



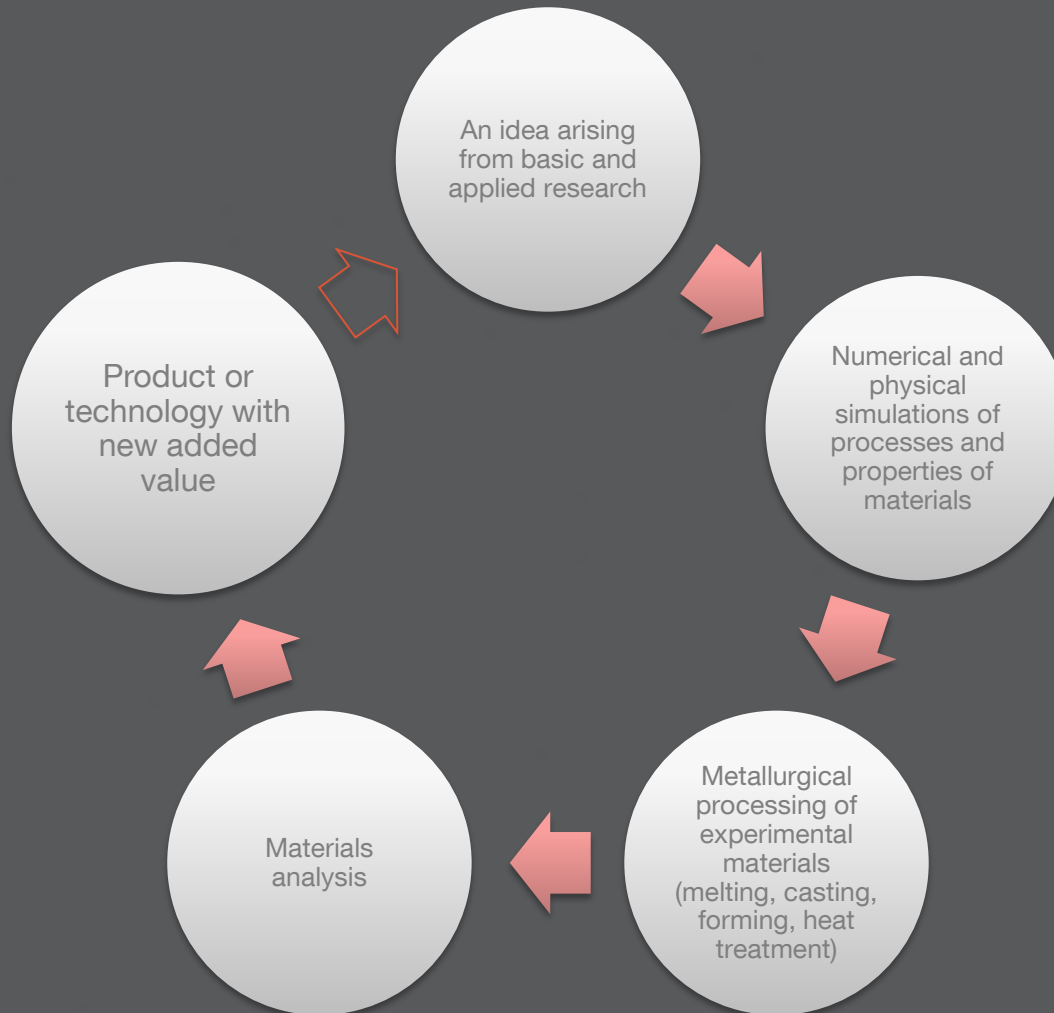
## Company presentation

# Top Innovation, Complex service in metals

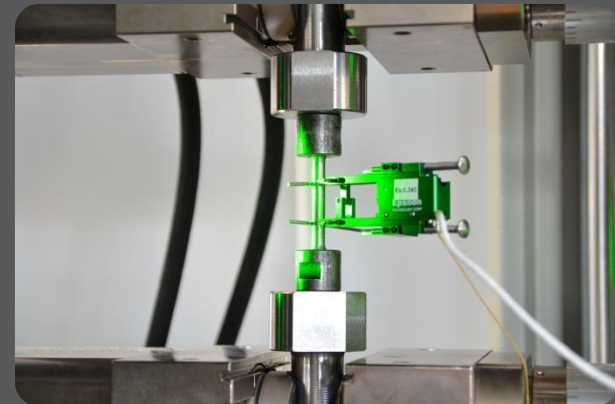
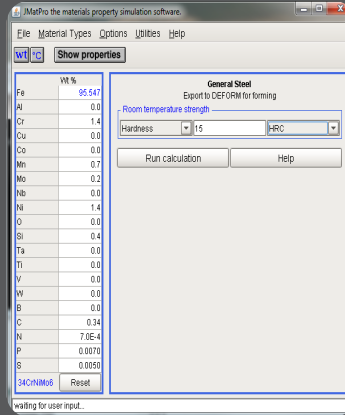


This is COMTES FHT a.s.

## Model example: Development of new material



# Model example: Development of new material



## West-Bohemian Centre of Materials and Metallurgy (WBCMM)



EVROPSKÁ UNIE  
EVROPSKÝ FOND PRO REGIONÁLNÍ ROZVOJ  
INVESTICE DO VAŠÍ BUDOUCNOSTI



OP Výzkum  
a vývoj pro inovace

## West-Bohemian Centre of Materials and Metallurgy (WBCMM)



## COMTES FHT a.s. Complex view



## Examples of successful R & D

### Patents

- 299495: A 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: The method of work hardening the surface of the metal blank and device for performing this method

### Utility models

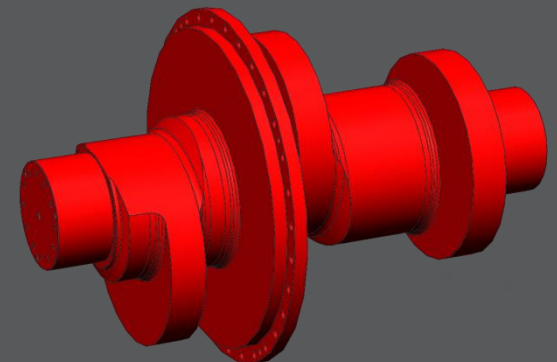
- 22084: The skeleton of the seat frame of public transport
- 23289: Equipment for corrosion tests in steam at high temperatures
- 24922: Forming device for the continuous production of fine grained blanks of high-strength meta.

### Established technology

- VÍTKOVICE HEAVY MACHINERY a.s. – technology of forging of cam
- GMA Stanztechnik Kaplice s.r.o. – Forming of neck for thread

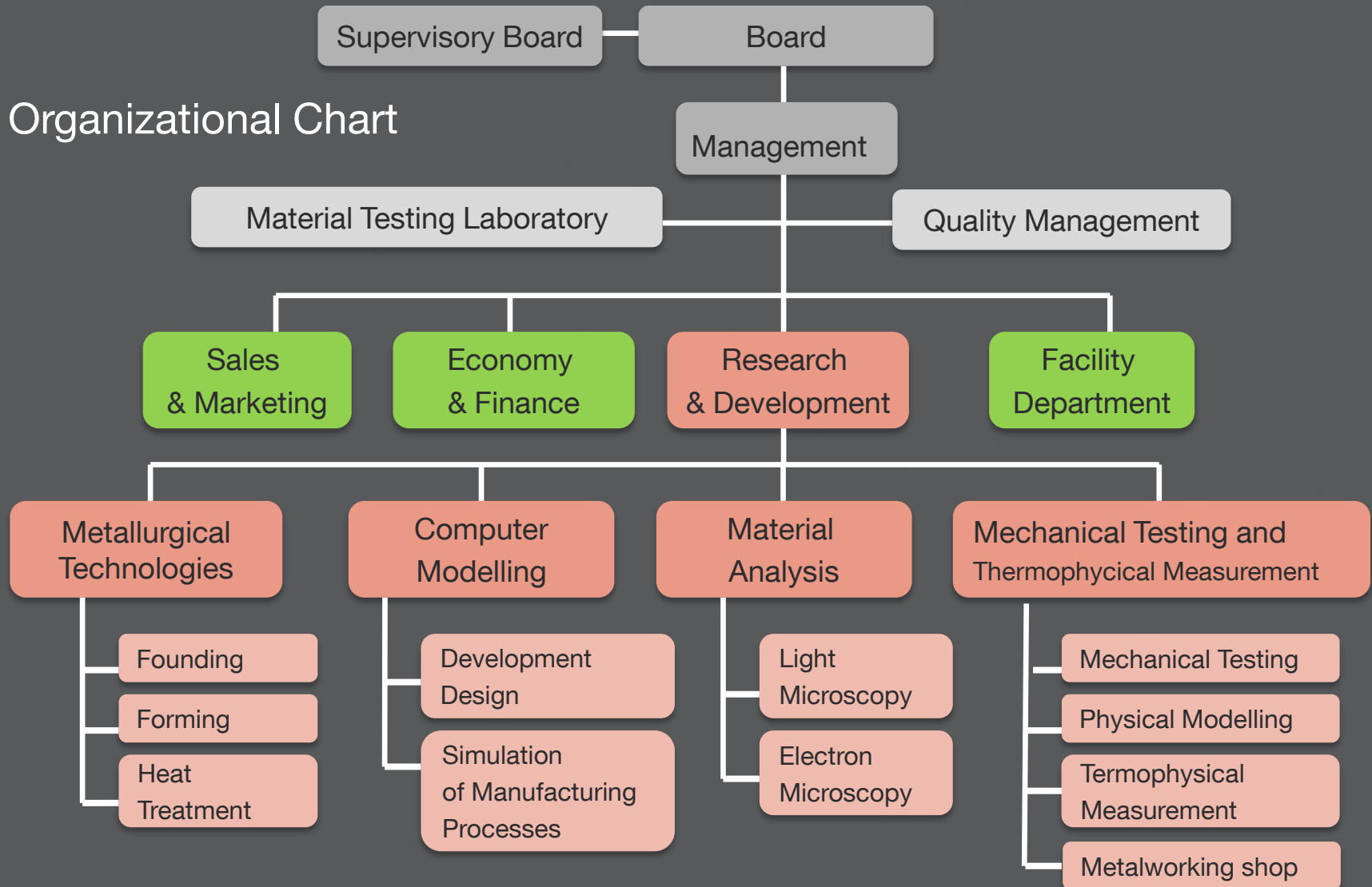
### Publications

- Papers in journals with impact factor, citations and others



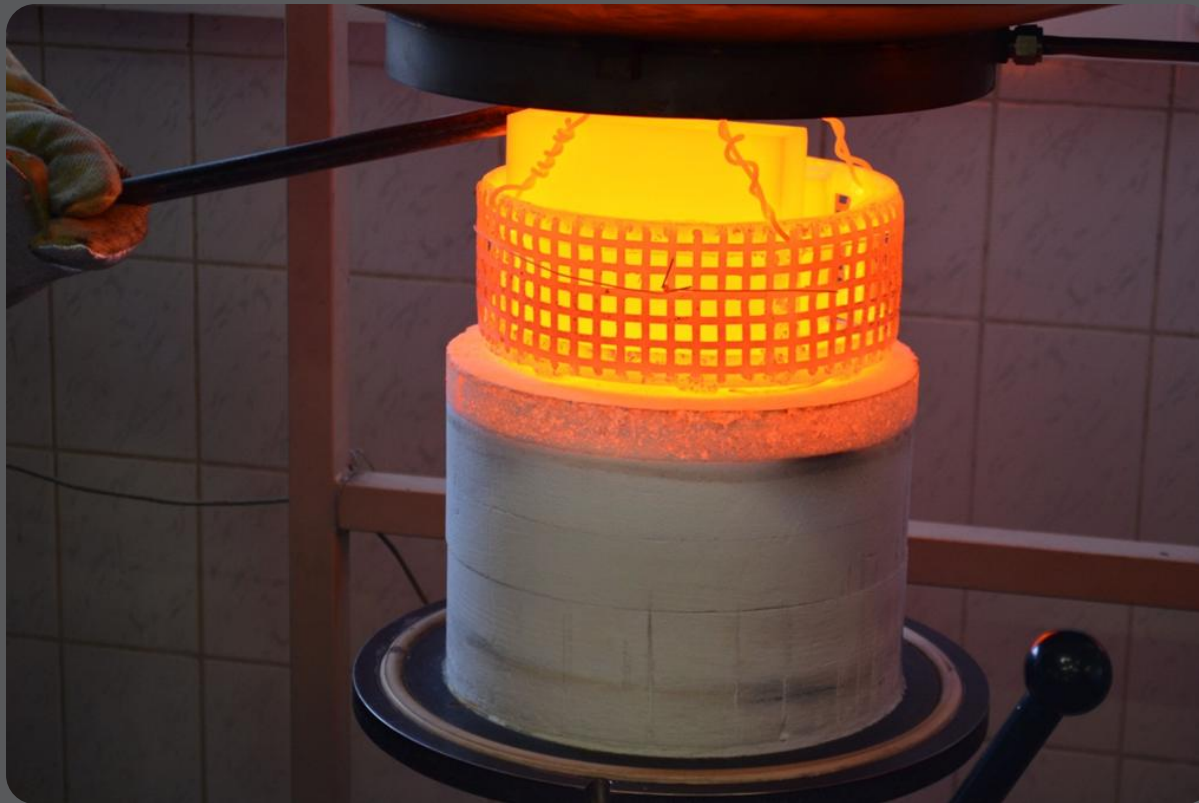


## Organizational Chart





## Metallurgical Technologies





## Metallurgical Technologies

- Casting of ingots and die castings in VIM furnace, max. lot 50 l (steel, Ni alloys, Al alloys etc.)
- Alloying in protective gas



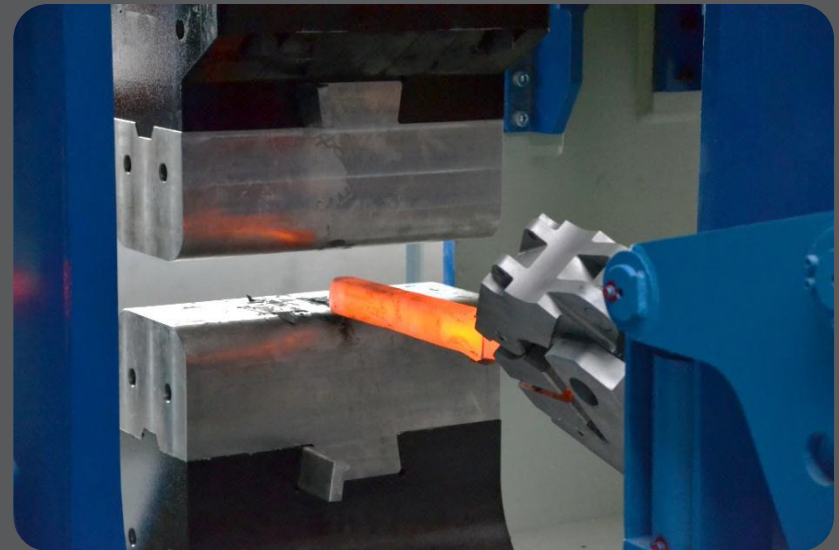
*VIM furnace at COMTES FHT*



## Metallurgical Technologies

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

Max. power	2 500 t
Working table	800 x 800 mm
Max. stroke	500 mm
Max. opening	900 mm



*New forging press 2 500 t at COMTES FHT*

## Metallurgical Technologies



- Hot and cold rolling of bands and sheets down to 0,2 mm on reversible rolling mill (both two-high or four-high mill can be used)
- Thermo-mechanical rolling



*Rolling mill at COMTES FHT*

### TWO-HIGH MILL

Hot rolling

- Max. reduction 100 mm
- Max. temperature 1 250°C
- Rolling down to 2 mm

### FOUR-HIGH MILL

Cold rolling

- Max. reduction 10 %
- Rolling down to 0.2 mm

## Metallurgical Technologies



- Hardening in a vacuum furnace and/or conventional furnaces
- Deep cryogenic treatment using liquid nitrogen
- Thermo-chemical treatment (nitriding, carburizing, boronizing)

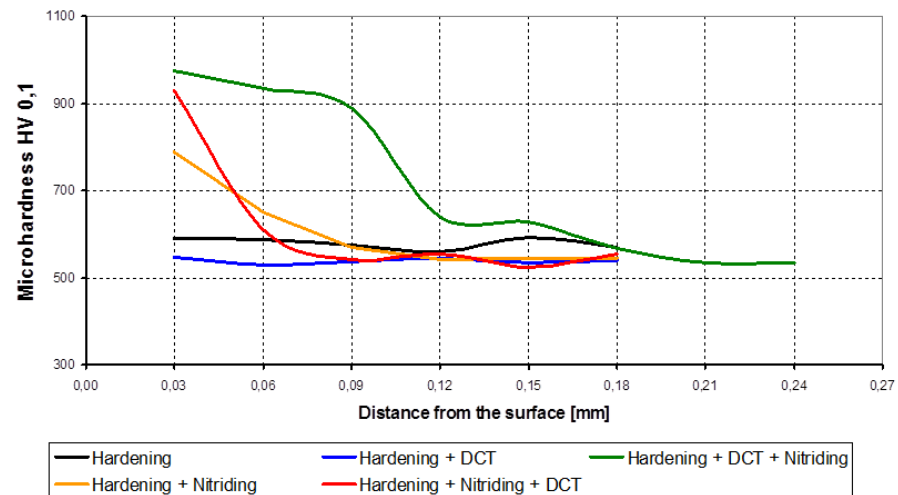


*Vacuum hardening furnace with a load inside*



## Metallurgical Technologies

- Optimizing of tools lifetime through improved heat treatment strategy
- Deep cryogenic treatment for wear resistance improvement of tool steels Werkzeugstählen (patents applied)

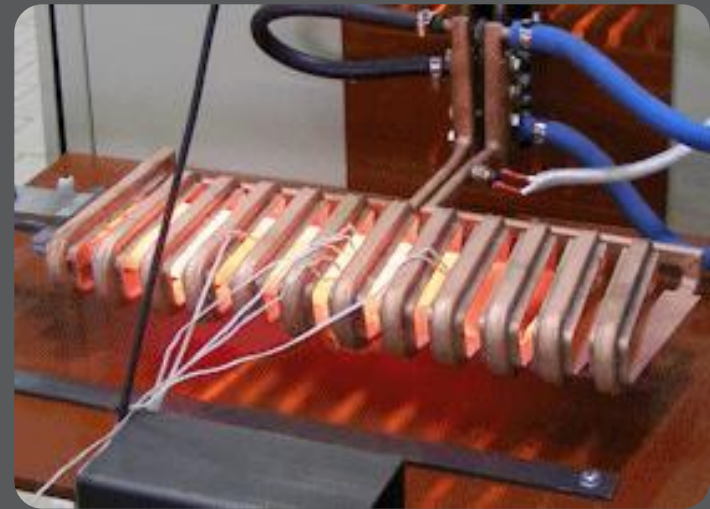


*Influence of deep cryogenic treatment on nitriding*



## Metallurgical Technologies

- Complex services for industrial application of induction heat treatment (hardening, normalising, soft annealing etc.)
- Incl. projects of induction lines, design and manufacturing of inductors etc.



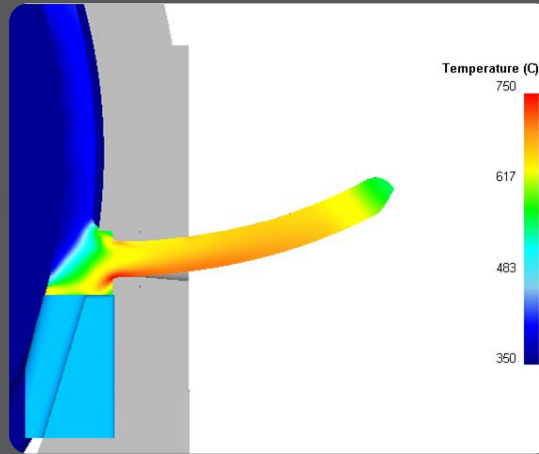
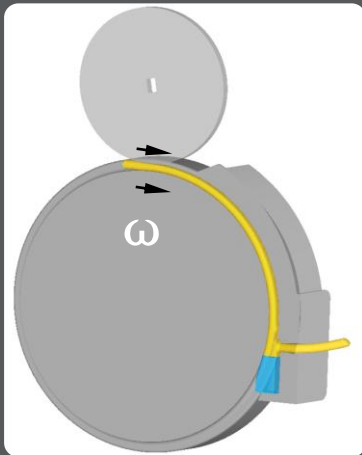
*Applications of induction heat treatment - examples*



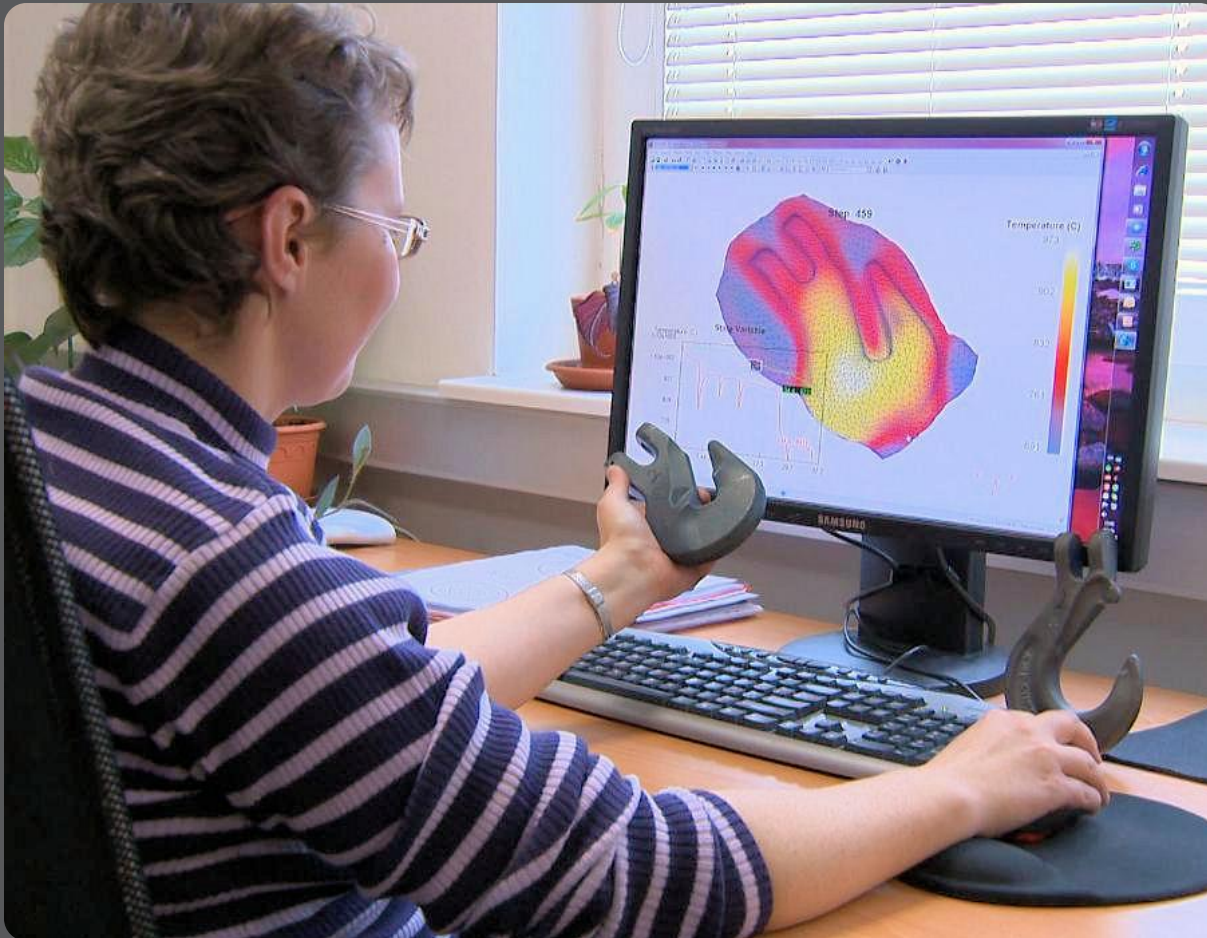
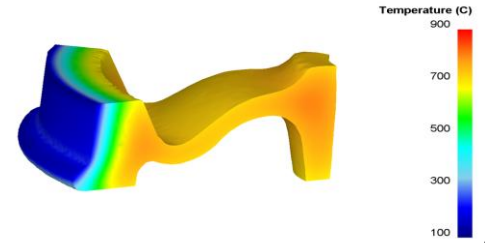


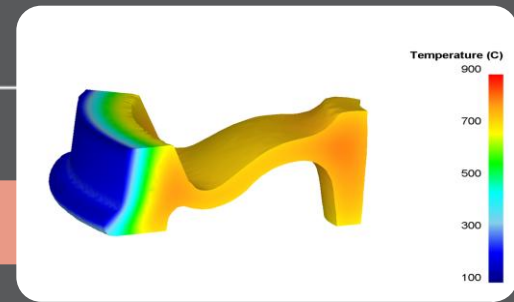
## Conform™

- Grain refinement
- Material flow analysis
- Temperature analysis



## Computer Modelling





## Computer Modelling

### Development Design

- development of tools and jigs
- analysis of static and dynamic problems
- optimising and extending lifetime of structures
- development of non-conventional joint types
- component geometry for numerical modelling
- programming CNC machine tools

### Simulation of Manufacturing Processes

- preparation of material property data for numerical simulations
- design and optimisation:
  - conventional forming processes (forging, rolling, extrusion, tube manufacturing)
  - special forming processes (hydroforming, SPD, microforming)
  - heat treatment, thermochemical treatment and thermomechanical treatment
  - induction and resistance heating

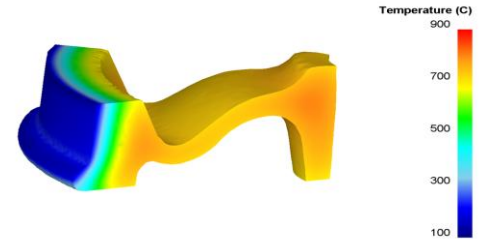
## Computer Modelling

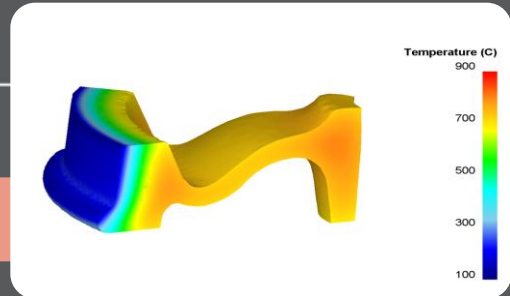
### Development Design

- Development of components and structures
- Optimisation of structures, material selection
- Extending the life of structures
- Tools and fixtures for forming and heat treatment
- Tools for special forming methods
- Fixtures for mechanical testing shops
- Development of alternative joints of special materials
- Programming of CNC machine tools

### Software:

- CAD packages: AutoCAD, SolidWorks, SolidEdge
- GibbsCAM software for CAM
- FEM packages: MSC.Marc, Nastran, Dytran, XFlow

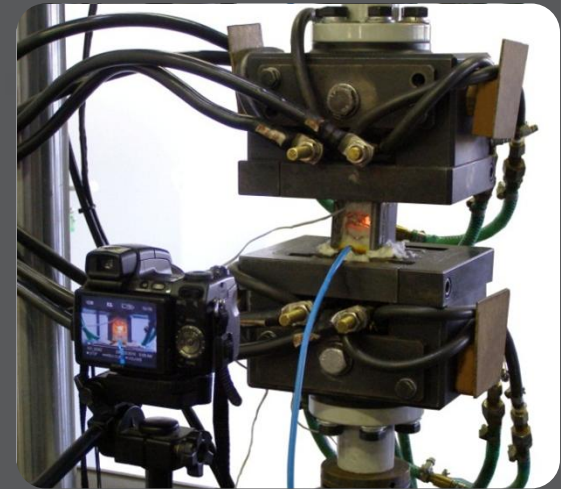
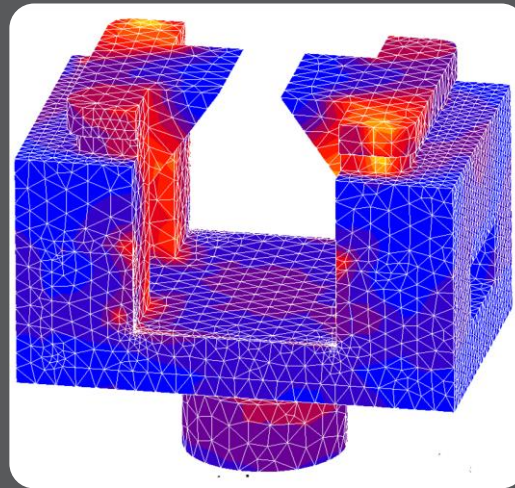
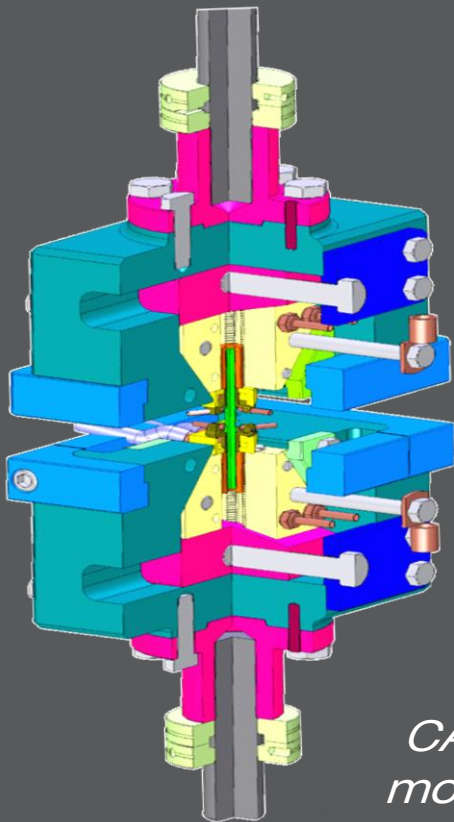




Computer Modelling

Development Design

Versatile grips  
for a thermomechanical simulator



*CAD  
model*



*Numerical  
simulation*



*Testing  
device*

## Computer Modelling

### Simulation of Manufacturing Processes

- **Adapting materials data  
for numerical simulation**

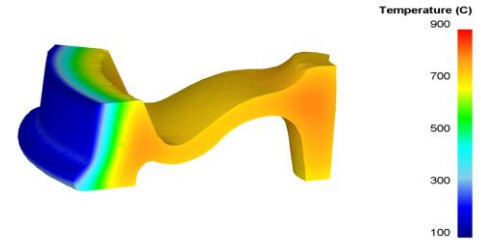
- **Design and optimisation:**

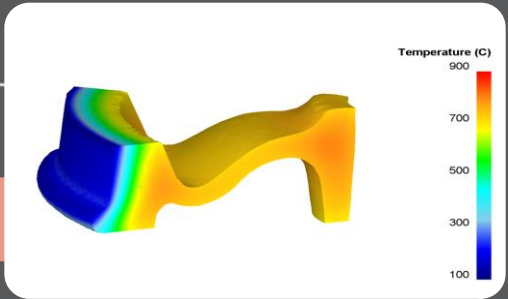
- conventional forming processes (forming, rolling, extrusion, tube production)
- special forming processes (hydroforming, SPD, microforming)
- heat, thermochemical and thermomechanical treatment processes
- induction and resistance heating

- **Software:**

CAE software **DEFORM**

**JMatPro** software for computing materials properties

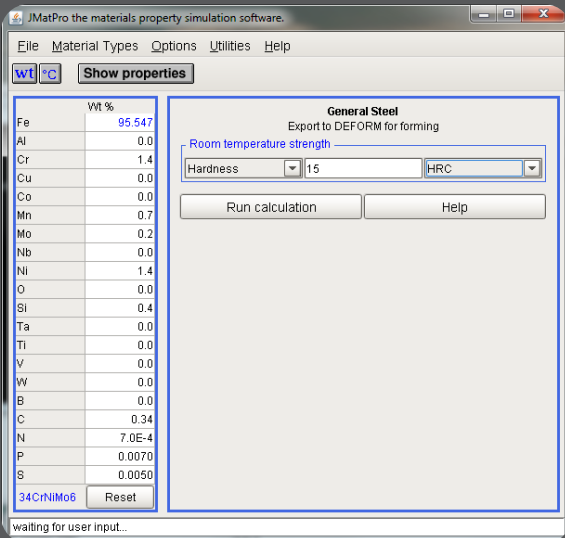




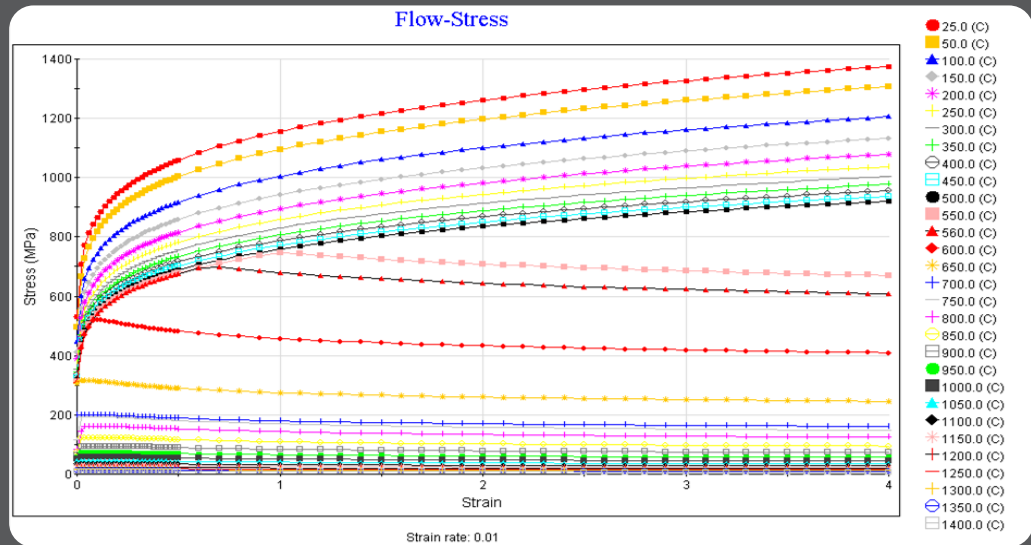
# Computer Modelling

## Simulation of Manufacturing Processes

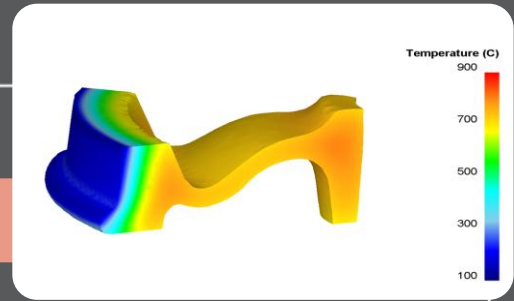
- Thermo-mechanical properties calculation based on chemical composition



Input of chemical composition



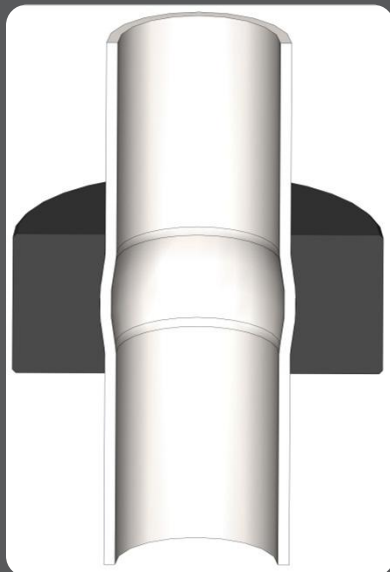
Calculated flow stress curves



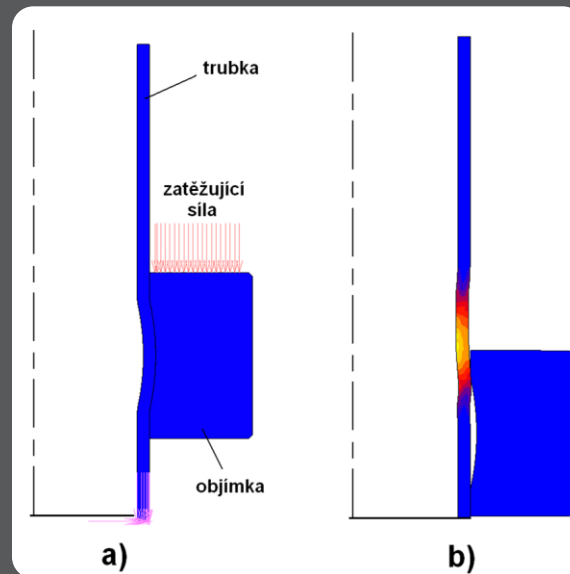
Computer Modelling

Simulation of Manufacturing Processes

## Explosive forming: alternative joining techniques



*CAD model*

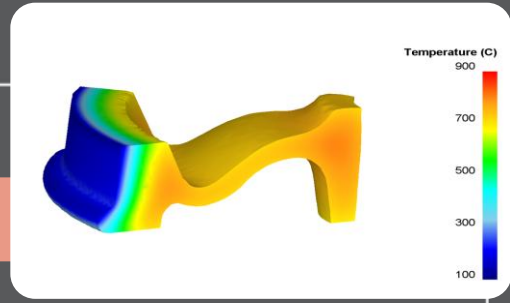


*Numerical simulation*



*Test sample*

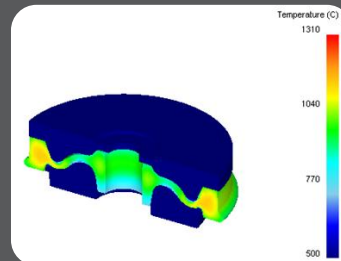
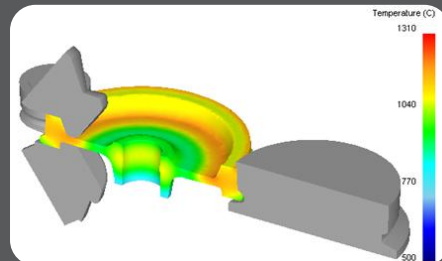
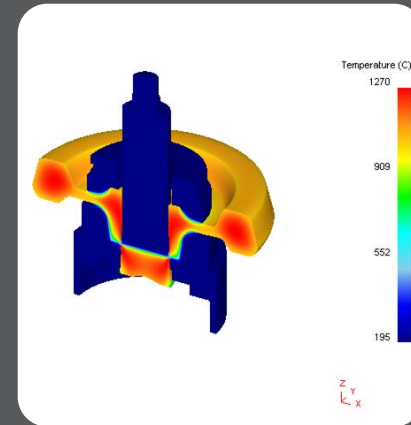
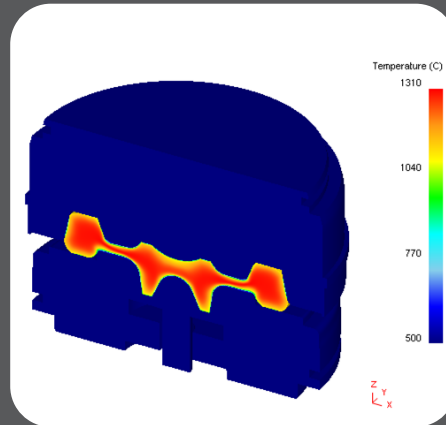
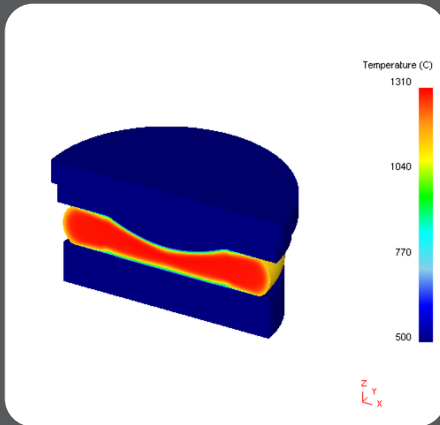


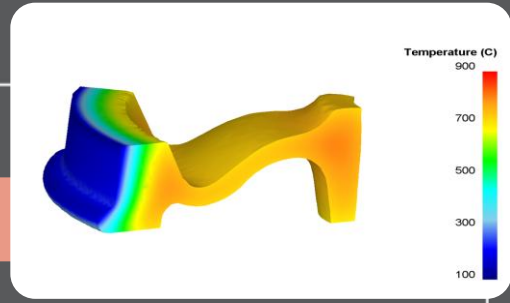


## Computer Modelling

## Simulation of Manufacturing Processes

# Production of rail wheels - procedure

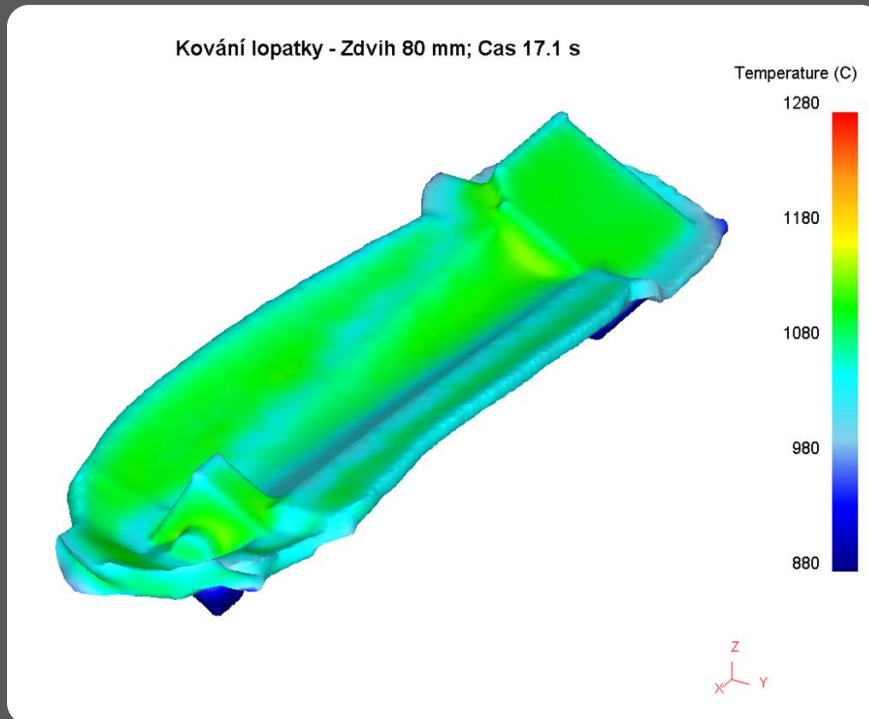


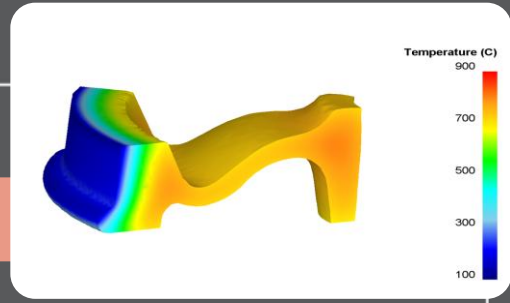


Computer Modelling

Simulation of Manufacturing Processes

## Simulation of blade forging

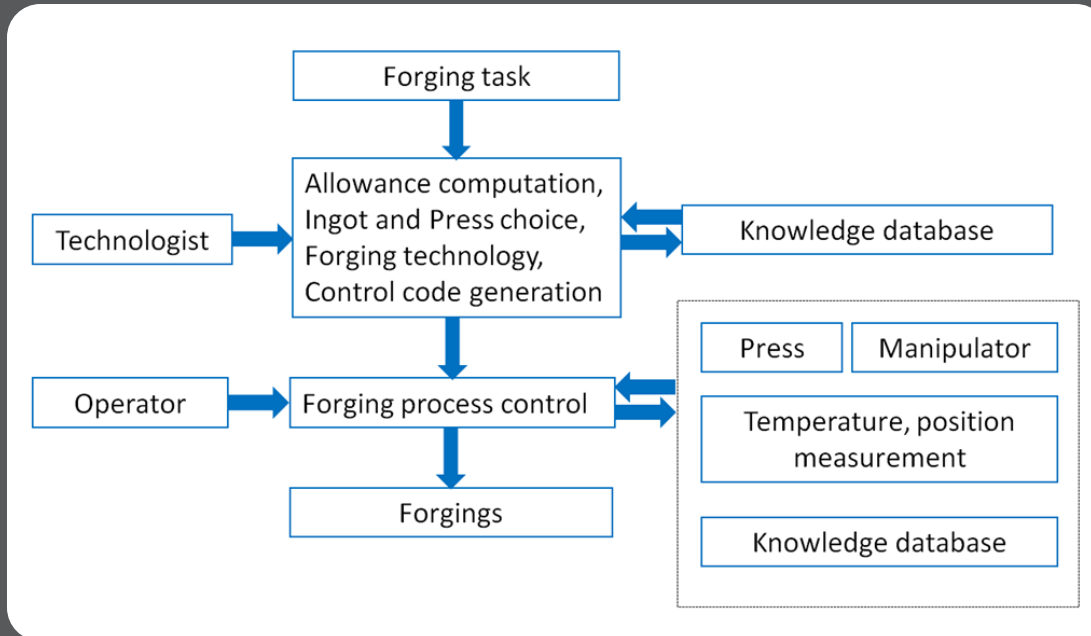




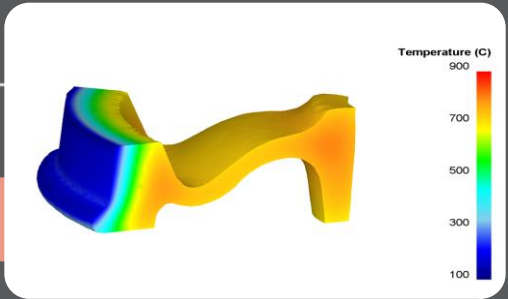
## Computer Modelling

### Project forging software – Open die forging solution

- Fast and precise design of a new manufacturing process
- Repeatability of production with the same quality
- High accuracy
- Documentation of production



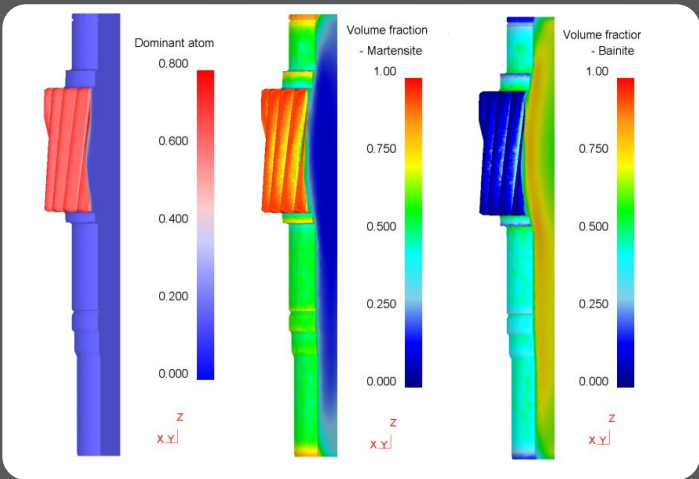
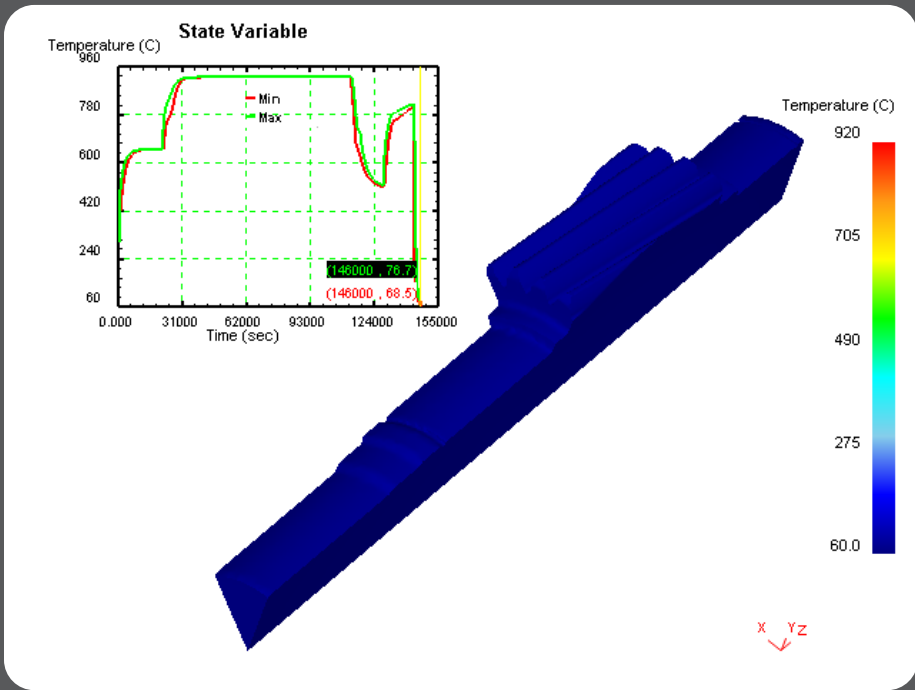
*Developing diagram of open die forging*



# Computer Modelling

## Simulation of Manufacturing Processes

### Thermochemical treatment



*Diffusion of carbon in teeth region .*

*Calculation of phase composition.*



## Material analyses





## Material 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



## Material analyses

### Facilities

- 4 optic microscopes (Nikon and Carl Zeiss)
- 2 scanning electron microscopes (Jeol with EDX and EBSD)
- Preparation of metallographic samples with modern machinery

Struers and Buehler

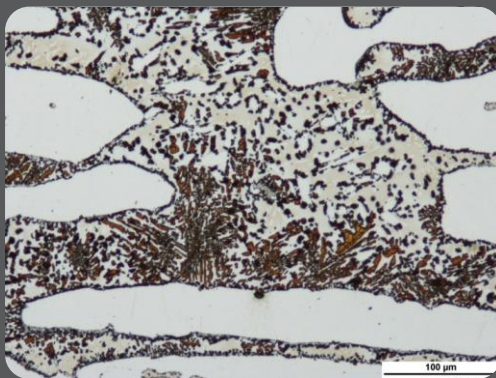
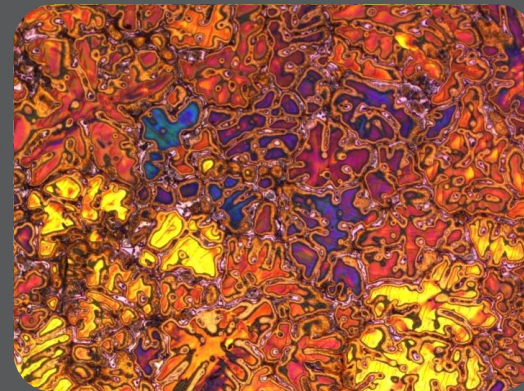
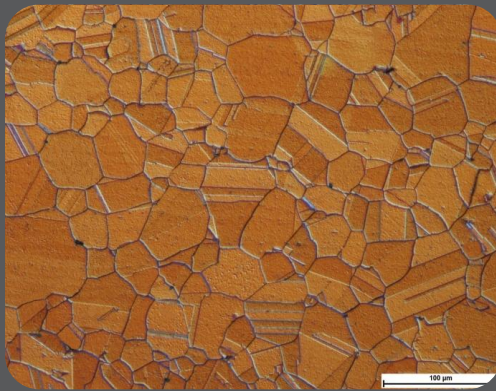




*Duplex steel*

## Material analyses

### Metallography of metals and alloys



*Clockwise:*

- *nickel alloy*
- *cast aluminum alloy structure*
- *duplex steel annealed for the occurrence of sigma phase*





## Material analyses

### Macro and microstructure

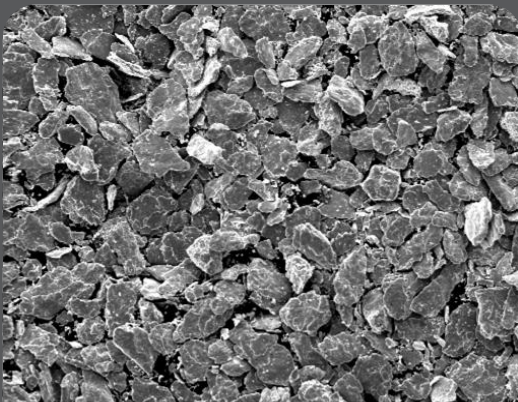


*Macrostructure – heel /alloy pin FeNi42*

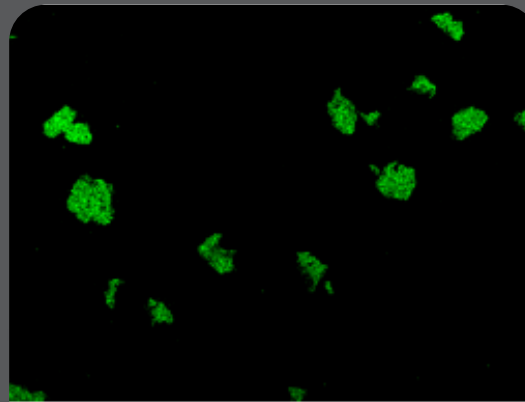


## Material analyses

### Electron microscopy

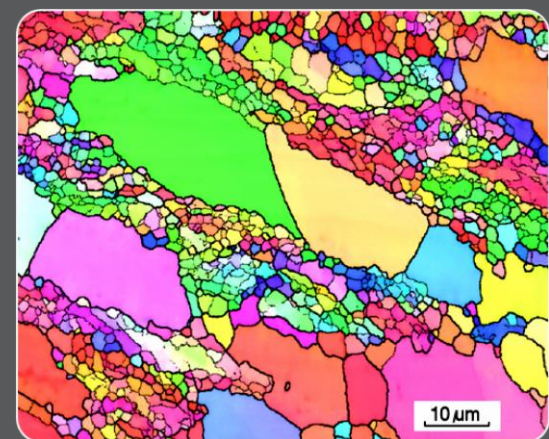


Electron Image 1



Cr Ka1

*EDX map - distribution of chromium  
in the powder material*



*EBSD Analysis of non-uniform  
recrystallization process*

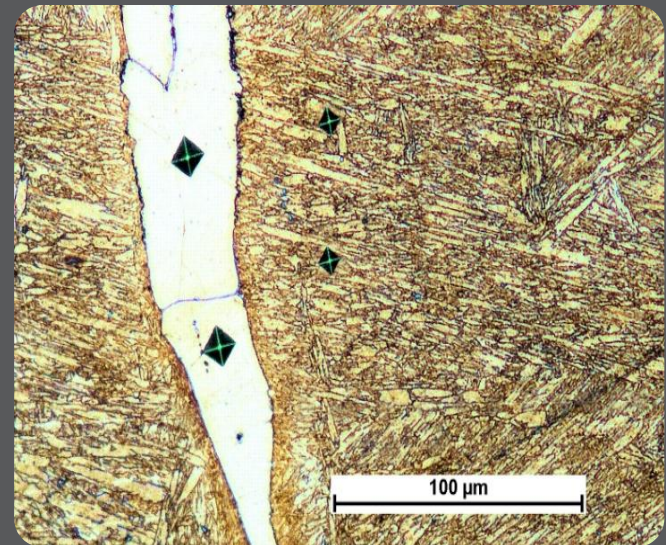


## Material analyses

### Microhardness measurement

Equipment: Struers DuraScan – 70 EMCO-TEST Prüfmaschinen GmbH

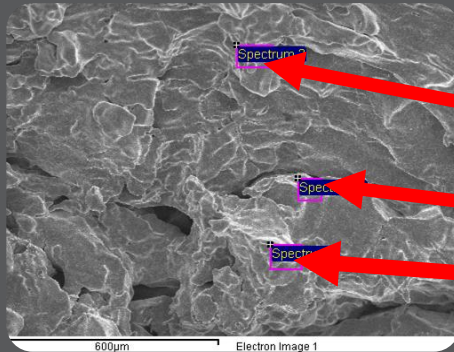
- Fully automatic testing cycle  
(select load / penetration / Focus / evaluation of hardness)
- Load **0.098 to 98.1 N**
- Measurement of micro and macrohardness
- Automatic table 200 x 120 mm  
accuracy 0.008 mm



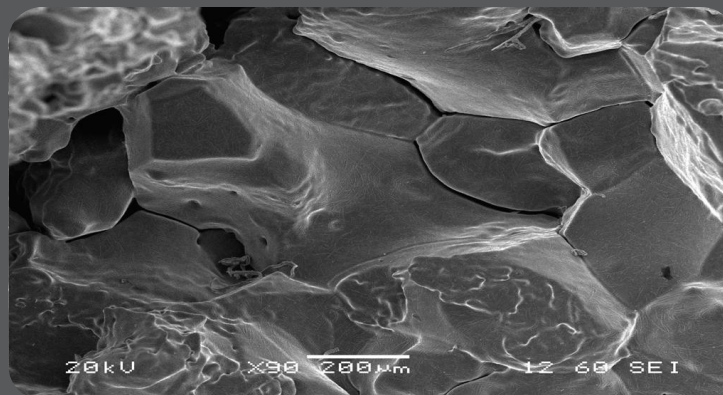


## Material analyses

### Fractography



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





## Material analyses

### Accredited laboratory

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

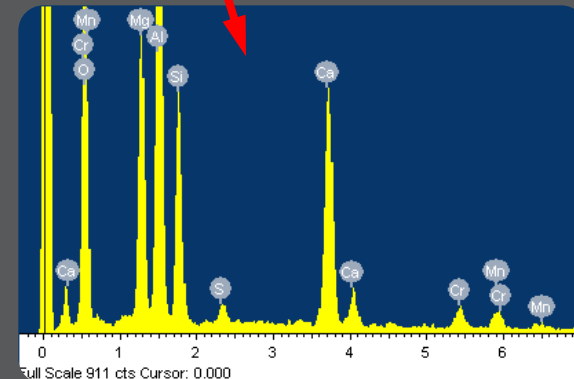
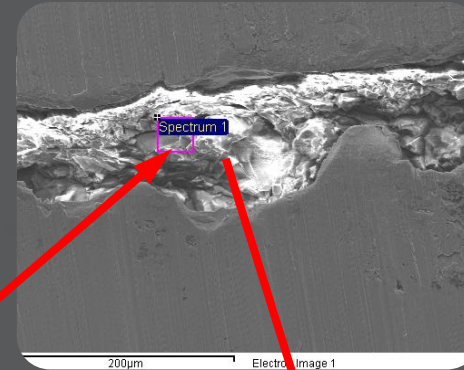
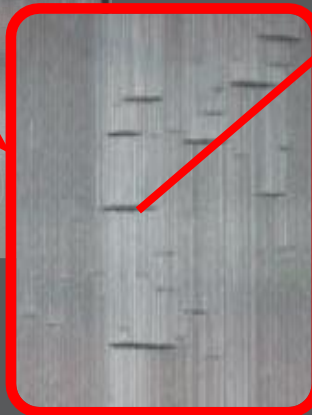
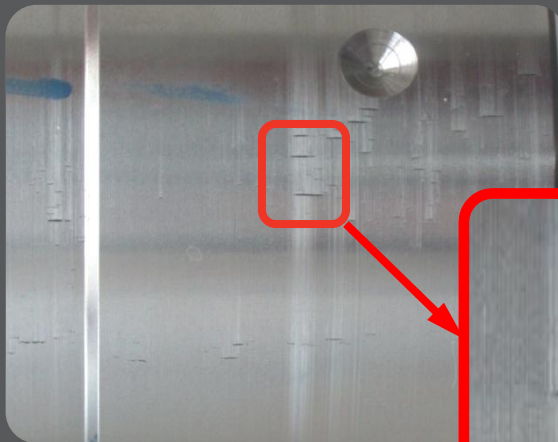


A comprehensive list of accredited tests: [www.comtesfht.cz/akreditovana-laborator/](http://www.comtesfht.cz/akreditovana-laborator/)



## Material analyses

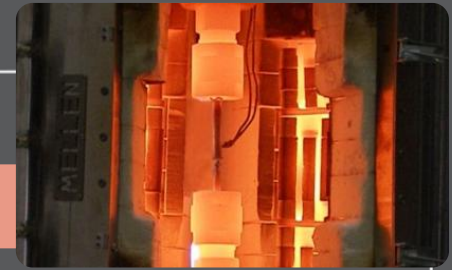
### Expert activities



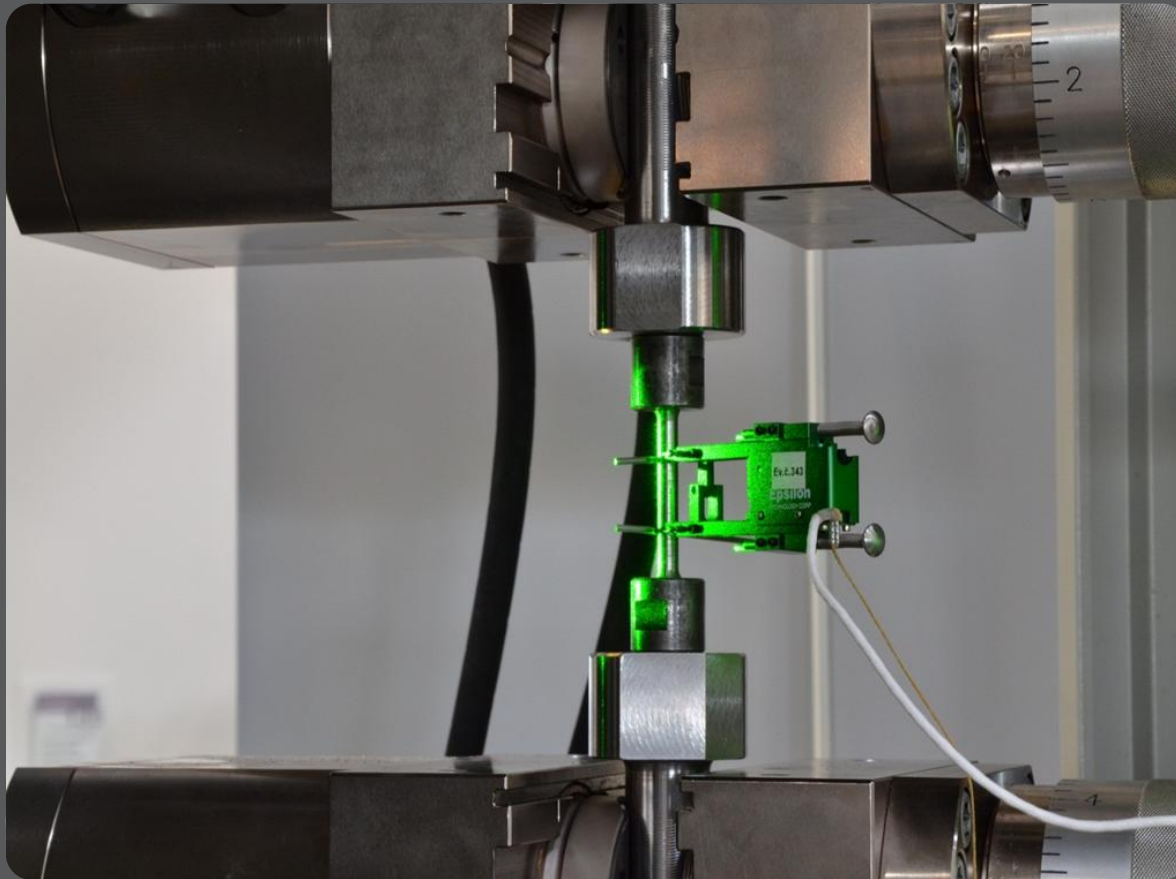
EDX analysis

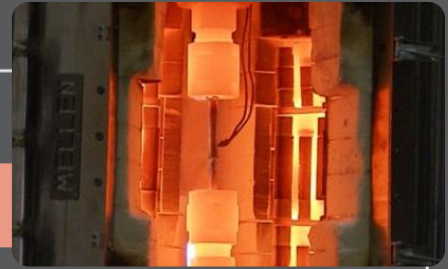
**Problem:** The surface of the workpiece with defects

**Result:** Excessive presence of large oxide inclusions - metallurgical defect



## Mechanical Testing & Thermophysical Measurement



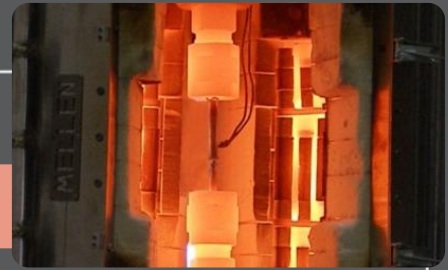


## Mechanical Testing

- 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 a Wöhler curve)
- Short-time creep tests
- Miniature-sample testing
- Torsion and biaxial testing
- Transition temperature determination
- Fracture toughness tests
  - J-R kcurves
  - Master curves
  - Fatigue crack growth rate, threshold value
- Component testing
- Non-standard tests per customer request







## Mechanical Testing

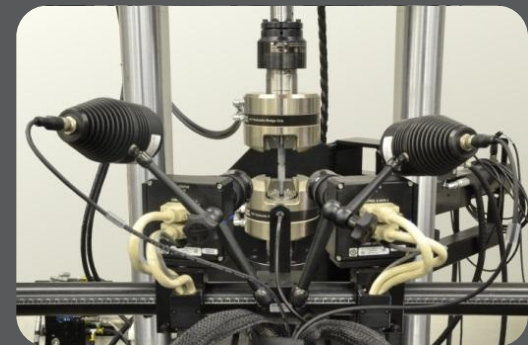
### Optical measurement systems

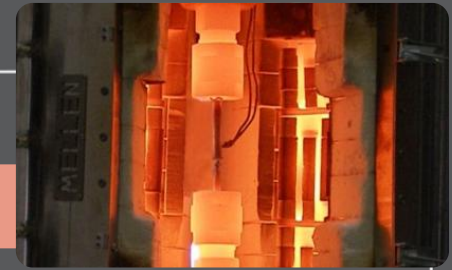
- ARAMIS, video-extensometer, laser-extensometer, high-speed camera
- Contactless measurements with data acquisition
- Ensure precise deformation measurements
- Available even for dynamic testing

### System ARAMIS

#### Digital Image Correlation (DIC)

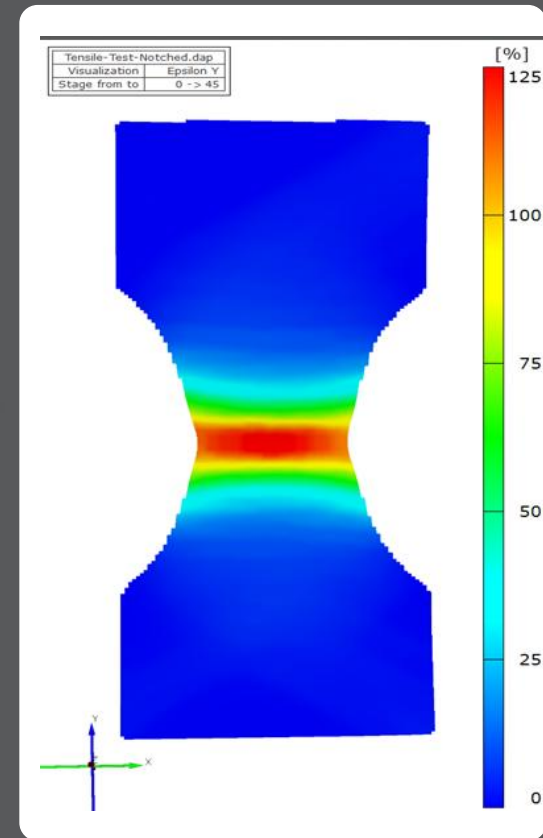
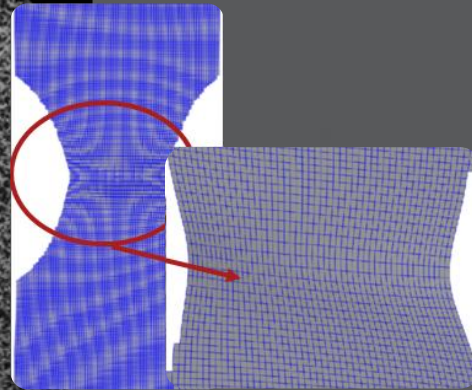
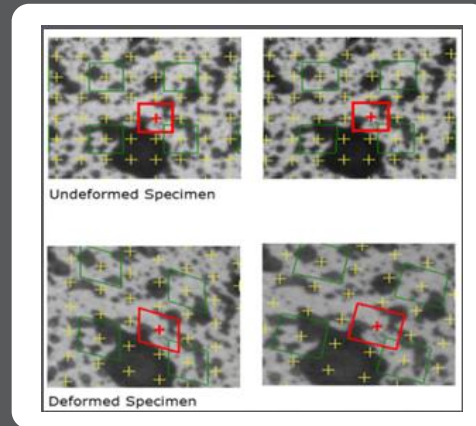
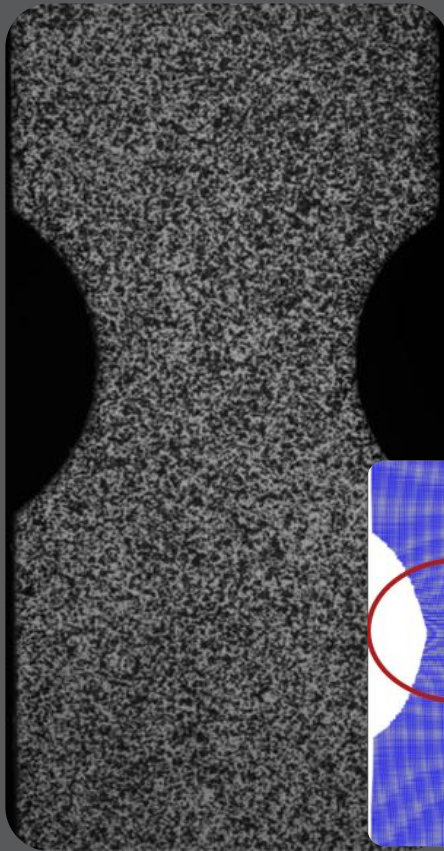
- Optical measurement method
- Measurement of surface deformation of tested sample
- 2D (1 camera) or 3D (2 cameras) measurement
- Video-extensometer
- True Stress-True Strain diagram measurements
- Flowing Limit Curve (FLC, FLD)

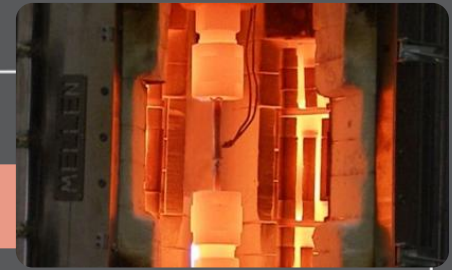




## Mechanical Testing

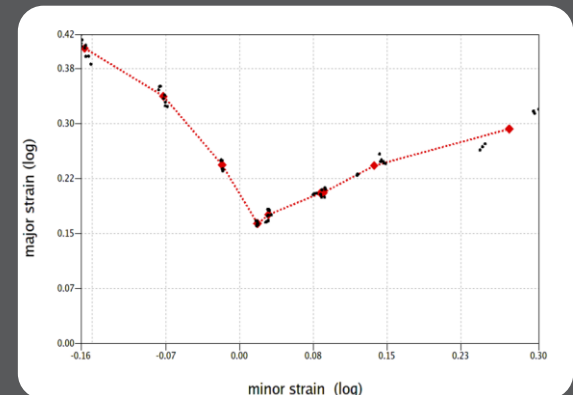
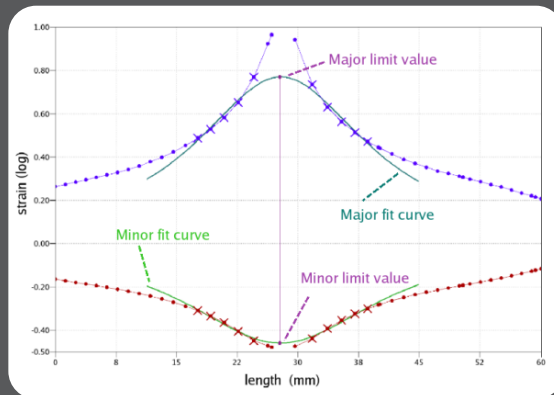
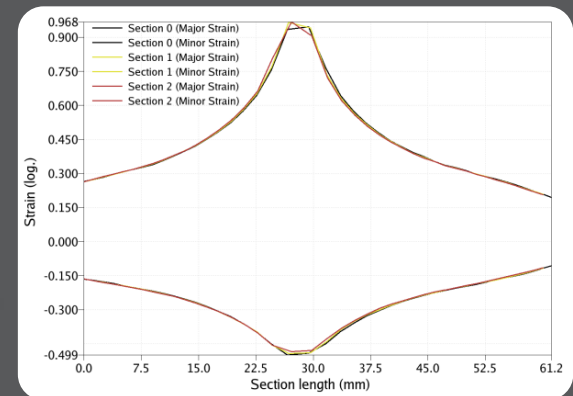
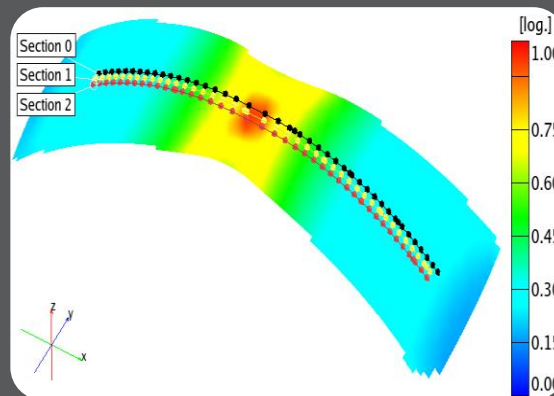
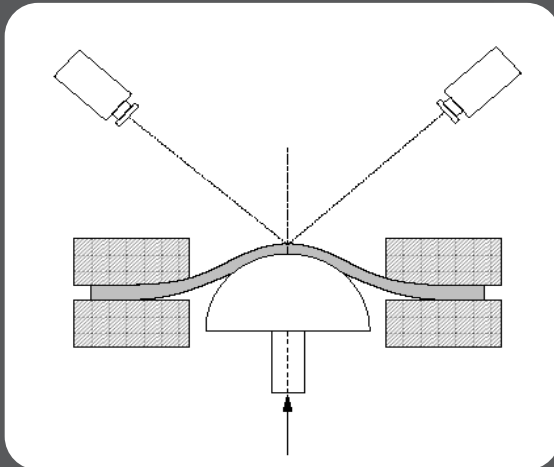
### ARAMIS - Digital Image Correlation

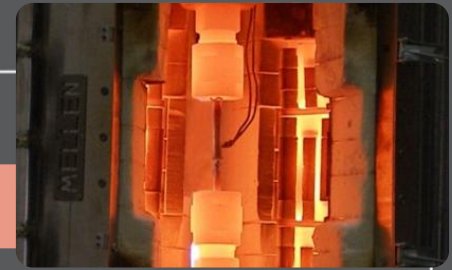




# Mechanical Testing

## ARAMIS – FLC diagram (Flowing Limit Curves)





## Mechanical Testing

### Dynamic testing

Impact tester IMATEK IM10T-30HV

#### Technical parameters:

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

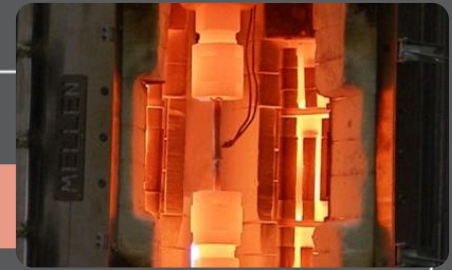
#### High-speed camera Phantom v710 1 Mpx camera

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

#### Possible tests

- tensile, compression, three-point bend ...
- dynamic component testing

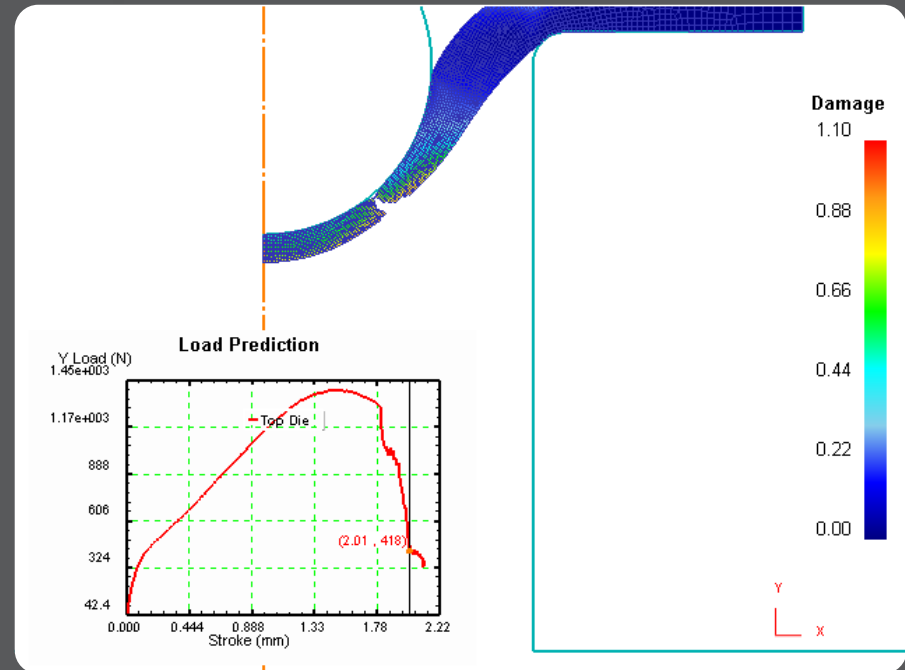
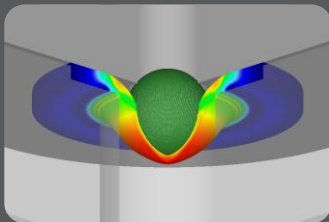


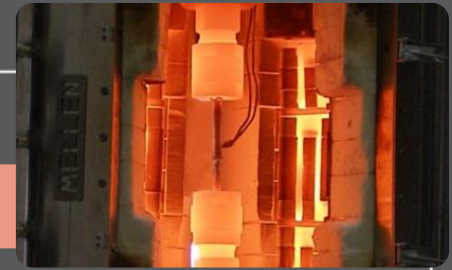


## Mechanical Testing

### Miniature-sample Testing - Small Punch Test (SPT)

- Sample-disc dimensions only  $D=8\text{mm}$ ,  $t=0,5\text{mm}$
- Stress-strain characteristics measurement
- Tensile properties determination
- Transition temperature measurement
- Estimation of fracture toughness

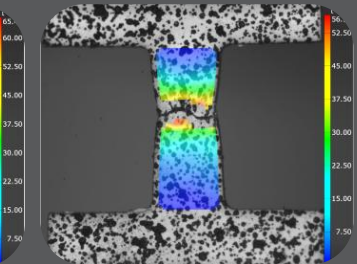
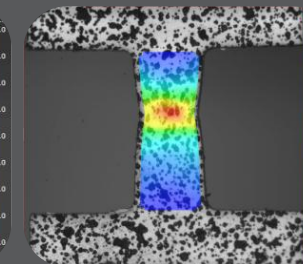
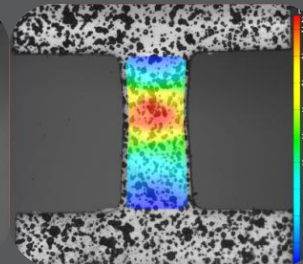
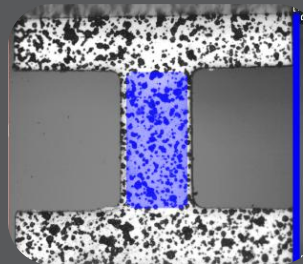
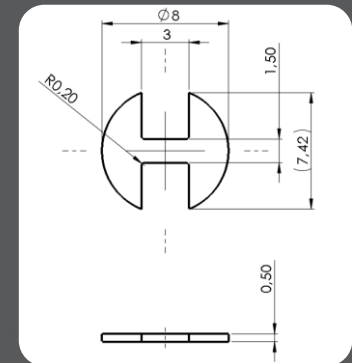
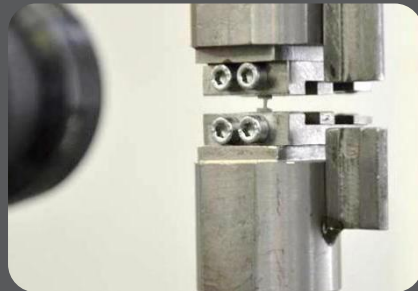


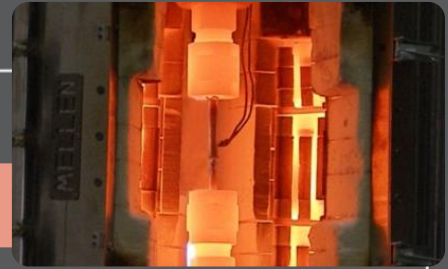


## Mechanical Testing

### Miniature-sample Testing – Micro-tensile Tests

- Sample dimensions comparable to SPT disc
- Deformation measurements using ARAMIS system
- Tensile diagrams identical with standard tests





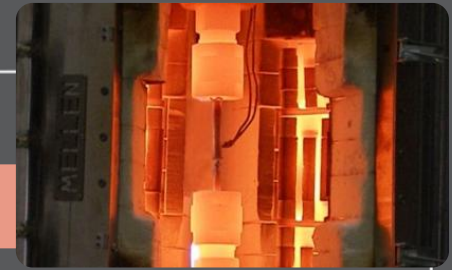
## Mechanical Testing

### Special Device for Sample Extraction

#### Electric Discharge Sampling Equipment

- „Non-destructive“ extraction of samples from devices in use
- Extracted sample is further analyzed
- Mechanical testing (Small Punch test, micro-tensile tests)
- Hardness measurement
- Chemical composition determination
- Microstructure analysis
- Residual life determination



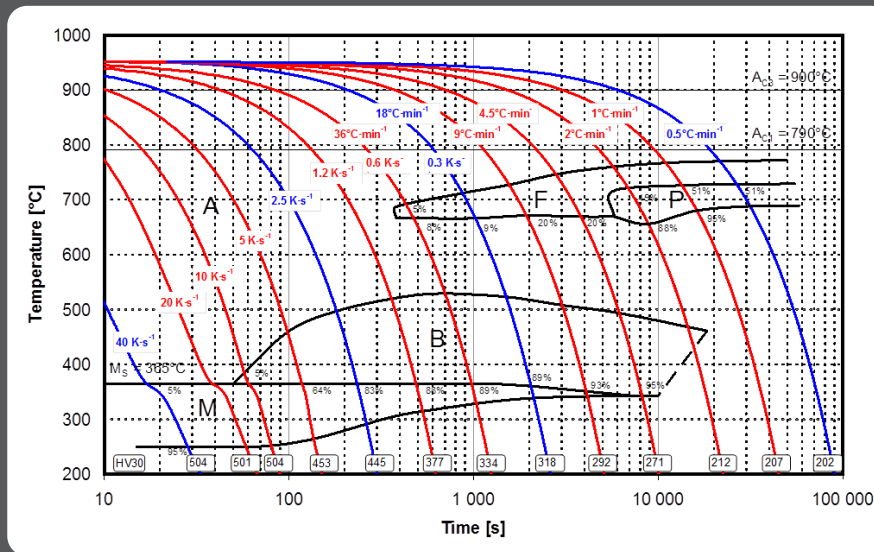
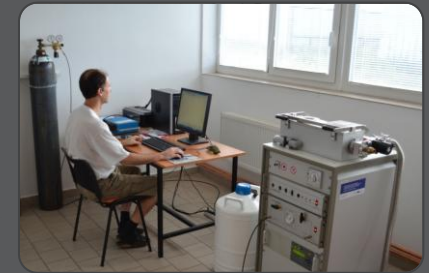


## Thermophysical Measurements

### CCT and TTT diagrams

Hardening dilatometer LINSEIS L78 RITA

- Induction heating – high heating rate (up to 200°C/s)
- Measurements in vacuum and inert gas, vacuum  $10^{-2}$  Pa
- Temperature range from -160 °C to 1 600 °C

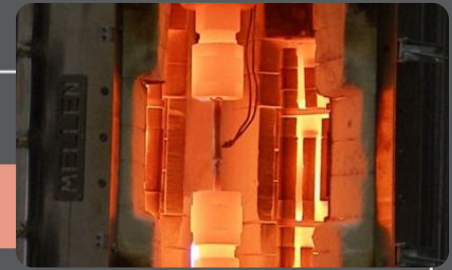


### Further use:

- 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

 processes optimization



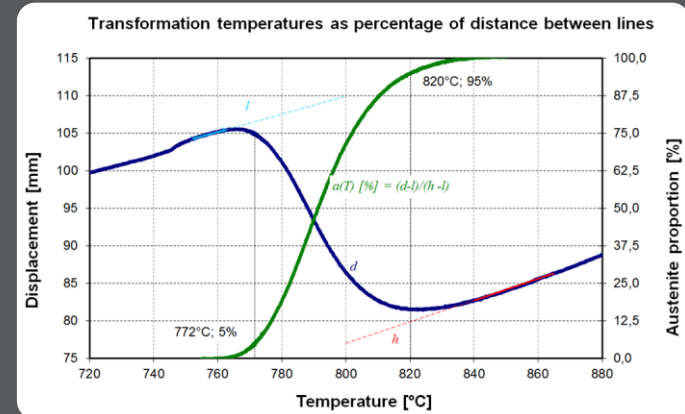
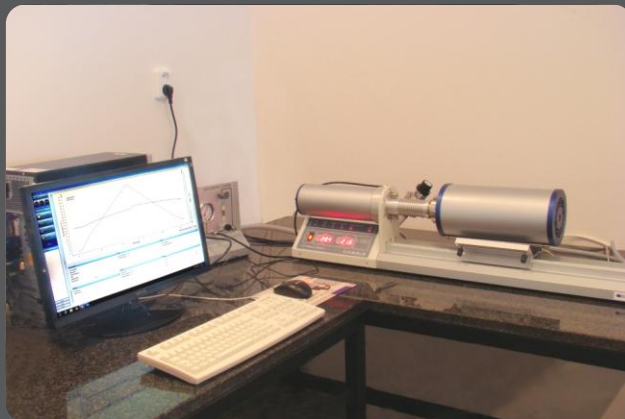


## Thermophysical Measurements

### Determination of temperatures of phase transformations and thermal expansion

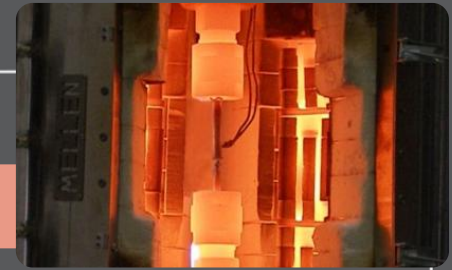
High-temperature dilatometer LINSEIS L75HS1600C PT

- 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  $\mu\text{m}$  to 5000  $\mu\text{m}$
- 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

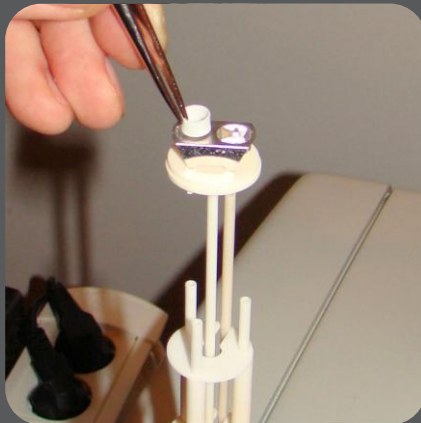


## Thermophysical Measurements

### Calorimetric measurements

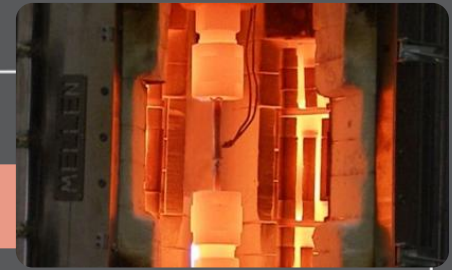
High-temperature calorimeter LINSEIS DSC HDSC PT1600

- Temperature range 25 to 1400 °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.  $\varnothing$  5 mm,
- Resolution 0,3  $\mu$ W.



#### 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



## Thermophysical Measurements

### Thermal diffusivity and thermal conductivity

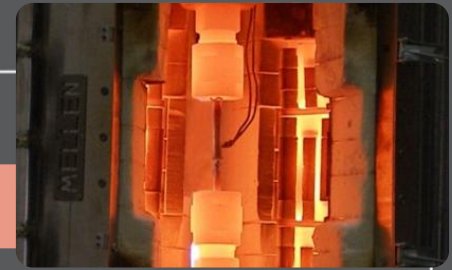
LINSEIS Laser Flash LFA-I 000/1400 °C

- Temperature range from 25 to 1400 °C
- Inert gas, vacuum 10<sup>-2</sup> 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

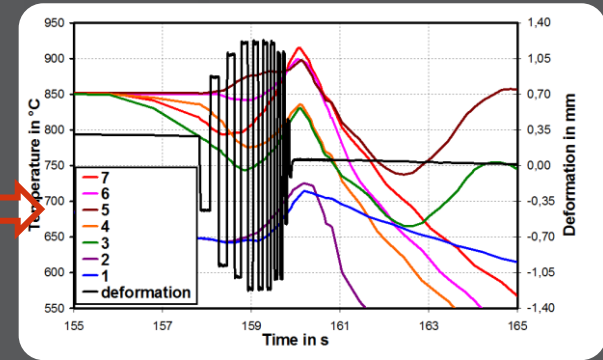
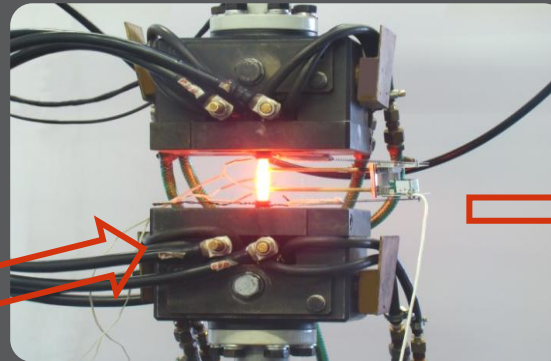
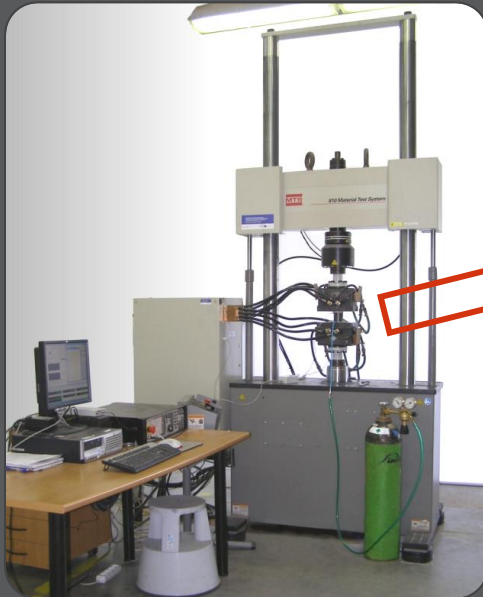


## Thermophysical Measurements

### Simulation of the Forging Process

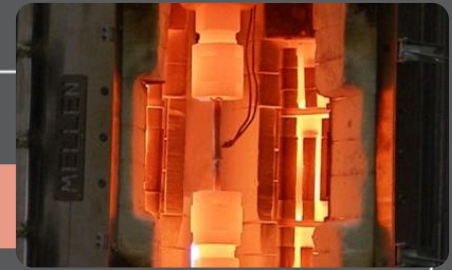
Servo-hydraulic system MTS 810 with resistance heating

- Heating / cooling rate 150 °C/s
- Temperature range - 150°C to 1 400 °C
- Max. cyclic loading 30 Hz
- Max. loading velocity 600 mm/s
- Max. force 250 kN



#### Further use:

- Complex modelling of the forming process
- Choise of temperature and deformation characteristics
- Simulation of forming parameters influence on final microstructure

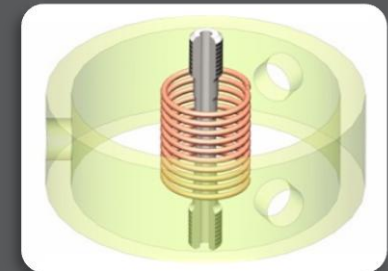
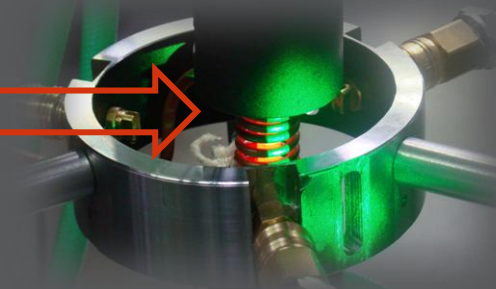
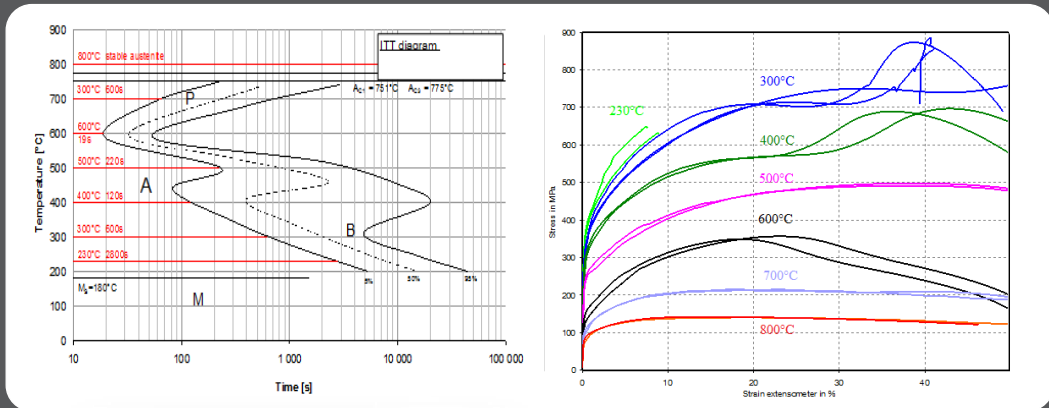


## Thermophysical Measurements

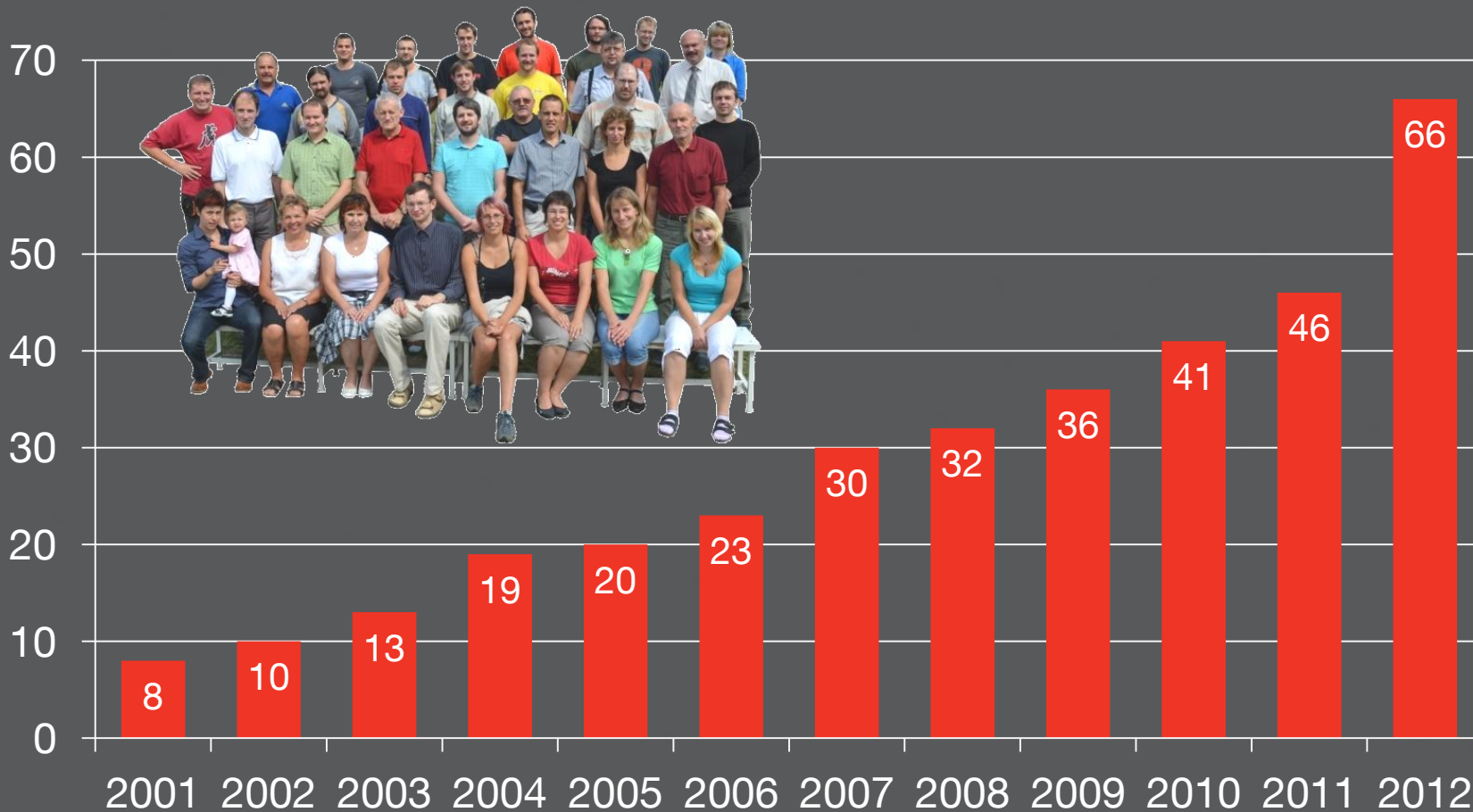
### Customer-based tests

#### Mechanical properties of undercooled austenite

- Electromechanical testing machine Zwick/Roell 250 kN, laser extensometer, induction heating, fast cooling



# Employees

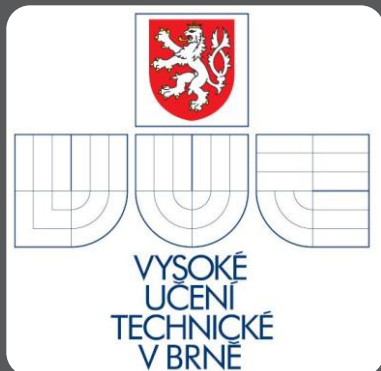
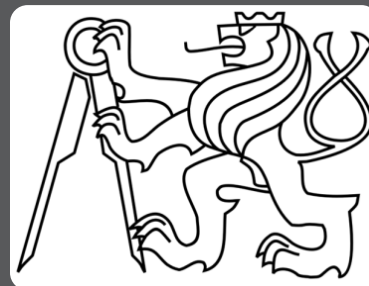


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