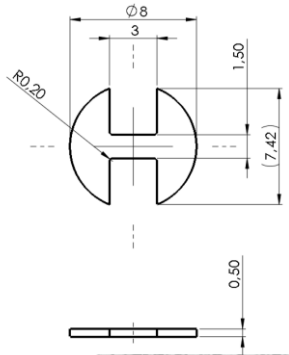


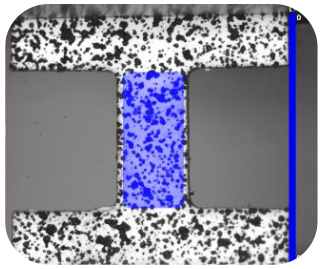


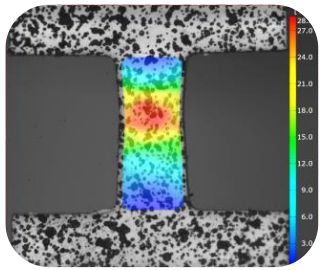
Mechanical Testing

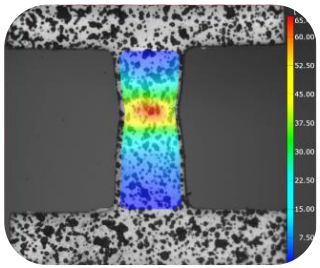
- Testing of miniature samples – micro-tensile test
  - Sample dimensions comparable to SPT disc
  - Strain measurements using ARAMIS system
  - Tensile diagrams identical with standard tests

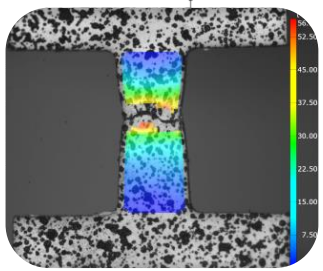


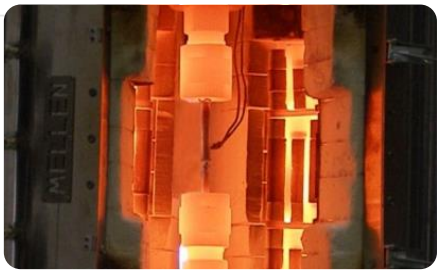










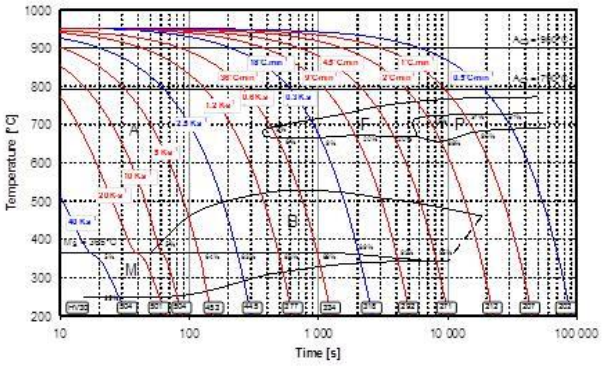


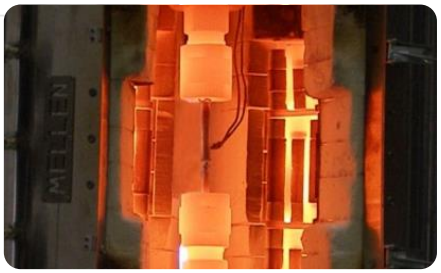
Thermo-physical Measurements

- TTT and CCT diagrams – quenching dilatometer LINSEIS L78 RITA
  - Induction heating – high heating rate (up to 200°C/s)
  - Measurements in vacuum or inert gas; vacuum 10-2 Pa
  - Temperature range from -160 °C to 1 600 °C

- Further use
  - Isothermal modes (annealing, tempering)
  - Highly dynamic modes (welding, hardening)
  - Phase transformation during dynamic modes and estimation of phase fractions at a given temperature and time

Process optimisation



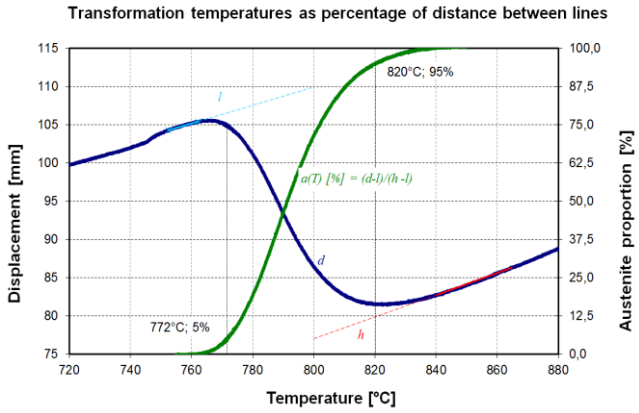


Thermo-physical measurements

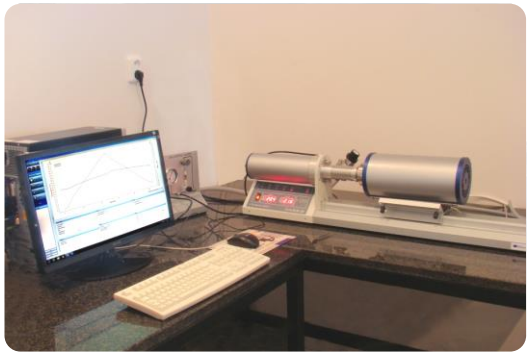
- Determination of temperatures of phase transformations and thermal expansion

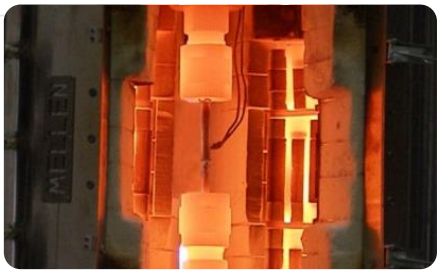
High-temperature dilatometr LINSEIS L75HS1600C PT

- Temperature range from 20 °C to 1600 °C,
- Heating rate from 0,6 °C/min to 20 °C/min,
- inert gas, vacuum 10-2 Pa,
- Measurement range from 100 µm to 5000 µm
- Maximal resolution 0,125 nm/digit.



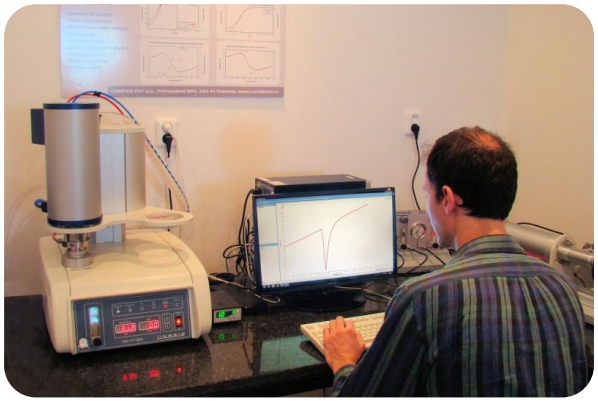
- Further use:
  - Study of recrystallization and recovery
  - Slow and isothermal modes (annealing, slow cooling in furnace)
  - Determination of coefficient of thermal expans.
  - Estimation of phase fractions





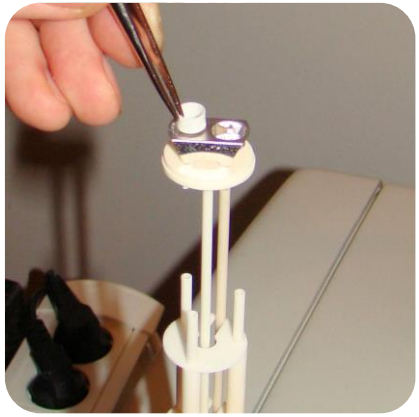
Thermo-physical measurements

- Calorimetry

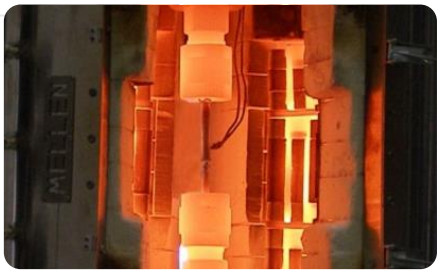


High-temperature calorimeter LINSEIS DSC HDSC PT1600

- Temperature range from 25 to1400 °C
- Heating and cooling rate from 0,1 to 50 °C/min
- Measurement accuracy +/-0,5 °C,
- Inert gas, vacuum 10-2 Pa,
- Sample dimensions max. ▪ 5 mm,
- Resolution 0,3 µW



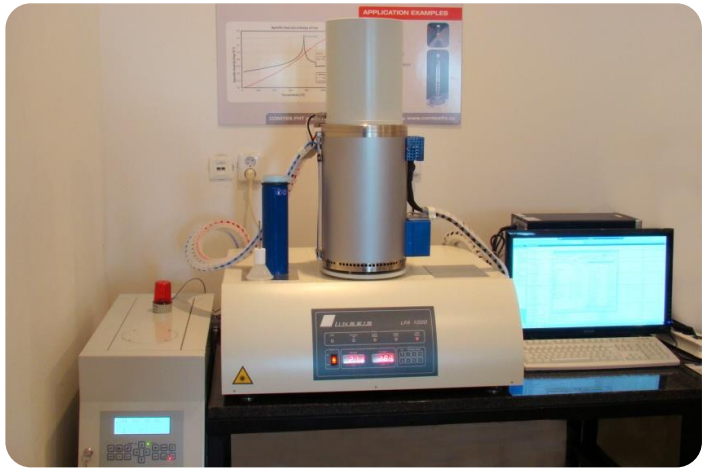
- Further use:
  - Temperatures and enthalpy of phase transformations
  - Study of recrystallization and recovery
  - Study of precipitation and precipitate dissolution
  - Specific heat capacity determination
  - Melting point determination



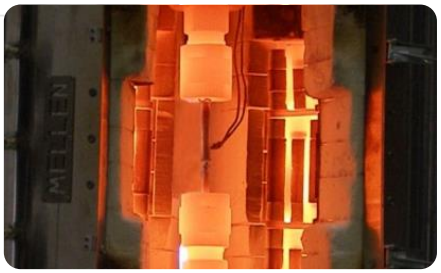
Thermo-physical measurements

- Thermal diffusivity and thermal conductivity

  LINSEIS Laser Flash LFA-I 000/1400 °C
  - Temperature range from 25 to1400 °C
  - Inert gas, vacuum 10-2 Pa
  - Measurement accuracy ≤5%
  - Measurement repeatability ≤5%
  - Sample diameter 12,7 mm or 25,4 mm
  - Holder for 3 or 6 samples



- Further use:
  - Thermal diffusivity measurement
  - Thermal conductivity determination

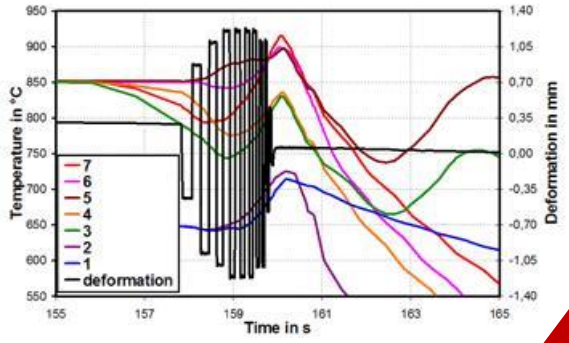


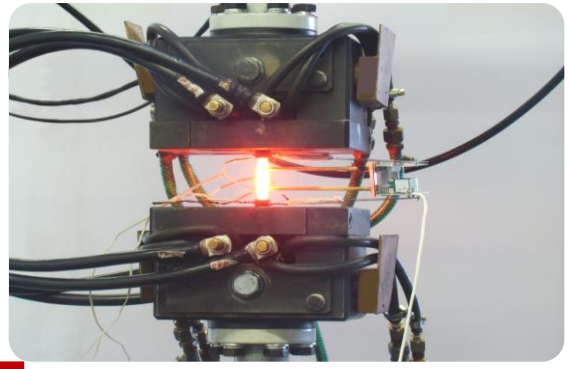
Thermo-physical measurements

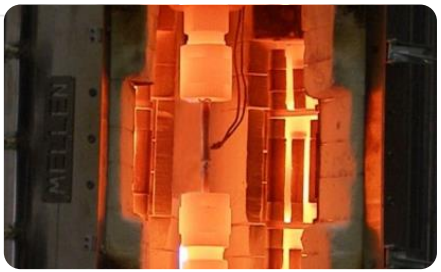
- Physical simulation of hot forming processes

  Servo-hydraulic testing machine MTS 810 with resistive heating
  - Heating / cooling rate 150 °C/s
  - Temperature range - 150°C to 1 400 °C
  - Max. cyclic loading 30 Hz

- Further use
  - Complex modelling of hot forming processes
  - Temperature and deformation characteristics can be set near to reality

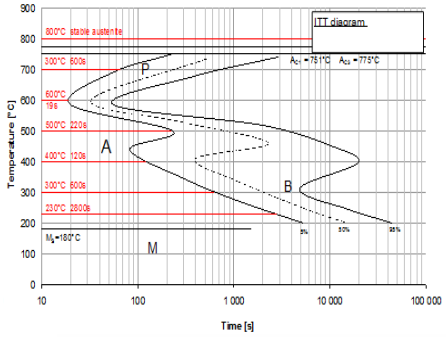


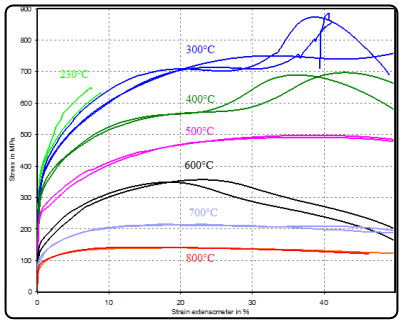


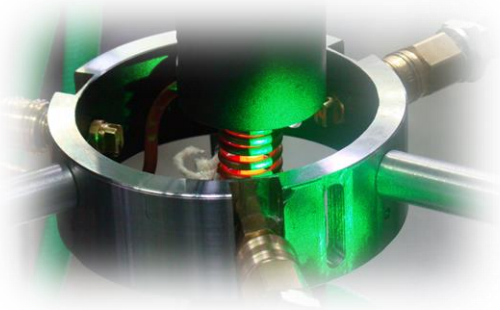


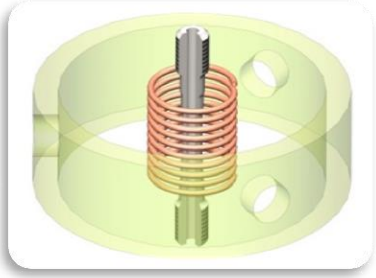
Tailor made tests

- Mechanical properties of supercooled austenite
  - Electro-mechanic testing machine Zwick/Roell 250 kN, laser extensometer, induction heating, rapid cooling









R&D efforts

Metal mould sizes:

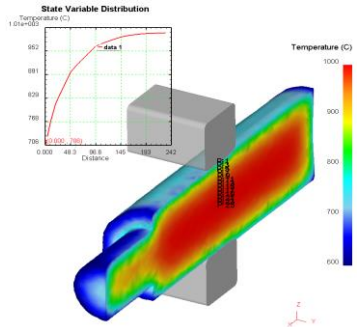
Ø 210 × 1230 mm
for 450 kg

Ø 110 × 720 mm
for 50 kg

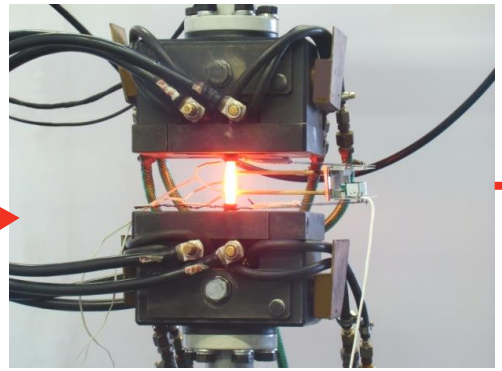
Ø 300 × 1400 mm
for 500 kg

- Materials are made and cast in a vacuum melting furnace to customer specifications

R&D efforts

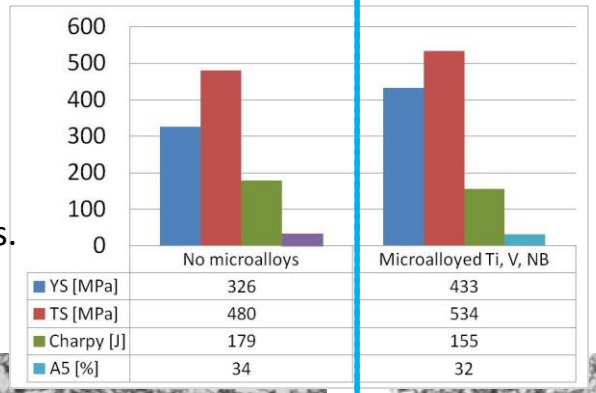


Computer simulation of forming

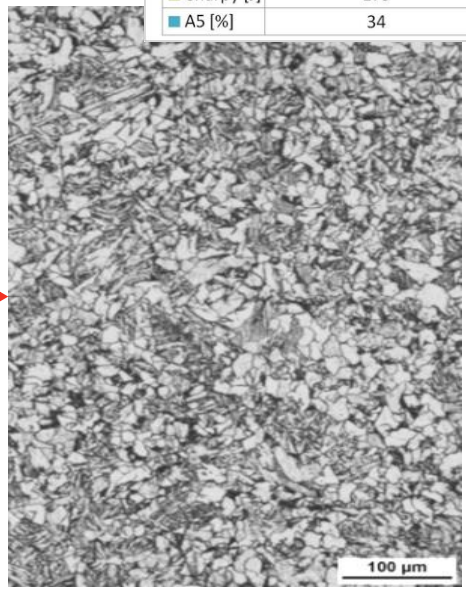


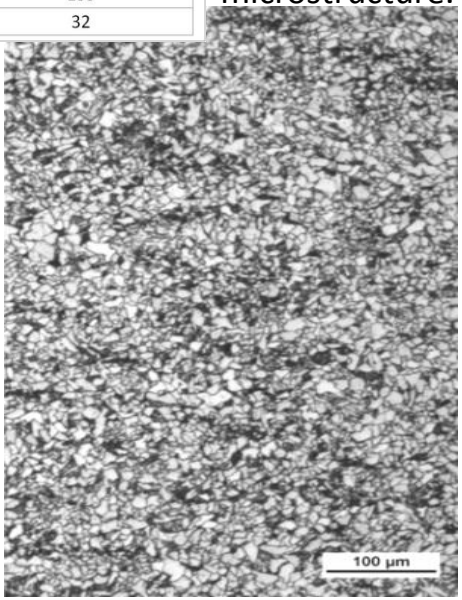
Physical simulation of forming

Before process optimisation and without micro-alloying elements.



	No microalloys	Microalloyed Ti, V, NB
YS [MPa]	326	433
TS [MPa]	480	534
Charpy [J]	179	155
A5 [%]	34	32

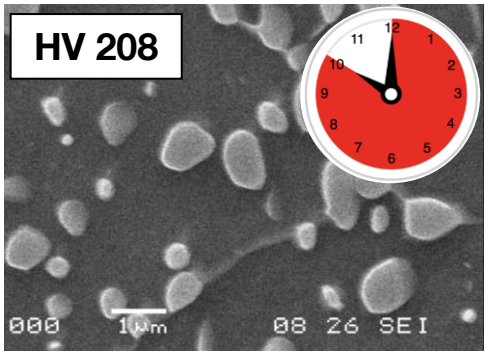




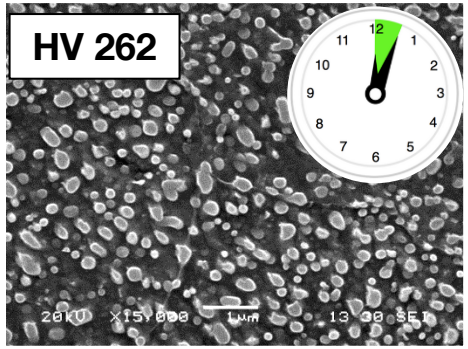
After process optimisation and with added microalloying elements: better strength and fine microstructure.

- Development of microalloyed steels: forming and heat treating

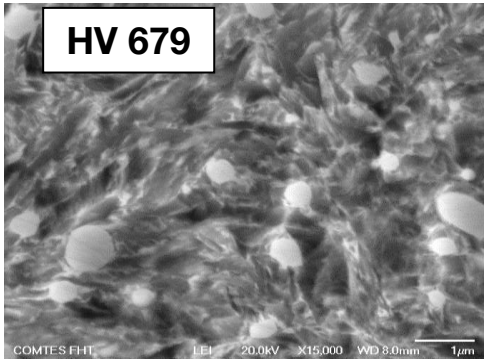
R&D efforts



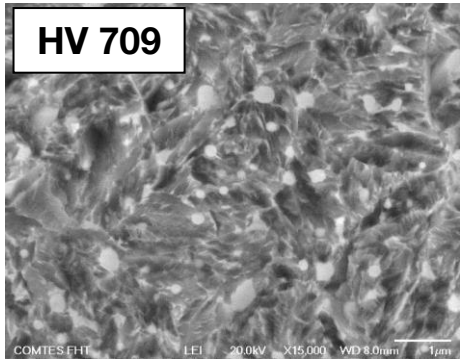
Conventional annealing



ASR annealing



Conventional hardening



Hardening after ASR

The ASR process provides:

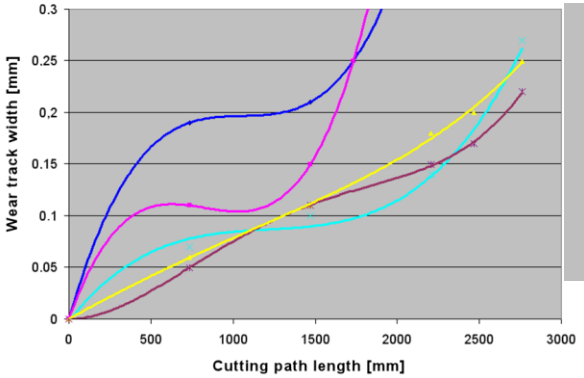
- Time and energy savings
- Finer carbides
- Finer austenite grain
- Finer martensite after quenching and tempering
- Improved mechanical properties

Implementation:

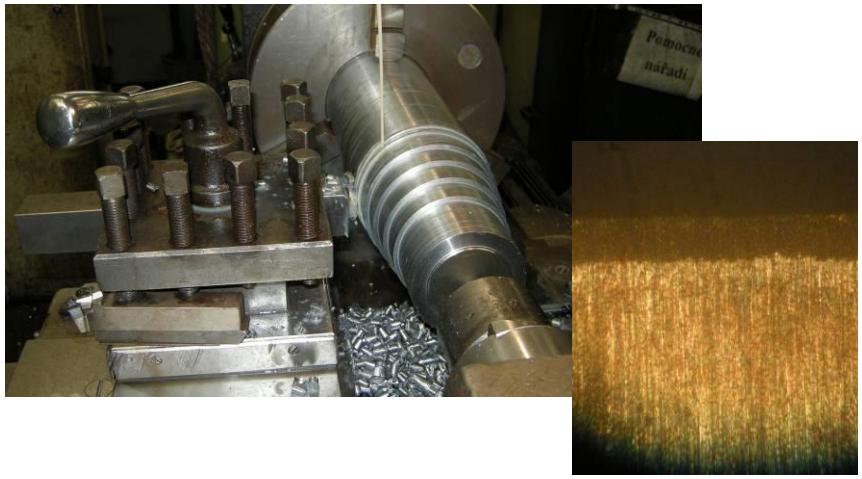
- Thermomechanical treatment (carried out in rolling mills and other equipment)
- Induction heat treatment

- ASR (Accelerated Spheroidisation and Refinement) – accelerated soft annealing and recrystallization annealing

R&D efforts



Conventional HT
Conventional HT
-80 °C / 8 hrs
-180 °C / 6 hrs
-180 °C / 6 hrs

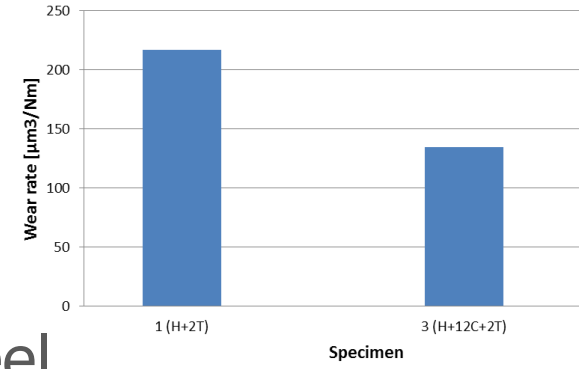


Implementation:

- Quenching + deep freezing below -100 °C
- Holding at the deep cryogenic temperature of approx. 2 – 15 hours, depending on the size of the part and the chemical composition of steel
- Conventional tempering

Effects:

- Elimination of retained austenite
- Refinement of martensite and carbides
- Improved wear resistance



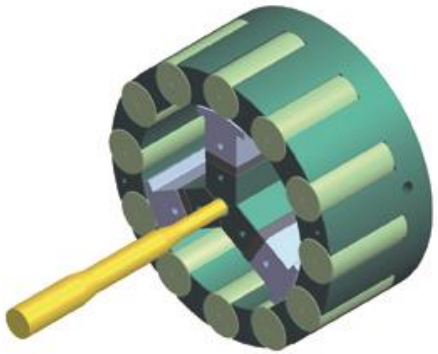
- Deep cryogenic treatment of steel

R&D efforts

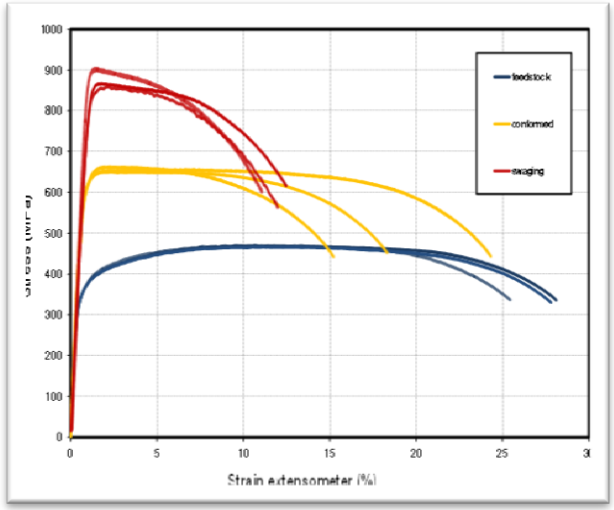
- Diffusion bonding of various types of steels by means of hot rolling
- Potential for combining various mechanical properties
- Capability to create highly attractive visual patterns
- Plain carbon as well as stainless steels
- Knife making, jewellery making and other fields
- Max. size: 380 × 4000 mm; thickness: 3-8 mm

- Industrially-produced rolled Damascus steel

R&D efforts



- Grain refinement, most notable in titanium alloys to less than 1 μm
- 60 – 80 % increase in strength
- For medical applications (implants), precision engineering (shafts for mechanical watches) and others

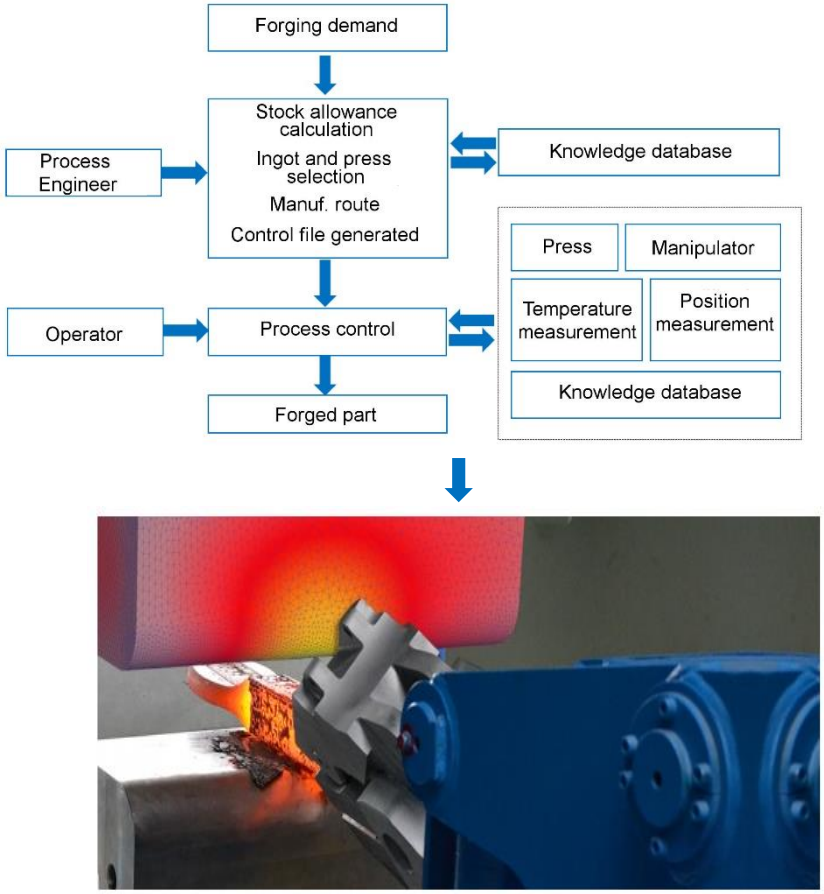


- Creating ultrafine structures in metallic materials

R&D efforts

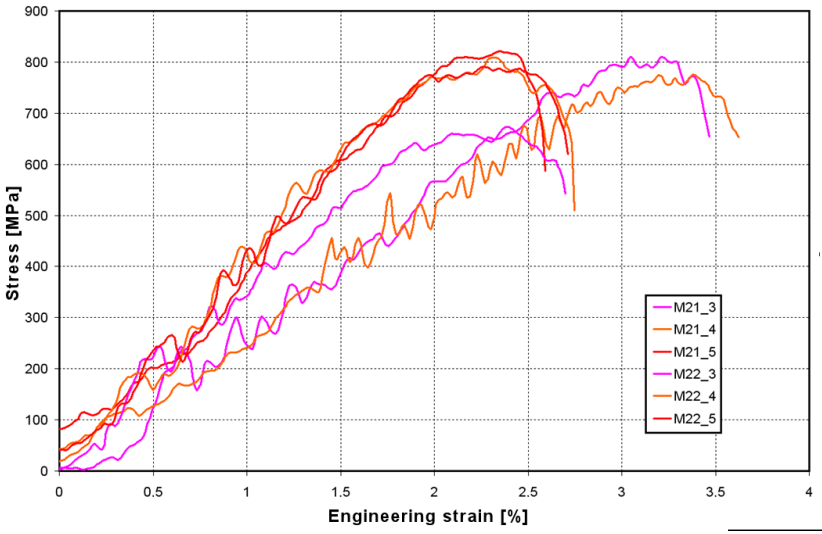
Benefits of Software-Controlled Forging

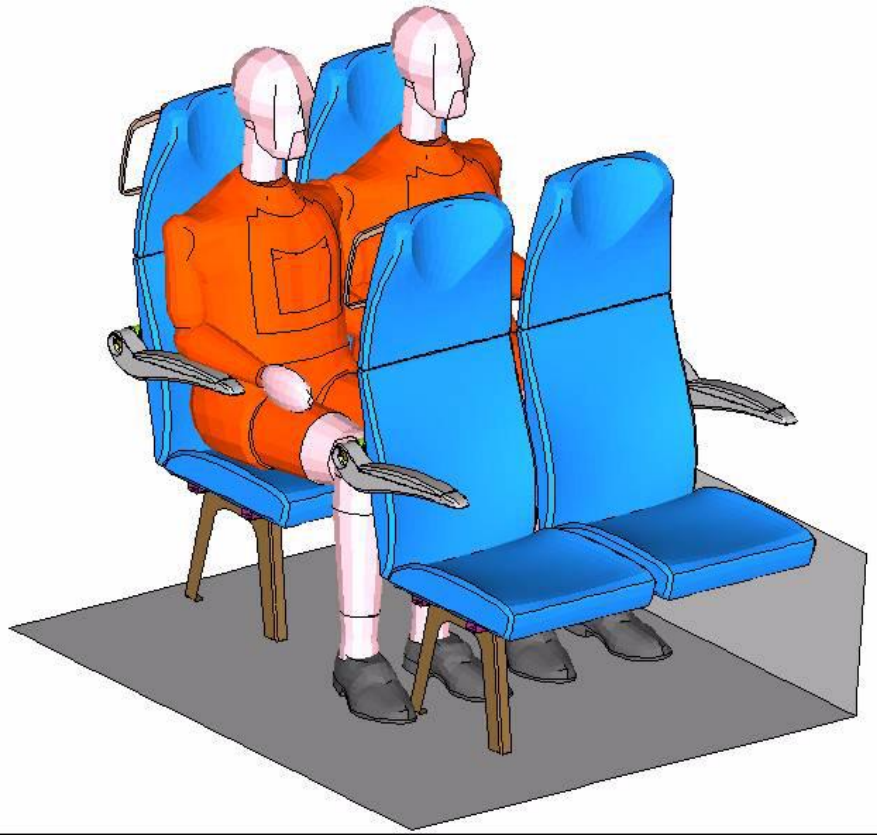
- Rapid and accurate design of new manufacturing processes
- Prediction of strains, forces and temperatures during the process
- Repeatability of production and consistent quality
- Correct production documentation
- Development of process know-how



- Automatic generation of open-die forging sequences

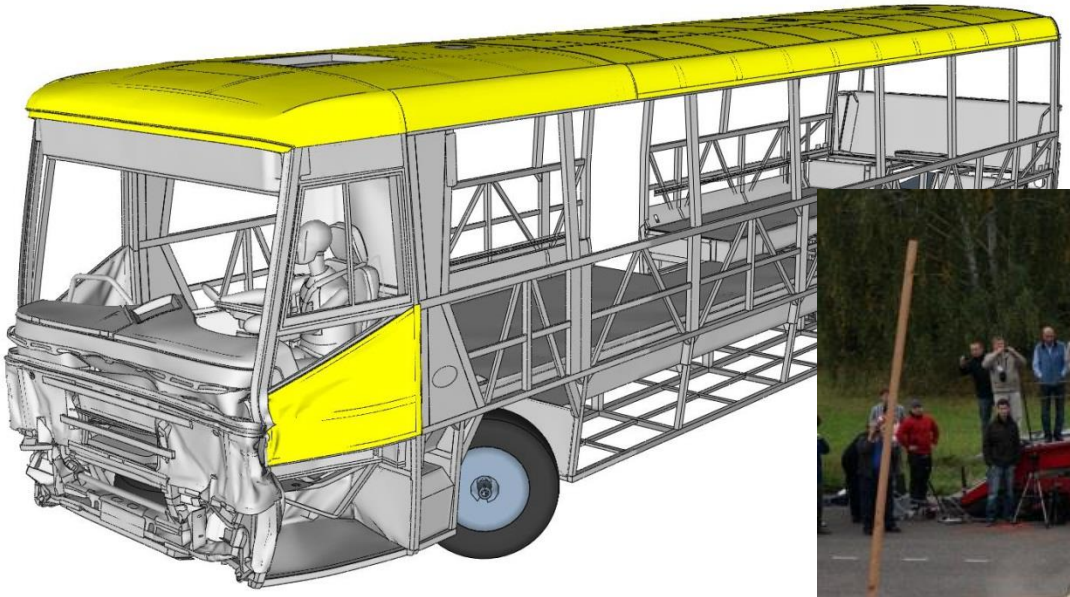
R&D efforts





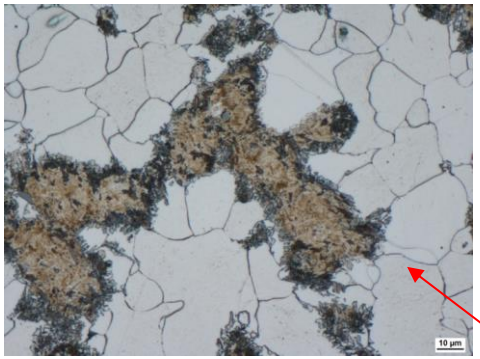
- Measurement of data for simulating aircraft seat crash tests

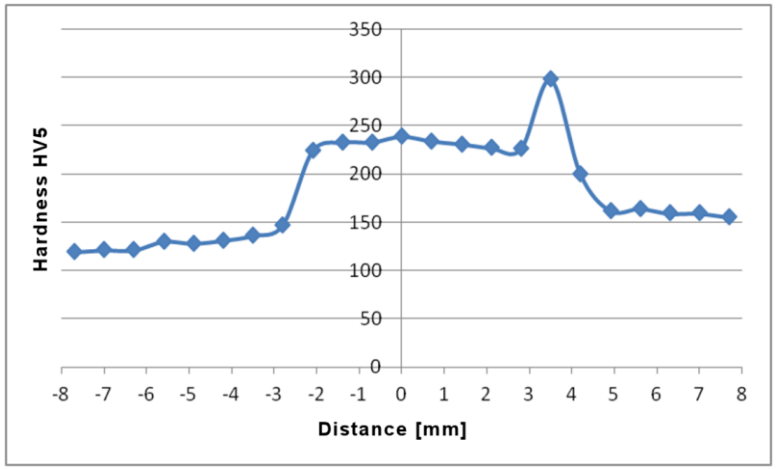
R&D efforts

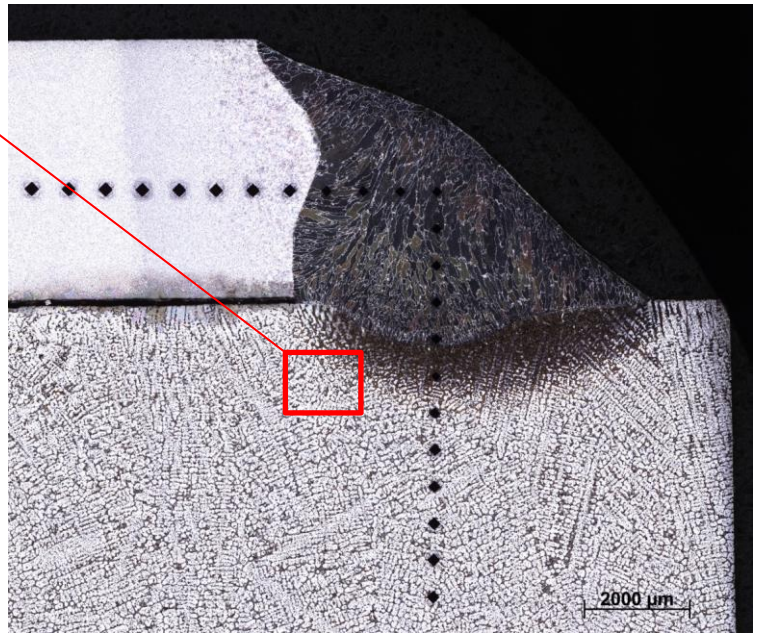


- Enhancing the passive safety of buses

R&D efforts

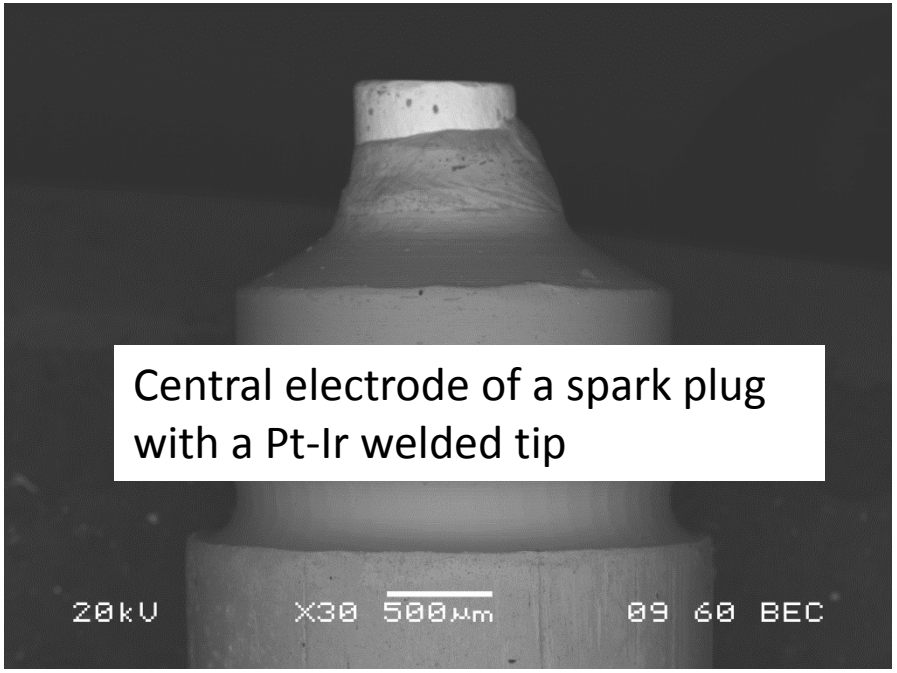




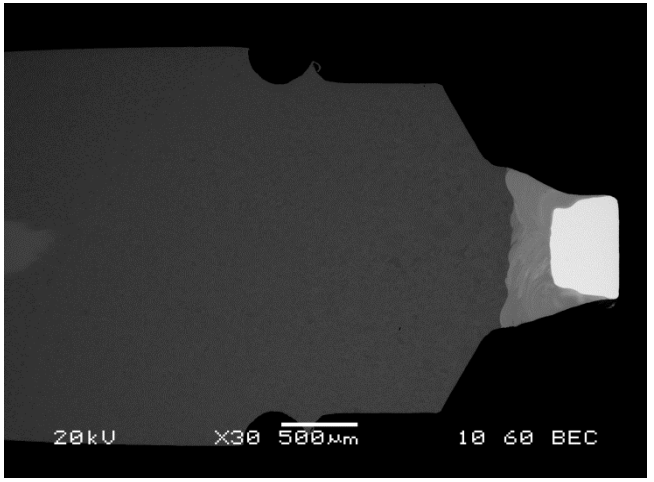


- WPQR – weld assessment

R&D efforts



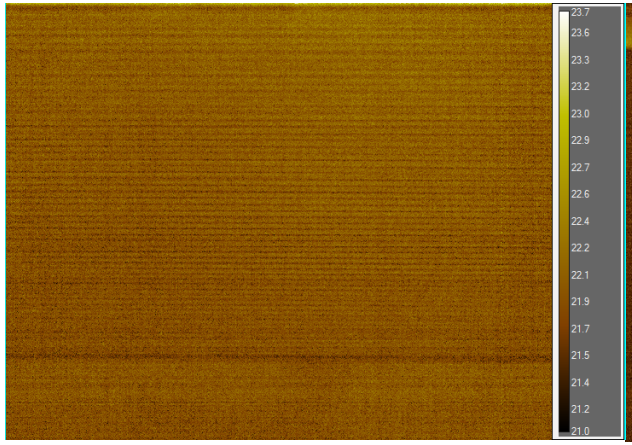
Central electrode of a spark plug with a Pt-Ir welded tip

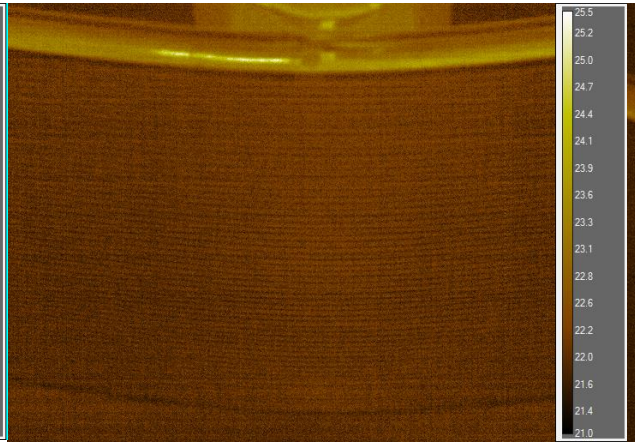


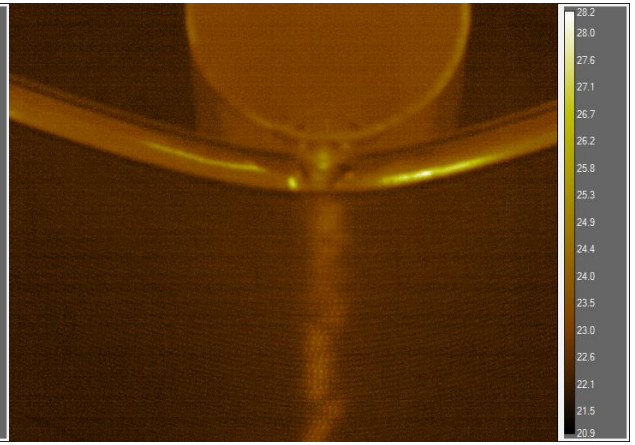
Longitudinal metallographic section through the central electrode. In the weld, partial dilution between the Pt-Ir tip and nickel wire is visible.

- Analysis and development of spark plugs

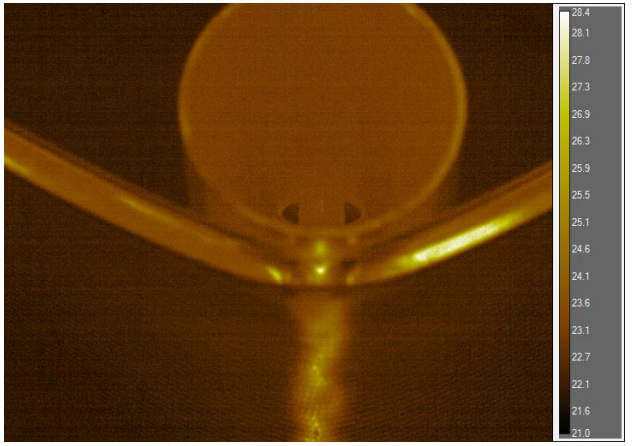
R&D efforts



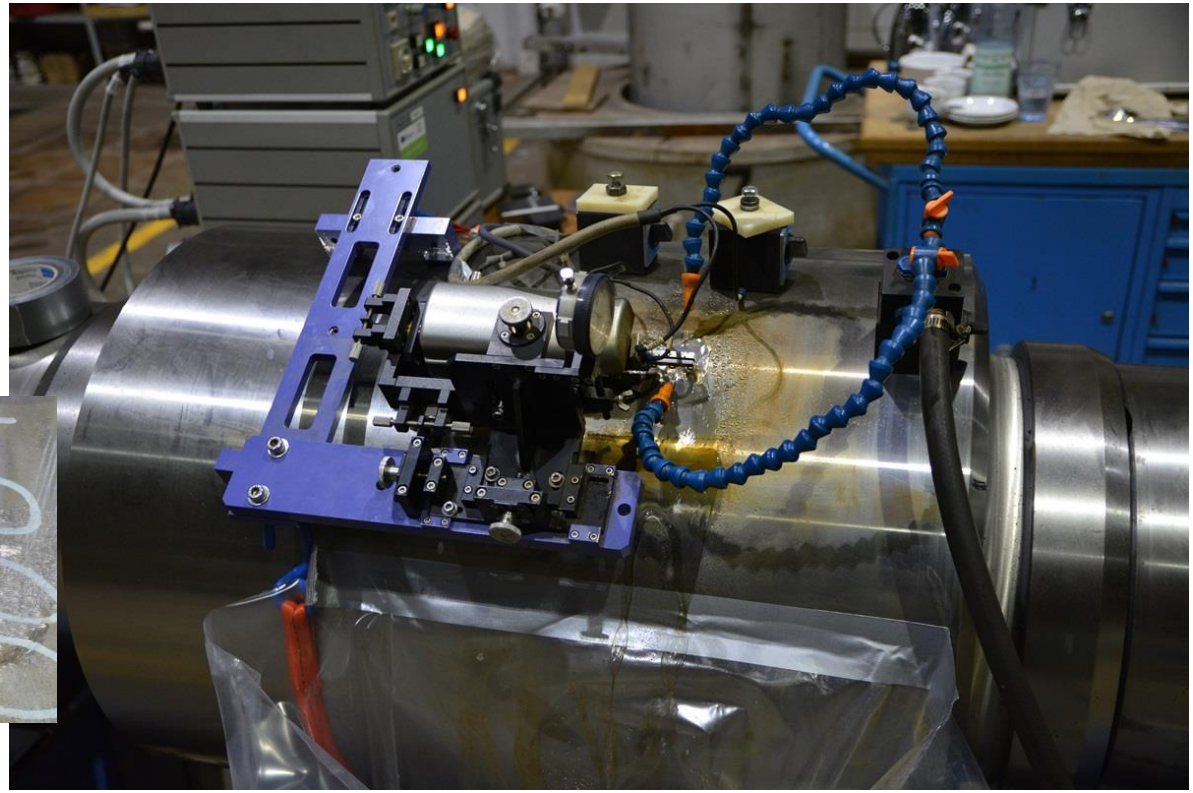




- Dynamic bending test of a cooler FLIR X 6580sc high-speed thermal imaging camera footage

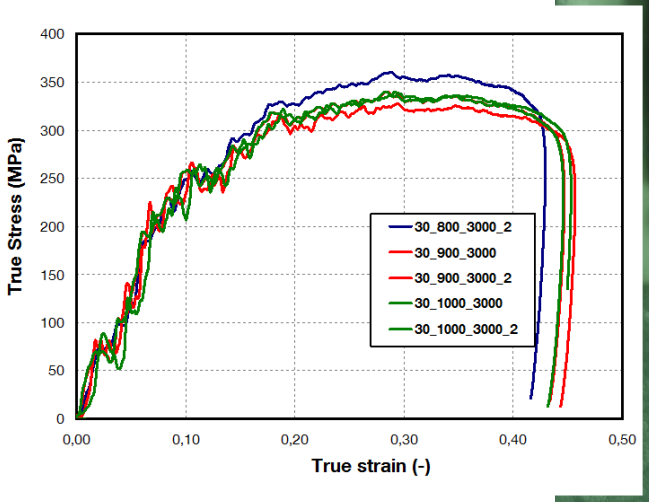


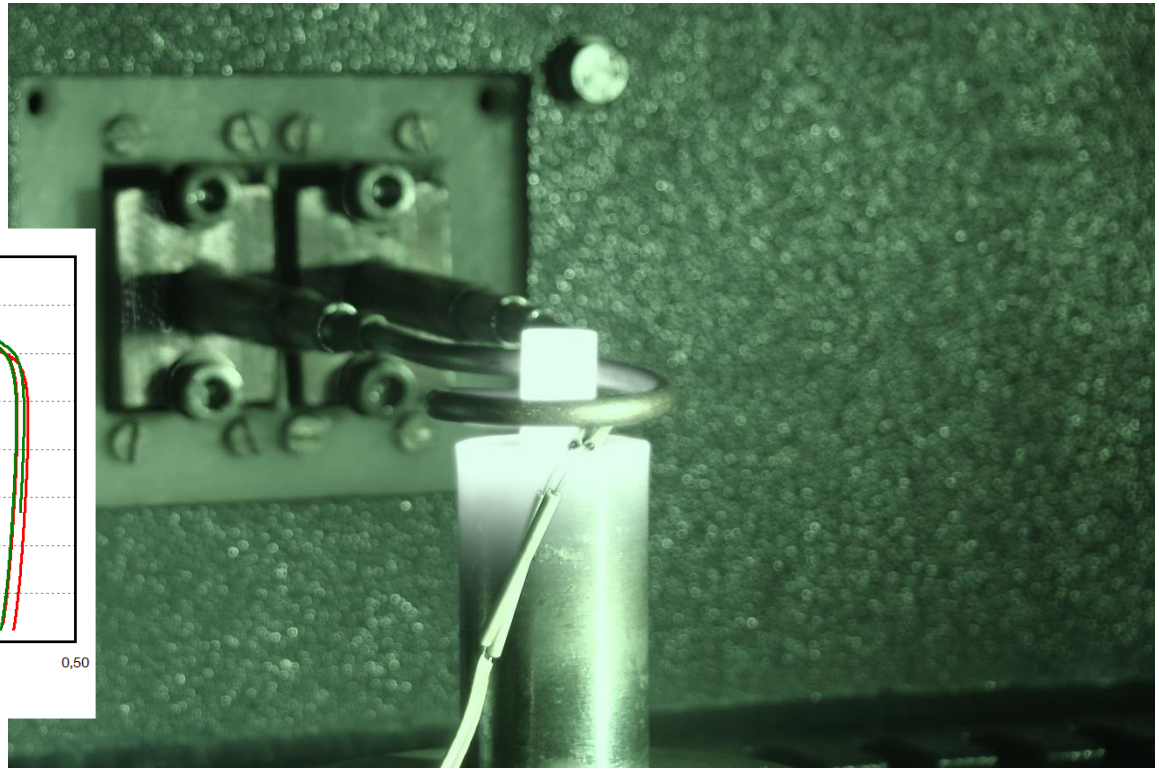
R&D efforts



- Taking miniature samples on site

R&D efforts



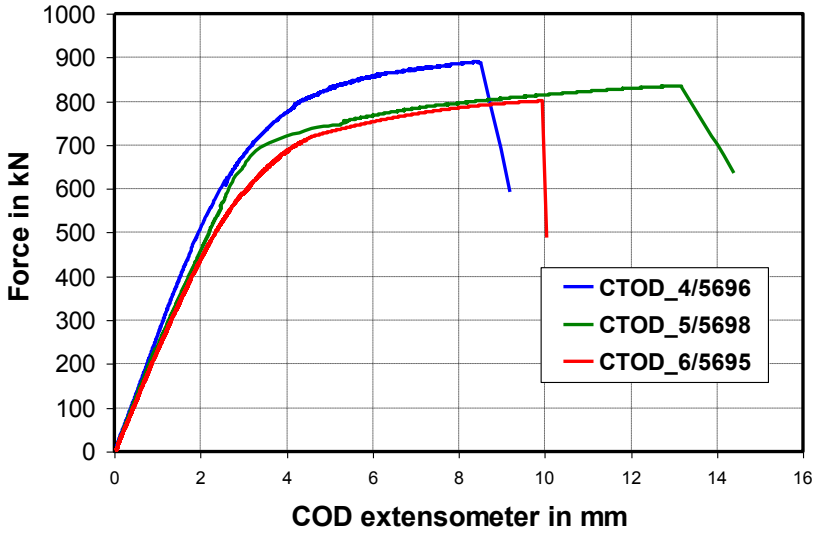


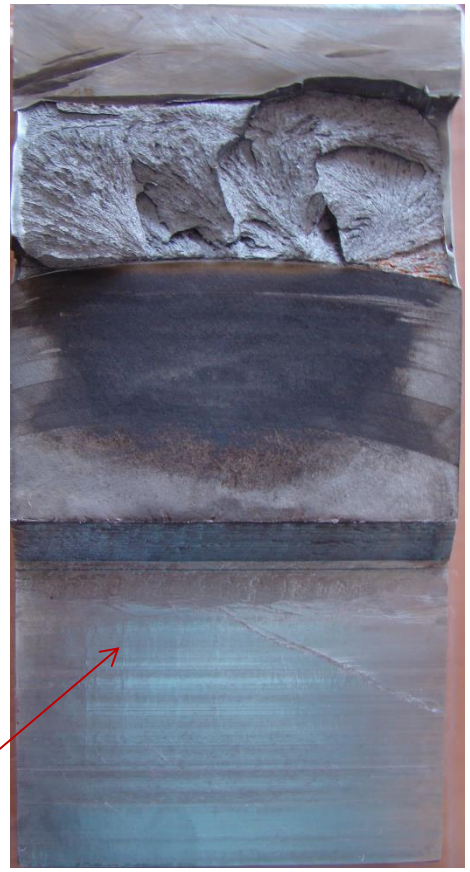
- Dynamic compression test in a drop weight tower with induction heating (900 °C, $\dot{\varepsilon} > 300\ s^{-1}$)

R&D efforts

RUMUL magnetic resonance testing machine
Preparation of a fatigue crack in specimens

Results of measurement: CTOD



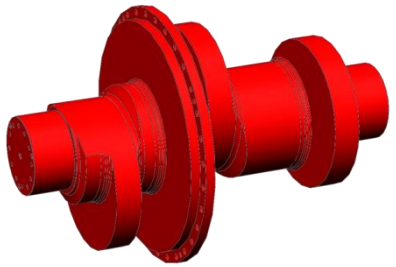


Fracture surface upon testing

- CTOD testing – 300 kg specimen, 1170 × 200 × 260 mm

Examples of R&D results

- Patents
  - 299495: Method for producing high-strength low-alloy steel tubes
  - 301718: Method of processing semi-finished steel temperature above Ac1
  - 302676: Method of annealing steel blank
  - 302940: Method of surface work hardening of the metal blank and device for performing this method
- Utility models
  - 22084: Skeleton of the seat frame of public transport
  - 23289: Equipment for corrosion tests in steam at high temperatures
  - 24922: Forming device for the continuous extrusion of fine grained blanks of high-strength metals
- Established technologies
  - VÍTKOVICE HEAVY MACHINERY a.s. – forging of camshafts
  - GMA Stanztechnik Kaplice s.r.o. – forming of necks for special threads
- Publications
  - Papers in journals with impact factor, citations and others

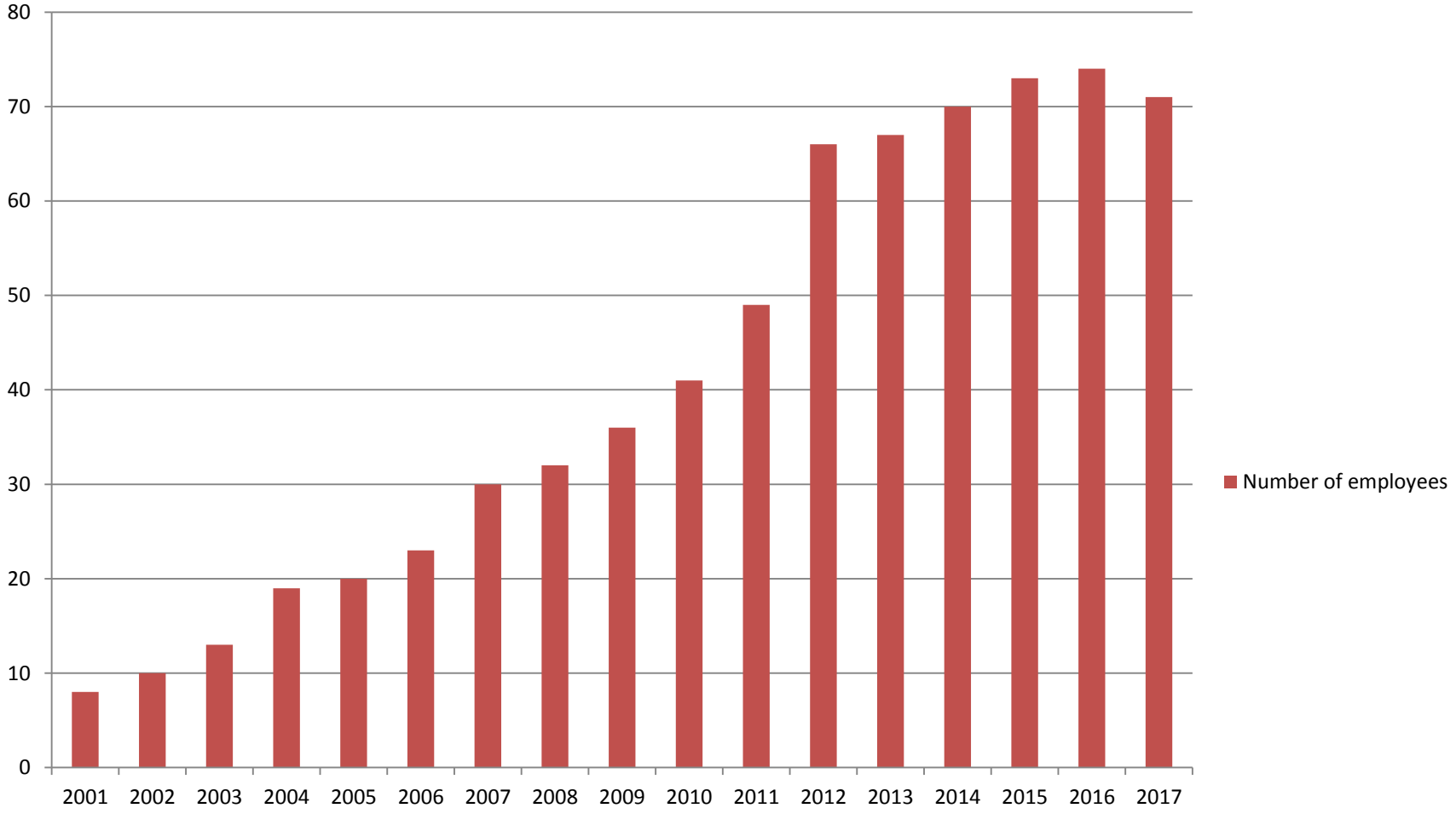


Awards for research and development activities

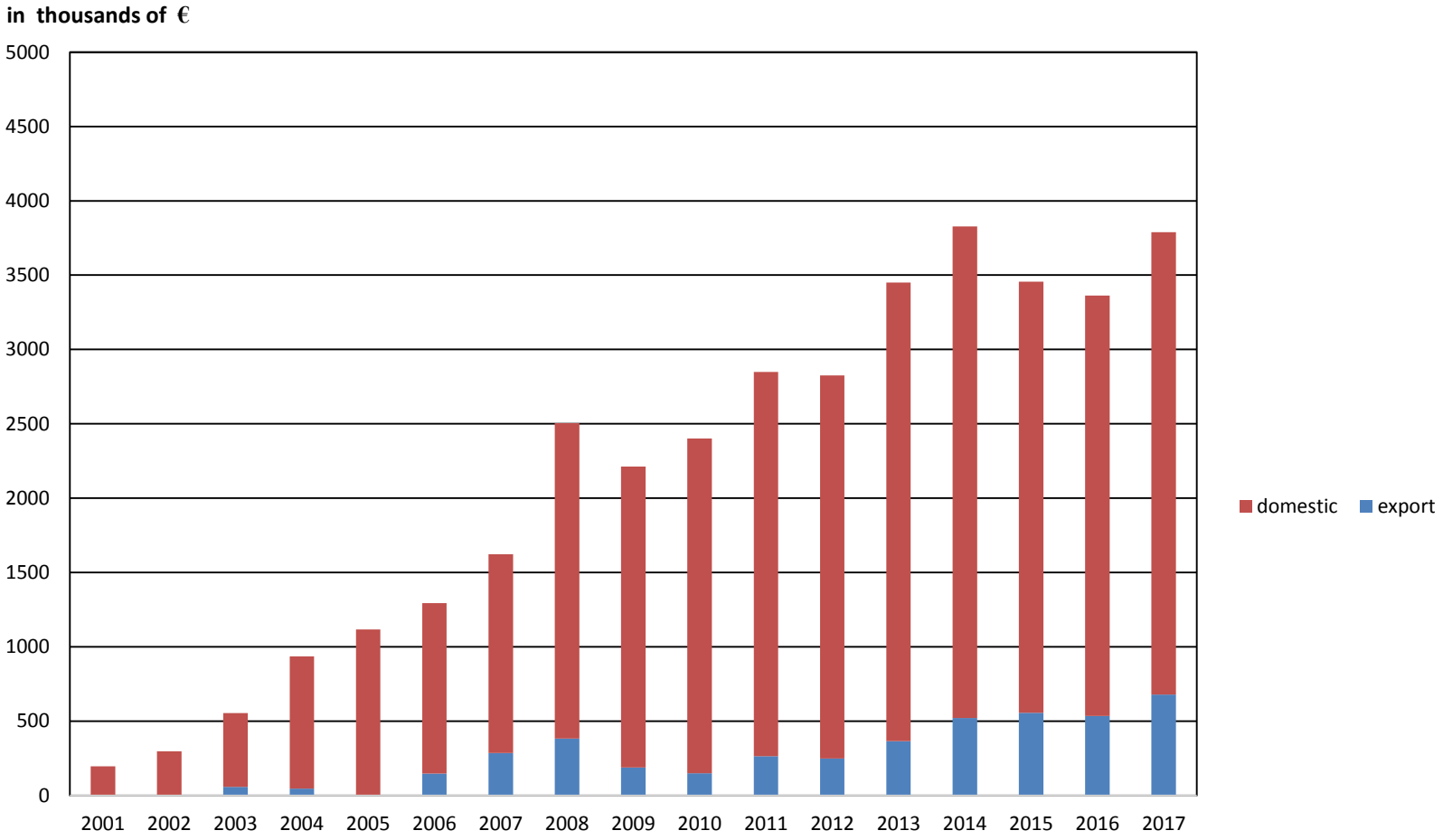
- First prizes awarded in the Czech Republic

Our people

Number of employees



Financial turnover of the company



Our partners

ZÁPADOČESKÁ UNIVERZITA V PLZNI

FACULTAS MATHEMATICA PHYSICAQUE

VŠB-TU OSTRAVA 1849 FAKULTA METALURGIE A MATERIÁLOVÉHO INŽENÝRSTVÍ

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

Institute of Physics of Advanced Materials

УГАТУ

МИСиС

BERGAKADEMIE FREIBERG TECHNISCHE UNIVERSITÄT

TECHNISCHE UNIVERSITÄT CHEMNITZ

University of Glasgow
VIA VERITAS VITA

References

ŠKODA

SCHAEFFLER
LUK INA FAG

BILSTEIN
Ein Name für Kaltband

DOOSAN
Doosan Škoda Power

ANDRITZ

ŠKODA

voestalpine
EINEN SCHRITT VORAUS.

Buderus | Edelstahl

Mubea
light.efficient.global.

BENTELER

_metatech

VÍTKOVICE
MACHINERY GROUP

BONATRANS

ŠKODA
ŠKODA JS a.s.

Honeywell

ZDAS

PILSEN STEEL

CPF
CZECH PRECISION FORGE

MECAS ESI
S.R.O.

Technology park COMTES FHT

Project number:	CZ.01.1.02/0.0/0.0/15_036/0007116
Financing:	OP PIK Infrastructure development
Project start:	1. 11. 2016
Project finish:	31. 10. 2019
Budget:	148 504 800 Kč
Aim:	Building of a technology park near to COMTES FHT facility to create premises for technology oriented SMEs.

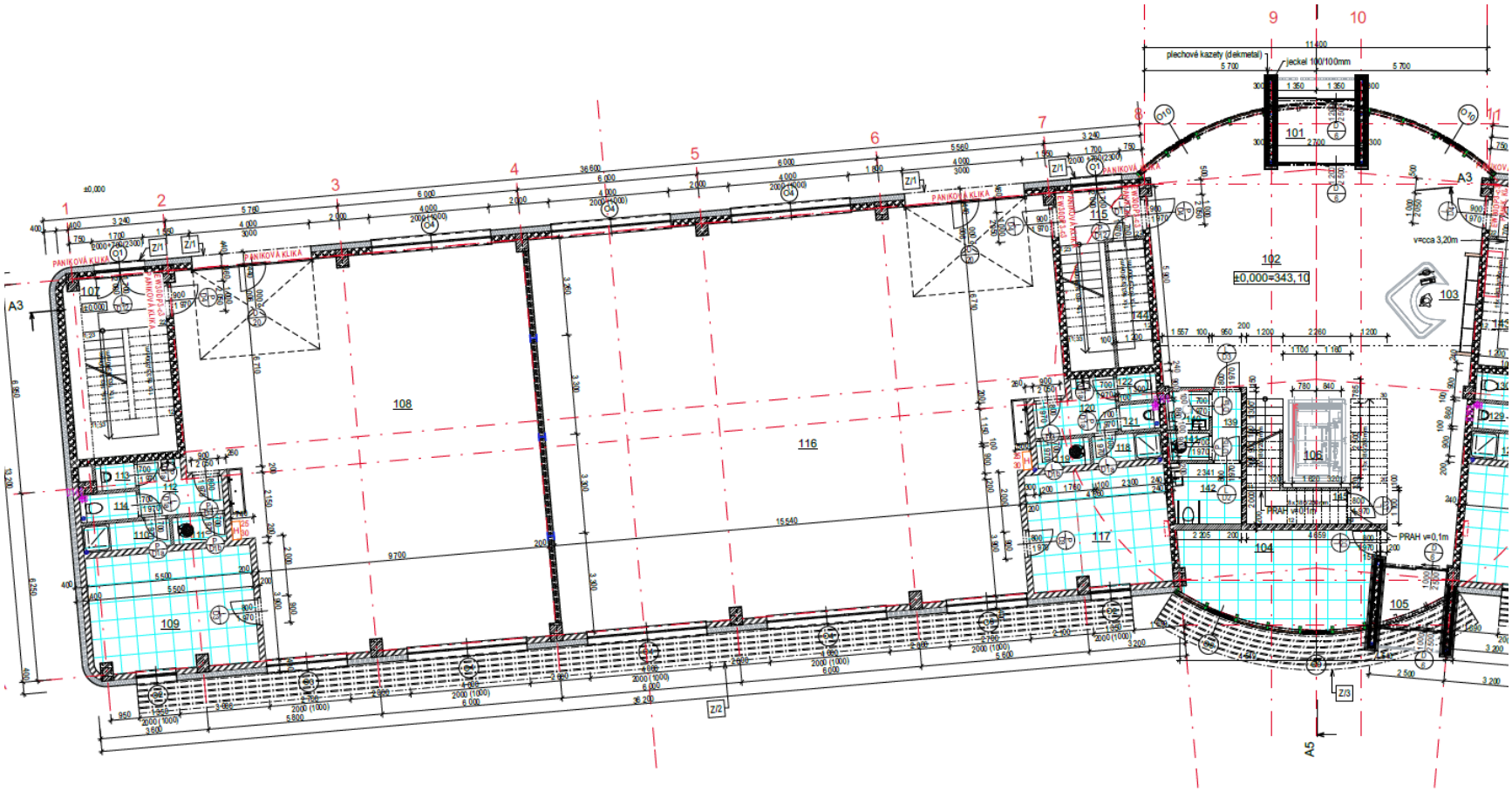
Investments

- 3 buildings of the technology park
- 3D printer for metals
- Charging station for e-cars
- CAD and simulation software

Utilization

- Premises to be rented to technology-oriented SMEs
- Conference center
- Kindergarden

1st floor (manufacturing facility)



2nd floor (offices)