tenova
LOI THERMPROCESS

HEAT TREATMENT OF TUBES, BARS AND WIRE COILS

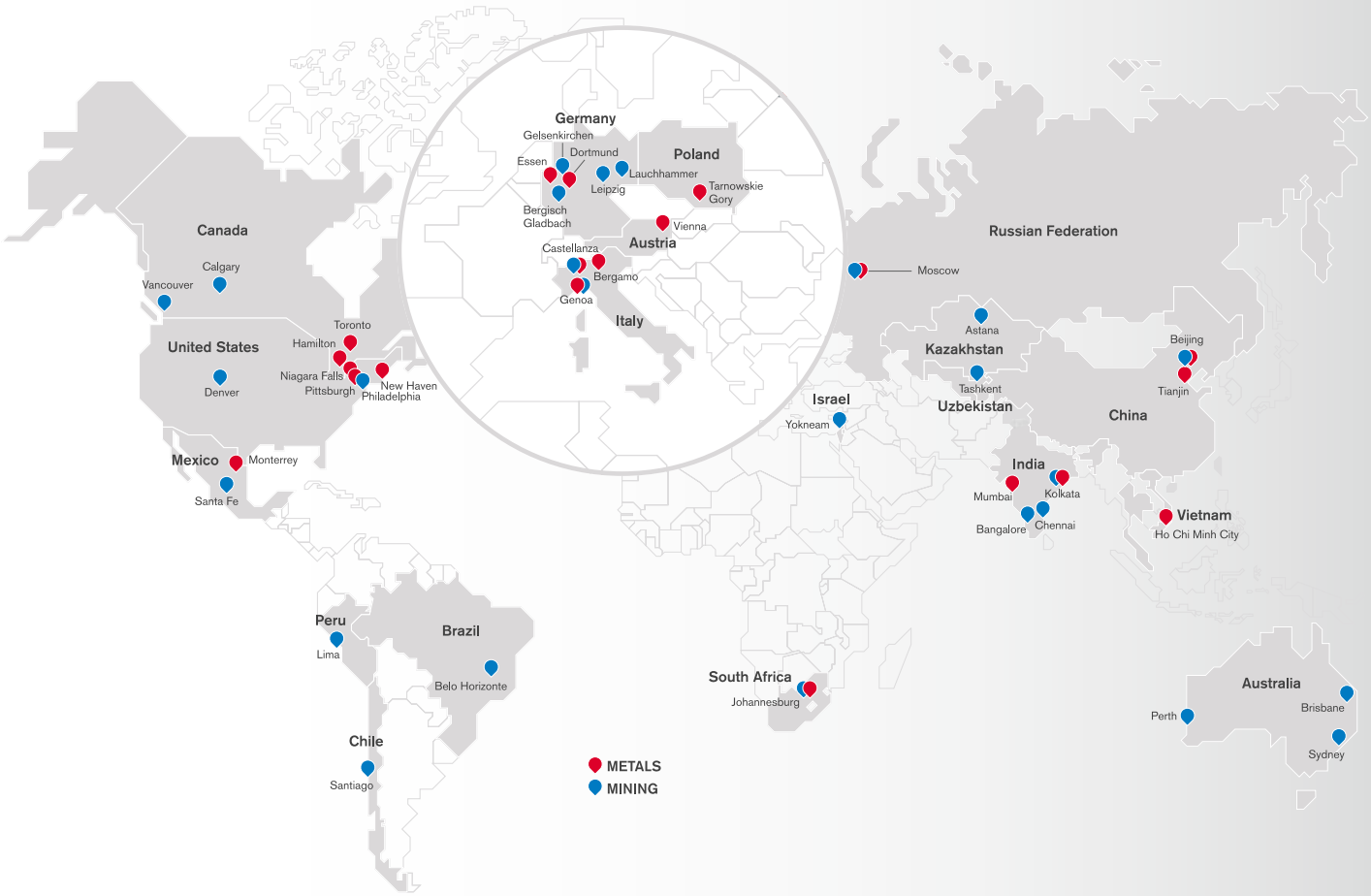
Roller Hearth Furnaces – Plant and Process Technology

TENOVA. INNOVATIVE SOLUTIONS FOR METALS AND MINING

TENOVA
LOI THERMPROCESS

Tenova LOI Thermprocess is your global partner in the world of industrial furnace technology. Our clients appreciate our know-how and experience backed by thousands of references and a history of over 100 years in the furnace sector. We offer highly advanced process technologies, high reliability, high-quality products and services, and a wide range of custom-tailored solutions for reheating and heat treatment plants for the metal industry.

Tenova LOI Thermprocess is a member of the Tenova Group, leveraging a total staff of more than 2,500 forward-thinking employees located in 19 countries across 5 continents. Tenova works alongside clients to design and develop innovative technologies and services that help mining and metal companies reduce costs, save energy, limit environmental impact and improve working conditions for their employees.



Tenova LOI Thermprocess – The Market Leader in Roller Hearth Furnace Technology

Continuous Roller Hearth Furnaces are highly productive heat treatment plants that are used for treating large quantities of long and coiled products in controlled atmospheres. With innovative plant design, process technology and safety systems, especially with the use of process gases, our company has been the market leader in the field of indirectly heated Roller Hearth Furnaces for decades.

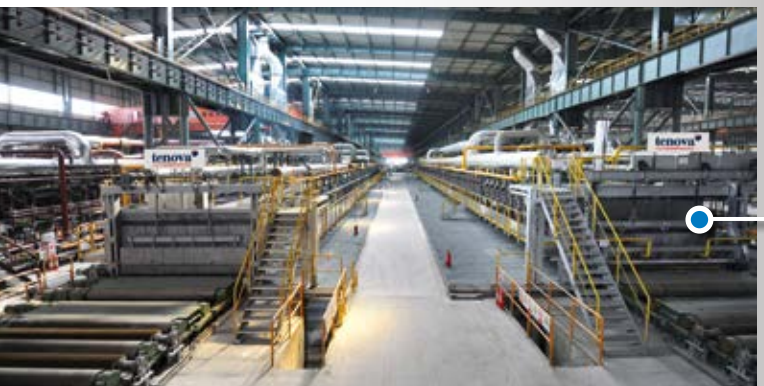
Steel/stainless steel tubes and bars

Non-ferrous metal tubes and bars

Wire coils

Level Wound Coils (LWCs)

Electrical sheet



Heavy plates

HISTORY OF TENOVA LOI THERMPROCESS ROLLER HEARTH FURNACE TECHNOLOGY

Tenova LOI Thermprocess has more than 100 years of experience with Roller Hearth Furnace technology. **LOI** was founded in 1965, pooling the experience of the companies **L**udwig (established in 1934), **O**FAG (established in 1920) and **I**ndugas (established in 1928). With the acquisition of Nassheuer (established in 1910) in

1920

OFAG develops the “new” type of Roller Hearth Furnace.

1980

Nassheuer LOI develops the first high-temperature cooling sections with waste heat recovery.

1910 | 1920 | 1930 | 1940 | 1955 | 1960 | 1970

1955

Nassheuer launches the first Roller Hearth Furnace with open firing and indirect heating.

1960

Nassheuer supplies a complete Roller Hearth Furnace plant including atmosphere gas generator.

1986, the company which remains the market leader for controlled-atmosphere Roller Hearth Furnaces to this day, as Tenova LOI Thermprocess, was finally established. Innovative further developments in line with and even exceeding the highest technical requirements have continually reinforced this leading position.

For example, Tenova LOI Thermprocess has developed a continuous Roller Hearth Furnace with a process gas atmosphere of up to 100 % hydrogen which does not require vacuum or purging locks. This furnace represents the state of the art in highly advanced process gas, heating, cooling and especially safety systems and is used by customers including the world's leading stainless steel tube producers.

2017

Tenova LOI Thermprocess presents a further development of Roller Hearth Furnace technology in line with CQ I-9 requirements.

1980 1990 **1997** 2000 2010 **2017**

1997

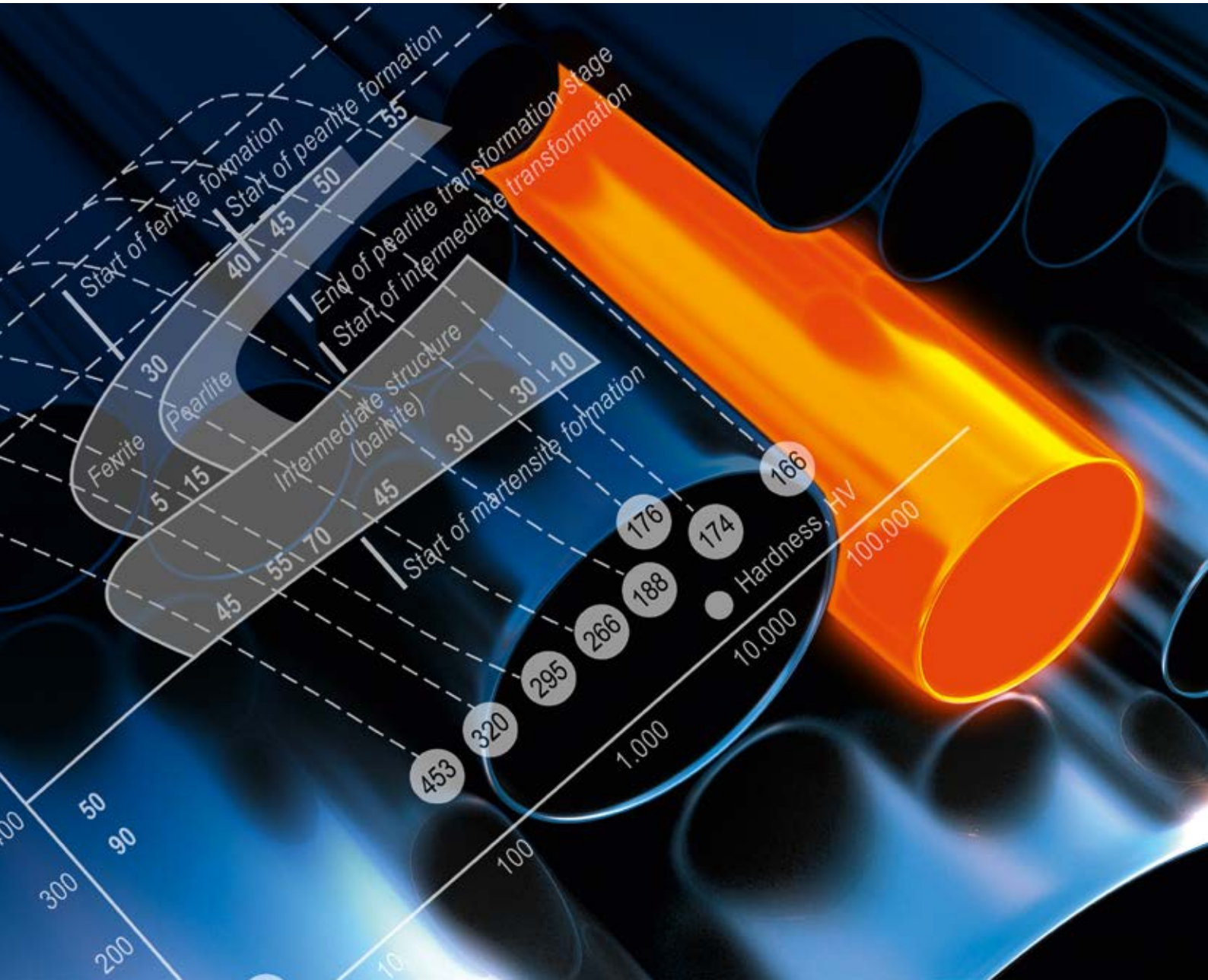
LOI develops and produces the first fully continuous Roller Hearth Furnace with a 100 % hydrogen atmosphere without vacuum or purging locks.

LOI THERMPROCESS

tenova LOI THERMPROCESS

WE ARE THE PROCESS EXPERTS FOR THE HEAT TREATMENT OF TUBES, BARS AND WIRE COILS

Following the forming process, low-alloy or non-alloy carbon steels call for heat treatment in the temperature range from 450 °C to 1,050 °C, with processes including normalizing, recrystallizing, stress relieving, soft annealing or spheroidizing. Steel and non-ferrous metal tubes, bars and wire coils are heat-treated in continuous Roller Hearth Furnace plants using a variety of different controlled atmospheres. The atmosphere gas is selected on the basis of the charge material and the requirements to be met by the surface following treatment.

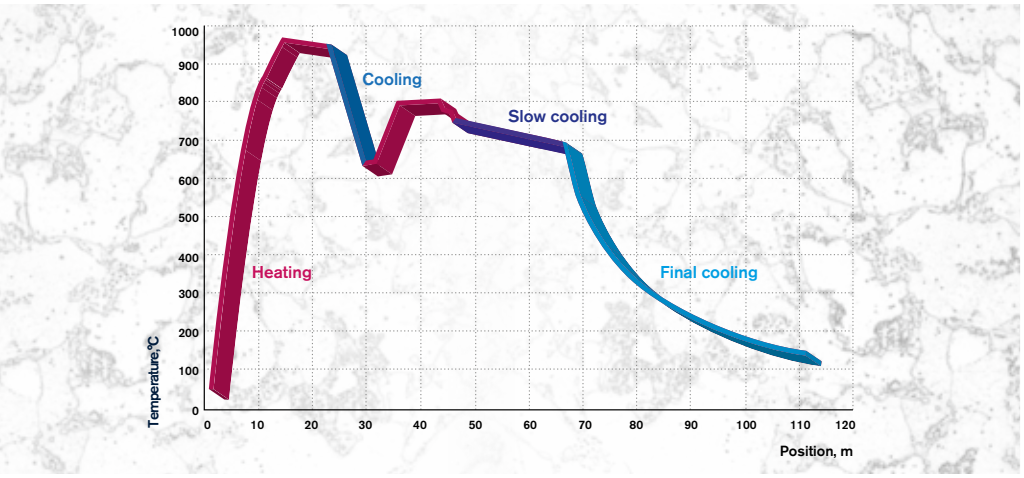


Process Gas

In the case of carbon steel grades, neutral atmosphere gases are mainly used to prevent oxidation on the metal surface. These gases are used both as purging gases and as carrier gases. Reactive gases are either added to the process gas or used as pure gases depending on the specific application. The function of reactive gases is to reduce any oxidation layers or to prevent further surface oxidation. Depending on the material and the type of reactive gas, surface decarburization may be avoided or a slight carburization of the surface may be achieved.

▼ Controlled-atmosphere Roller Hearth Furnace for non-alloy or low-alloy carbon steel grades, type RoDR 6500

Heat Treatment Processes



▲ Jet cooling

NORMALIZING

The process steps of austenitizing and subsequent radiant cooling in a stationary atmosphere create a ferrite-pearlite structure in the case of sub-eutectoid steels and a pearlite-carbide structure in the case of super-eutectoid steels. Depending on the material composition, temperatures above A_{c3} or A_{c1} may be needed. Roller Hearth Furnaces designed for normalizing are also used for the following two annealing processes.

RECRYSTALLIZING

This process eliminates the deformation of the crystalline structure and resulting hardening caused by cold forming. Depending on the preceding forming operations and the composition of the alloy, the treatment temperature is below A_{c1}, at about 700 °C.

STRESS RELIEVE ANNEALING

This process relieves residual stress caused by thermal or mechanical effects without any significant change in the crystalline structure. The temperature must therefore be below a maximum of 550 °C, the point where recrystallization starts.

▼ Controlled-atmosphere Roller Hearth Furnace, type RoDR 7000, with enclosed waste gas system

▲ Low-temperature cooling section (NT)

▲ High-temperature cooling section (HT)

SOFT ANNEALING (SPHEROIDIZING)

In order to maintain low strength values for better machinability, sub-eutectoid steels are annealed at a temperature below A_{c1} and super-eutectoid steels are annealed above A_{c1}. The charge material must be cooled as slowly as possible so that it remains soft and machinable.

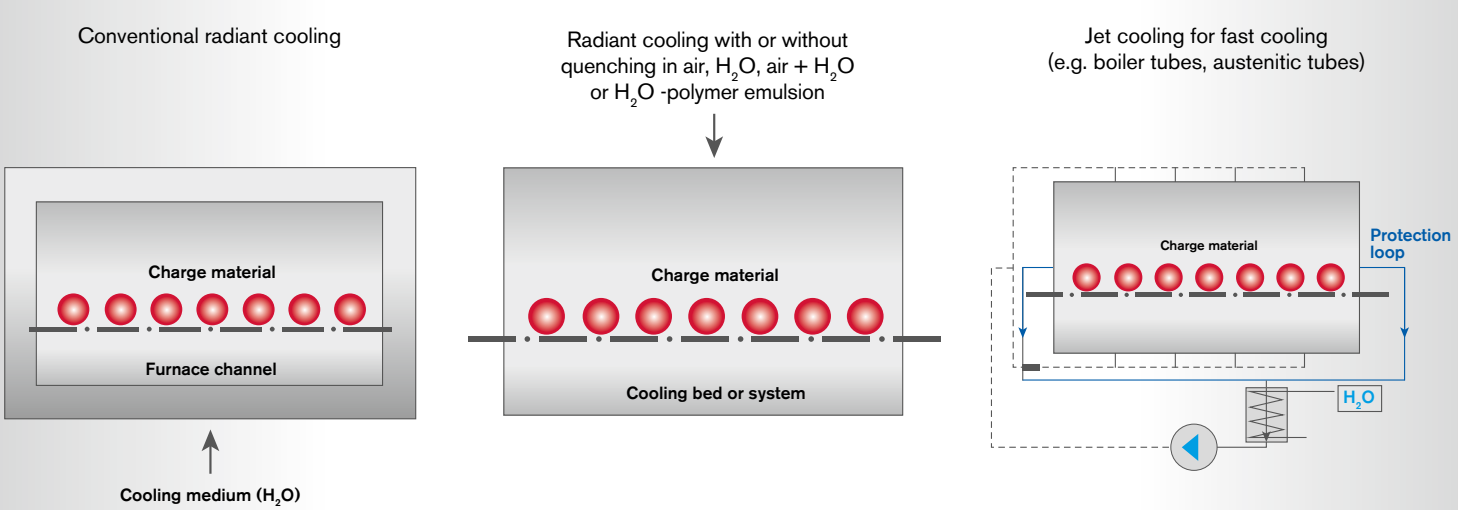
QUENCHING AND TEMPERING

Austenitizing followed by quenching transforms the structure into martensite. Subsequent heating transforms the martensite in order to adapt material properties such as hardness and toughness to the requirements faced. The quenching gradient of the cooling systems required depends on the material and the hardening time (shares of martensite and bainite in the structure). The temperature used for tempering (≤ 600 °C) determines the hardness value and the results of the process.

SOLUTION ANNEALING

Application for high-alloy steels. The process is comparable with hardening in the case of quenching and tempering. The objective is to dissolve grain boundary carbides (T = 1,050 – 1,250 °C with austenitic steels) and to maintain (freeze) the structure.

COOLING PROCESSES



Steels

▲ 3-D illustration of a Roller Hearth Furnace for carbon steel tubes with radiant cooling

NON-ALLOY/LOW-ALLOY CARBON STEELS

In order to meet the stringent requirements faced after annealing, especially as regards the carbon concentration at the surface of the charge, the furnace is operated using a nitrogen atmosphere gas which has no impact on carbon concentrations. Endothermal gas e.g. is added to the furnace atmosphere to create a certain carbon potential, which is adapted to the carbon content of the charge material. The CO content of the atmosphere can be adjusted between 1 % and 6 %. A zirconium dioxide probe or gas analyser is used for the continuous monitoring of the carbon potential. In the event of any deviations, e.g. propane is automatically injected to create a richer mixture or air is added for a leaner mixture.

HIGH-ALLOY AUSTENITIC STEELS

Hydrogen is used as the process gas for the bright solution annealing of high-alloy stainless steel. In the case of products with a larger open cross-section or higher charge weights, the use of vacuum inlet and outlet locks is a tried and tested solution. These locks, which are hermetically sealed against the outside atmosphere, significantly reduce process gas consumption.

▲ 3-D illustration of a Roller Hearth Furnace for high-alloy steel tubes with hydrogen jet cooling

For products with smaller open cross sections or flatter charge materials, special moving curtains ensure the reliable sealing of the furnace. In this case it is therefore not absolutely necessary to install inlet or outlet locks which may make it difficult or even impossible to operate a continuous process in the furnace.

A PC/PLC-based process control system monitors and documents the process and plant safety. Especially with these materials, rapid, precisely controlled cooling plays a key role in the quality of the final product.

LOI jet coolers can achieve cooling gradients higher than 5 K/s in the temperature range from 900 to 400 °C.

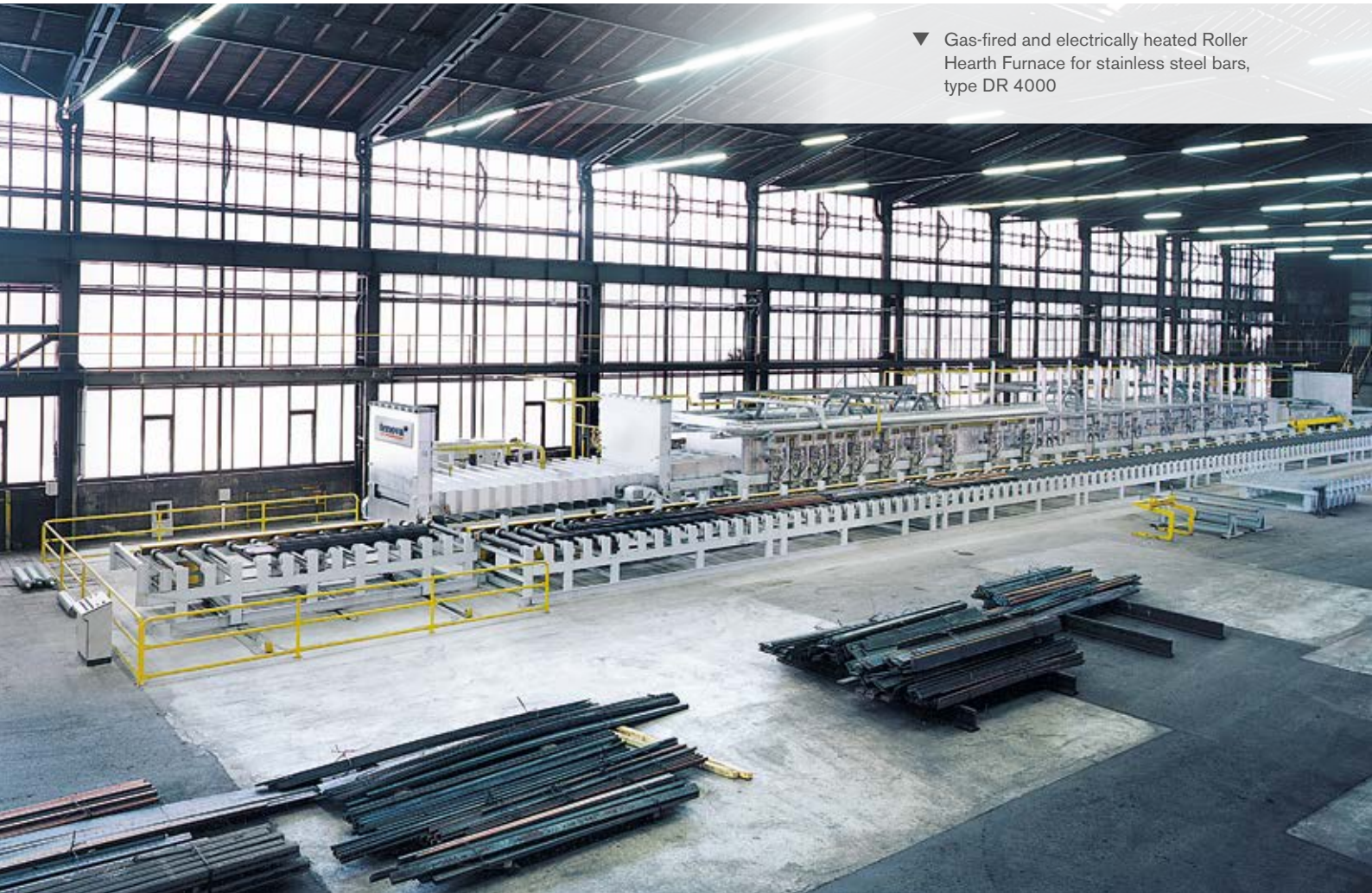
In a continuous furnace plant, these cooling gradients can only be achieved if the distance between the heating section and the jet cooler is very short. In addition, the cooling gradients may be influenced by the frequency converter of the recirculation fan.

▼ Roller Hearth Furnace for the bright annealing of precision steel tubes

WE ARE THE ROLLER HEARTH FURNACE EXPERTS

Roller Hearth Furnaces for the heat treatment of tubes or bars are outstandingly well-suited for continuous production and high throughputs. In continuous operation, they ensure homogeneous heating, customisable soaking times and subsequent cooling in accordance with material requirements. The high temperature uniformity and low energy consumption of these plants allow reproducible processes which can be precisely adapted to the heat treatment requirements for individual materials. Material transfer systems can be ideally adapted to the specific annealing process. In addition, this type of plant does not call for repeated heating and cooling operations for each charge, combined with tightness testing.

Tubes, bars and sections are mainly supplied to the automotive and aerospace industries; for this reason, the plants may be certified in accordance with CQI 9 (automotive) or AMS 2750 E (aerospace). Precisely controlled and monitored temperature management is a quality feature of LOI Roller Hearth Furnaces. User-friendly software developed in-house allows the in-situ acquisition and management of measurement results. At the same time, the data are processed and made available to the user in digital form.



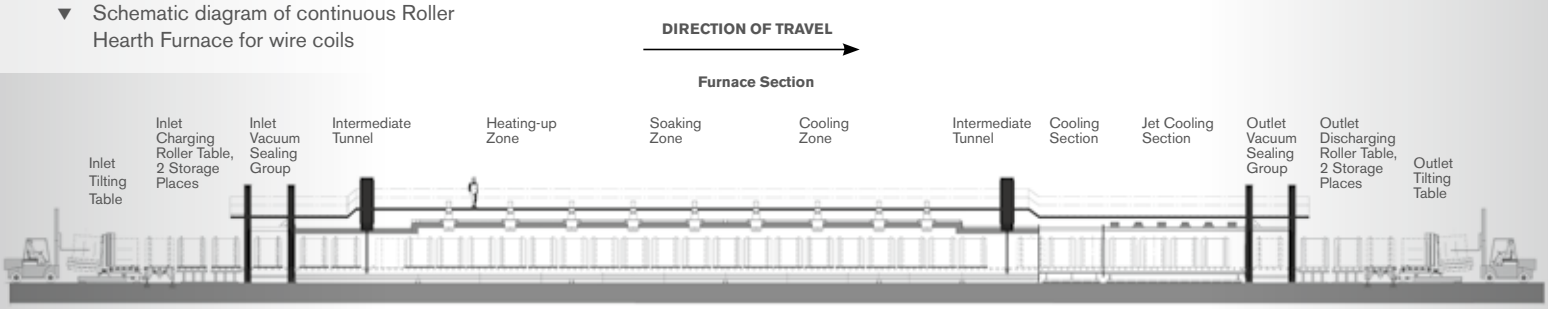
▼ Gas-fired and electrically heated Roller Hearth Furnace for stainless steel bars, type DR 4000

Furnace design

Typically, the design of a controlled-atmosphere Roller Hearth Furnace includes facilities for sealing the controlled process gas atmosphere in the furnace off from the ambient atmosphere at the furnace inlet and outlet. Depending on the individual process, these facilities may consist of special curtains and/or locks. The furnace line may also include an intermediate tunnel between the inlet lock or curtains and the furnace chamber.

Downstream from the main section of the furnace plant, the furnace chamber, a cooling section is installed. Depending on the requirements of the individual project, Tenova LOI Thermprocess uses a variety of cooling system designs for Roller Hearth Furnaces. Systems ranging from low-temperature cooling sections via high-temperature cooling sections both based on radiation and natural convection to jet cooling are designed and combined for the individual furnace. To ensure improved energy efficiency, the cooling systems may also be equipped with appropriate heat exchangers for waste heat recovery.

▼ Schematic diagram of continuous Roller Hearth Furnace for wire coils



FEATURES OF LOI ROLLER HEARTH FURNACES

Tenova LOI Thermprocess Roller Hearth Furnaces:

- are gas-tight thanks to their especially design and
- can therefore be used for all types of atmosphere gases with up to 100 % H_2 and dew points as low as -60 °C.
- are extremely flexible and operate at high throughputs.
- have very low maintenance requirements and high availability.

Tenova LOI Thermprocess offers

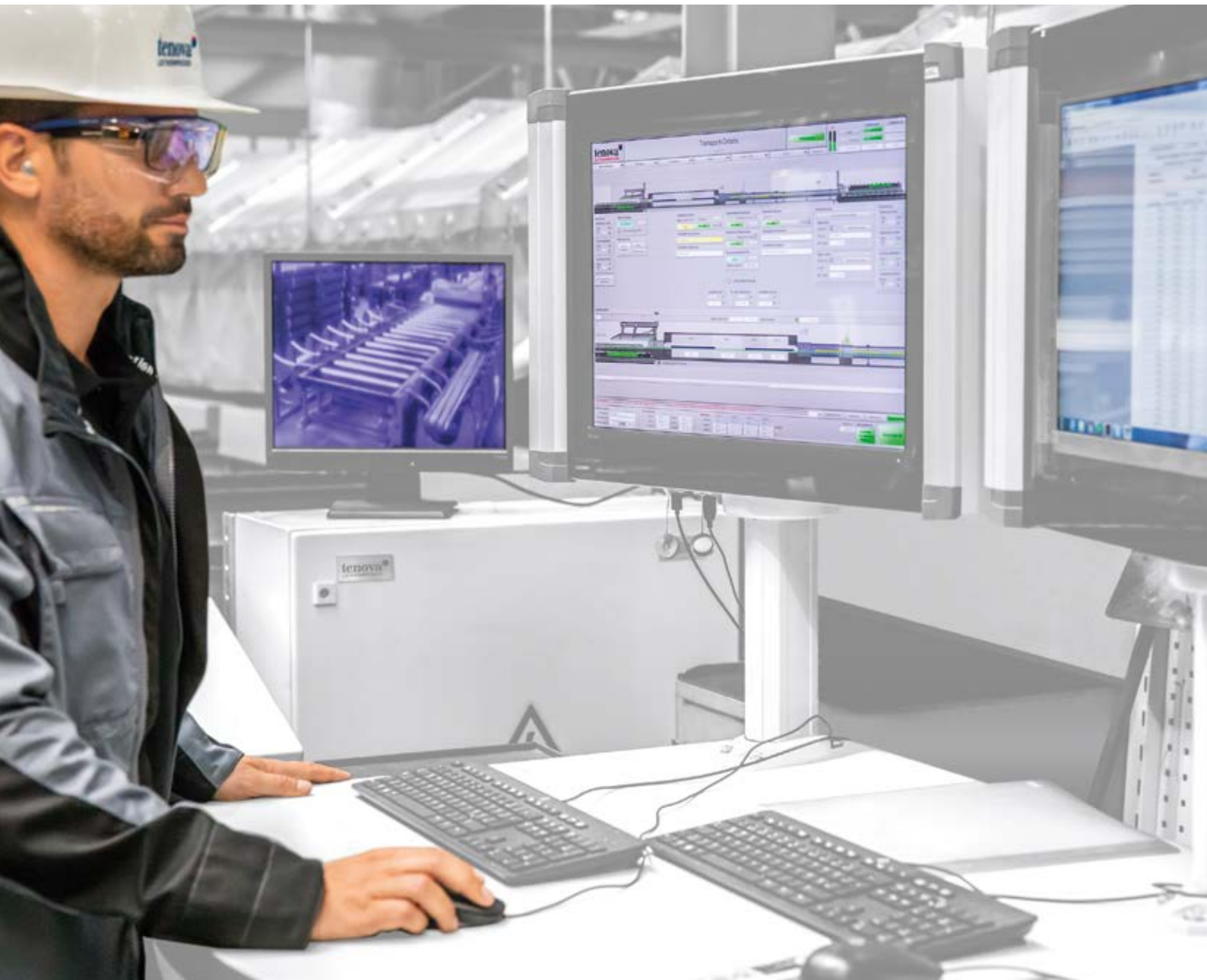
- gas and electric heating
- special automation solutions for handling tubes without any risk of surface damage
- compliance with demanding quality and control standards (such as CQI-9)

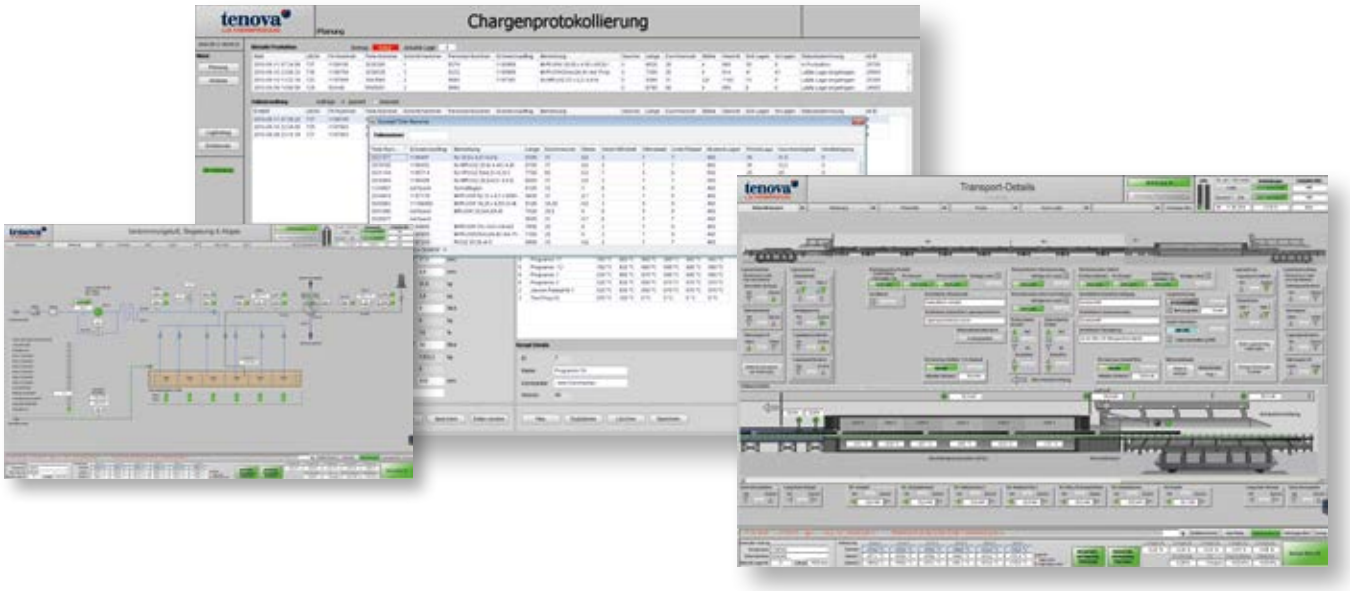
▼ Roller Hearth Furnace for wire coils, type DR 4500

CONTROL AND AUTOMATION SYSTEMS

Control systems allowing the fully automated operation of plants are essential to ensure constant high product quality, ideal operation and maintenance conditions and efficient operation.

The control systems supplied by Tenova LOI Thermprocess include all the hardware and software required from switchgear through to supervisory control systems. Our control systems are based on a modern application development system designed for the latest Windows operating systems. Mobile versions are also available for smartphones and tablets.





CONTROL

The user-friendly plant visualization system ensures that users always have a clear, up-to-date view of the process and the status of plant components. Plant automation include closed-loop and open-loop control, as well as charge generation, charging, tracking and reporting.

PLANT ANALYSIS

The fully automated plant control system provides functions not only including the closed-loop and open-loop control of the process but also the automatic analysis of plant components and information for preventive maintenance. Standardized software modules enable remote diagnosis by our specialists and allow us to provide remote support and accesses.

Level 0: Instrumentation

- Planning and design of plant systems (process systems, quench and transport systems)
- Preparation of specifications
- Preparation of P + I diagrams
- Motor and component list
- SLD safety logic diagram
- Innovative development work with leading process system producers
- Member of DIN-EN 746-2 standardization committee

Level 1: PLC & HMI Control

- Planning and design of plant systems (process systems, quench and transport systems)
- Use of LOI standard function library
- Programming languages FUP, SCL, S7-Graph, AWL
- Simulation of plants prior to commissioning, e.g. using S7-PLCSIM

Level 2

DMC (data management computer)

- Job planning
- Heat treatment history
- Recipe management
- Certified recipe issue (audit)
- Level 3 TCP/IP/database interface

Tenova LOI Thermprocess 4.0 offers:

- Production data exchange with higher-level ERP/MES systems
- Production data logging and analysis at all times during and after the process
- Process and throughput optimization
- Alarm management via app/email/text message
- Mobile entry of production and measured data

AMS 2750 E/CQI-9 goes mobile

Heat treatment plants for automobile or aircraft components must be continuously audited according to the applicable standards. These standards are mostly related to instrumentation that demonstrates system accuracy and temperature uniformity. In order to ensure continuous AMS 2750 E/CQI-9 auditing holistically and without major bureaucracy, Tenova LOI Thermprocess has developed an all-in-one software solution. This allows the audit procedure to be completed directly and paperlessly at the plant using a mobile panel or tablet. Thanks to the instrumentation provided by Tenova LOI Thermprocess, the audit can be carried out and reported by only one auditor without additional personnel during production.

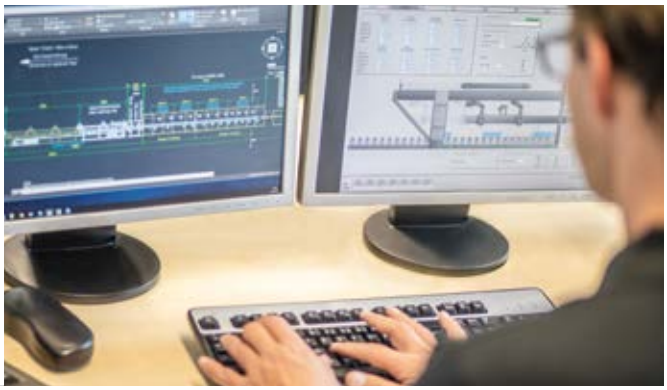
OUR HIGHLIGHTS... YOUR ADVANTAGES:

- Auditing of SAT check possible on regular working days during production
- Paperless AMS 2750 E/CQI-9 documentation
- Convenient mobile touch panel or tablet for in field entry of measurement and verification data
- Convenient PC-based audit management and reporting
- Easy scheduling of audit procedures
- Plant-specific parameters
- Convenient management of thermocouple data (e.g. type, supplier, interpolation values…)
- Convenient management of measuring instrument data (e.g. type, supplier, calibration values…)
- SAT report (System Accuracy Test)
- TUS analysis (Temperature Uniformity Survey) and report
- Direct application of logger result data to TUS procedure

Tenova LOI Thermprocess supplies intensive consulting and operation support for the implementation and execution of customer audit procedures.

RETROFITTING AND MODERNIZATION

With almost 400 Roller Hearth Furnace plants constructed throughout the world, Tenova LOI Thermprocess is one of the market leaders for heat treatment plans for the tube industry. Thanks to our highly qualified, experienced personnel, we cannot only offer new plants but also optimum solutions for the retrofitting and optimization of existing plants.



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 and 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.

Modernization of heating systems

HIGH CAPACITY INCREASE THROUGH MODERNIZATION OF HEATING SYSTEMS

Modern high-performance recuperative burner systems in ceramic radiant tubes improve plant efficiency at the same time as reducing pollutant emissions. The possible performance improvements can be illustrated most effectively by reference to specific projects. The photographs show the modernization of the heating systems installed on an existing Roller Hearth Furnace for the heat treatment of steel tubes. In the first stage of the project, it was already possible to boost annealing capacity by a factor of 2.5. In the second stage, capacity was boosted threefold, to as much as 6,000 kg /h.

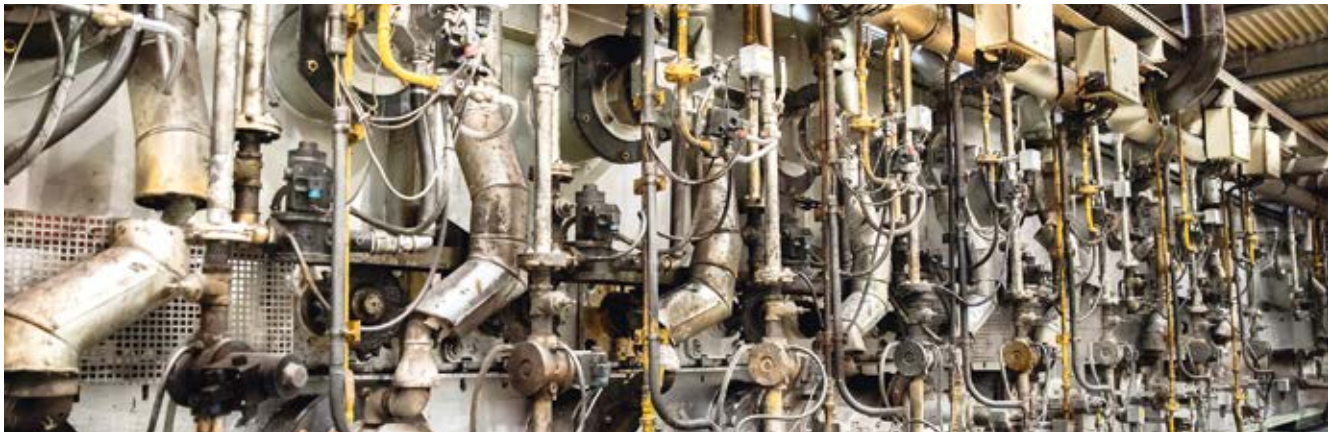
HIGH EFFICIENCY IMPROVEMENT THROUGH MODERNIZATION OF COOLING SECTIONS

Heat losses can be reduced by using microporous insulation materials to replace refractory materials. In addition, heat can be recovered by installing new high-temperature and low-temperature cooling section segments, further optimizing the energy consumption of the entire plant.

SHORT DOWNTIMES

Normally, it is only necessary to shut an existing plant down for between one and two months for the installation of new assemblies.

▼ Modernization of the heating system of a Roller Hearth Furnace



SERVICE AND SPARE PARTS

Services backed by the expertise developed by Tenova LOI Thermprocess are available to our customers at all times and places. The world-wide presence of Tenova offers our customers direct access to our maintenance and modernization specialists.

SERVICES

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

SPARE PARTS

The right spare parts can be supplied within the shortest time (e.g. 24 h). On request, a web-based catalog for new and old equipment can be created, which facilitates the identification of spare parts and simplifies procurement considerably.

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.

MODEM AND TELEPHONE SERVICE

Control systems and connected plants can also be inspected online by remote diagnosis.

RETROFIT AND MODERNIZATION

Our specialized service solutions allow customers to operate at the highest possible productivity and efficiency levels at the same time as focusing on safety and sustainable development.

CONSULTANCY

Our process engineers and our commissioning and control systems specialists are available to provide advice to customers either on-site or via remote diagnosis.

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