

Aluminium Thermal Processes

For Optimized Material Properties





TENOVA LOI THERMPROCESS

Tenova LOI Thermprocess is one of the leading companies in supplying industrial furnace systems for the heat treatment and melting of metals. Worldwide clients from the steel, aluminium and automotive industries rely on the technical solution competence and thousands of references backed by a history of over 100 years representing the entire know-how in the field of material properties and thermal processing. Tenova LOI Thermprocess is a global partner represented in all major markets throughout the world.

Being a driver in the transformation of the metals industry towards decarbonization and sustainability, we implement proven thermoprocessing solutions and focus on the development and implementation of fossil-free annealing technologies, especially Hydrogen, as well as electrical heating capabilities in new plants and revamps. The wide portfolio of technologies for reheating and heat treatment plants meets the most demanding market requirements.

As digitalization is one of the key drivers in our business, all our processes are enhanced by our smart digital solutions. We provide the full range of solutions for the whole life-cycle of the equipment from a single source: from new plants to modernization, maintenance and service.

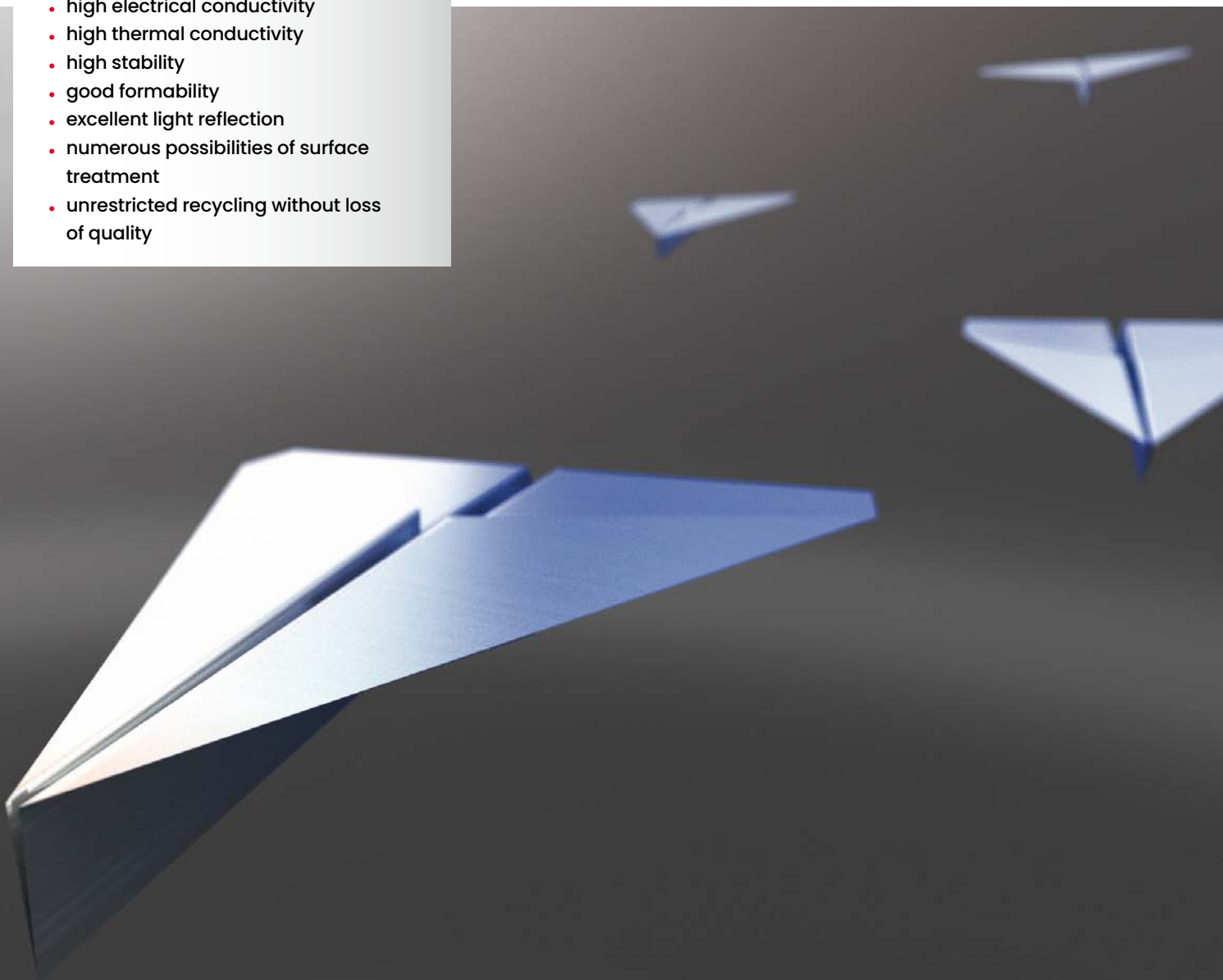
Tenova LOI Thermprocess offers reliable and sustainable solutions that minimize the environmental impact and guarantee quality, production efficiency and safety. Tenova LOI Thermprocess is a trademark of Tenova.

ALUMINIUM – LIGHTWEIGHT, INNOVATIVE AND COMPLETELY RECYCLABLE

Due to its unique properties and the optimal recyclability of used aluminium components, aluminium is a trend-setting material for automobiles, mechanical engineering and aviation industry and outclasses alternative materials with regard to many future-oriented solutions.

Aluminium

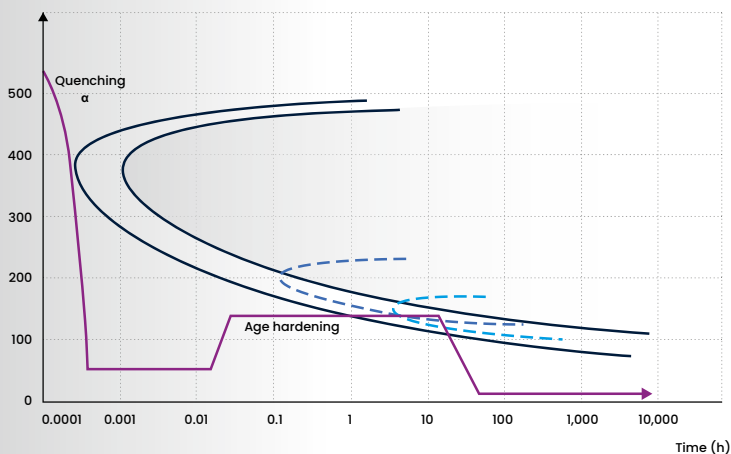
- low density
- favourable corrosion resistance
- high electrical conductivity
- high thermal conductivity
- high stability
- good formability
- excellent light reflection
- numerous possibilities of surface treatment
- unrestricted recycling without loss of quality



ALUMINIUM HEAT TREATMENT

Aluminium is alloyed prior to the casting process in order to achieve specified material properties. Depending on alloy, geometry and the desired features of the structural components, their final characteristics are attained by a component-specific heat treatment program including solution annealing, quenching and ageing.

al-loi® PROCESS TECHNOLOGIES FOR ALUMINIUM



al-loiH Heat treatment technologies for aluminium

al-loiQ Quenching technologies for aluminium

al-loiQ W Water

al-loiQ P Polymer

al-loiQ A Air

al-loi® Process development

- physical tests are validated in pre-series
- process development and optimization stipulated in recipes
- supported by mathematical models and
- specified in more details during commissioning and production start-up

Starting with an alloy-dependent process definition, the process development leads to component-specific tests. Mathematical models and the consideration of experiences gathered from commissioning and production start-up contribute to the continuous process optimization.

al-loi®
**THERMAL PROCESSES
FOR ALUMINIUM**



HEATING PROCESSES **al-loiH**

The heating processes for aluminium structural parts include solution annealing and age hardening. During the solution annealing process all alloy components are uniformly dissolved and homogeneously distributed in the material. At the same time the tensions resulting from the casting process are released. This solution state is frozen by quenching.

The strength of the parts is reached during the age hardening process at an increased temperature. The final strength depends on the chosen alloy, the ageing temperature and the ageing time. The ageing process requires an exact and reproducible temperature control as even a minor deviation from the setpoint temperature will have an impact on the material properties.

al-loiH offers the heat treatment processes which are indispensable for complying with the most sophisticated requirements. The adherence to the process parameters, which is necessary for achieving optimal material properties, is ensured by the appropriate plants.

The reliable **al-loiH** process allows the pinpoint treatment of the components aiming at low deformation and low residual stress.

QUENCHING PROCESSES

al-loiQ

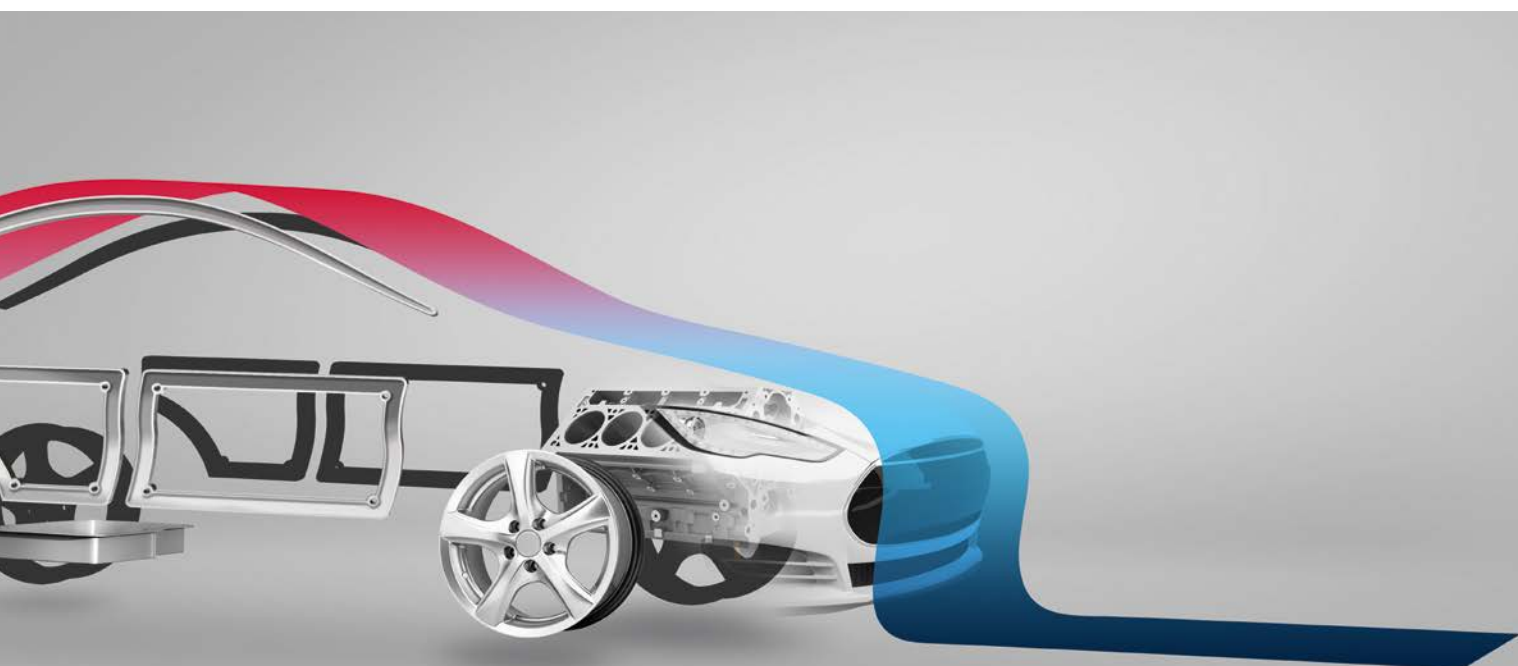
A high strength in the structural component is ensured thanks to the homogeneous distribution of the alloy components during the solution annealing process. To avoid warping of the structural parts and the resulting significant residual tension,

which might affect the lifetime of the parts, these parts need to be quenched in an extremely homogeneous manner. **al-loiQ** provides the required quenching processes including the necessary plant technology.

al-loiQ A ensures a rapid and homogeneous quenching of the parts by use of air with homogeneous and high flow speed.

al-loiQ P, using polymer, offers a more abrupt quenching which is applied particularly to components with thicker walls. It ensures low warping and residual tension of the components.

al-loiQ W, using water, offers a very abrupt, but uniform quenching. For physical reasons this process, however, entails potentially a higher residual tension.



ALUMINIUM AUTOMOTIVE CASTINGS

The more the weight will be reduced, the more often components made of aluminium are used for a vehicle. As the parts additionally play an important role with regard to safety technology, their properties have to meet utmost requirements. This is also applicable to components for airplanes.



AUTOMOTIVE CASTINGS

Castings made of Al-alloys are used in the automotive industry:

- cylinder heads
- engine blocks
- chassis
- trailing and transverse control arms
- cast nodes
- passenger car wheels
- truck wheels

al-loi® heat treatment plants distinguish themselves with

- reliable reproducibility of results
- closed material flow
- high flexibility of processes
- little work required for adjustment to particular heat treatment jobs
- adjustability to small lots
- low energy consumption

FLEX-PLANTS

Meeting the high process and equipment requirements, flex-plants are also suitable to fully automatically treat small lots. Flexible heat treatment lines allow the sophisticated process control promised by **al-loiH**. These plants dispose of a flexible quenching system which is also adequate for the treatment of small lots in **al-loiQ** processes.

TYPICAL PLANT DATA

	Overhead furnace line OAL	Chamber furnace line BHL
Products		castings forgings
Part size	up to 8,000 mm	up to 4,000 mm
Charge weight	500 – 6,000 kg	500 – 7,000 kg
Heating system	direct or indirect heating with natural gas electrical heating	
Air circulation		vertical horizontal
Quenching media	water polymer air	water polymer air

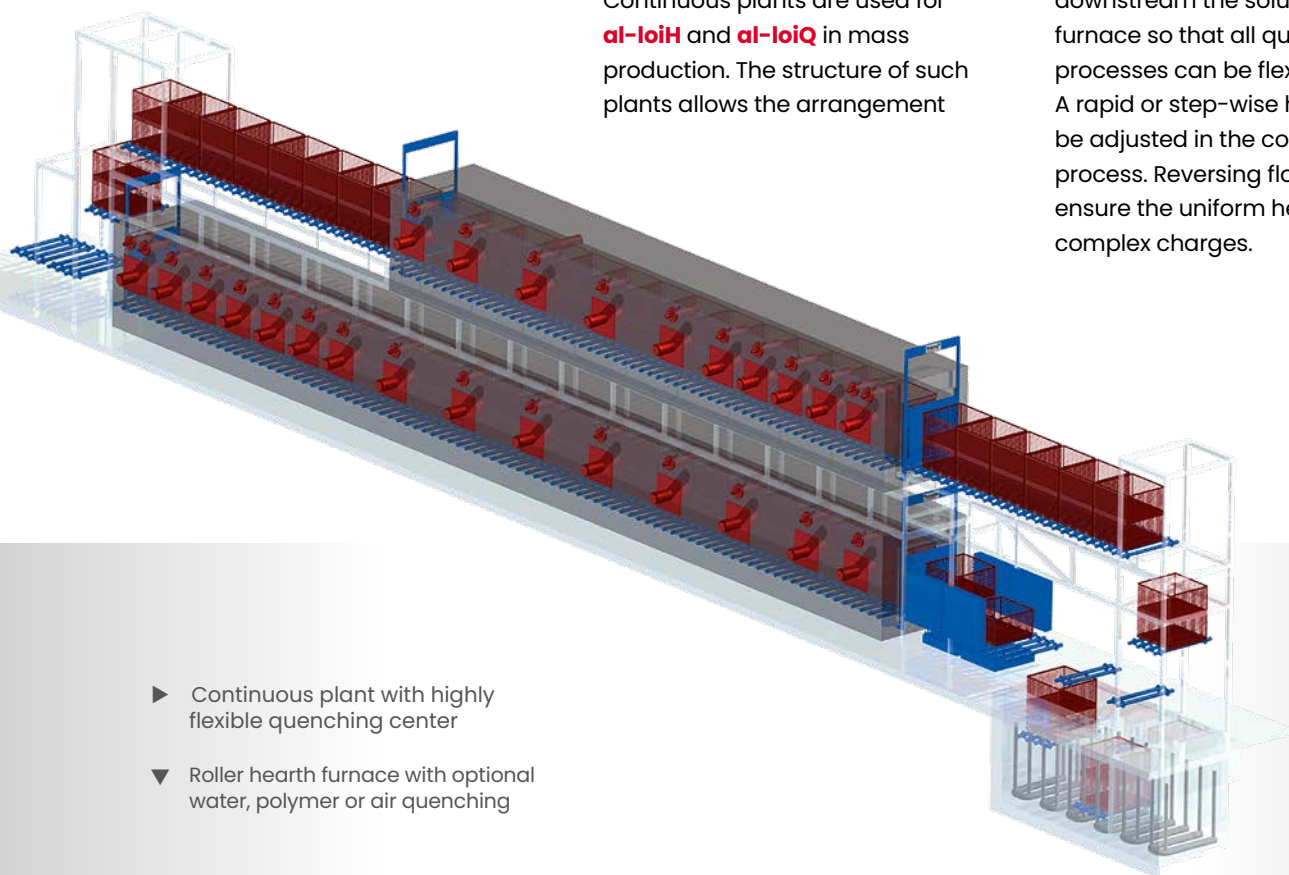
▼ Artificial ageing plant (overhead furnace line OAL) with air, polymer and water quenching



CONTINUOUS PLANTS

Continuous plants are used for **al-loiH** and **al-loiQ** in mass production. The structure of such plants allows the arrangement

of a suitable quenching center downstream the solution annealing furnace so that all quenching processes can be flexibly applied. A rapid or step-wise heating can be adjusted in the continuous process. Reversing flow directions ensure the uniform heating-up of complex charges.



- Continuous plant with highly flexible quenching center
- ▼ Roller hearth furnace with optional water, polymer or air quenching



AVIATION



Aircraft components

The artificial ageing for aircraft components is particularly challenging for the plant engineering and technology. An extremely quick immersion of the sometimes partially filigree components into the quenching medium and a very precise temperature and process control are indispensable for meeting the high quality requirements.

The **al-loi*** heat treatment plants of Tenova LOI Thermprocess fulfill these process conditions.

Quenching delays of less than 7 s and temperature accuracies of $< \pm 3\text{K}$ are reliably implemented in the **al-loiH** overhead furnace lines in a reproducible manner. These furnace plants are equipped in accordance with the latest AMS standards.

▼ Quenching station, optional for air, polymer or water



ALUMINIUM AUTOMOTIVE – FORGINGS

Aluminium forgings are used for highly stressed applications which require meticulous, individual heat treatment including solution annealing, quenching and age hardening. Tenova LOI Thermprocess offers the right equipment for heat treatment of forged aluminium chassis components and wheels.



CONTINUOUS FURNACE CCF

Products	forgings
Part size	up to 650 mm
Throughput	4,000 kg/h
Heating system	direct or indirect heating with natural gas electrical heating
Air circulation	vertical horizontal
Quenching media	water

CONTINUOUS FURNACE PLANTS FOR FORGINGS

The continuous furnace plants with continuous process control offer optimal conditions for large throughputs required for the production of automotive components. The furnace plants may be operated with racks, trays or without any transport auxiliaries.

CHAIN CONVEYOR FURNACES CCF

Chain conveyor furnaces ensure a precise transport of the parts without racks. As the parts to be

heated are accessible from all sides and considering the smooth transport, this type of furnace plants is suitable for the heat treatment of geometrically complex, sensitive parts.

The charging is executed by a robot which is also used for discharging the heating goods from the solution annealing furnace and its immersion into the quenching bath.

OVERHEAD FURNACES OAL

In overhead furnaces, forgings are placed in charge racks and optimally quenched due to

the short quenching delay. After the racks have been charged by the operator, they pass the heat treatment process fully automatically.

CHARGE TRACKING

The automatic charge tracking including documentation of batches and single charging goods is implemented in all furnace plants of Tenova LOI Thermprocess. They can be equipped according to the actual specification AMS2750 or CQI9.

FURNACE PLANT DESIGNS FOR FORGINGS

Chain conveyor furnace CCF

- entire integration of the furnace into the fully automatic production line
- parallel charging of several forged parts
- precise and continuous material flow through the heat treatment plant without baskets or grids
- automatic charging and discharging

Overhead conveyor furnace OCF

- compact plant design; the goods to be heat-treated are arranged in multi-layer racks

- external conveyors, uniform heating and horizontal storage; i.e. low-warping heat treatment
- automatic charging and discharging

Overhead furnace OAL

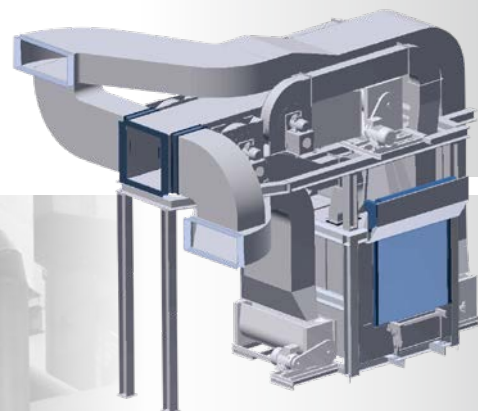
- flexible plant conception
- ideal for the heat treatment of small lots
- highly flexible quenching
- fully automatic heat treatment

▼ Multi-lane chain conveyor furnace including single-part quenching facility



ALUMINIUM AUTOMOTIVE STRUCTURAL COMPONENTS

The heat treatment of structural components for the automotive industry typically aims at achieving the state T5, T6 and T7. The precise and stable temperature control and the quenching process are the decisive factors for the quality of the final product.



▲ Air quenching chamber for structural components



al-loiH and **al-loiQ** are the necessary basis for the plant technology to comply with the requirements of the heat treatment of automotive structural components. The **al-loiQ A** air quench can feature either a form-fitting quenching of parts or a piston flow for the quenching of complete rack piles.

A specific carrier is developed for each structural component. That is inserted into the charge rack and supports the structural part during the complete heat treatment process.

The **al-loiQ A** process with air is actually used for quenching. In future the **al-loiQ P** process with polymer will be a possible alternative for structural components. As result from the ongoing further development of polymer-water-mixtures, the structural parts could be cooled down more rapidly with acceptable warping.

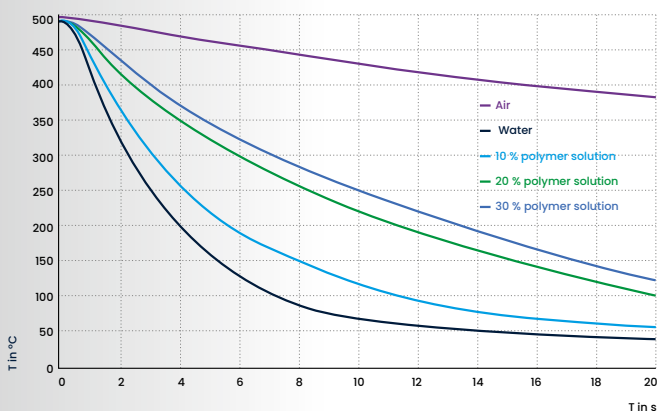
TYPICAL PLANT DATA

	Continuous furnace RCF
Products	structural components pressure die casting
Heating system	direct or indirect heating with natural gas electrical heating
Air circulation	nozzle field vertical horizontal
Quenching medium	air
Quenching speed	6 K/s
Furnace temperatures	420 – 520 °C 150 – 250 °C

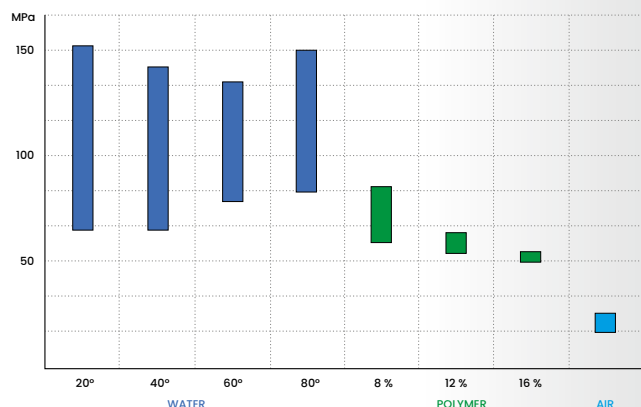


▲ Air quenching chamber for structural components

QUENCHING



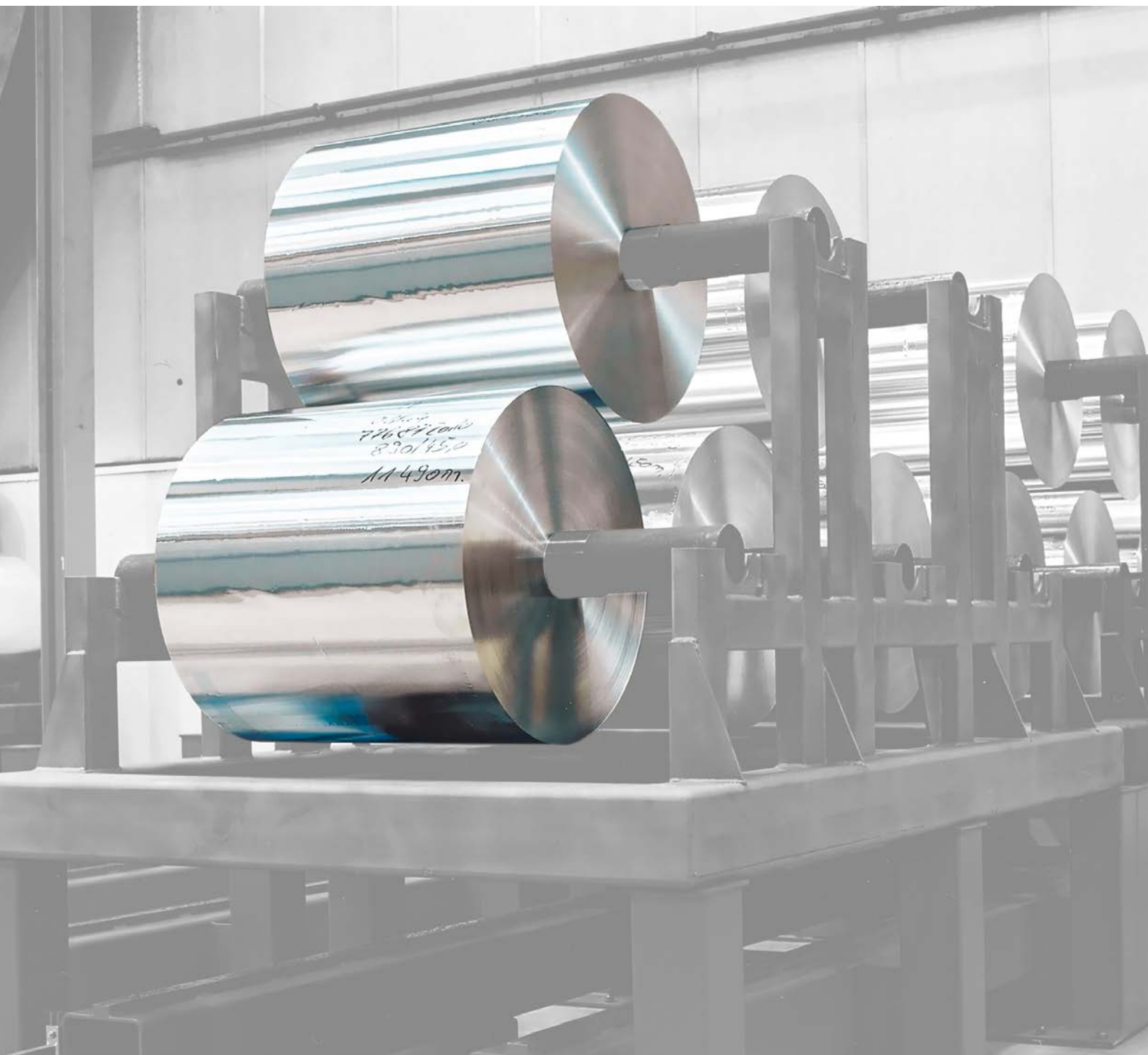
▲ Cooling curves for different quenching media



▲ Residual stress after quenching in water, polymer and air

ALUMINIUM HEAT TREATMENT ROLLING MILL

Strips are annealed after the rolling process to allow further forming. The strain hardening, which results from the rolling process, is reduced by soft annealing. This soft annealing is executed on the strip coil.



MULTI-CHAMBER FURNACE PLANT FAL

The foil annealing furnace FAL of Tenova LOI Thermprocess consists of max. 5 separated chambers which can be operated individually. The charges of the foil coils arriving from

the rolling mill are collected on suitable storage places. A set of foil coils is then compiled to a charge and positioned on an annealing rack. The charging is executed by a charging machine which transversely travels to the individual furnace

chambers. All functional processes are executed fully automatically. Every individual heat treatment is assigned to the respective, individual charge, rack or single part, registered and documented.

TYPICAL PLANT DATA

	Foil annealing furnace plant FAL
Products	foil rolls
Alloy	pure aluminium aluminium alloys
Foil thickness	6 – 200 µm
Coil diameter	1,250 mm
Coil width	1,600 mm
Charge weight	30,000 kg
Heating system	indirect heating with natural gas electrical heating
Air circulation	vertical
Heat recovery	recuperative burners
Temperatures	400 °C
Temperature tolerance	< +/- 3K



▲ Multi-chamber annealing furnace
▼ for annealing of foil coils FAL.



COIL ANNEALING FURNACE PLANTS

Strip coils are annealed for the purpose of intermediate annealing during cold rolling, for softening and recrystallization. The annealing can take place under protective gas atmosphere in the furnaces of the Single-Coil Lifting Hearth furnace SCL and Multi-Coil Chamber furnace MCL to prevent the oxidation of the strip surface.

A uniform and rapid heating-up, which aims at heating the strip coil to the desired temperature, is achieved by the impact of jets of the circulated gas on the strip coil.

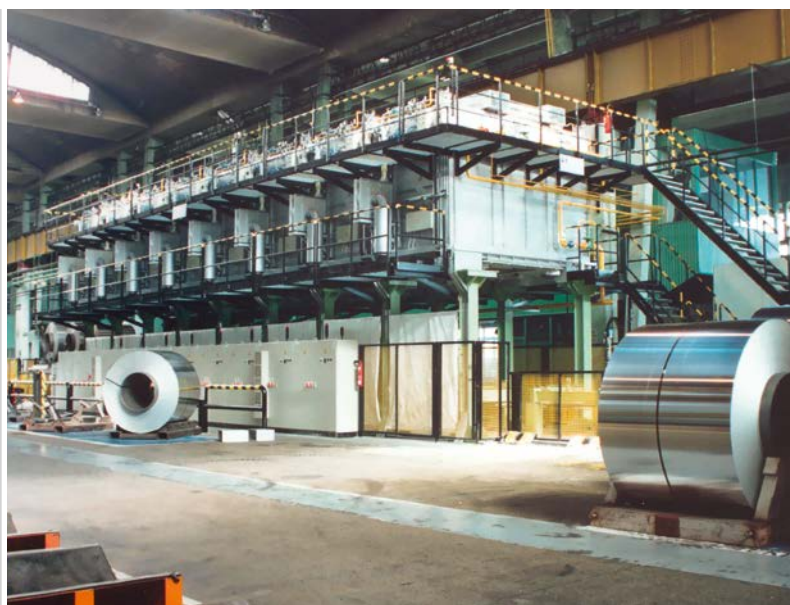
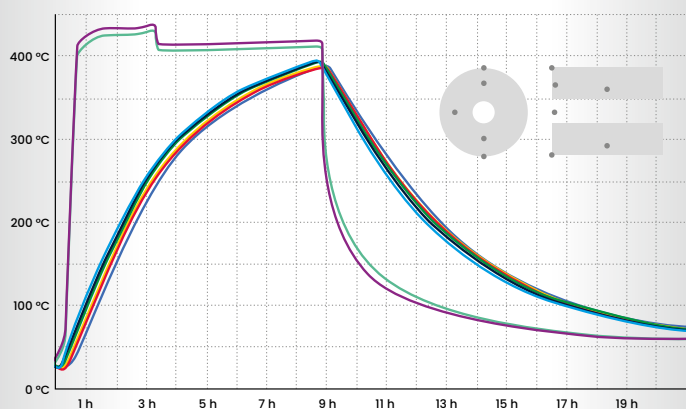
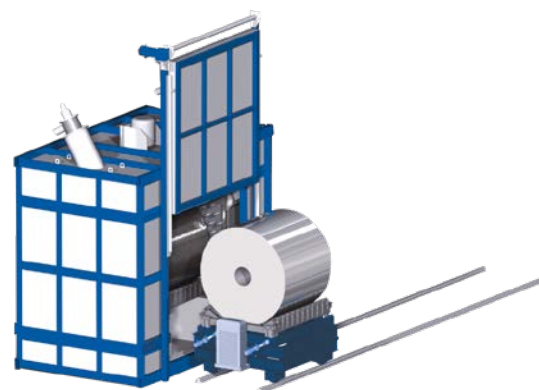
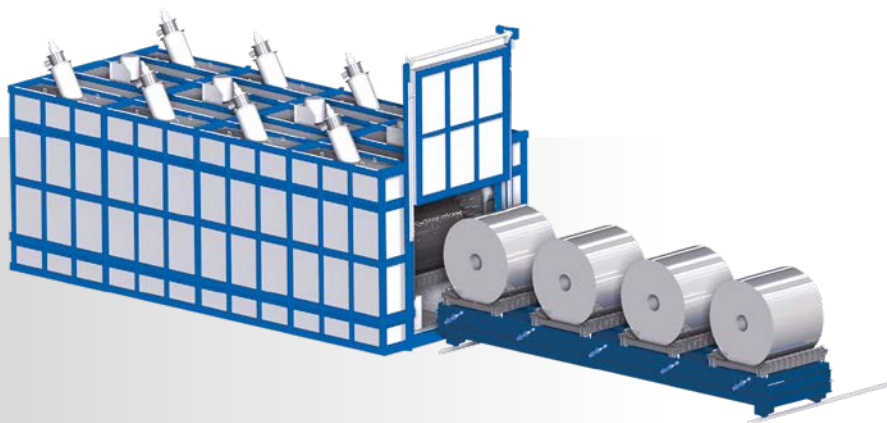
After the rolling process, oil is removed from the strip surface by annealing. The strip coil is heated up step-wise and held on defined temperatures so that residual oil can evaporate. The resulting steam leaves the furnace during the subsequent purging. It is treated in a thermal post-combustion to make sure that only completely burnt-out waste gas will be released to the environment.

The controlled strip cooling in the furnace – under protective gas atmosphere – is necessary to prevent oxidation. It can be carried out in both furnace lines,

the MCL and the SCL. The furnace atmosphere is directed into a bypass and cooled via a heat exchanger.

MULTI-COIL CHAMBER FURNACES MCL

Multi-coil chamber furnaces MCL are used in case of large production capacities with homogenous strip coils. Each strip coil is heated in an individually controlled furnace zone. A single or several homogenous strip coils are compiled on a storage place to form the individual charges. A charging machine is used for the automatic furnace charging and discharging.



SINGLE-COIL LIFTING HEARTH FURNACE SCL

The furnaces are elevated on supports and arranged one behind the other in a row. Travelling below the furnaces, the charging machine charges every furnace with a strip coil placed on the furnace hearth. Every furnace is charged with only one strip coil. The respective recipes are stored in the control system. They can be re-called and activated at any time.

HeatMod, the software package Tenova LOI Thermprocess is used for the control of the heat treatment process. Based on the furnace sensor data, the actual state of the strip coil is calculated and the actual process parameters are adjusted accordingly.

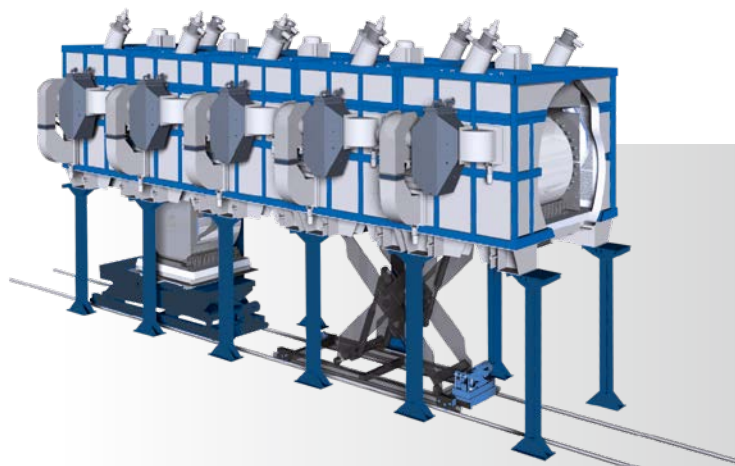
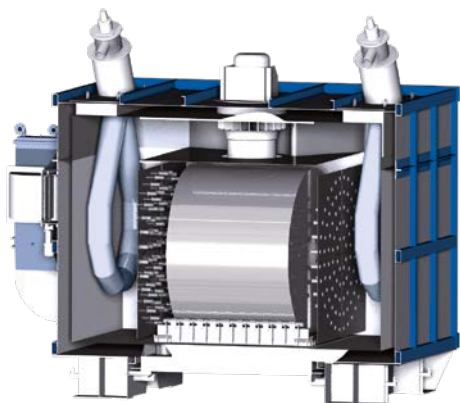
The coil annealing furnaces SCL and MCL distinguish themselves with:

- utmost temperature uniformity
- annealing and cooling process under protective gas
- post-combustion of furnace atmosphere in a TNV
- low energy consumption
- easy handling due to fully automatic charging and discharging

- max. efficiency due to application of the Delta-radiant tube-technology of Tenova LOI Thermprocess
- minimal process gas costs

Furthermore, the line with Single-Coil Lifting Hearth furnaces SCL offers:

- high flexibility due to quickly adjusted production
- individual annealing of single strip coil
- high efficiency in case of small lots
- connection of furnace plant to fully automatic high-rack and flat storage facilities



RETROFITTING AND MODERNIZATION

Being a driver in the transformation of the metals industry towards decarbonization and sustainability, Tenova LOI Thermprocess offers a wide variety of innovative revamping and modernization solutions to help pave the way towards a climate-neutral society.

As each furnace plant is unique, we implement proven process solutions and focus on the development and implementation of fossil-free melting and annealing under usage of electrical heating or Hydrogen combustion.



Especially the relatively short down times and the partial reuse of existing infrastructure combined with performance improvements make modernization an attractive alternative. Irrespective of the original supplier, we can design and implement modernization projects for continuous Roller Hearth Furnaces in accordance with customers' requirements and national regulations. Plants modernized by Tenova LOI Thermprocess offer considerably higher productivity and efficiency. Our retrofit packages are also designed in line with safety and sustainability requirements.

We have the expertise required for the modernization, modification and repair of

- Steel structures
- Refractories
- Electrical systems

- Instrumentation systems
- Automation and control systems

With our digital products, we offer preventive maintenance, remote support as well as electronic, digitalized spare parts catalogues both for new plants and for the modernization of existing plants.

MODERNIZATION OF INSTRUMENTATION AND CONTROL SYSTEMS FOR HIGH QUALITY IMPROVEMENT AND UPDATED SAFETY SYSTEMS

Modifications may be needed as a result of more stringent quality, certification and safety requirements of the final customer for the products treated. One example is the continuous improvement of quality in accordance with CQI-9 for automotive industry products. This standard poses stringent requirements for the pyrometric

equipment of heat treatment lines. Another example is the modernization of safety systems by our electrical and control experts in accordance with the state of the art.

HIGH DECARBONIZATION POTENTIAL BY RETROFITTING THE HEATING TECHNOLOGY

Aluminium heat treatment furnaces have a high potential for reducing CO₂ emissions due to their ease of retrofitting/modernization. In contrast to measures in new plant construction, where the necessary investments are very high, modernizations are an efficient way to reduce the CO₂ footprint in the short term. In addition, modernization can easily be carried out in phases and does not necessarily have to be done in one step, and can be adapted to the specific circumstances of the customer.



SERVICE AND SPARE PARTS

Each furnace plant is unique. With know-how developed over many decades and backed by thousands of references worldwide, Tenova LOI Thermprocess supplies targeted and experienced services, as well as maintenance and spare parts specially aligned for your thermal process plant. The worldwide service network assures high availability and fast delivery.



SERVICES

We provide our customers with tailor-made maintenance programs, regular technological updates, operation assessment and personnel training.

SPARE PARTS

We supply original spare parts for LOI's wide portfolio of industrial furnace systems as well as third party equipment. With **LOI-SIS®** (LOI Service-Information System), a web-based catalogue for new and old equipment can be created on demand to facilitate the identification of parts and simplify the procurement process significantly.

MAINTENANCE AND REPAIR

Our experts are available for maintenance work on process control systems including mathematical models and on

systems including mechanical and electrical elements, refractory linings, burners, heating/cooling systems, controllers and automation devices.

DIGITAL SERVICE

LOI's wide portfolio of different digital services help you to improve product quality, minimize downtimes and enhance your production process. These are e.g.:

- Remote Services including Remote Assistance to offer live support at your plant and Remote Control for performance monitoring
- Digital Equipment Twins using Virtual Reality that allows you to experience your equipment before it is installed

- Digital Automation Twin to accelerate your plant commissioning
- Video Furnace Inspection to easily analyze your plant
- A variety of Intelligent Process Models and Monitoring Systems for performance increases

RETROFIT AND MODERNIZATION

Our innovative and sustainable modernization solutions allow customers to minimize the environmental impact of their plant and decarbonize processes. Productivity and efficiency levels are improved, while focusing at the same time on plant safety.



Sustainable solutions for a green transition of metals

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