Thermo-mechanical Simulation

with a „GLEEBLE 3500“

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Definition, Background

Since 1960 the US-American enterprise **Dynamics System Incorporation (DSI)** has developed and produced thermo-mechanical simulation facilities.

The designation „GLEEBLE“ has not been explained.
The type „3500“ corresponds with the 3rd generation. For each facility type there are several customer-specific completion variants.

The simulator „Gleeble 3500“ at the SLV M-V GmbH connects – to put it simply – high velocity dilatometric investigations with tensile / pressure tests.

It is physically possible to simulate absolutely thermal or thermal combined with mechanical or in particular cases absolutely mechanical processes.

In 1996 Rostock’s facility was planned and produced for physical simulation of beam welding first. In 2010 there was the last upgrade.

Facility

Equipment

GSI SLV Mecklenburg-Vorpommern

Basics

- Test machine for thermo-mechanical investigations
- Control panel with industrial computer
- PC with software for physical simulation and analysis
- Hydraulic pump
- Mechanical system (10 t) for tensile / pressure tests
- Standard clampings for different specimen shapes
- Tactile capture of transverse and longitudinal expansion
- Software controlled physical simulation (QUICKSIM)
- Software controlled data analysis (ORIGIN)

Equipment

GSI SLV Mecklenburg-Vorpommern

Others

- Chiller
- Compressor / pressured air
- Vacuum pump
- High-Flow-Quench-System / hydraulic accumulator
- Spray device for fast cooling
- Thermal couple
- Unit for welding of thermocouples

Technical features

- Heating rate up to 6000 K/s – due to material and specimen shape/ size.
- System for inner cooling of dilatometric specimens.
- Inertialess optical capture of the transverse expansion via optical micrometer.
- Tactile capture of the longitudinal expansion.
- Maximum test force 100 kN.
- Strain rates from 0,01 mm/s to 1000 mm/s.
- Software for determination of suitable specimen shapes and thermal cycles.

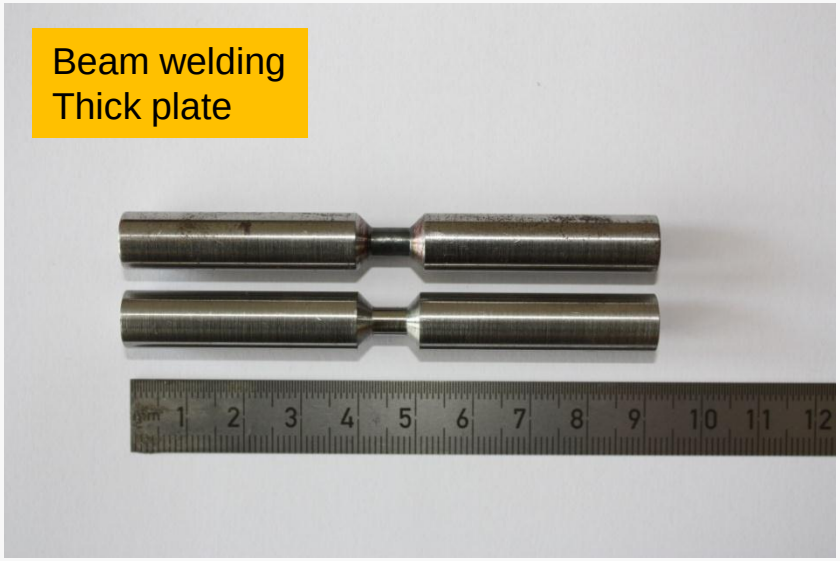
Application possibilities

- Physical simulation of short time cycles, e.g. beam welding.
- Physical simulation of conventional fusion welding processes.
- Welding – ttt - diagrams.
- Continuous cct-diagrams.
- Isothermal cct-diagrams.
- Estimation of weldability.
- Microstructure and properties in the HAZ.
- Determination of microstructure and properties depending on location and temperature.
- Study of diffusion activities.

Application possibilities

- Physical simulation of heat treatments.
- Measurement of the thermal expansion coefficient.
- Hot tensile / hot pressure test.
- Determination of Young‘s Modulus and flow stress.
- Resistance to thermal shock, thermal fatigue.
- Creep tests.
- Low cycle fatigue (const. temperature).
- Test of hot crack susceptibility possible.
- Fusion tests.
- Providing material data for FEM.

Specimen shapes



Conventional welding
Thin plate:

Tensile test specimen - initial state
Initial state
Tensile test specimen after simulation

Physical simulation
Fusion welding

Specimen shapes

Conventional welding
Thick plate

Impact specimen

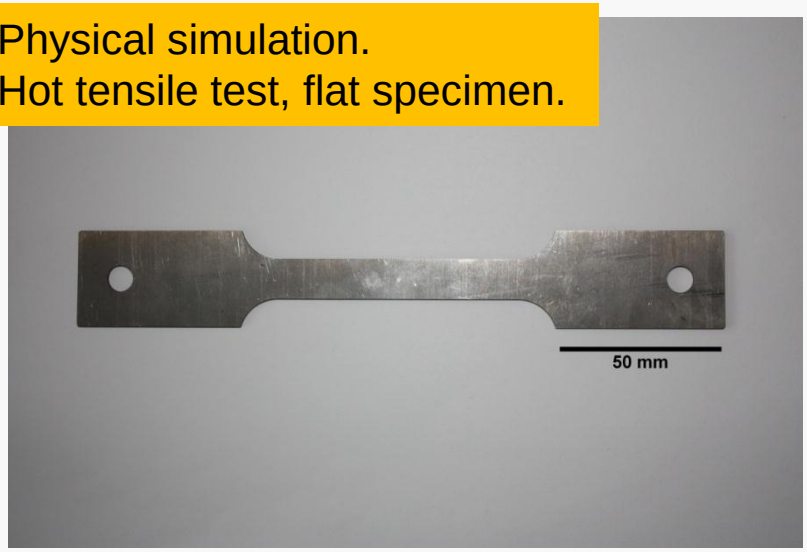
Beam welding
Thick plate

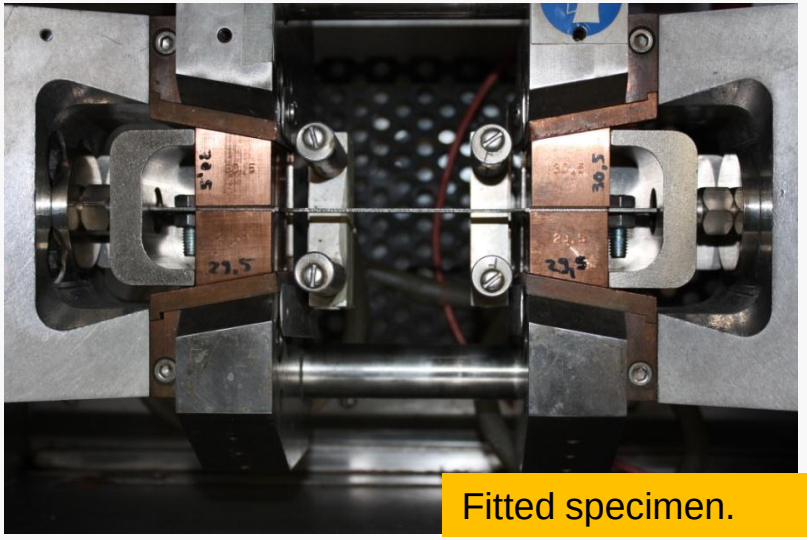
Impact specimens
Special size

Physical simulation
Fusion welding

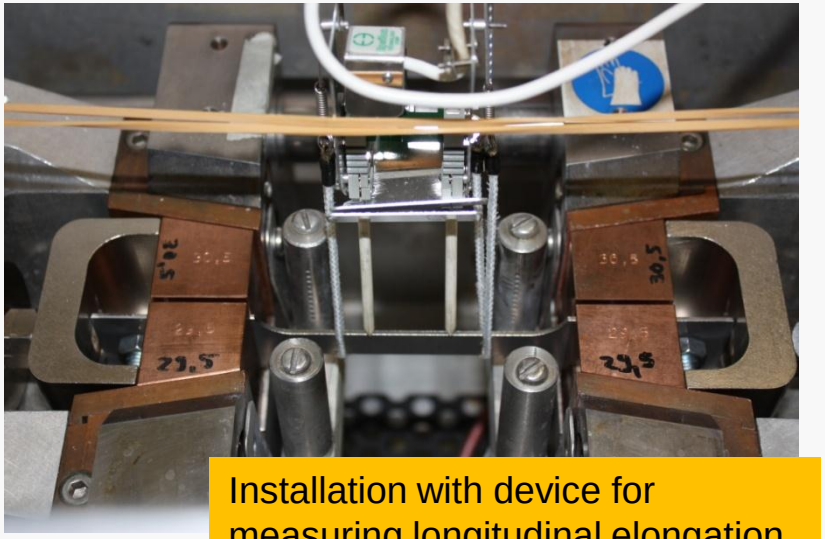
Specimen shapes

Physical simulation.
Hot tensile test, flat specimen.

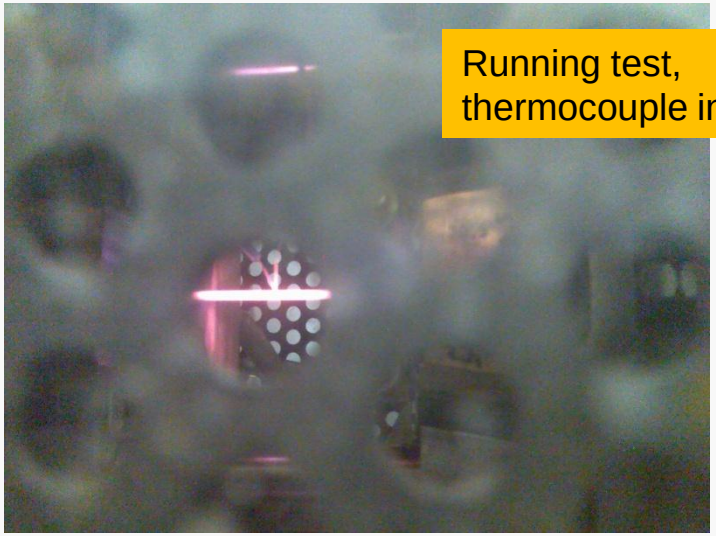




Fitted specimen.



Installation with device for measuring longitudinal elongation.



Running test, thermocouple in centre.

Specimen shapes

Physical simulation.
Hot tensile test, round specimen.

Left side, below:
Specimen in centre reduced in diameter.

Physical simulation.
Hot pressure test, round specimen.

Proved materials

Rolled steel:

- Steel, unalloyed
- Steel, low alloyed
- Duplex steel
- Fine grain steel

  (355 - 1100 N/mm² yield strength)
- Laser steel
- Pipe steel
- Steel, austenitic
- Steel, ferritic
- Steel, air-hardening

Ferrous cast materials:

- Cast steel, unalloyed
- Cast steel, low alloyed
- Gray cast iron

NF – metals and alloys:

- Aluminium
- Al - alloys
- Titanium
- Ti - alloys

Our experiences

GSI SLV Mecklenburg-Vorpommern

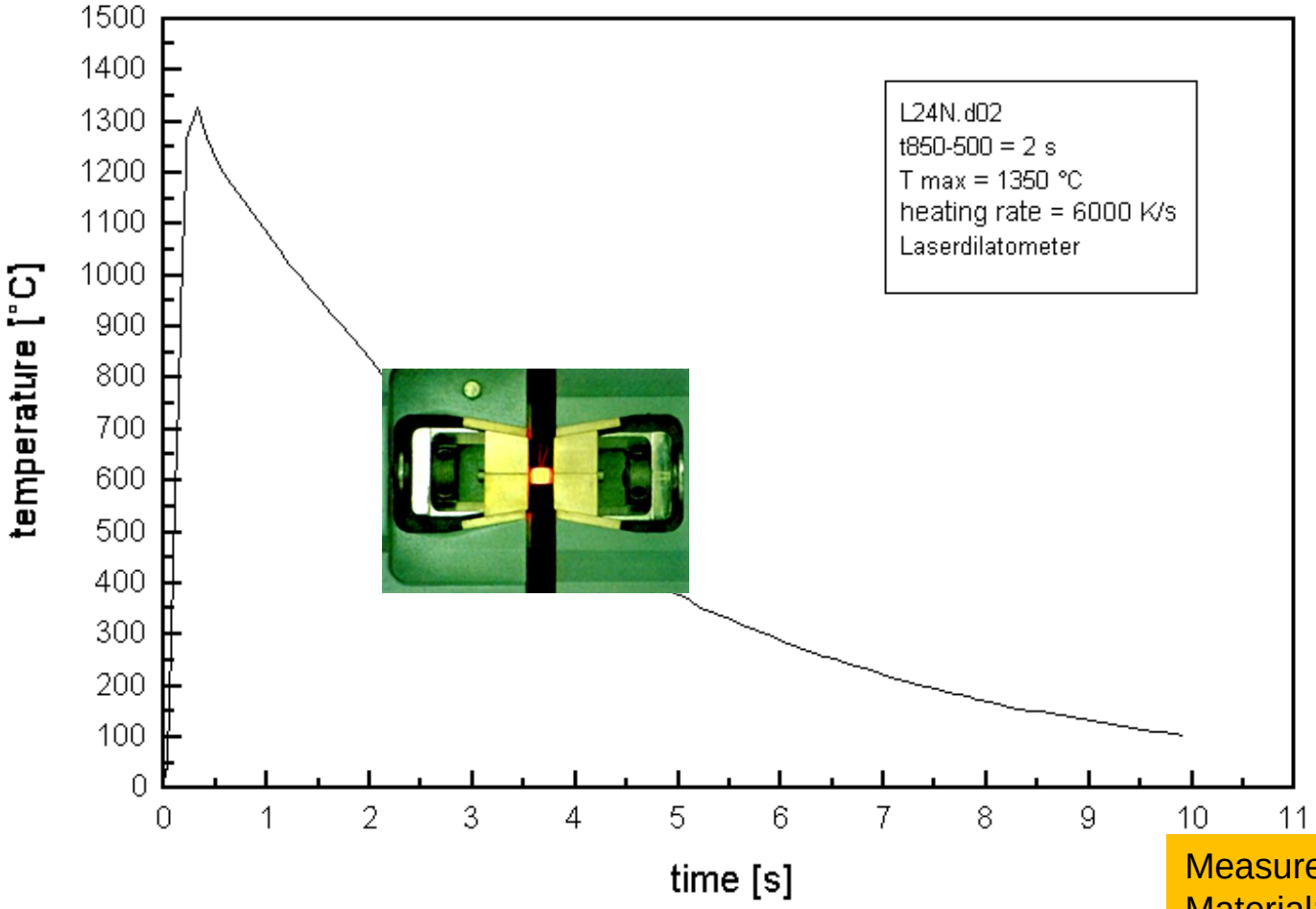
- Development of welding – ttt – diagrams
- Estimation of the weldability
- Determination of the linear thermal expansion coefficient
- Determination of the microstructure
- Diagrams of mechanical properties in the HAZ of welds
- Evaluation of material characteristics depending on temperature
- Conventional cct - diagrams
- Physical simulation of laser beam / electron beam welding

Our experiences

- Simulation of heat treatments
- Thermo-mechanical simulation of material properties for FEM
- Tests due to resistance of thermal shock
- Hot tensile tests
- Determination of flow stress and Young’s modulus
- Special investigations

Samples

Physical simulation.
Laser beam welding.

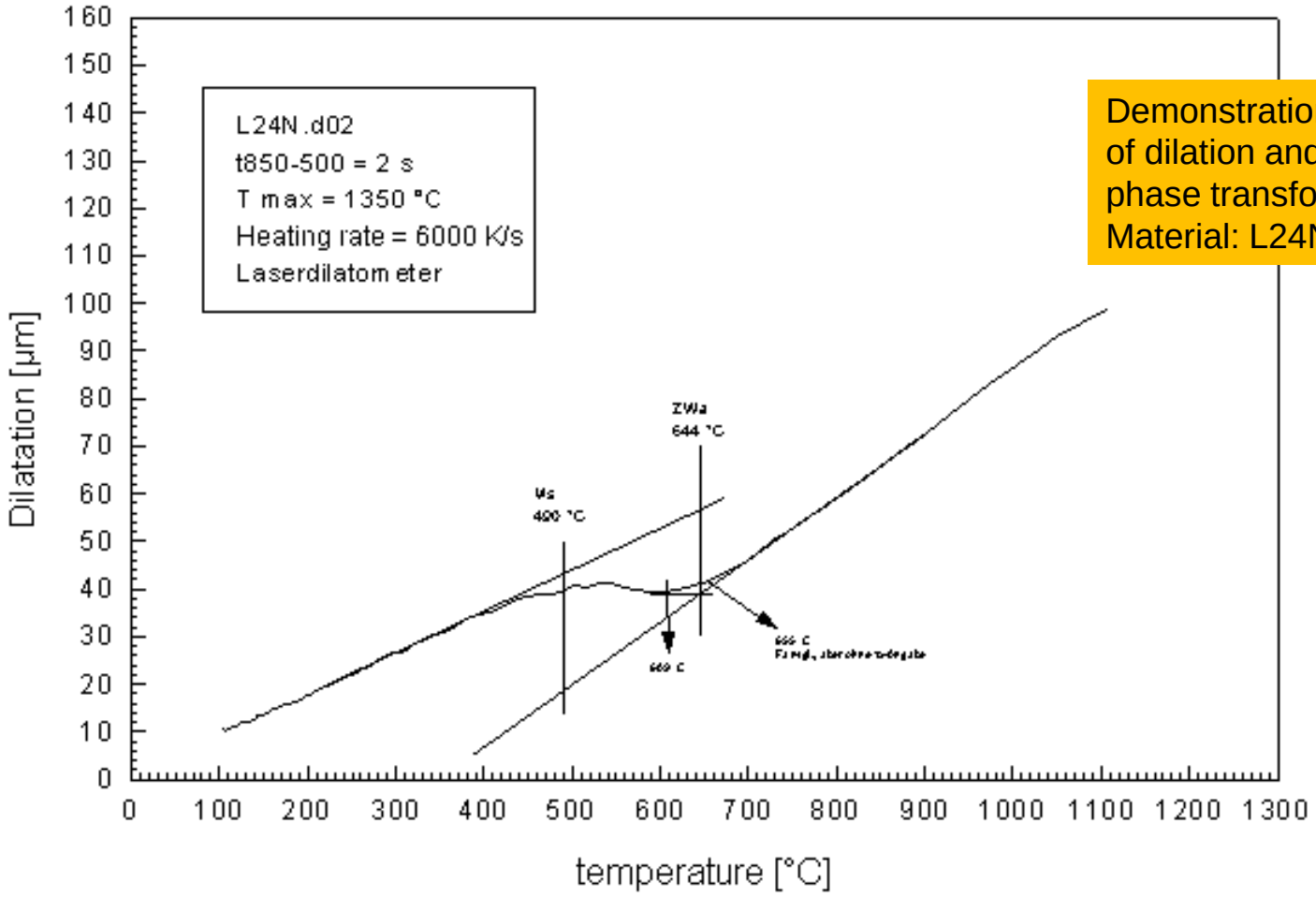


Measured T-t-Cycle.
Material: laser steel L24N.

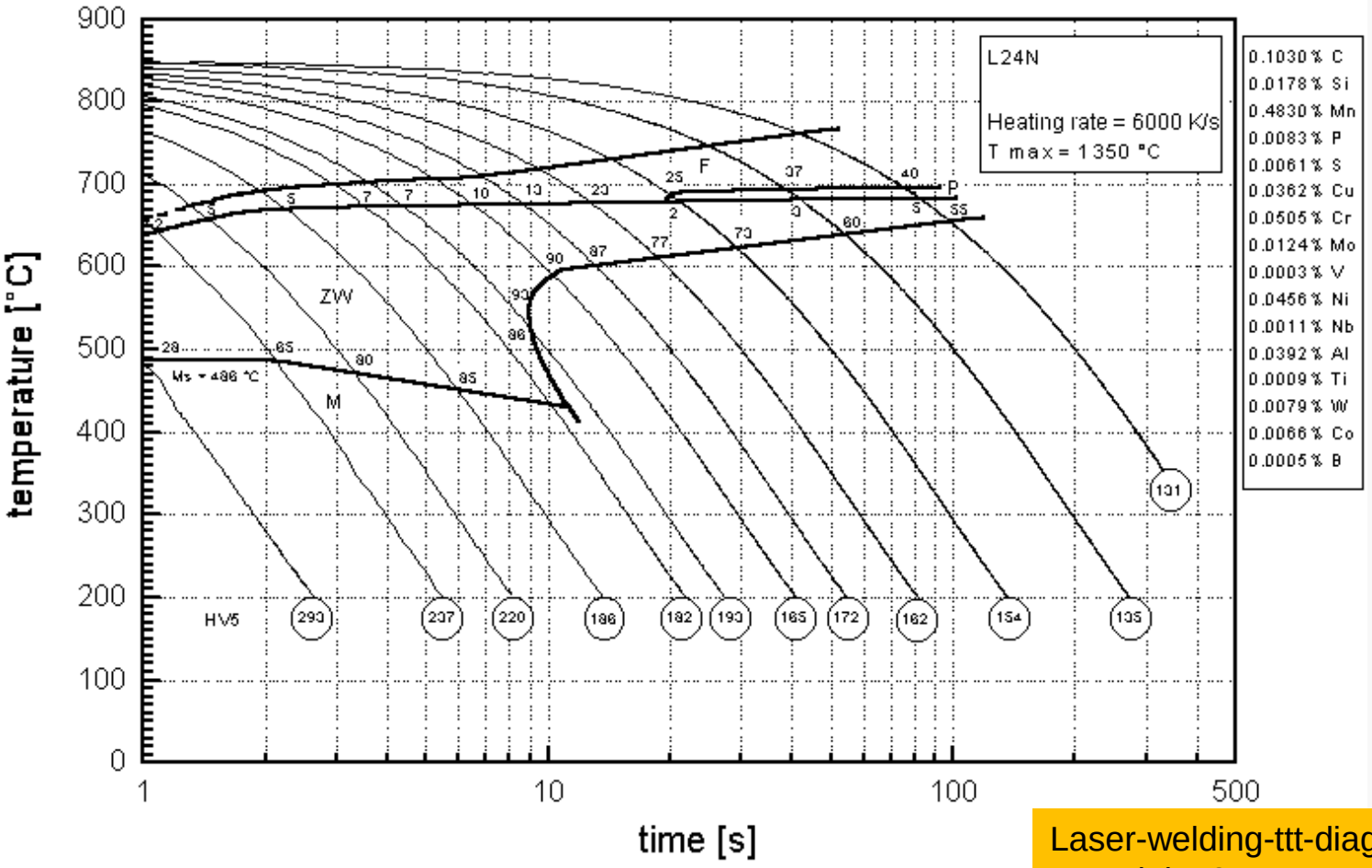
Sample

Physical simulation.
Laser beam welding.

Demonstration and analysis of dilation and phase transformation.
Material: L24N.



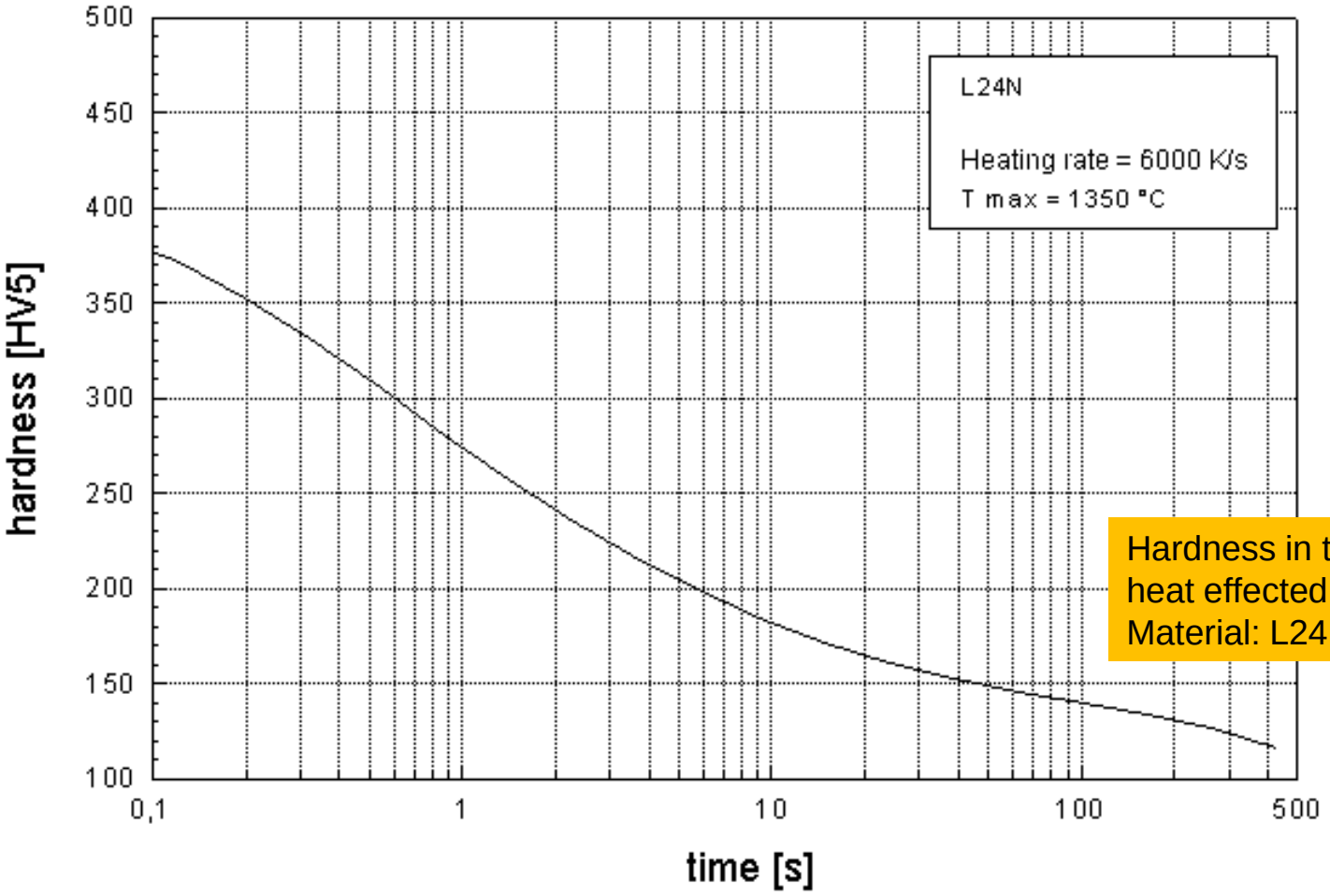
Physical simulation.
Laser beam welding.



Laser-welding-ttt-diagram.
Material: L24N.

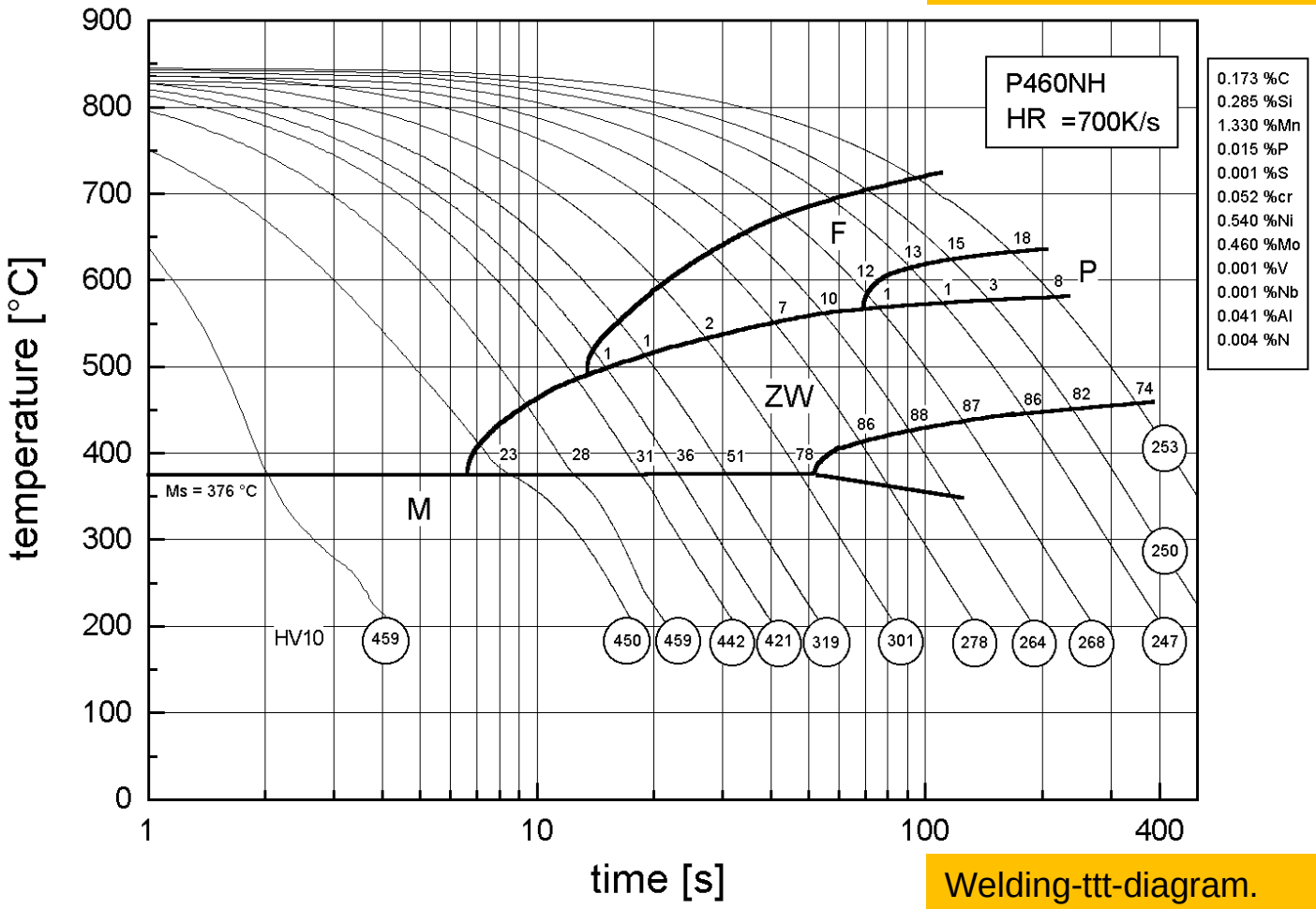
Sample

Physical simulation.
Laser beam welding.



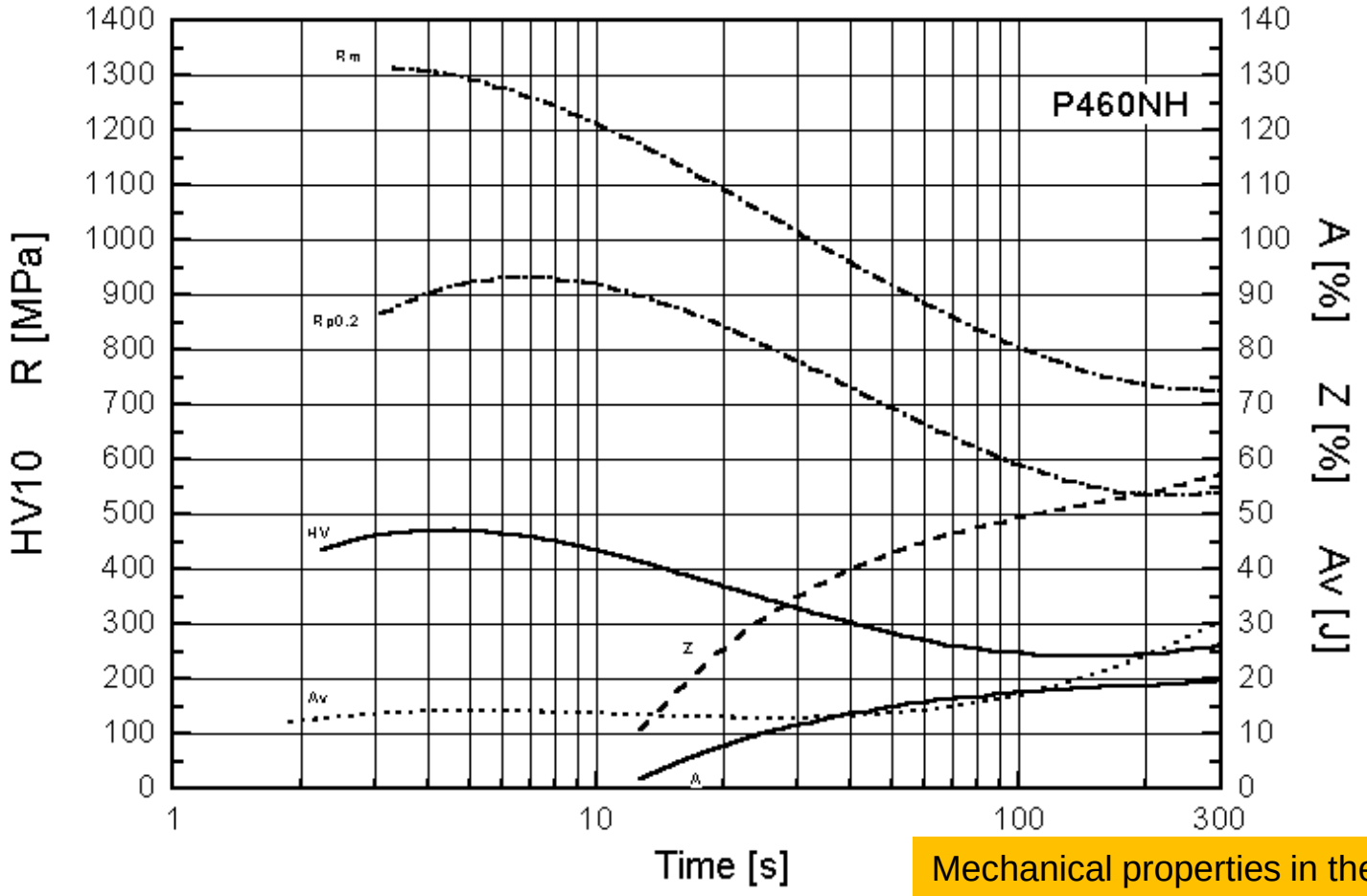
Hardness in the
heat effected zone.
Material: L24N.

Physical simulation.
Conventional fusion welding.



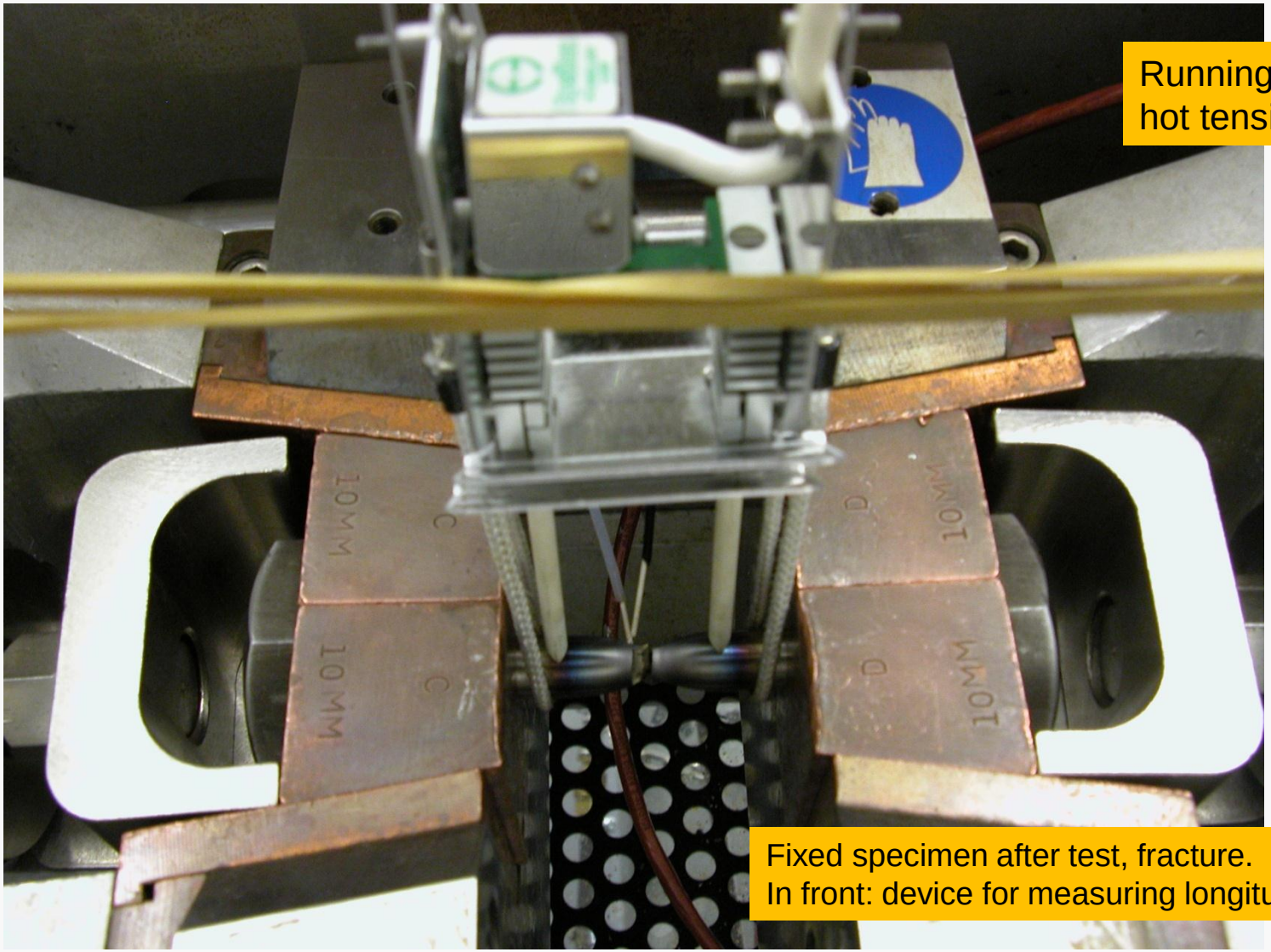
Welding-ttt-diagram.
Material: fine grain steel P460NH.

Physical simulation.
Conventional fusion welding.



Mechanical properties in the HAZ.
Material: fine grain steel P460NH.

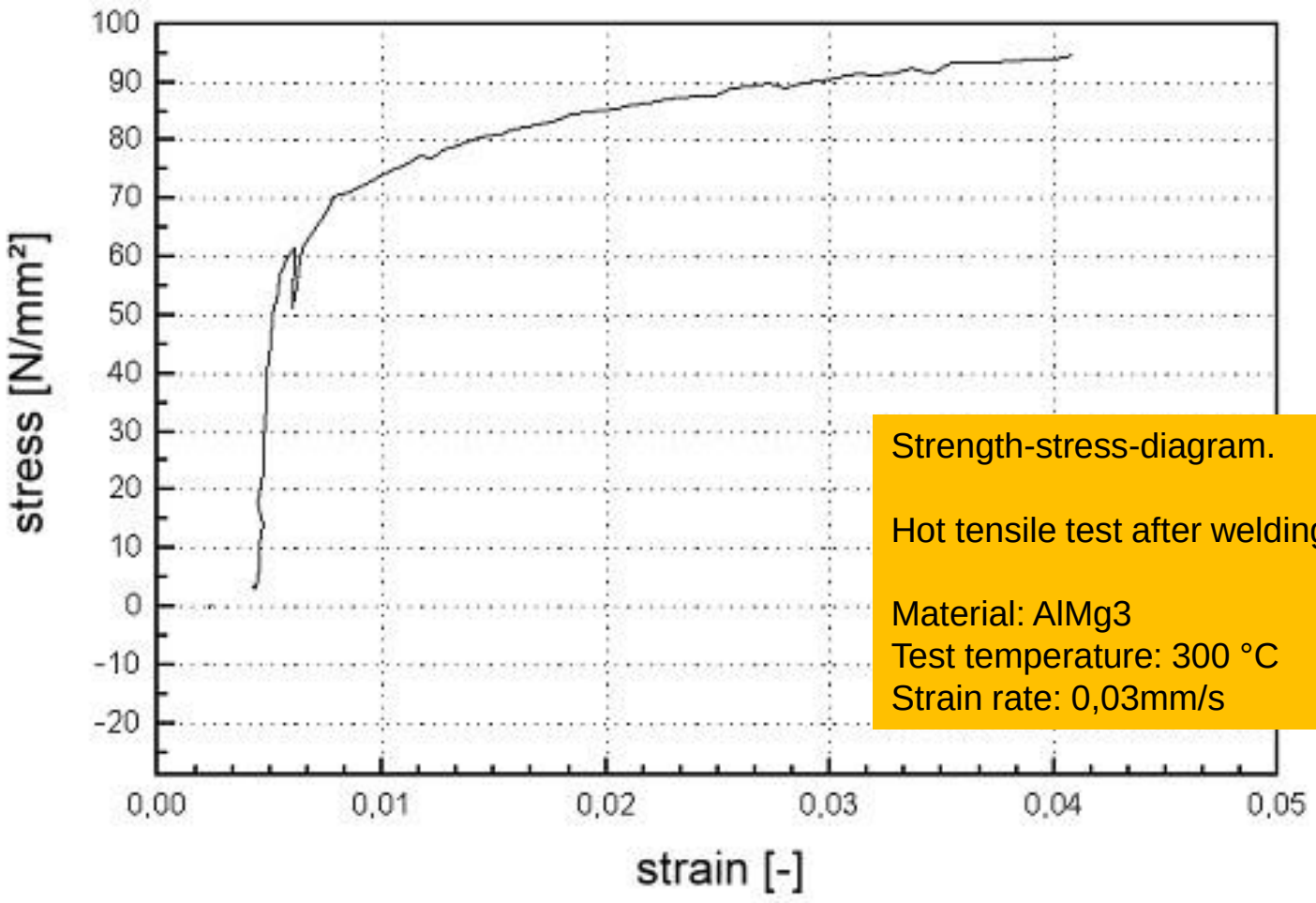
Sample



Running of
hot tensile tests.

Fixed specimen after test, fracture.
In front: device for measuring longitudinal elongation.

Execution of
hot tensile test

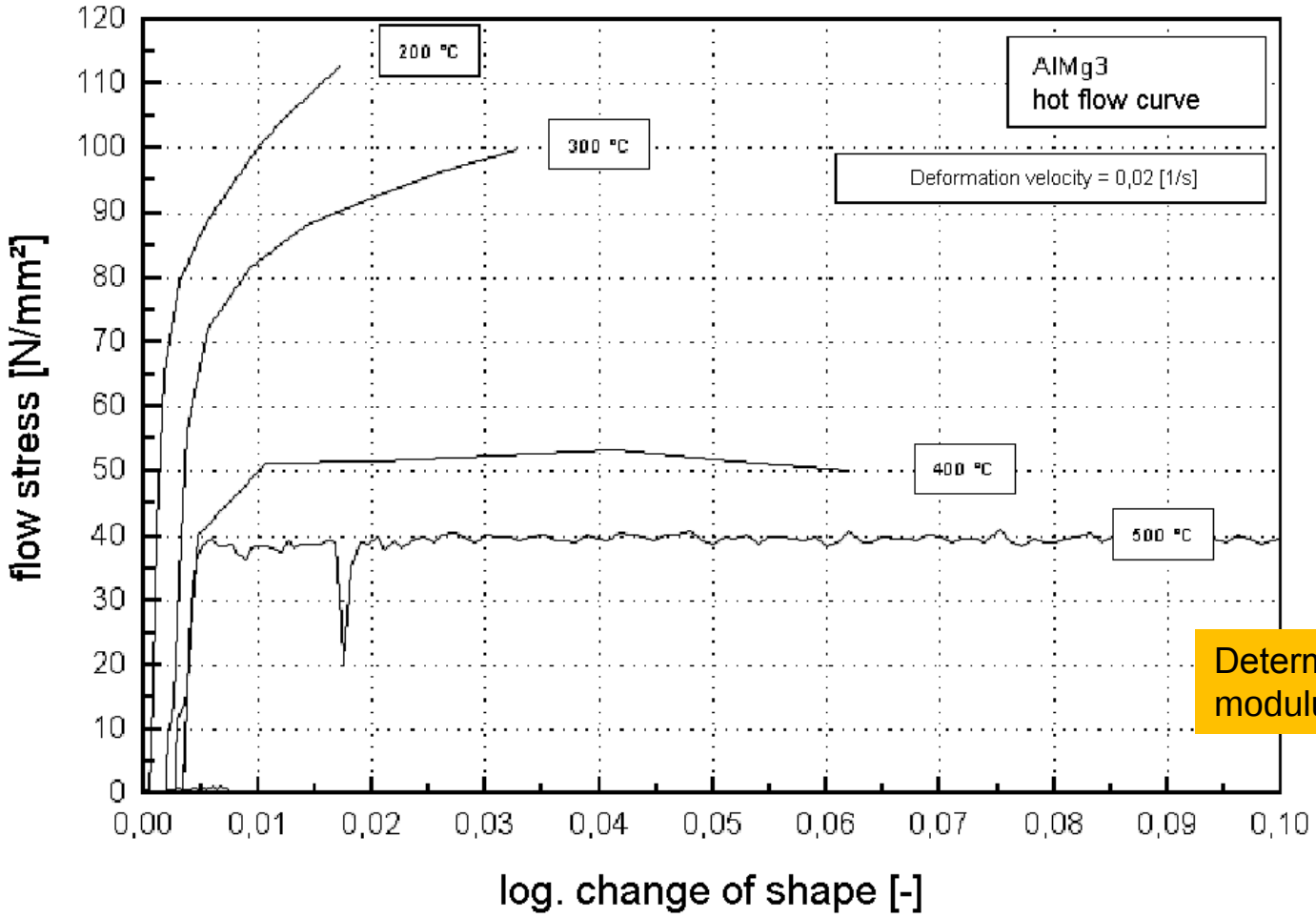


Strength-stress-diagram.

Hot tensile test after welding cycle.

Material: AlMg3
Test temperature: 300 °C
Strain rate: 0,03mm/s

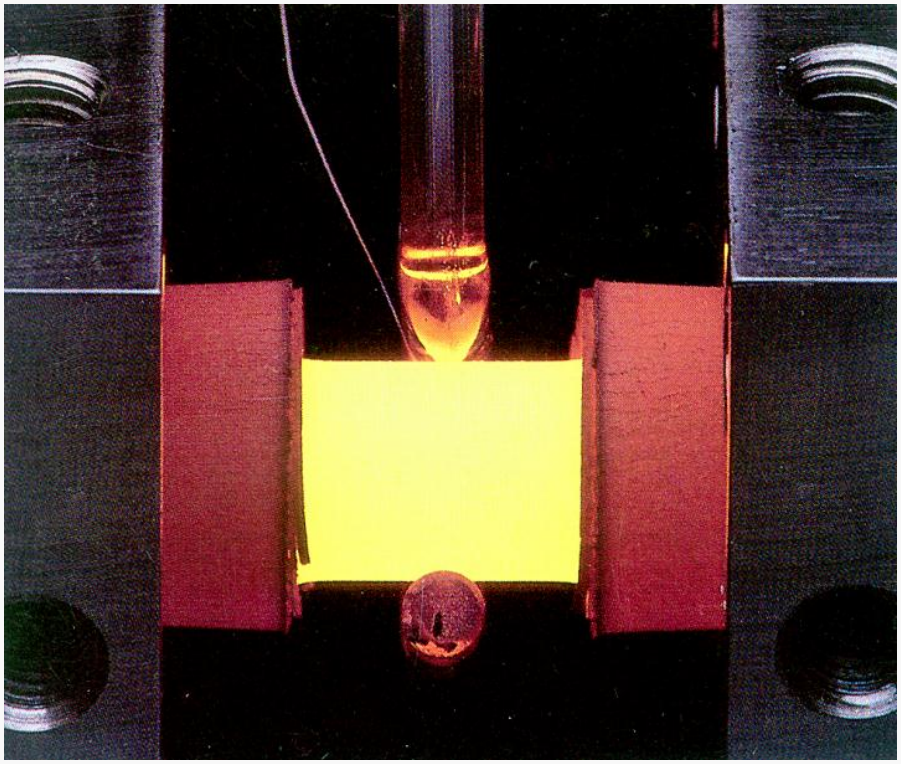
Sample



Execution of
hot tensile test

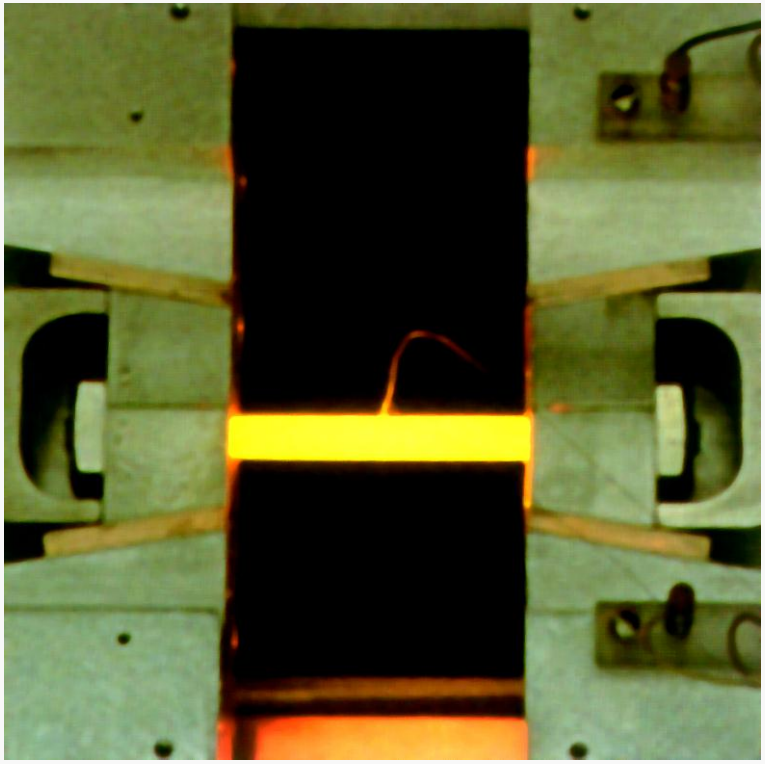
Determination of Young's
modulus and flow stress.

Sample



Gleeble 3500 during hot pressure test.

Quartz pins for grabbing changes in volume at a heated specimen.

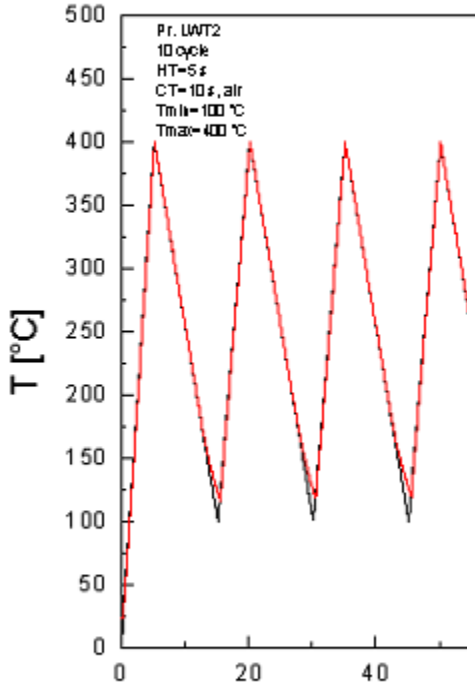


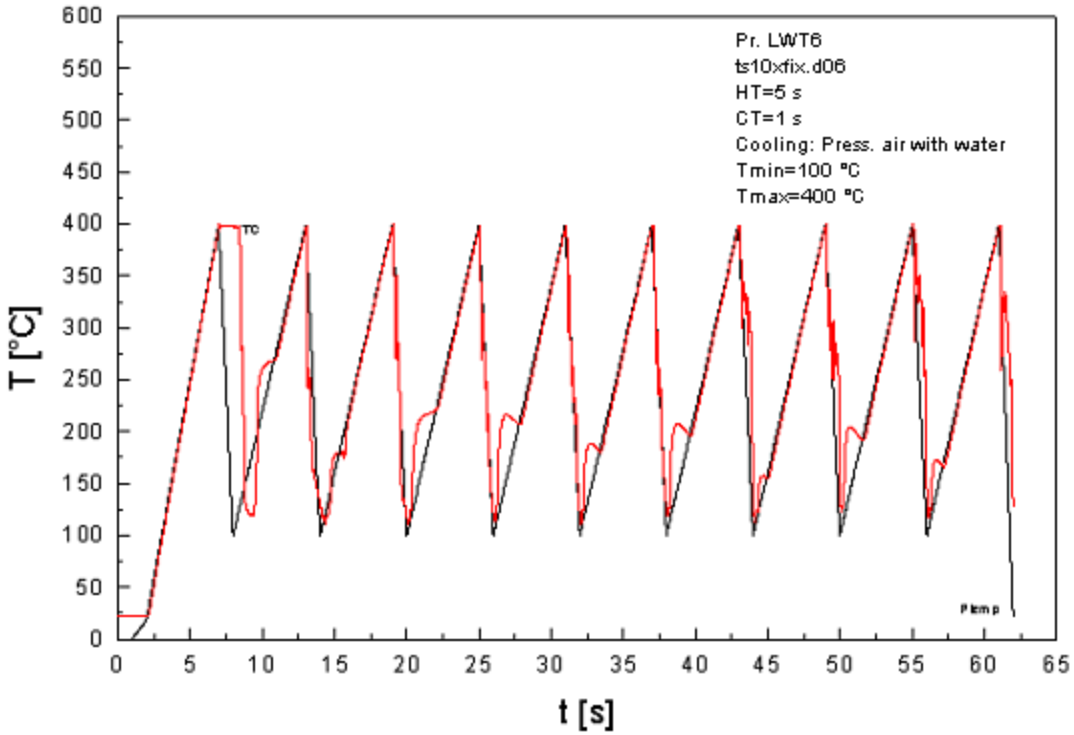
Hot tensile test.

Heated specimen with thermocouple to control the specified thermal cycle.

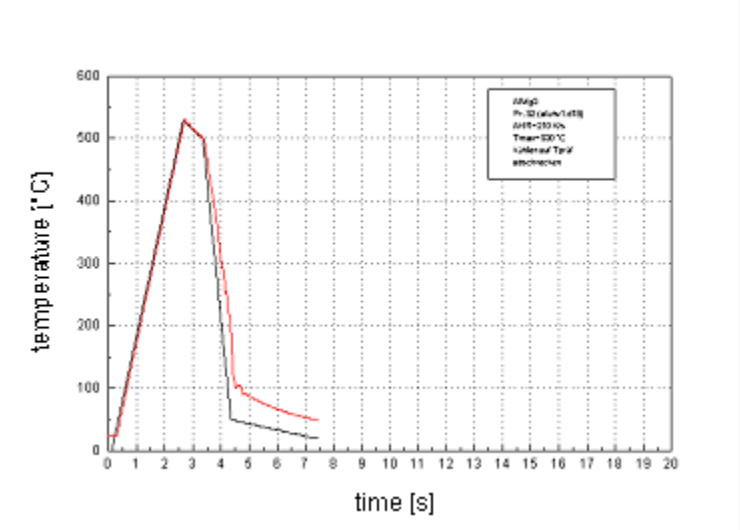
Sample

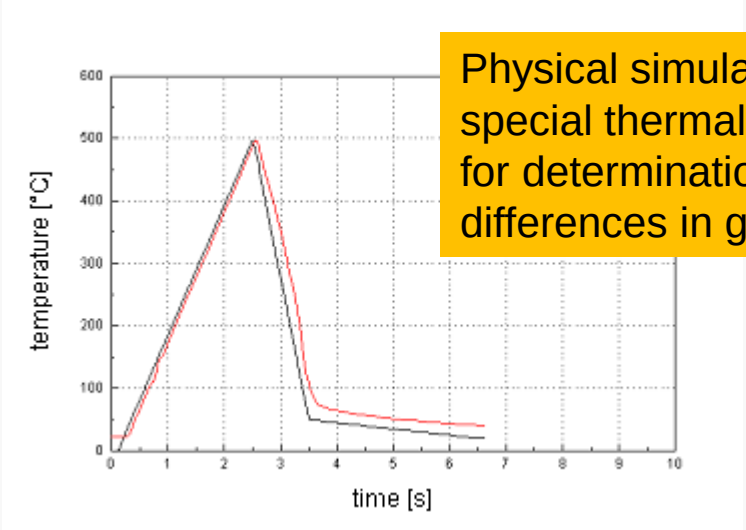
Testing the resistance to thermal shock at coated specimens.



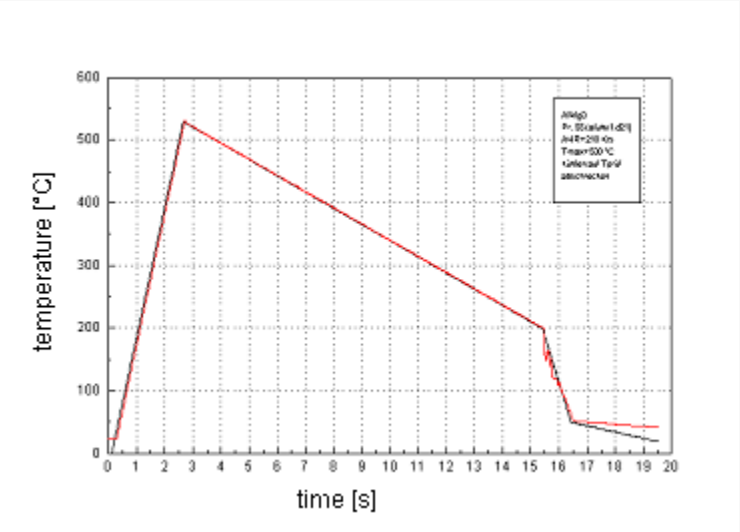


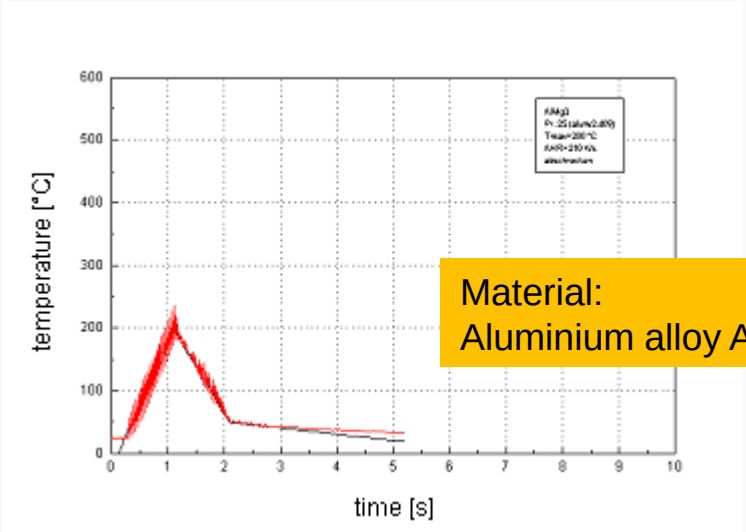
Sample





Physical simulation of special thermal cycles for determination of differences in grain size.





Material:
Aluminium alloy AlMg3

Our Customers

GSI SLV Mecklenburg-Vorpommern

- BAM Bundesanstalt für Materialprüfung, Berlin, D
- Benteler Automobiltechnik GmbH, Paderborn, D
- Benteler Tube Management GmbH, Paderborn, D
- Eberspächer GmbH, Esslingen, D
- GMS Gesellschaft für metallurgische Systeme mbH, Bernau, D
- IBOK a.s., Bratislava, SK
- Industry Research Centre Arcelor Innovation - R&D, OCAS N.V., Zelzate, B
- Ing.-Büro Tobias Loose, Wössingen, D
- Ing.-Gemeinschaft Meyer & Horn-Samodelkin GbR, Rostock, D
- RWTH Aachen, ISF Inst. für Schweißtechnik und Fügetechnik, Aachen, D
- Leibnitz Universität Hannover, Inst. für Werkstoffkunde, Garbsen, D
- Leibnitz Universität Hannover, LS Werkstofftechnik, Hannover, D
- Liebherr MCCtec, Rostock, D

Our Customers

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- MET Motoren- und Energietechnik GmbH, Rostock, D
- Nordtest GmbH, Rostock, D
- Robert Bosch GmbH, Stuttgart, D
- Rautaruukki Oyj, Ruukki Metals, Raahe, FIN
- Salzgitter Mannesmann Forschung GmbH, Mühlheim an der Ruhr, D
- SLV Halle GmbH, Halle, D
- SLV Hannover GmbH, Hannover, D
- TU Carolo Wilhelmina zu Braunschweig, Fak. für Masch.-bau, Braunschweig, D
- TU Duisburg-Essen, Fak. für Ingenieurwissenschaften, Essen, D
- Universität Rostock, LS Fertigungstechnik/Schweißtechnik, Rostock, D
- Universität Stuttgart, Inst. für Konstruktion und Entwurf, Stuttgart, D
- V & M DEUTSCHLAND GmbH, Düsseldorf, D
- Ventilatorenfabrik Oelde GmbH, Oelde, D

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