SERVOTEST

Thermo-Mechanical Treatment Simulator Equipment (TMTS)

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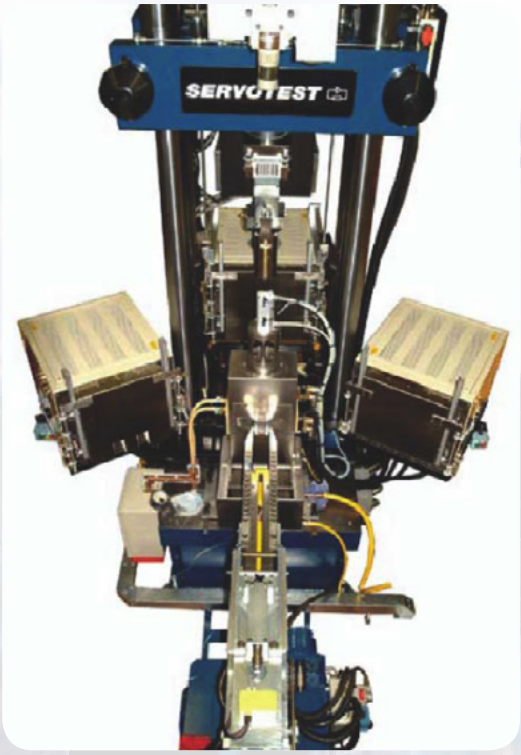
Servotest Metallurgy Testing

The World of Thermo-Mechanical Treatment

The Thermo-Mechanical Treatment Simulator (TMTS) was developed by Servotest in conjunction with Hoogovens R & D, in order to meet all foreseeable needs of the Metallurgy testing industry in investigating the effects of thermal and deformation processes on the final properties of a given material.
TMTS is capable of simulating industrial thermo-mechanical processing steps (Single and multi-pass), integrating complex annealing procedures into the test procedures, and specimen analyses with (for instance) the Stress Relaxation or the Creep facility. The control system allows the user to predefine an individual test sequence of up to 99 process steps (segments), including 31 deformation steps, for each of the 4 samples which may be tested in a given sequence. International service is reliably supplied through a series of satellite offices and partner organisations. Spare parts are stored and available locally to avoid long lead times for repairs and upgrades. Turnkey facilities including planning, updating, installation and maintenance are available and can be individually designed to suit specific needs.



A world of experience…

Servotest is a World Class Test and Motion Simulation Company, with experience of operating around the globe, for multi national corporations and smaller specialist companies and Government Departments.
Since the 1950's our engineers and equipment has been at the forefront of our industry. Product and Service quality is maintained by a program of continuous training and development of our people and equipment.
We operate in all of the key industry sectors for our market place, including Automotive, Marine, Civil Engineering, Aviation, Defence, Aerospace and Traction. The company holds both ISO14001 and 9001 Quality accreditation marks and is a member of many national & international trade organisations.

Thermo-Mechanical Treatment Simulator Equipment (TMTS)

Discovery of new metal composites, material optimisation, and the need for modern simulation aids has driven the development of Thermo Mechanical Treatment Simulators. Over the past three decades Servotest Systems have accumulated considerable experience in the design, manufacture and installation of Metal Forging Test Machines.

Models

This lead to the expansion of TMTS product line to investigate the effects of thermal and deformation processes, on the final properties of a given material. This lead to the development of two Metal Forging Test machine categories:

1. Thixoforming.
2. Thermo Mechanical Treatment Simulators (TMTS) – (Research into Hot Rolling Processes).

The latter splits into 2 further testing modes:

2.1 Axisymmetric.

2.2 Plane Strain.

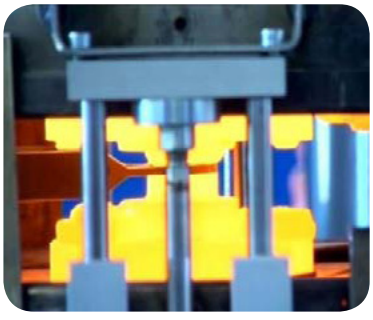
Test Operation

1. Furnace segments – terminate on time or sample temperature as specified.
2. Deformation segments – the form of the deformations may be chosen from the following:
   - Constant True Strain Rate at 0.001 to 100/s (for 12mm sample height to specified final strain.
   - User Specified Strain rate/Strain Profile from ASCII file.
   - Each of the above deformations may be followed by either Stress Relaxation (constant height) or Constant True Stress (creep) segments up to 100 Hrs, with bumpless transfer to stress control in the second case.
   - Zener Hollomon i.e. Constant temperature compensated strain rate using sample temperature either as measured or from a real time model.
3. FTTU segments – Linear or Exponential Heating and Cooling using closed loop control of the induction heating and forced air/mist cooling from a thermocouple in the sample.

During the test sequence data is collected by two datalogging systems within PULSAR.

High Speed Logger collects the Sample Load, Height, Velocity, and Temperature from individual transducers at up to 20kHz, i.e. 80k values/s, during the deformation and at exponentially reducing rate during Stress Relaxation or Creep segments. Sample height and velocity are compensated to remove the effects of the machine frame compliance. Low Speed Logger collects the Sample Temperature and up to 15 other user selectable parameters at rates up to 100Hz during the entire test sequence.

Data is written to disc as the test proceeds, later the two files are processed into one ASCII file. From this file the mechanical and thermal history of the specimen can be read and displayed.



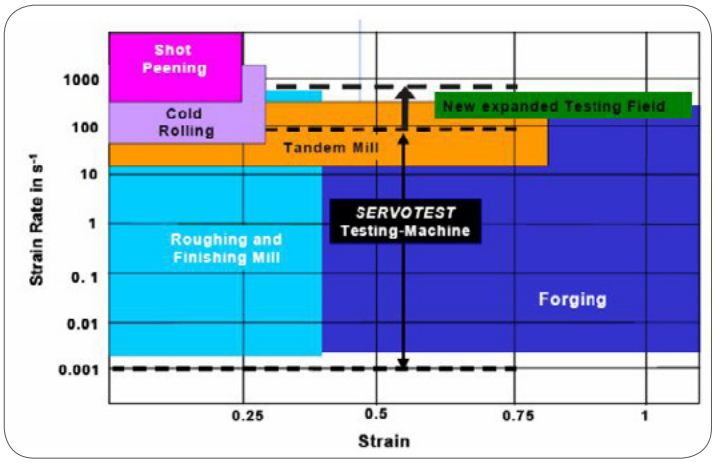
Testing Modes

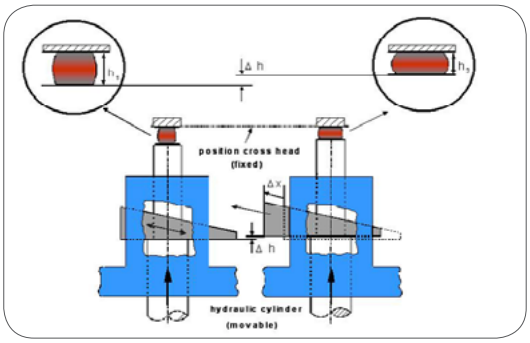
- Single / Multiple deformations
- Constant strain rate, profiles, constant Z
- Stress Relaxation tests
- Creep testing
- Thermal treatments before and after the deformation(s)

Deformation tests capabilities include the following:

1. Uni-axial compression – single and multi stage compression test used for flow-curve determination.
2. Plane strain compression test up to a predefined strain with constant strain rate – can be automated.
3. Stress relaxation test, the decrease in material stress is recorded with a constant temperature over time for constant sample height.
4. Creep testing consists of isothermal deformation under constant true stress – sample height over time is recorded.
5. Multi stage – user is able to simulate microstructure changes/developments and flow stress at a certain position in the workpiece – samples can be analysed metallographically for validation of FE microstructure simulation.

Multistage compression tests allow simulation of stress and microstructure development during complex multi-step forming process. 99 Successive treatment sequences (forming, holding time, hot treatment) are achievable with SERVOTEST TMTS, as shown in Strain rate Vs Strain graph below.

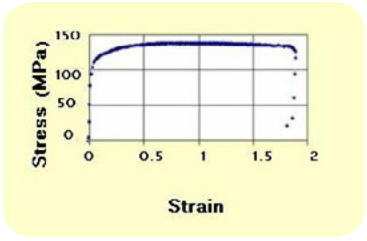




Post Testing

During the test the following parameters are measured and stored to file:

- Force
- Displacement
- Velocity
- Temperature
- Time



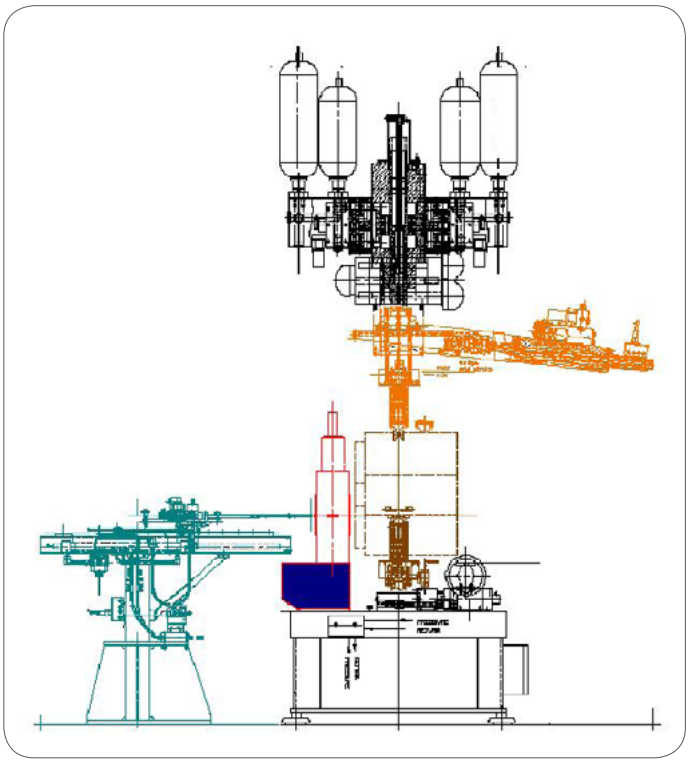
These results provide stress, strain, strain rate data. The modeling data for hot rolling can then be readily obtained correcting for friction effects and lateral spread and this data can be stored in a data base.

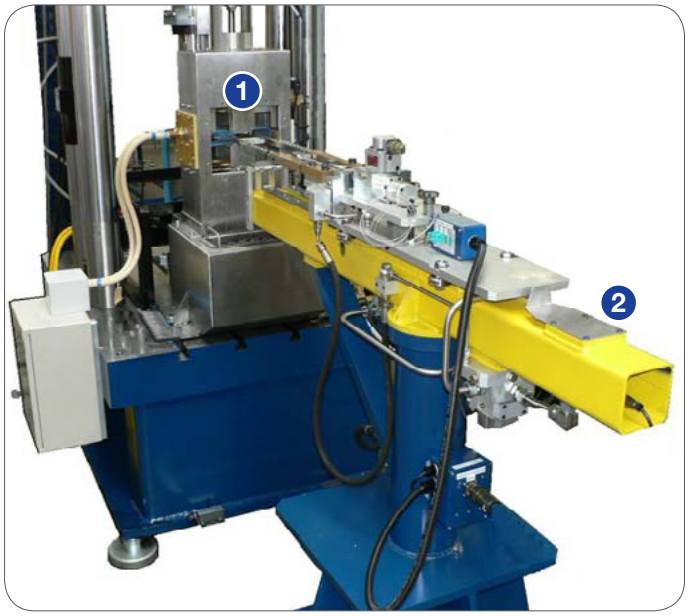
The results can be utilized to adjust the forming/ rolling process to obtain the most desirable reduction schedule. Both from a rolling mill point of view and with regards to the microstructure (i.e. grain size and physical properties).

Alternatives to TMTS (e.g. laboratory rolling) do not offer the possibility to control the process parameters (e.g. Temperature, strain (rate), inter-stand time) to this accuracy. Also TMTS provides the possibility to change all these parameters independently, enabling a much wider scope for research.

TMTS Architecture

- Preheat Furnace - which can heat up to 4 samples to a maximum of 1200°C.
- Hydrostatic Bearing Wedge Actuator – to provide the deformation profiles at up to 1m/s.
- Fast Thermal Treatment Unit (FTTU) – with induction heating and forced air/mist and water cooling to simulate inter-stand temperature profiles.
- Test Furnace – to provide the environmental temperature during deformations.
- Annealing Furnace – for post test heat treatment of the 4 samples up to 750°C.
- Manipulator (Robot) – to transfer the samples between the process stations above.
- Quench Tank – when required the Manipulator will drop the sample into the tank.
- Digital Control System (PULSAR) – which programs and controls the whole TMTS.
- Hydraulic Power Supply – to power the Test Machine and Manipulator.
- Compressed Air Supply – for FTTU.





1. Fast Thermal Treatment Unit (FTTU)

- Induction Furnace system 20 KW
- Maximum temperature 1300C
- Phase (PLL) transistorised Induction Heater
- IR Standard work head
- Water/air injection manifolds
- Inductance coil to suit Plane Strain Specimens and uniaxial (cylindrical) Specimens or two if necessary.

2. Manipulator

Servocontrolled hydraulic operation, linear and rotary positioning for rapid sample movement between process stations, especially between test deformation positions, FTTU, and quench position. Linear travel range 550 mm.
Consisting of:

- Robot arm
- Hydraulic manifold
- Slide and slide ram
- LVDT (Temposonics)
- Clamp actuator
- Directional control valves

TMTS Architecture (cont.)

1.System Accumulators

Pressure (20LT) and Return (20LT) Accumulator 2”SAE-6000 PORT. To achieve located Maximum Velocity 1.5 m/s (no load), 1.0 m/s (full load).

2. Main Actuator

The main actuator, which produces the deformation profile, is provided with an adjustable mechanical stop such that deformations at high strain rates can be terminated within a fraction of a mm to ensure that the quenched microstructure is the same as during the deformation.

This uses a wedge mechanism moved by a second actuator to correspond with the final sample height, a system proved on Servotest machines for over 20 years.

- Dynamic force rated to 500 kN (280 bar)
- Working stroke 100 mm

3. Manifold and Servovalves

Manifold to provide mounting for up to 4 servovalves. To optimise the control at low deformation velocities the main actuator is fitted with two servovalves. 38L/m Servovalve is used for velocities up to 25 mm/sec, above this velocity a larger (1200L/m) three stage servovalve is selected automatically to provide the full system performance. When not in use the larger valve is hydraulically isolated from the actuator.

4. Wedge Actuator Assembly

Hydrostatic bearing actuator:

- Dynamic force rated to 50 kN
- Working stroke 200 mm

All Servotest actuators are fitted with:

- Coaxially mounted LVDT
- Hydrostatic bearing

Wedge Assy, suitable for main ram velocities up to 3 m/sec.

Providing a stopping height adjustment range of 25 mm Height adjustment speed 50 mm/second.

5. Compressed Air Supply – for FTTU

Compressed air at 6 Bar from 2 cu.m receiver, forced air/mist and water cooling to simulate interstand temperature profiles.

The forced air cooling in the FTTU is controlled by a special servovalve using a hydraulic pilot stage to achieve the response necessary for accurate control during rapid cooling where rates approach 100°C per second.

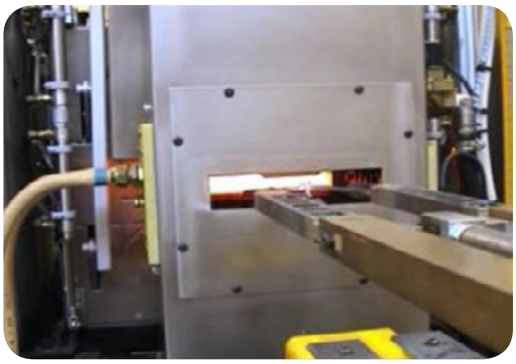
6. T- Slotted Table

To provide easy mounting for the test furnace.

TMTS System Benefits

- TMTS simulates the industrial situation without the need for extrapolation to higher strain rates and/or temperatures.
- The principle usage is to simulate hot and cold rolling - up to a strain rate of 100 s-1 with 12 mm thick specimen, 200 s-1 by testing half thickness. This machine provides an excellent way to obtain the experimental data that are necessary for the models on which modern rolling mills are run.
- Other uses include investigation into extrusion by extrapolation up to 4000 s-1.
- Any materials can be investigated including Aluminum, Steel, Zinc, Nickel and Lead.
- The force and velocity are high enough to achieve these rates with 12 mm thick standard specimens, which means that the specimens are large enough to provide samples for hardness tests, tensile tests, and micro structural examination from the section which has been correctly deformed.
- The forced air cooling in the FTTU is controlled by a special servovalve using a hydraulic pilot stage to achieve the response necessary for accurate control during rapid cooling where rates approach 100°C per second.
- A range of tools for Plane Strain and Uni-axial samples are available in various materials, including Tungsten Carbide, Ceramic, and Nickel Based Super Alloy. For tool temperatures up to 700 °C the tool holders are fitted with cartridge heaters, and tool temperatures are controlled separately from the furnace temperature.

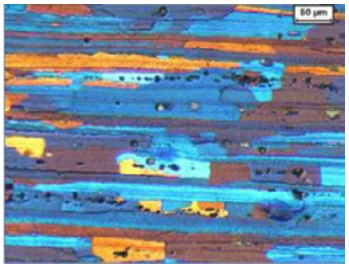
Fast Temperature Transformation Unit – (FTTU)
Speeds up the testing for aluminum, saving time and increasing throughput. A necessity for steel testing is to provide high rates of heating and cooling to obtain the required microstructure and to also save time.



Additional benefits include:

- Easy programming.
- Fully automated testing.
- Simple to operate with user friendly Windows control panels.
- Up to 20 specimens per day through put.
- Reproduces the process repeatedly to provide consistent results.
- The microstructural development of any multi-pass rolling sequence can be studied by quenching the specimen at intermediate stages of the simulation.

Characterization Possibilities of the Deformed Samples
Microstructure analysis e.g. light microscopy, electron microscopy, Electrical Resistivity measurements, etc.
Physical properties e.g. hardness, tensile strength, texture analysis, etc.



TMTS Technical Specifications

Furnaces

Preheat:

- Preheat Maximum Temperature 1200°C
- Maximum Input Power 16kW
- Sample Tray Capacity 4 samples (3 with width > 60mm)

Test:

- Test Maximum Temperature 1200°C
- Maximum Input Power 6 kW

Post Test:

- Annealing Maximum Temperature 750 °C (with air circulation fan)
- Maximum Input Power 3 kW
- Tooling heaters 2 off 800 W in each of upper and lower tools
- Temperature Control Individual Eurotherm 904 controllers for each furnace and upper and lower tools.

Fast Thermal Treatment Unit

- MF Induction Heater 16 kW
- Maximum Temperature 1200°C

Heating Rates:

- Steel Samples >10°C/s to Curie point / Aluminium Samples > 5°C/s

Cooling Methods and Rates:

- Forced Air > 20°/s at 400°C
- Forced Air / Water Mist > 75°/s at 900°C
- Water Jet TBA

Test Machine

Main Actuator:

- Maximum Force 500 kN
- Maximum Velocity 1.5 m/s (no load)
- 1.0 m/s (full load)
- Working Stroke 100 mm

Wedge System Actuator:

- Actuator Force 50 kN
- Actuator Stroke 200 mm
- Actuator Velocity 400 mm/s
- Final Height Range 25 mm
- Height Adjustment Speed 50 mm/sec

Manipulator

- Linear Travel 550 mm
- Angular Movement +/- 30°
- Time from Test Position to FTTU or Quench < 1 s

Measurement Accuracy:

- Sample Height +/- 0.05 mm
- Sample Load > 50 kN +/- 0.1% of FS (500 kN) / < 50 kN +/- 0.5% of FS (50 kN)
- Deformation Velocity +/- 1% of reading
- Sample Temperature 4 off 'N' Type Thermocouples
- < 400°C +/- 1°C / > 400°C +/- 0.25% of reading
- Wedge Height +/- 0.05 mm

Control Accuracy:

- Strain Rate Error Max. < 10% of demanded after first 0.5 mm of deformation
- Typical < 2.5% of demanded

Hydraulic Power Supply

- 37kW producing 70 L/m at 280 Bar
- Total Power requirement:- 400V 3 phase 145kVA
- 85 L/m cooling water at 20°C

Air Supply

- Compressed air at 6 Bar from 2 cu.m receiver

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