

# Aluminium Thermal Processes

For optimized material properties

## 铝的热处理技术

用于提高材料性能



## TENOVA LOI THERMPROCESS

Tenova LOI Thermprocess is one of the leading companies in supplying industrial furnace systems for the heat treatment 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.

Being a driver in the transformation of the metals industry towards decarbonization and sustainability, we implement proven process solutions and focus on the development and implementation of fossil-free melting and annealing processes under usage of electrical heating or Hydrogen combustion.

Tenova LOI Thermprocess is a trademark of Tenova and LOI was identified as China well known trademark.

## 特诺恩-洛伊热工工程

特诺恩-洛伊热工工程有限公司（Tenova LOI Thermprocess）是一家为金属热处理提供工业炉系统解决方案的龙头企业。基于百年历史，数以千计的业绩，其技术能力赢得了来自钢铁、铝和汽车行业全球客户的信赖。

作为金属行业向减碳和可持续发展转型的推动者，我们提供经验证的工艺解决方案，并专注于在使用电加热或氢气燃烧的情况下开发和实施无化石燃料熔化和退火工艺。

特诺恩-洛伊热工工程（Tenova LOI Thermprocess）是特诺恩的注册商标。其中洛伊（LOI）荣膺中国驰名商标。



# Tenova companies for thermal processes and systems for Aluminium:

特诺恩集团的公司能够为铝行业提供的热工技术及设备：



Melting / casting /  
recycling plants  
熔化/铸造/废铝回收重熔设备



Heat treatment plants  
热处理设备



Strip processing lines  
带材处理线  
(汽车板/航空板连退线/化学线)



Energy recovery  
technologies  
热能回收利用技术



Roll grinding equipment  
轧辊磨床



# ALUMINIUM – LIGHT-WEIGHT, 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.

## 铝 — 轻量化、创新、可完全回收

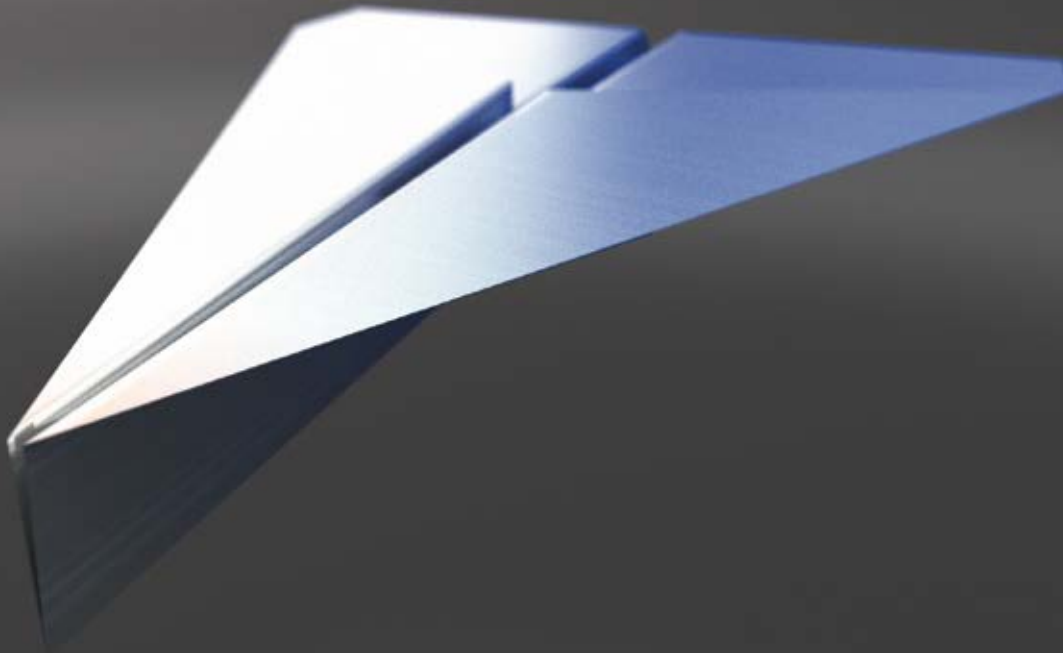
由于铝的独特属性及使用过的铝件具有最佳的再回收性，在汽车行业、机械工程及航空工业，铝以其所具备的许多面向未来的解决方案，已经成为最受欢迎的替代材料。

### 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

### 铝

- 低密度
- 良好的抗腐蚀性
- 高导电和导热性
- 高稳定性
- 良好的成形性
- 优良的反光性
- 表面处理的众多可能性
- 不受限制、不影响质量的再回收利用性



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# ALUMINIUM MELTING AND CASTING FURNACE PLANTS

Aluminium melting and casting furnaces are used to melt block metal and clean scrap and to cast the liquid metal in casting plants. The furnaces are either stationary or tiltable; they can be equipped with special charging machines and be adjusted to individual production conditions.

## 铝的熔化炉和铸造炉设备

铝的熔化炉和铸造炉设备用于熔化铝的块料及干净的废料并用铸造机将铝液铸成铝锭。炉子可以是固定的也可以是可倾的。可以配备专用的上料机并可根据不同的生产条件进行调整。





## MELTING AND CASTING PLANTS

The melting and casting furnaces of Tenova LOI Thermprocess can be either tiltable or stationary. They are heated with gas or hydrogen burners. The energy consumption is reduced due to regenerative heat recovery and furnace pressure control. A fully automatic control system ensures the constant quality of the melt; an optimal process control contributes to reduced metal loss. The today's optimized furnace plants result from the know-how of design and process technology which was gathered in decades of practical experience.

The **al-loi** melting and casting plants distinguish themselves with

- high energy density
- uniform heating of melting bath
- metal circulation for melt homogenization
- purging gas treatment in the furnace
- reduced hydrogen absorption
- charging machines for optimized production process
- melting aggregates for chips

Aiming at reduced energy consumption and metal loss, the individual burner control takes care of uniform and optimal combustion conditions. Burner regenerators (BCR) or a central regenerator (CCR) can be used for the regenerative heat recovery.

The **al-loi** heating technology offers

- gas heating
- hydrogen heating
- regenerative heat recovery
- central regenerator CCR
- low oxygen furnace atmosphere
- low noxious emission

## 熔铸设备

特诺恩-洛伊热工工程的熔化和铸造炉可以是可倾式的也可能是固定式的，燃气或氢气加热。由于使用蓄热式换热器及炉压控制，炉子的能耗非常低。全自动控制系统保证了稳定的熔化质量，最佳的工艺控制降低了金属的烧损。该优化的炉子设备是从数十年实践经验中积累的设计和工艺技术诀窍发展的成果。

**al-loi** 铝熔铸设备的特点：

- 高能量密度
- 熔池加热均匀
- 铝液循环，熔化均匀
- 在炉内进行有害气体净化处理
- 减少吸氢
- 配备可优化生产工艺的上料机
- 碎料的熔化系统

为降低能耗并减少金属烧损，使用烧嘴独立控制使之处于最佳燃烧条件并均匀加热。烧嘴的蓄热器（BCR）或中央式蓄热器（CCR）进行蓄热式换热。

**al-loi** 加热技术：

- 燃气加热
- 氢气加热
- 蓄热式换热器
- 中央蓄热式换热器CCR
- 低氧炉子气氛
- 低排放

## ADVANTAGES OF CENTRAL REGENERATOR CCR | 中央蓄热式换热器CCR 的优点

- rapid cooling of combustion gas
- high air pre-heating temperature
- uniform heat recovery in a wide performance range
- only one waste gas opening at the furnace
- continuously burning flames
- no switch-over between burners
- optimal pre-conditions for meeting future emission requirements
- easy and quick maintenance

- 烟气急冷
- 助燃空气预热温度高
- 在较宽范围内均匀的热交换
- 炉子只有一个废气出口
- 连续的燃烧火焰
- 无烧嘴切换
- 具备满足未来排放要求的最佳先决条件
- 维护简便快捷

Waste gas heat recovery by use of central regenerator CCR ►  
使用中央蓄热式换热器CCR对废气进行余热利用



## MELTING FURNACES

As the melting furnaces are used for melting block metal or clean scrap, they are equipped with a large charging and cleaning door.

- melting of block metal
- melt treatment in the furnace
- regenerative heating
- metal circulation by use of a stirrer or pump
- charging machines for block metal and scrap
- large furnace doors
- flat inner walls for easy cleaning
- tiltable or stationary
- fully automatic furnace control
- low metal loss

### Lower CO<sub>2</sub> emissions

- high heat recovery
- low energy consumption
- reduced noxious emission

### High availability

- solid and robust design
- reliable components
- know-how gathered in decades of practical experience
- low maintenance required
- easy operation

▼ Melting furnaces MCF with a bath capacity of 55 t each

55t熔池容量的熔化炉MCF

## 熔化炉

熔化炉用于熔化块料或干净的废料，炉子有一个非常大的上料和清理用炉门。

- 熔化块料
- 在炉内进行熔化处理
- 蓄热式加热
- 使用搅拌器或泵进行铝液循环
- 用于块料或废料的上料机
- 大尺寸炉门
- 便于清理的平坦内墙
- 可倾式或固定式
- 全自动炉子控制系统
- 金属烧损低

## PLANT DATA | 设备参数

Final products   最终产品	rolling ingots   轧制锭 extrusion billets   挤压锭 pigs   重熔铝锭
Furnace capacity   炉子能力	35 – 140 t
Heating system   加热系统	regenerative burners BCR 蓄热式烧嘴BCR central regenerator CCR 中央蓄热式换热器CCR
Fuel   燃料	natural gas   天然气 hydrogen   氢气
Metal circulation   铝液循环	pump   泵 stirrer   搅拌器
Charging material   炉料	electrolysis metal   电解铝液 block metal   块料 scrap   废料
Melting rate   熔化率	5 – 25 t/h
Melt treatment   熔化处理	rotary gas injector   旋转式气体喷射器
Metal temperature   熔化温度	700 – 780 °C

低CO<sub>2</sub>排放

- 热回收率高
- 低能耗
- 低排放

实用性强

- 坚固耐用的设计
- 可靠的组件
- 数十年实践经验中积累的技术诀窍
- 低维护需求
- 生产操作简单





## 铸造炉

铸造炉用作保温炉，为铸造机提供铝液。液压倾动设计是这种炉子设备的典型特点，能以可控的方式将铝液注入铸造系统。在炉子相同水平，通过铰链式连接流槽将铝液从炉子传输到铸造设备。

### 特点

- 熔化处理
- 冷空气或蓄热式烧嘴加热
- 大尺寸炉门

- 易清洁的平坦内墙
- 可倾式
- 全自动炉子控制系统
- 能耗低

### 铝液质量高

- 铸造过程中温度均匀
- 低氢
- 流槽内液位精确控制
- 铸造过程中封闭的氧化膜
- 铝液流动顺畅

## PLANT DATA | 设备参数

Final products   最终产品	rolling ingots   轧制锭 extrusion billets   挤压锭 pigs   重熔铝锭
Furnace capacity   炉子能力	30 – 140 t
Heating system   加热系统	cold-air burners 冷空气烧嘴 regenerative burners BCR 蓄热式烧嘴BCR
Fuel   燃料	natural gas   天然气 hydrogen   氢气
Metal circulation   铝液循环	stirrer   搅拌器
Charging material   上料	liquid metal   铝液 alloy elements   中间合金
Melting rate   熔化率	2 – 5 t/h
Melt treatment   熔化处理	rotary gas injector   旋转式气体喷射器 porous plugs   多孔塞
Metal temperature   铝液温度	680 – 740 °C

## CASTING FURNACES

The casting furnaces are used as holding furnaces to provide the melt for the casting process. The hydraulically tiltable design is typical of these furnaces as it allows to smoothly feed a casting aggregate with the liquid metal in a controlled manner. The melt is transferred on the same level from the furnace into the casting equipment by means of a hinged launder.

### Particularities

- melt treatment
- cold air or regenerative heating
- large furnace door
- smooth inner walls for easy cleaning
- tiltable
- fully automatic furnace control
- low energy consumption

### High metal quality

- uniform temperature during casting
- low in hydrogen
- precise level control in the launder
- closed oxide skin during casting
- smooth metal flow

◀ Casting furnace CF to be fed with liquid aluminium, used for alloy up and for feeding casting plants. Bath capacity of 35 t, heated by natural gas.

接受熔化铝液的铸造炉CF，用于调整合金并为铸造机提供铝液。熔池容量35 t，天然气加热。



# ALUMINIUM RECYCLING

The TCF® process, developed by Tenova LOI Thermprocess is subject to continuous optimization. This process is applied for recycling aluminium scrap (returned from production) and scrap metal with sticking oil, grease, lacquer, plastic or thermal insulation layers (end of life). The combination of a Twin-Chamber Melting Furnace TCF® with a waste gas purification plant is a reasonable solution for aluminium recycling in ecological and economic terms.

## 废铝回收

特诺恩-洛伊热工工程开发的TCF®技术一直在不断地优化。该技术应用于废铝（生产返还料）及带有残油、油脂、油漆、塑料或隔热材料（报废产品）的回收。双室熔化炉TCF®与废气净化设备的结合使废铝回收从生态和经济方面都已成为一个可行的方案。





### TCF® TECHNOLOGY

- recycling of scrap with contamination
- chip recycling
- no scrap pre-treatment is required
- scrap pre-heating in reducing furnace atmosphere
- melting in liquid metal bath
- oxygen-free scrap chamber prevents metal loss
- recycling without using salt
- optimized oxygen control in the heating chamber
- waste gas quenching for emission reduction

- homogenous melting bath due to continuous metal circulation
- low metal loss
- lowest energy consumption

### Favourable Environmental Compatibility

- The pyrolysis gas originating from the adhering substances is led into the reaction zone of the heating chamber.
- Emissions and energy consumption are reduced due to the use of the pyrolysis gas.

- Integrated in the furnace with a long holding time and high temperatures, the pyrolysis gas is safely and environment-friendly burnt.
- A rapid quenching (2,500 K/sec) of the combustion gas avoids the re-combination of dioxins.
- Due to the regenerative heating system including CCR the combustion air pre-heating is increased; the energy consumption is reduced simultaneously.

### TCF® 技术

- 污染废铝的回收
- 碎料的回收
- 废铝不需要预处理
- 废铝在炉内还原气氛下预热
- 在熔池熔化
- 废料室无氧，避免了金属烧损
- 无盐的废铝回收
- 加热室最佳的氧含量控制
- 废气急冷，减少排放

- 连续铝液循环，熔池内熔化均匀
- 烧损低
- 能耗最低

### 环保

- 附着物的热分解气被导入加热室的反应区
- 热分解气的燃烧减少了排放，也降低了能耗

- 利用炉内高温和长时间的保温，确保热分解气安全并环保地烧掉
- 烟气急冷 (2,500 K/sec) 避免了二噁英的重新合成
- 蓄热式加热系统包括CCR换热器，使助燃空气预热温度提高，同时降低了能耗

▼ Left-hand side: Tilttable Recycling Plant TCF®  
Right-hand side: Recycling Plant TCF®

左图：可倾式废铝回收设备TCF®  
右图：废铝回收设备TCF®





## TWIN-CHAMBER MELTING FURNACE TCF®

The Twin-Chamber Melting Furnace TCF® comprises a furnace casing with two furnace chambers. While their atmospheres are separated, the two chambers dispose of a common melting bath. First, the scrap is placed and pre-heated on the dry hearth of the scrap chamber; the contaminants are pyrolysed. In the next step, the scrap is pushed into the melting bath for being melted there.

## Twin-Chamber Melting Furnace TCF®

- separated atmospheres in scrap chamber and heating chamber
- scrap pre-heating on the dry hearth
- melting in liquid metal bath
- oxygen-free scrap chamber
- rapid oxygen reduction upon charging process
- oxygen control in the heating chamber

- waste gas quenching by use of the central regenerator CCR
- lowest energy consumption
- charging machine with hood
- automatic chip charging

## CHIP CHARGING

The melting aggregate is automatically and continuously fed with chips from a hopper. As the central automatic process control system is responsible for control and monitoring, optimal charging is ensured.

## 双室熔化炉TCF®

双室熔化炉TCF®由2个炉室，1个炉壳构成。2个炉室的气氛是隔开的，而熔池是相通的。首先将废料放在废料室干燥的炉桥上并预热，使污染物热分解，下一步是将废料推入熔池并在熔池中熔化。

## 双室熔化炉TCF®

- 废料室和加热室的气氛是隔开的
- 废料在干燥的炉桥上预热
- 在熔池内熔化
- 废料室无氧
- 上料带入的氧可迅速减少
- 控制加热室氧含量
- 使用中央蓄热式换热器CCR将烟气急冷

- 能耗最低
- 上料机带烟罩
- 碎料自动上料

## 碎料上料

上料斗自动并连续不断地向熔化系统进料，中央自动化工艺控制系统进行控制和监控以确保优化上料。

▼ Twin-Chamber Melting Furnace (TCF®) for salt-free melting of aluminium scrap with sticking material  
双室熔化炉TCF®—用于带附着物废铝的无盐熔化



### USE OF BLOCK METAL

Having reached the heating chamber, the block metal is first placed on the dry hearth of the heating chamber for being pre-heated and dried.

### USE OF LIQUID METAL

For the purpose of alloy adjustment liquid metal can be used in the furnace and will be inserted via a liquid metal inlet pocket.

### DISCHARGE OF LIQUID METAL

The molten metal can be discharged from the furnace via tap cones or a pump and will be forwarded to a downstream aggregate (e.g. a casting furnace).

### 块料的使用

块料在加热室上料时，首先放在加热室干燥的炉床上进行预热和干燥。

### 铝液的注入

通过受液口注入，用于调整炉内铝液的合金成分。

### 铝液的排放

熔化的铝液可通过出液口或泵排放到下游设备（如：铸造炉）

### TYPICAL PLANT DATA | 典型设备参数

	TCF75	TCF90	TCF120
Final products 最终产品	rolling ingots – extrusion billets – pigs 轧制锭—挤压锭—重熔铝锭		
Bath content 熔池容量	75 t	90 t	120 t
Remaining liquid metal 剩余铝液	approx. 40 t 大约40 t	approx. 45 t 大约45 t	approx. 50 t 大约50 t
Heating system 加热系统	CCR/BCR	CCR	CCR
Air pre-heating 助燃空气预热	950 °C	950 °C	950 °C
Fuel 燃料	natural gas 天然气	natural gas 天然气	natural gas 天然气
Metal circulation 铝液循环	electro-magnetic/ mechanical 电磁/机械	electromagnetic 电磁	electromagnetic 电磁
Charging material 入炉炉料	contaminated scrap – block metal 污染废料—块料		
Charge per charging process 每次上料量	2.5 – 3 t	3 – 5 t	4 – 5 t
Chip charging 碎料上料	up to 2 t/h 至2 t/h	up to 4 t/h 至4 t/h	up to 6 t/h 至6 t/h
Production rate 生产率	80 t/d	160 t/d	210 t/d
Casting temperature 浇铸温度	680 – 760 °C	720 – 760 °C	720 – 780 °C



◀ Twin-Chamber Melting Furnace TCF® with automatic charging device CM  
带有自动上料机CM的双室熔化炉TCF®

▼ The CW (Charge-Well) aggregate allows the feeding of chips and small-sized scrap into the metal flow of the bath circulation, which reduces the metal loss due to oxidation.

上料井（CW）系统用于将碎料及小尺寸废料加入到循环流动的熔池铝液中，从而减少由氧化产生的金属烧损。





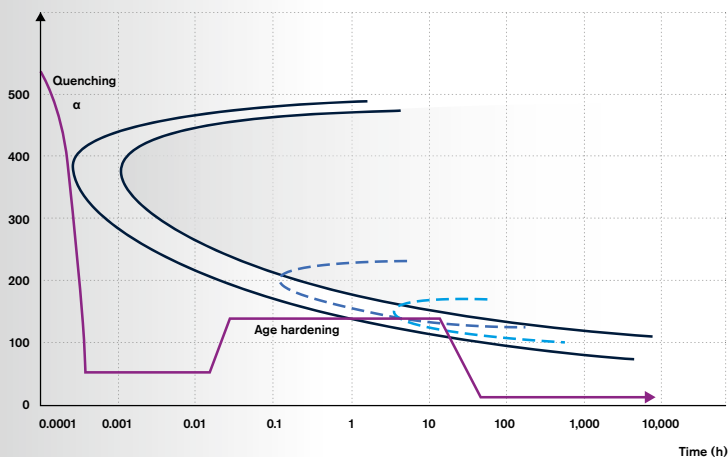
# ALUMINIUM HEAT TREATMENT

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.

## 铝件的热处理

为达到所要求的材料性能，铝件在铸造前已进行合金化。按照结构件的合金成分、几何形状及所需要的特性，对其进行特定的热处理包括固溶退火、淬火和时效，以获得最终性能。

### al-loi PROCESS TECHNOLOGIES FOR ALUMINIUM | 铝件的al-loi工艺技术



**al-loiH** Heat treatment technologies for aluminium  
用于铝件的热处理技术

**al-loiQ** Quenching technologies for aluminium  
用于铝件的淬火技术

**al-loiQ W** Water | 水

**al-loiQ P** Polymer | 淬火液

**al-loiQ A** Air | 空气

#### al-loi Process development

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

#### al-loi 工艺技术的开发

- 物理试验得出初始系列参数
- 工艺配方参数的工艺开发与优化
- 数学模型的支持
- 调试和试生产期间更多细节的确定

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





## HEATING PROCESSES **al-loiH**

The heating processes for aluminium structural parts include solution annealing and age hardening.

The strength of the parts is reached during the age hardening process at an increased temperature. 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 final strength.

## 加热工艺 **al-loiH**

铝结构件的加热工艺包括固溶退火和时效硬化。

零件强度是在较高温度的时效硬化过程中达到的。时效工艺需要非常精确并可重复的温度控制，因为即使有很小的设定温度波动也会对最终的零件强度产生影响。

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

## QUENCHING PROCESSES **AL-LOIQ**

A high strength in the structural component is ensured thanks to the homogenous 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 homogenous manner.

可靠的**al-loiH** 工艺可以使零件得到最佳的处理并将变形和残余应力降至最低。

## 淬火工艺 **al-loiQ**

只有在固溶退火时获得均匀分布的合金元素，才能保证结构件的高强度。为避免结构件变形从而产生影响结构件寿命的残余应力，需要以极其均匀的方式对这些零件进行淬火。

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

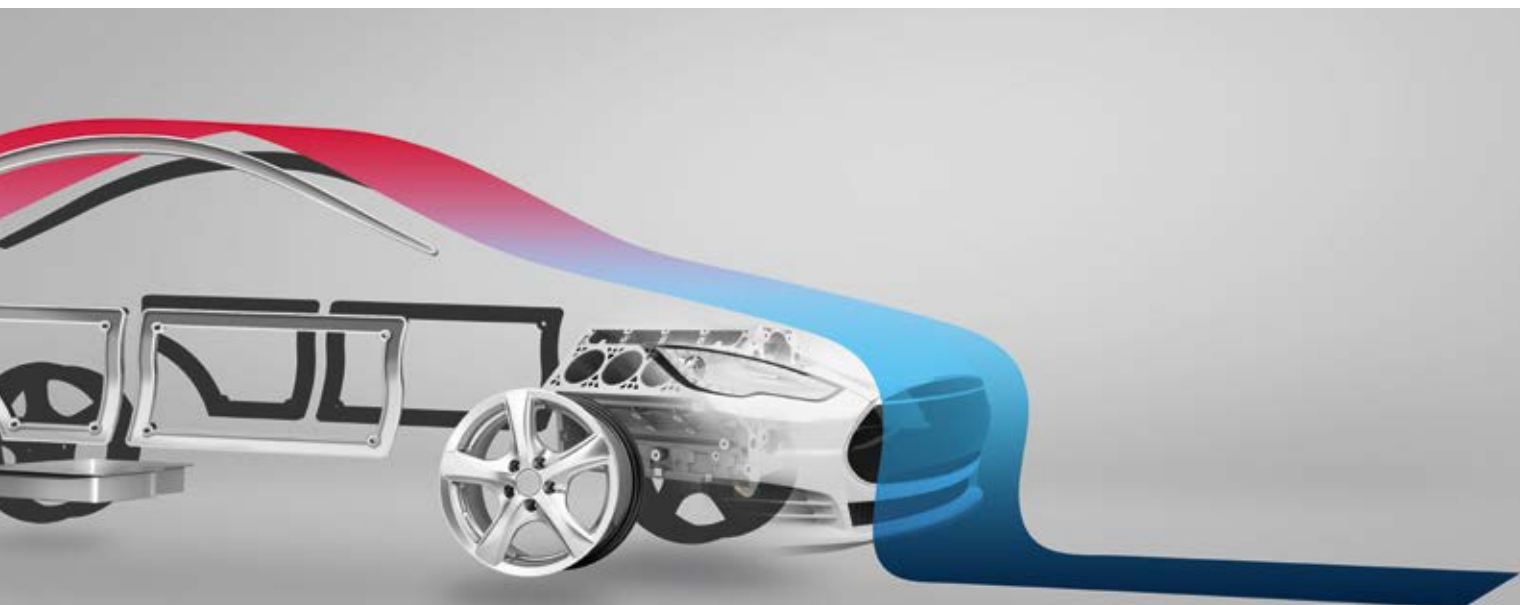
**al-loiQ P**, using polymer, offers a more abrupt quenching which is applied particularly to components with thicker walls. It ensures low warping and residual tension of the components.

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

**al-loiQ A** 使用均匀、高流速空气对零件进行快速和均匀的淬火。

**al-loiQ P**, 使用淬火液达到更快速度的淬火，特别用于厚壁零件，变形小且残余应力小。

**al-loiQ W**, 使用水对零件进行更快速但均匀的淬火。由于物理原因，这种工艺会形成较高的残余应力。



# 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.

## 汽车行业的铸铝件

汽车要轻量化，就要使用更多的铝制零件。由于汽车零件对安全性至关重要，其性能必须完全符合要求。航空零件也是如此。



## 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

**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.

## 汽车铸件

汽车工业的铝合金铸件包括：

- 气缸头
- 发动机壳体
- 底盘
- 牵引杆和横向控制臂
- 铸造转向器
- 轿车车轮

**al-loi** 热处理设备的特点：

- 可靠的质量可重复性
- 材料可回收使用
- 工艺灵活性高
- 特殊热处理仅需很少的调整
- 适应小批量处理
- 低能耗

## TYPICAL PLANT DATA | 设备参数

	Overhead furnace line 高架式炉子生产线 OAL	Chamber furnace line 室式炉生产线 BHL
Products 产品	castings   铸件 forgings   锻件	
Part size 工件尺寸	up to 8,000 mm 最大至 8,000 mm	up to 4,000 mm 最大至 4,000 mm
Charge weight 装料重量	500 – 6,000 kg	500 – 7,000 kg
Heating system 加热系统	direct or indirect heating with natural gas 天然气直接或间接加热 electrical heating 电加热	
Air circulation 空气循环	vertical   垂直 horizontal   水平	
Quenching media 淬火介质	water   水 polymer   淬火液 air   空气	water   水 polymer   淬火液 air   空气

## FLEX-设备

满足对工艺和设备的高要求, flex-p设备也适用于小批量全自动处理。

- ▼ Artificial ageing plant (overhead furnace line) with media quenching  
带介质淬火的时效设备（高架式炉子生产线）



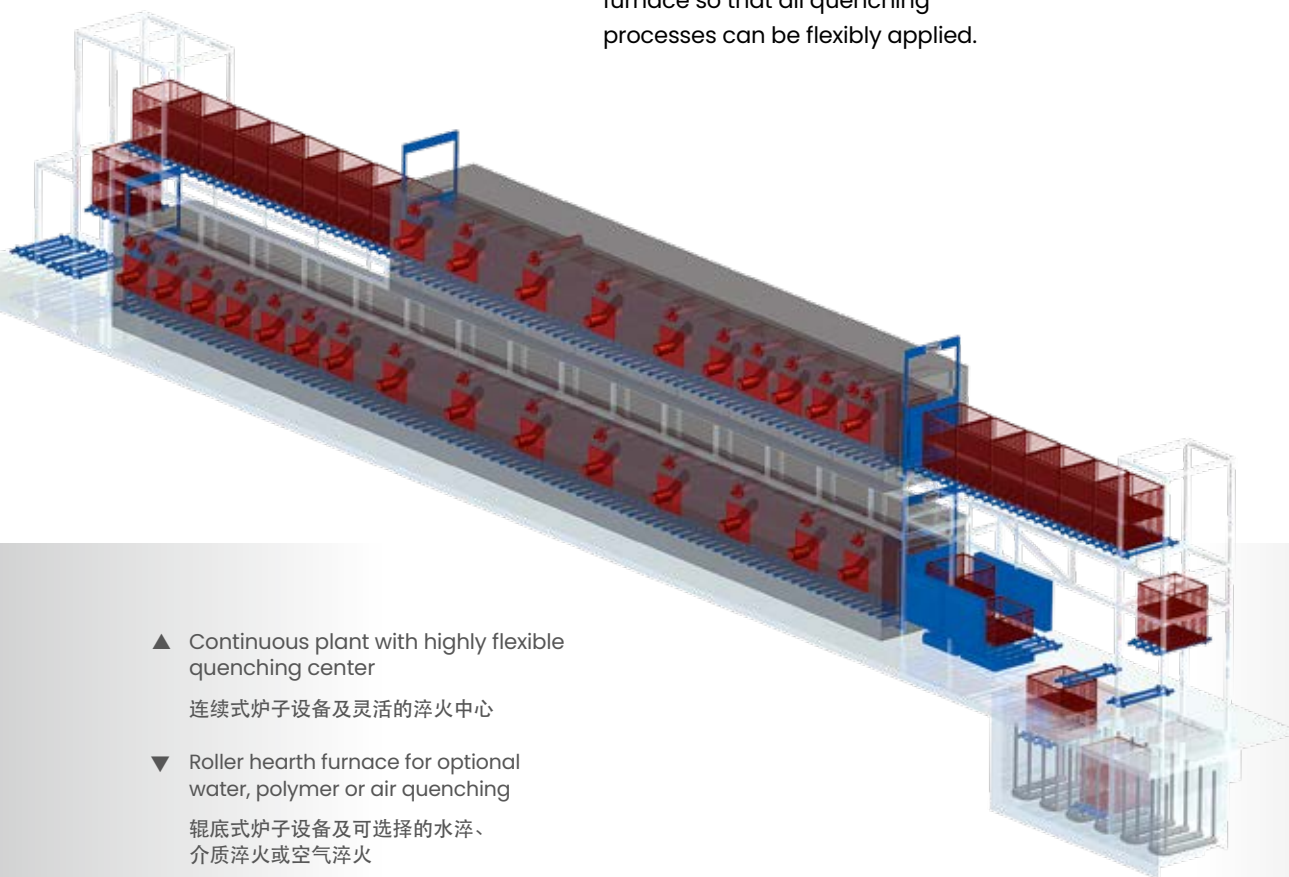


## CONTINUOUS PLANTS

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.

## 连续式生产设备

进行**al-loiH** 加热和 **al-loiQ** 淬火的大批量生产时要使用连续式设备。这种连续式设备可以将适用的淬火中心布置在固溶退火炉的下游，以便灵活运用各种淬火工艺。



- ▲ Continuous plant with highly flexible quenching center

连续式炉子设备及灵活的淬火中心

- ▼ Roller hearth furnace for optional water, polymer or air quenching

辊底式炉子设备及可选择的水淬、介质淬火或空气淬火







### 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.

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.

### 飞机零部件

飞机零部件的时效处理对设备设计和技术来说都是非常大的挑战。要满足产品的高质量要求，某些高精零部件要极快地浸入淬火介质，还必须有非常精确的温度控制及工艺控制。

**al-loiH**高架式炉生产线能够可靠、稳定地达到 $\pm 3\text{ K}$ 的温度精度及 $< 7\text{ s}$ 的淬火转移时间，并具有很好的可重复性。该炉子设备符合最新版 AMS 标准。

- ▼ Quenching station, optional for air, polymer or water  
淬火站，可选择空气淬火，淬火液淬火或水淬。



# ALUMINIUM AUTOMOTIVE – FORGINGS

Aluminium forgings are used for highly stressed applications which require meticulous, individual heat treatment including solution annealing, quenching and age hardening.

## 汽车铝锻件

应用在高强度条件下的汽车铝锻件需要进行精细的、有针对性的热处理，包括固溶退火、淬火和时效硬化。

### CONTINUOUS FURNACE CCF | 连续式炉CCF

Products   产品	forgings   锻件
Part size   零件尺寸	up to 650 mm   至650 mm
Throughput   产量	4,000 kg/h
Heating system   加热系统	direct or indirect heating with natural gas 天然气直接或间接加热 electrical heating   电加热
Air circulation   空气循环	vertical   垂直 horizontal   水平
Quenching media   淬火介质	water   水



## 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.

## CHAIN CONVEYOR FURNACES CCF

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 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 quench delay.

## 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.

## 用于锻件热处理的连续炉

连续式炉子设备能够对工艺进行连续控制，对大批量汽车零部件的生产提供最佳处理条件。

## 链传输式炉CCF

可从各个方向对工件各面进行加热，传输平稳。这种炉型适用于敏感工件的热处理。

机械手负责上料、从固溶退火炉出料、并且浸入淬火槽淬火。

## 高架式炉OAL

在高架式炉内，锻件置于料架内，以最佳方式淬火以获得最短的淬火转移时间。

## 炉料跟踪

在所有特诺恩-洛伊热工工程的炉子设备上都装备有包括批料和单个炉料的自动跟踪系统。设备可按照现行的AMS2750或CQI9标准配备。

## FURNACE PLANT DESIGNS FOR FORGINGS | 锻件热处理炉的设计

### 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

### 链输送式炉CCF

- 炉子与自动生产线完全集成在一起
- 数个锻件同时上料
- 炉料准确并连续地通过热处理炉，不需要料筐或料架
- 自动上下料

### 悬挂输送式炉 OCF

- 设计紧凑，待处理件布置在多层料架上
- 配备炉外传输装置，工件水平布放，加热均匀，即：低变形热处理
- 自动上下料

### 高架式炉 OAL

- 灵活的设备概念
- 适于小批量热处理
- 淬火灵活性高
- 热处理全自动化

▼ Multi-lane chain conveyor furnace including single-part quenching facility | 多道链传输式炉，包括单件淬火设备

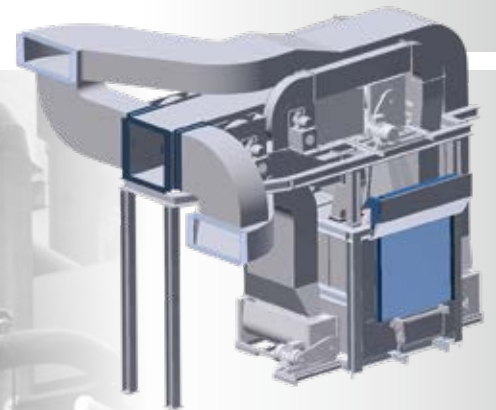


# ALUMINIUM AUTOMOTIVE STRUCTURAL COMPONENTS

## 汽车铝结构件

The heat treatment of structural components for the automotive industry typically aims at achieving the state T5, T6 and T7.

汽车结构件典型的热处理目的是获得T5, T6 和T7状态。



▲ Air quenching chamber for structural components  
结构件的气淬室



**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 design or a piston flow for the quenching of complete rack piles.

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.

**al-loiH** 加热和 **al-loiQ** 淬火是达到汽车结构件热处理要求的设备必须的基础。**al-loiQ A** 气淬可实行设计定制，也可对整个料架进行淬火。

目前使用**al-loiQ A** 气淬工艺淬火，未来**al-loiQ P** 淬火液淬火工艺将是结构件的可选方案。

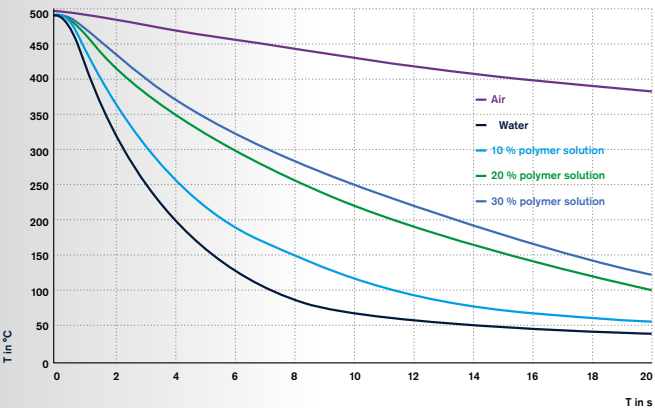
TYPICAL PLANT DATA | 典型设备参数

Continuous furnace RCF 连续炉RCF	
Products 产品	structural components 结构件 pressure die casting 压铸件
Heating system 加热系统	direct or indirect heating with natural gas 天然气直接或间接加热 electrical heating 电加热
Air circulation 空气循环	nozzle field 喷嘴区域 vertical 垂直 horizontal 水平
Quenching medium 淬火介质	air 空气
Quenching speed 淬火速率	6 K/s
Temperatures 温度	420 – 520 °C 150 – 250 °C

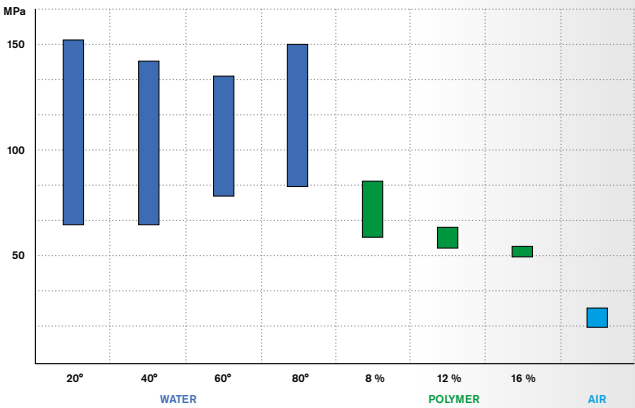


▲ Air quenching chamber for structural components  
结构件的气淬室

QUENCHING | 淬火



▲ Cooling curves for different quenching media  
不同淬火介质的冷却曲线



▲ Residual stress after quenching in water, polymer and air  
水淬、淬火液淬火和空气淬火后的残留应力

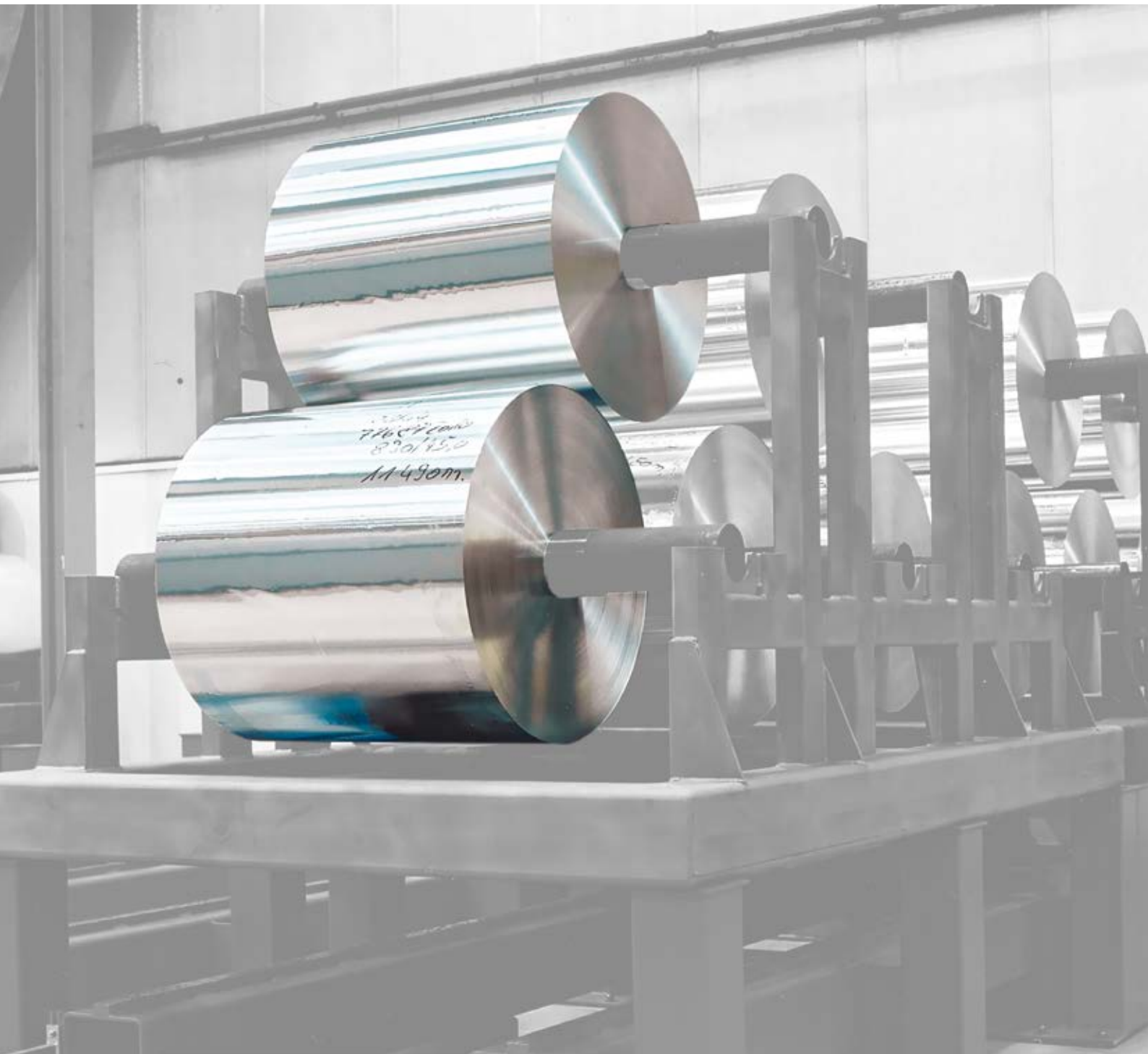


## ALUMINIUM HEAT TREATMENT ROLLING MILL

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.

## 轧制车间铝产品的热处理

铝带需要在轧制后退火以便进一步成型。软化退火可以降低轧制工艺产生的应变硬化。该软化退火是对带卷进行处理。



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  
charging is executed by a charging  
machine which transversely travels

to the individual furnace chambers.  
Every individual heat treatment is  
assigned to the respective, individual  
charge, registered and documented.

多室式炉设备FAL

特诺恩-洛伊热工工程的铝箔退火炉FAL  
包括最多五个单独的炉室，

这些炉室可以独立运行。通过各炉室前  
横向移动的上料机上料。

每一批零件都会有其相应的、针对性的  
热处理并记录、生成文档。

TYPICAL PLANT DATA | 典型设备参数

	Foil annealing furnace plant FAL 铝箔退火炉设备FAL
Products   产品	foil rolls   铝箔卷
Alloy   合金	pure aluminium   纯铝 aluminium alloys   铝合金
Foil thickness   铝箔厚度	6 – 200 µm
Coil diameter   箔卷直径	1,250 mm
Coil width   箔卷宽度	1,600 mm
Charge weight   箔卷重量	30,000 kg
Heating system   加热系统	indirect heating with natural gas 天然气间接加热 electrical heating 电加热
Air circulation   空气循环	vertical   垂直
Heat recovery   热回收	recuperative burners 自身预热烧嘴
Temperatures   温度	400 °C
Temperature tolerance   温度精度	< +/- 3K



▲ Multi-chamber annealing furnace  
plant for annealing of foil coils FAL.  
▼ 用于铝箔卷材退火的多室式退火炉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 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.

## 铝卷退火炉

在冷轧过程中要对铝带卷进行中间退火以达到软化和再结晶的目的。退火可以在单卷底升式炉SCL或多卷室式炉MCL中、在保护气氛下进行，以避免铝带表面氧化。

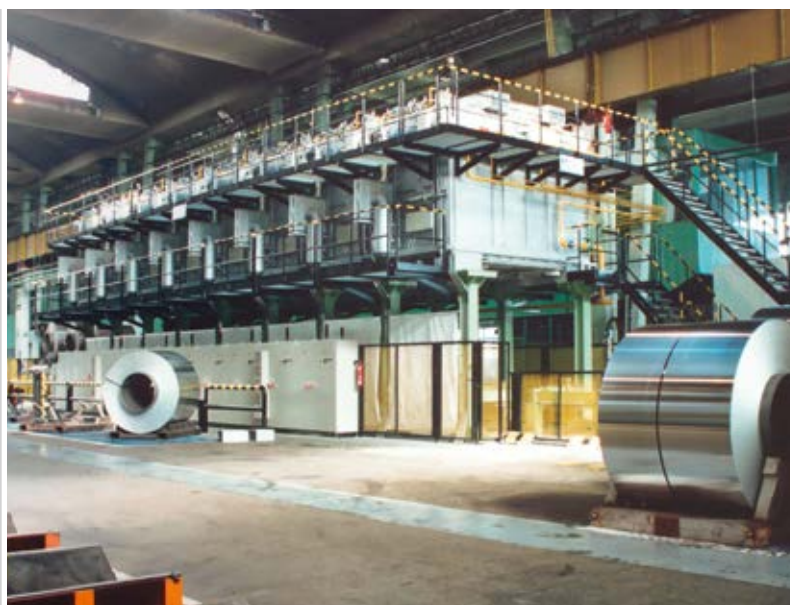
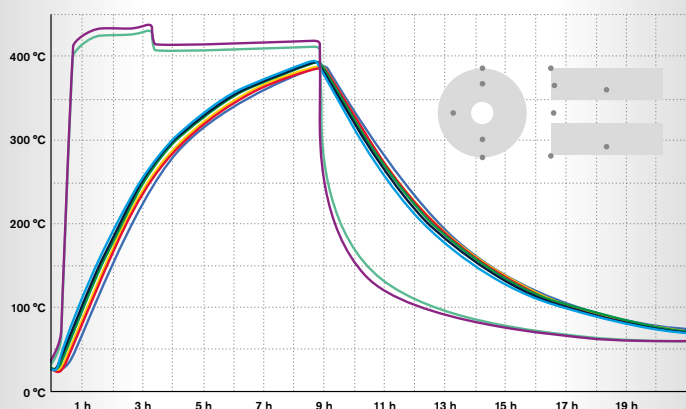
为将带卷均匀并快速地加热至所需温度，可将循环气氛喷射到铝带卷上。退火可去除轧制后铝带表面的残油。

MCL 和 SCL 两种炉型都可以在炉内-在保护气氛下-控制铝带冷却以避免氧化。

炉气定向通过旁路由热交换器冷却。

## 多卷室式炉MCL

多卷室式炉MCL用于相近带卷规格的大批量生产。每个带卷在单独控制的炉区内加热。





## SINGLE-COIL LIFTING HEARTH FURNACE SCL

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.

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 (option)
- 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

## 单卷底升式炉SCL

每台炉子只装一个带卷，相应的退火工艺配方储存在控制系统中并可随时调出及存档。

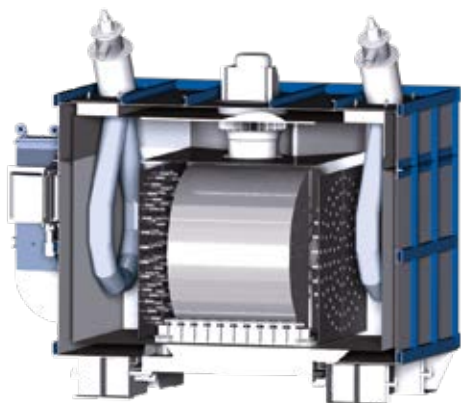
单卷退火炉SCL与MCL的特点：

- 最佳的温度均匀性
- 保护气氛下的退火和冷却工艺

- 炉子气氛在TNV进行后燃烧（选项）
- 能耗低
- 上下料全自动，操作简单
- 使用特诺恩-LOI热工工程的Delta-辐射管技术，效率高
- 工艺气氛成本低

此外，单卷底升式炉子生产线SCL还具有如下特点：

- 可快速调整生产，灵活性高
- 单个带卷独立退火
- 小批量生产效率高
- 炉子设备可与全自动高架库和平面存储设施衔接

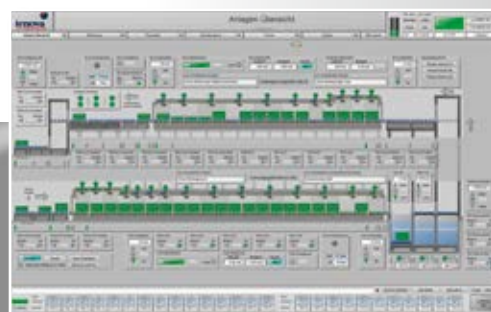


# ALUMINIUM AUTOMATION – SERVICE

Fully automatic processes are indispensable for achieving a high and consistent process quality as well as a reliable and economic series production.

## 自动化与服务

全自动化工艺是实现高品质和一致性的产品质量以及可靠和经济的系列生产不可缺少的。





## AUTOMATION

Taking care of the process and furnace plant control, the automatic control system provides the following:

- mathematical models of the processes for the furnace plant control
- recipe administration
- optimized furnace plant operation
- automation systems according to CQI9 HTSA and AMS2750
- result reproducibility
- process optimization

DMC (Data Management Computer)

- job planning
- job history
- recipe administration

- certified reports
- Level 3 data interface

The automatic data recording concerns the

- administration and analysis of sensors/actuators
- process analysis
- recording of operation times
- trend analysis
- signal monitoring and alarm activation

## PLANT ANALYSIS

The fully automatic furnace plant control does not only consist of the process control, but additionally of the automatic analysis of the plant

components and indications for preventive maintenance work.

The automatic intelligent data analysis for preventive maintenance work allows:

- anticipatory provision of spare parts
- saving of costs and shutdown times
- optimization of maintenance works
- optimized consumption and analysis
- maintenance assistance system
- proposal of preventive maintenance works
- protocols issued regarding maintenance works

## REMOTE DIAGNOSIS

Thanks to the remote diagnosis our specialists are available within short to support you throughout the world.

## 自动化

自动化控制系统负责工艺及炉子设备控制，具备以下特点：

- 具有炉子设备控制的工艺数学模型
- 工艺参数配方的管理
- 优化炉子设备操作
- 按照CQI9 HTSA 和 AMS2750标准配备的自动化系统
- 结果可重复性
- 工艺优化

数据管理计算机DMC

- 工作任务的计划
- 工作任务的历史

- 工艺参数配方的管理
- 认证报告
- 三级数据接口

自动化数据记录包括：

- 传感器/执行器的管理和分析
- 工艺分析
- 操作时间记录
- 趋势分析
- 信号监测及报警激活

## 设备分析

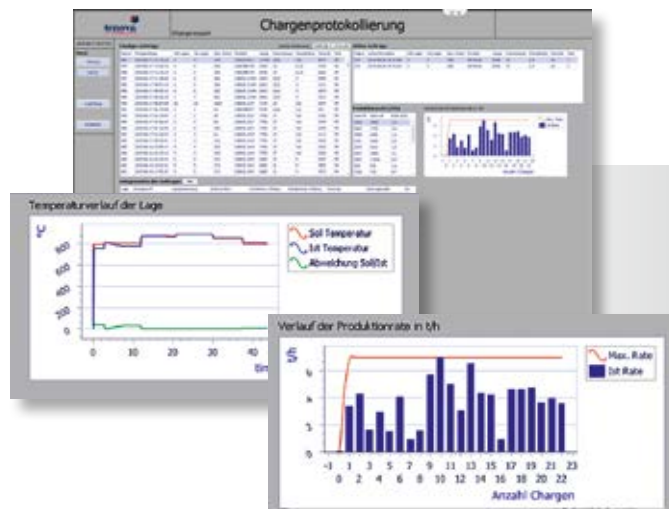
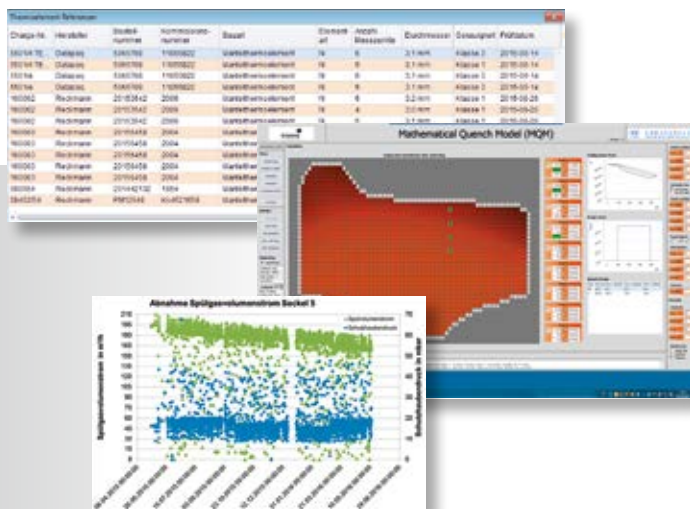
炉子设备的全自动控制不仅包括工艺控制，还有对设备零部件的自动分析并预先提示定期检修工作。

用于定期维护的智能自动化数据分析包括：

- 预设备件准备
- 节省成本，减少停机时间
- 优化维护工作
- 优化耗量并分析
- 维护帮助系统
- 预防性维护工作建议
- 维护报告

## 远程诊断

我们全球的专家能够快速地通过远程诊断提供技术支持





# ALUMINIUM SERVICE

## 服务

The worldwide representation of Tenova grants our customers a direct access to our specialists for maintenance and modernisation.

维护和升级改造: 通过特诺恩在世界各地的机构, 用户能够直接与技术专家取得联系



### DEVELOPMENT OF NEW PROCESSES RESP. OPTIMIZATION OF CURRENT PROCESSES

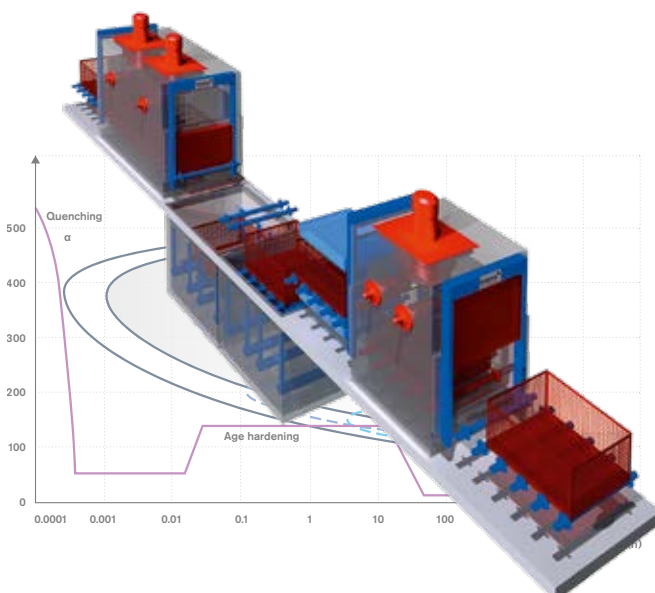
The services of LOI Thermprocess offer support in the development of new processes and in the optimization of current processes.

A small-series production plant, which can automatically heat-treat components under normal production conditions, is at our disposal for the creation and development of new recipes and processes.

### 新工艺的开发及对现有工艺 技术的优化

特诺恩-洛伊热工工程的服务包括对新工艺的开发及对现有工艺技术的优化。

我们正在开发一种能够在常规生产条件下对零件自动热处理的小型系列装备, 可用于新工艺及菜单的创新和开发。



**[service-loi@tenova.com](mailto:service-loi@tenova.com)**

100 % accessibility

100 % cost reliability

100 % planning security

0 % additional cost

**[service-loi@tenova.com](mailto:service-loi@tenova.com)**

100 % 可访问性

100 % 成本可靠性

100 % 规划安全性

0 % 附加费用

## SERVICE

Our service comprises the remote diagnosis by a specialist of Tenova LOI Thermprocess, a specialist's work on site at the plant and the repair, optimization and extension of furnace plants to adjust them to new process requirements or production capacities.

Thanks to regular software updates, the automation system always

disposes of the latest developments and information. This is applicable to the analysis algorithms and the process documentation.

Classical topics regarding furnace plant modernization are:

- increase of productivity
- increase of efficiency
- increase of operational safety
- software updates

- relocation service
- integration of other plants

Tenova LOI Thermprocess offers the external data storage, issue of charge protocols, continuous remote supervision of the furnace plant and analysis of sensor data during ongoing operation.

Our service activities can be combined to individual packages.

## 服务

我们的服务包括特诺恩-洛伊热工工程的专家与设备现场的技术专家进行的远程诊断, 包括对炉子设备进行修复、优化及根据新工艺或生产能力要求进行调整和扩展。

借助于常规软件升级, 自动化系统总是能够处理最新的开发和信息。这对分析运算和工艺文件也适用。

关于炉子设备现代化的典型主题:

- 提高生产率
- 提高效率
- 提高生产安全性
- 软件升级

- 搬迁服务
- 与其他设备集成

特诺恩-洛伊热工工程能够为炉子设备提供外部数据存储、出具炉料备忘、连续远程监控并在生产进行中对传感器数据进行分析。

我们的服务可以组成不同的套餐。

## INDUSTRY 4.0 | 工业4.0



### Digital Audit System

All-in-one software solution to cover the process of auditing heat treatment systems in a holistic way.

- Data input on the spot via a mobile Touch Panel
- Import of TUS-measuring data and their evaluation
- Permanent storage of measuring data
- Memory management for the next tests

As the Mobile Alarm-Management MAM can be implemented on various platforms, the alarms are available everywhere and at all times. As a consequence reaction times can be shortened.

### Tenova LOI Thermprocess 4.0 offers:

- production data exchange with superordinate ERP/MES systems
- production data recording and analysis at any time... during and after the process
- process and throughput optimization
- alarm management via App/e-mail/SMS
- mobile input of production or measuring data

### 数字审查系统

一体化软件解决方案, 全面覆盖热处理系统审查流程

- 通过移动触摸屏在现场输入数据
- 导入 TUS-测量参数及其评估
- 测量数据永久储存
- 用于下一个测试的记忆管理

因为可以在各种平台上安装“可移动通讯报警管理”, 所以在任何地方和时间都可以收到报警, 可以缩短反应时间。

### 特诺恩-洛伊热工工程 4.0 能够提供:

- 生产数据可以与上级 ERP/MES 系统交换
- 随时对生产数据进行记录和分析---生产期间或工艺之后
- 工艺和产量优化
- 通过App/e-mail/SMS管理报警
- 利用可移动通讯装置输入生产或测量参数





# Sustainable solutions for a green transition of metals

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