

Multi-Purpose Chamber Furnace Plant

The Universal Heat Treatment Plant



AICHELIN Multi-Purpose Chamber Furnace Plant

1. INTRODUCTION

Over the past few decades, AICHELIN Group has built far more than 1,000 protective gas chamber furnaces and put them into operation. The big majority of these plants is still operating smoothly to this day. This is impressive proof of the consistently high quality, reliability, and economic efficiency of these plants.

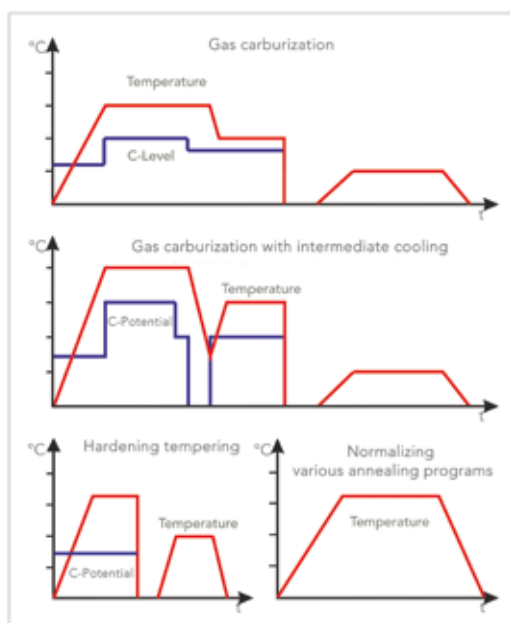
The fundamental importance of this type of furnace means that together with our customers, we constantly advance it and keep it at the state of the art. This led to the creation of three series, each optimally tailored to your needs:

STANDARD-LINE

The low-price series for superior components. Consult this publication for more information.

INDIVIDUAL-LINE

Powerful and affordable. For if the standard line does not meet 100% of your requirements. Find information on this here as well.



2. AREAS OF APPLICATION FOR CHAMBER FURNACES

Possible types of heat treatment

For example:

- Gas carburizing
 - with direct hardening
 - with intermediate cooling
 - with load cooling under protective gas atmosphere
- Recarburizing
- Carbonitriding
- NITROC® Nitrocarburizing
- Nitriding
- Hardening in oil or salt
- Normalizing
- Annealing
- Tempering

What is the preferential application of chamber furnaces?

- for smaller and medium capacities
- for different heat treatment processes with different types of parts and high diversity of parts, at charge weights of around 150 – 1,800 kg (in special cases even more) if flexibility is required
- for different types of production requirements

3. SETUP OF A MULTI-PURPOSE CHAMBER FURNACE PLANT

3.1 Quality features of the multi-purpose chamber furnace at AICHELIN

- Heat treatments with high quality and economic efficiency
- Excellent temperature uniformity (10 K) and precision, easy operation
- Fully automatic and reproducible heat treatment
- High production reliability with long service life
- Low energy and media consumption
- Low pollutant and noise emissions
- Short transportation times from furnace to oil bath: 15 sec depending on loading weight
- Tray transport unit in cold vestibule
- When using the air-oil cooling system: NO COOLING WATER at the furnace plant!
- Precise process documentation

3.2 Dimensions of the AICHELIN Chamber Furnace

STANDARD-LINE

Size *1	Size of the charges WxLxH in mm	Gross charge max. kg
500 (3)	600 x 1,100 x 650	650
800 (4/2)	700 x 1,300 x 850	1,200
1,100 (5/2)	900 x 1,500 x 850	1,500
XXL (5/3)	900 x 1,500 x 1,300	1,800

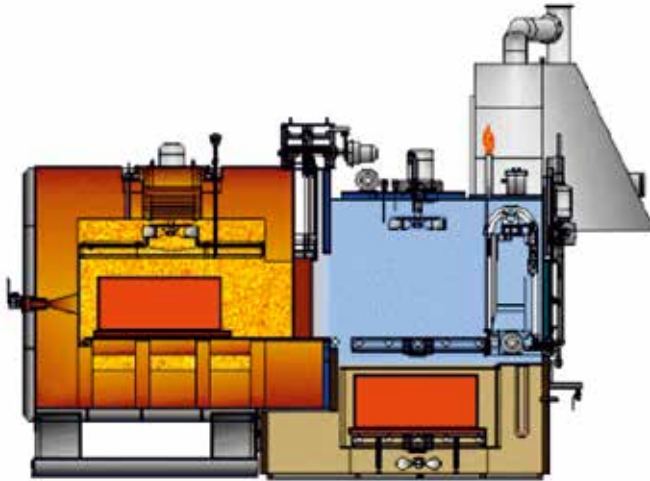
INDIVIDUAL-LINE

Size *1	Size of the charges WxLxH in mm	Gross charge max. kg
300 (2)	500 x 900 x 650	500
600 (4/1)	700 x 1,300 x 650	1,000
800 (5/1)	900 x 1,500 x 650	1,200
1,000 (4/3)	700 x 1,300 x 1,150	1,200

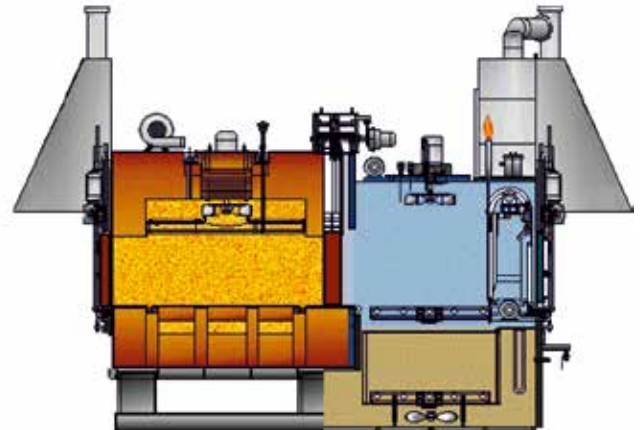
*1 Dimensions in () old designation, more dimensions and load weights upon request

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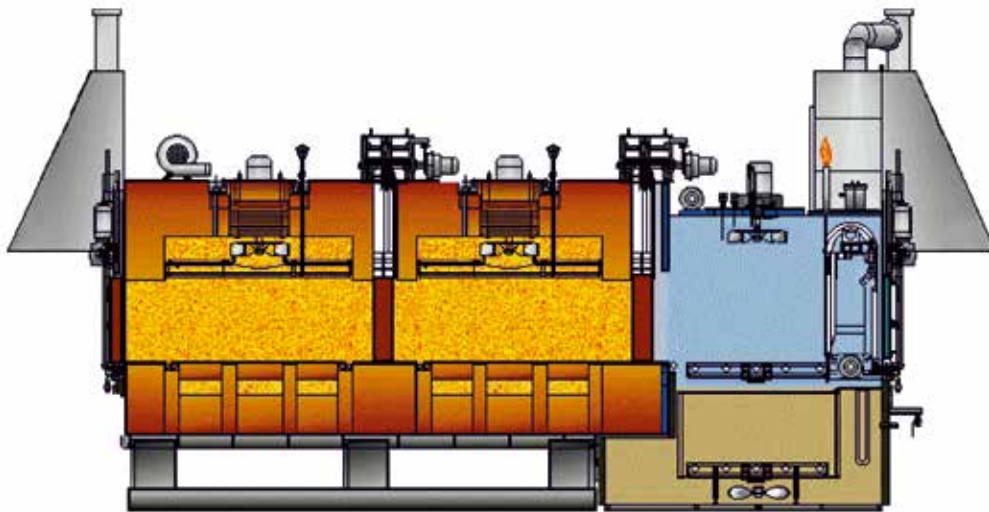
3.3 Possible designs of the multi-purpose chamber furnace



Front loading chamber furnace [VKE(G)s]



Continuous chamber furnace [DKE(G)s]



Continuous double-chamber furnace [2KDKE(G)s]

3.4 Construction features of the AICHELIN chamber furnace

- Uniform insulation of the furnace chamber without ruptures
- Bulky, well-insulated tight-fitting furnace door
- Generously sized oil bath with flow-optimized, multi-level oil bath circulation
- State-of-the-art measuring, switch, and control system to record and save automatic heat treatment processes, and with all necessary safety and monitoring equipment

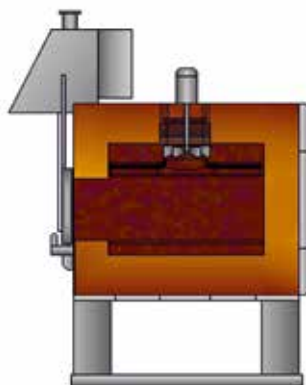
4. AUXILIARY UNITS OF THE MULTI-PURPOSE CHAMBER FURNACE

4.1 Chamber and Stress-relieving furnace without protective gas

Furnace temperature max. 500°C

- VKHLE electrically heated as tempering, stress relieving, and preheating furnace
- VKHLG gas-heated as preheating furnace

NEW: NOW UP TO 700 °C

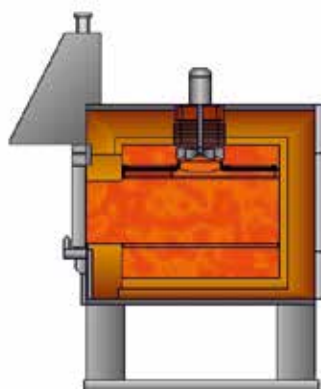


Chamber furnace without protective gas

Furnace temperature max. 750 °C

- KE electrically heated
- KG gas heated

NEW: NOW UP TO 850°C



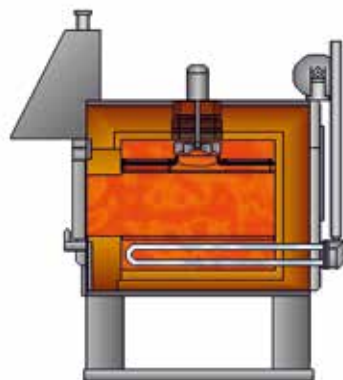
4.3 Chamber furnace for atmosphere gas

Furnace temperature max. 750 °C

- KEs electrically heated with load-cooling equipment
- KGs gas-heated with load-cooling equipment

Optional: „NITROC®“ Nitro-Carbonitriding equipment

NEW: NOW UP TO 850°C



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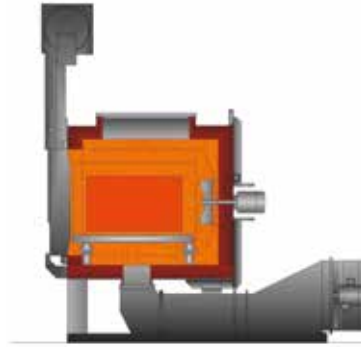
4.4 Chamber-retort furnace

Furnace temperature approx. 700 °C

- KREs electrically heated / KRGs gas-heated

With forced load cooling equipment under nitrogen for

- Nitro-carbonitriding
- Water/steam oxidizing
- Gas nitriding
- Annealing and tempering under nitrogen
- Bright annealing processes

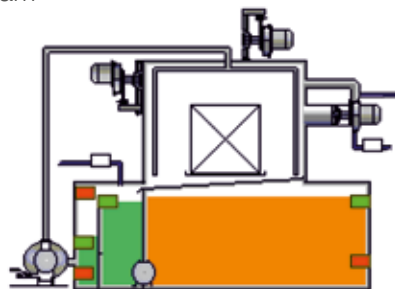


4.5 Chamber-immersion-spray washer

- KEKTE electrically heated
- KEKTG gas heated
- KEKTD steam heated

For simple washing processes with aqueous solution

- With immersion and spray system
- Two washing liquid tanks
- Drying equipment with steam condenser (optional)



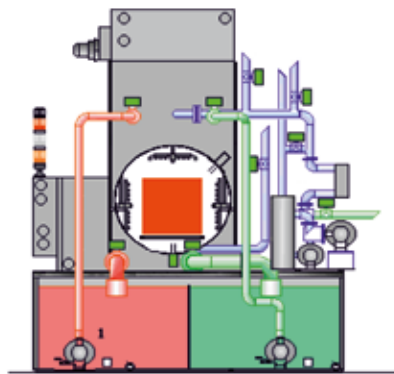
**NEW: NOW ALSO AS A COST-EFFECTIVE
SPRAY-WASHER**

4.6 FLEXICLEAN® Chamber washer

- EKFE electrically heated
- EKFG gas-heated
- EKFD steam-heated

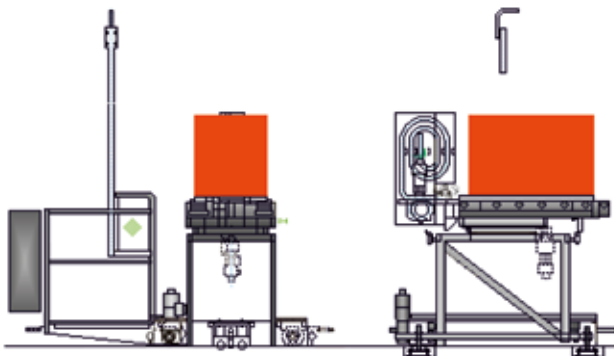
for high-quality washing processes with aqueous solution (especially with neutral cleaners) with two washing liquid tanks (third tank optional)

With vacuum cooker "Vacupearl", spray and flotation system and vacuum drying equipment



4.7 Loading and Unloading table

For single-line or opposite-line plants



Optional lifting function for two-level load storage

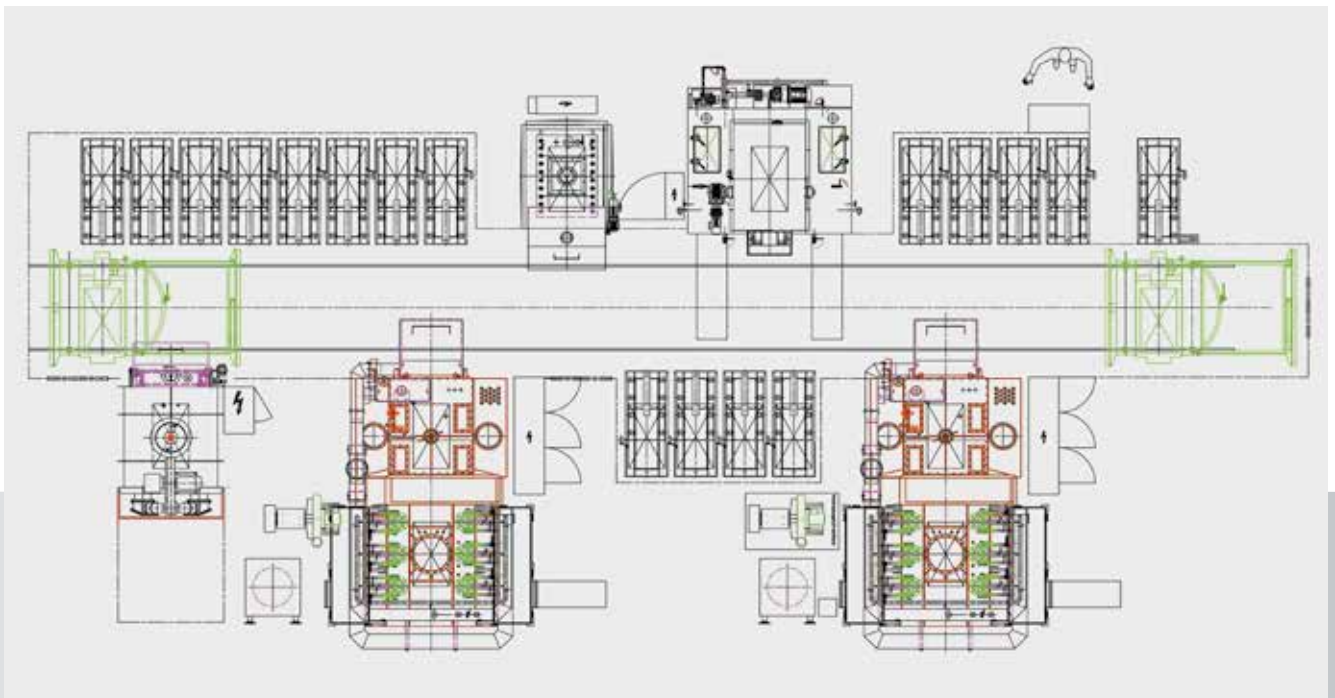


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5. EXAMPLES OF DIFFERENT SET-UPS OF MULTI-PURPOSE CHAMBER FURNACE LINES

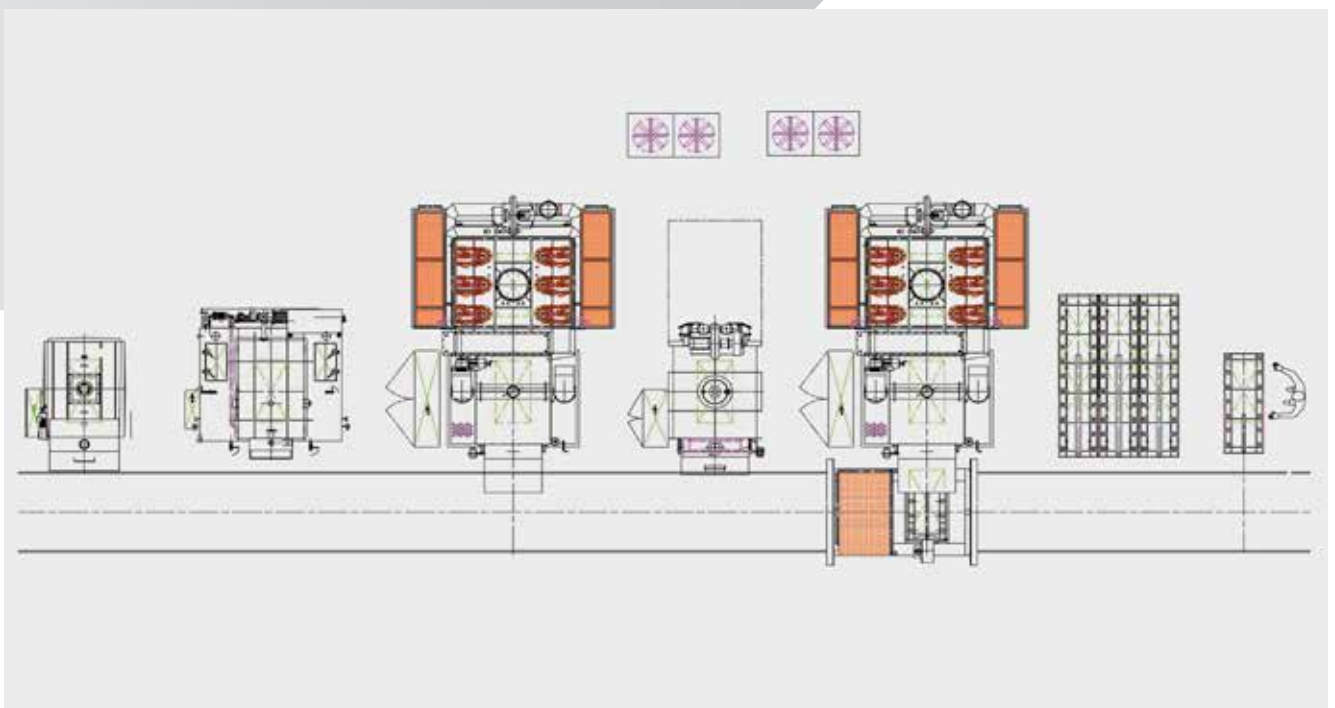
5.1 Chamber furnace line for agricultural machinery gearboxes, gas-heated

Tray 1,100x600x600 mm (LxWxH), max. 650 kg gross weight



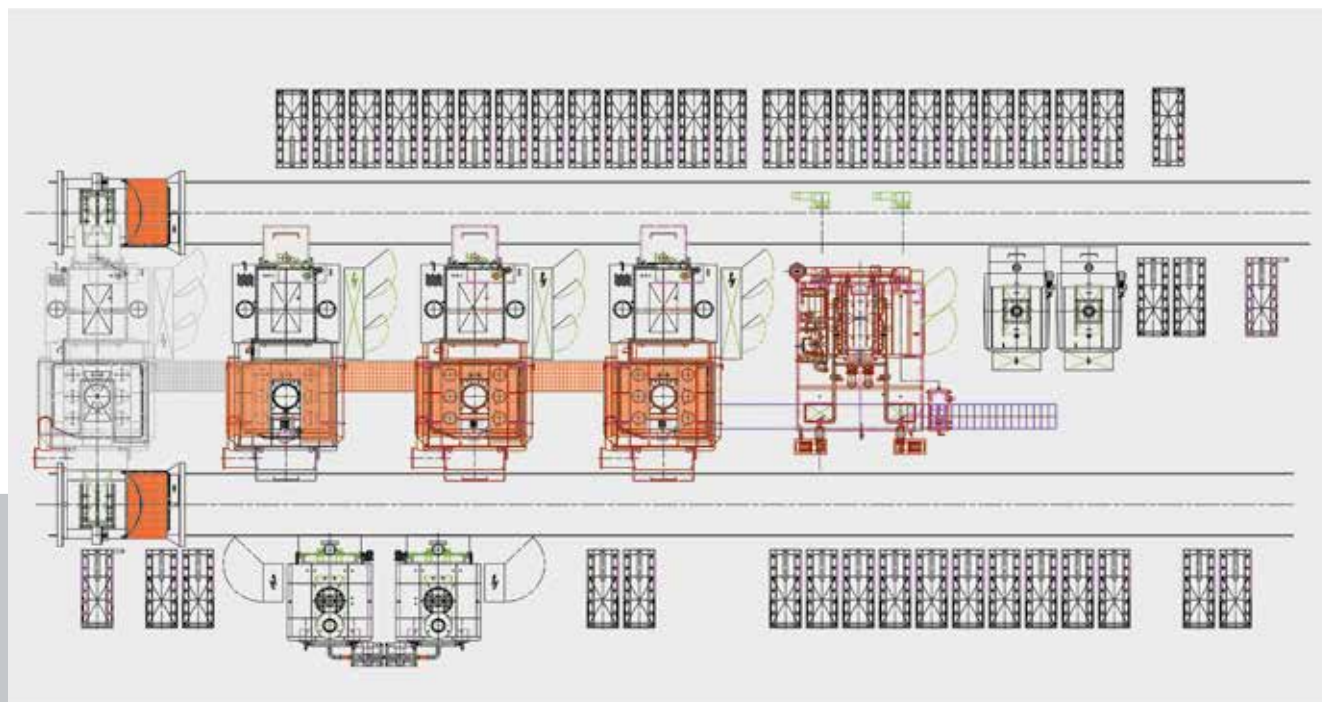
5.2 Chamber furnace line for a heat treatment facility, gas-heated

Tray 1,300x700x800 mm (LxWxH), max. 1,000 kg gross weight



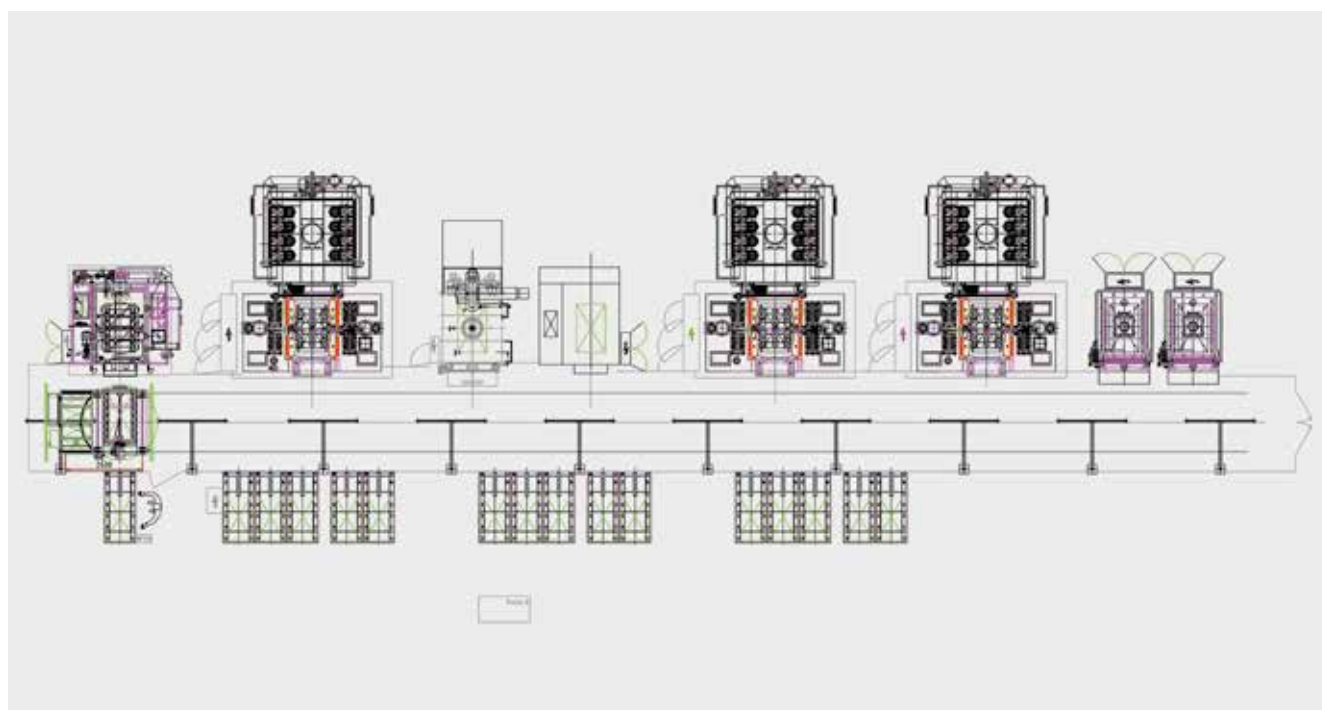
5.3 Continuous chamber furnace line for gear parts, gas-heated

Tray 1,300x700x800 mm (LxWxH), max. 1,000 kg gross weight



5.4 Chamber furnace line for low-warpage salt bath hardening of components (roller bearings and ADI method)

Tray 1,500x900x800 mm (LxWxH), max. 1,200 kg gross weight



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5.5 Continuous double-chamber furnace line for gear parts, gas-heated

Tray 1,500x900x1,300 mm (LxWxH), max. 1,800 kg gross weight

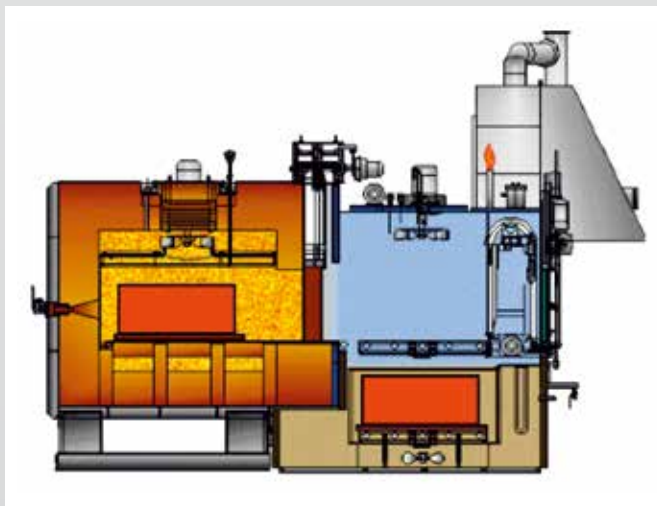


6. TECHNICAL DESCRIPTION OF THE FRONT LOADING CHAMBER FURNACE TYPE VKE (G) S

The multi-purpose chamber furnace consists of the following sub-assemblies:

6.1 Furnace chamber:

The furnace chamber consists of a gastight furnace housing and a high-quality insulation lining. The ceramic stove made from silicon carbide stones has a large free surface for gas perfusion. The optional silicon carbide gas baffle and the intensely efficient gas atmosphere fan guarantee uniform perfusion of the load and excellent temperature uniformity. The gas atmosphere fan is very compact thanks to the flange design with an extended motor shaft. The shaft seal of the furnace chamber is done via an oil buffer. With the closed oil cooling circuit with the thermosiphon effect, the cooling of the engine mounts works even without power supply! The inner door sits close and tight on the furnace chamber. Maintenance catwalks on the furnace chamber are an AICHELIN standard, as are extraction ducts all the way to the customer's flange.



6.2 Heating:

There are vertically mounted radiant tubes for heating, either electrically or with gas. For gas heating, automatic gas burners® (Type AICHELIN NOXMAT) with recuperative preheating are used. They have very high firing efficiency. A variable operation cycle guarantees top temperature uniformity. If using gas heating, the radiant tubes can be used as cooling tubes in order to quickly reduce the temperature from carburizing to hardening temperature. This makes for a reduced total heat treatment time. To control excess temperature, a special excess temperature thermocouple is installed between the two jacket tubes, which protects the radiant tubes from overheating.

6.3 Vestibule – quenching tank:

The vestibule with an oil bath is mounted gastight to side of the furnace chamber. The vestibule may also be used for cooling loads down to removal temperature or for intermediate cooling (isothermal annealing). A separate cooling device with its own heat transfer oil-cooling cycle via finned tube heat exchanger is provided for this purpose. To support the load cooling, a gas atmosphere fan with baffle has been installed. The oil bath and vestibule cooling with oil/air heat exchanger is part of the standard version. This means that no cooling water is required in the plant.

The vestibule door is pressed into the door seal via shifting links and a toothed rack, through a gear motor with spring contact pressure.

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Below the vestibule door there is a monitored flame curtain device with automatic piezo ignition. The outer door cannot open until the flame curtain is ignited.

The oil bath volume of the quenching tank is tailored optimally to the load. The double-walled housing design with oil detector safely prevents hazardous oil leaks. The oil level in the quenching tank can be monitored with a minimum/maximum display.

A heat exchanger is responsible for oil cooling (oil/water for hardening temperatures or oil/air for hardening temperatures $<60^{\circ}\text{C}$). An electric immersion heater is used to heat the oil bath. Two oil circulation units with two adjustable speeds are used for the oil circulation. With oil baffles close to the load, a targeted, forced perfusion of the load is possible. This is essential for tightly packed loads to also reach a uniform hardening result.

Depending on the specific demand, the hardening bath may also be equipped with a reinforced oil bath circulation rate and with program-controlled, continuously adjustable circulation rate of the oil circulators.

6.4 Elevator, Load transport:

The elevator has two floors, meaning the furnace can be loaded with a new load while another one is still in the oil bath.

The vestibule houses the automatic tray transport unit.

The synergy of the elevator's high speeds and the intermediate transport makes for very short moving times; for instance, for the multi-purpose chamber furnace size 3: Start from the furnace chamber until complete immersion into the oil bath: approx. 20 seconds.

All drives are electromotive with safe state. Handwheels are provided for the first actuator setting and for emergency operation mode.

6.5 Safety mechanism:

To keep the load from damaging in case of power loss or malfunctions, the multi-purpose chamber furnace is equipped with an automatic N₂ safety gassing device. During the negative-pressure phase while oil hardening, N₂ is fed into the vestibule for approx. 10-15 seconds at a 5 bar.

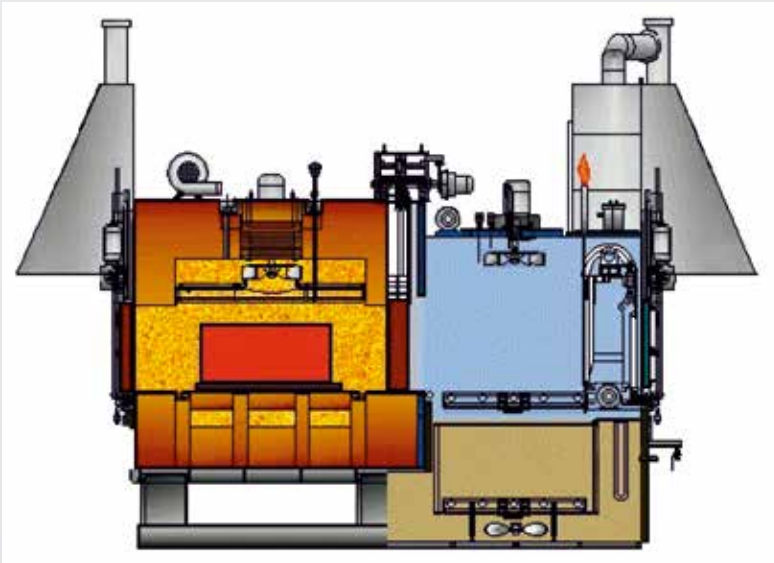
Moreover, all faults in energy supply, any malfunctions of the drives, heating etc. are signaled as error reports.

6.6 Gassing:

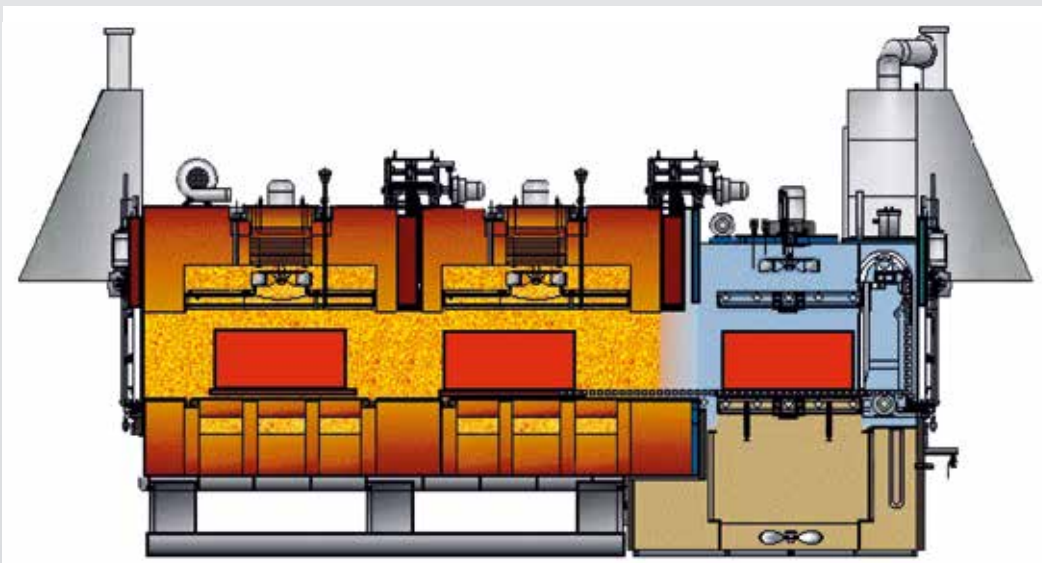
The multi-purpose chamber furnace can be equipped with different types of gassing: Endogas, N₂-methanole, propane, natural gas, or additive gasses can be used as protective gasses.

When it comes to additive gasses, propane, natural gas, LPG gas, acetone or other liquid carburization media can be used. The automatic control of the carbon potential is done via oxygen probe as a standard (alternatively via Lambda probe).

7. CONTINUOUS FURNACE AND CONTINUOUS DOUBLE-CHAMBER FURNACE



Continuous chamber furnace [DKE(G)s]



Continuous double-chamber furnace [2KDKE(G)s]

From a components-focused point of view, the furnace types essentially resemble the front loading chamber furnace. Load transport is carried out according to the continuous principle. For the continuous chamber furnace, the load is pushed from the loading table into the vestibule. For double-chamber furnaces, the load also goes from the loading table into the first chamber, and then on into the second (with the furnace door slightly ajar). The transport device in the vestibule transfers the loads into the oil bath.

The continuous double-chamber furnace has its own temperature and c-potential control for each zone. An inner door separates the two furnace chambers.

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8. CONTROL SYSTEM OF A MULTI-PURPOSE CHAMBER FURNACE

8.1 Control

The control level is divided into three operation modes:

- Set-up mode
- Manual mode
- Automatic mode

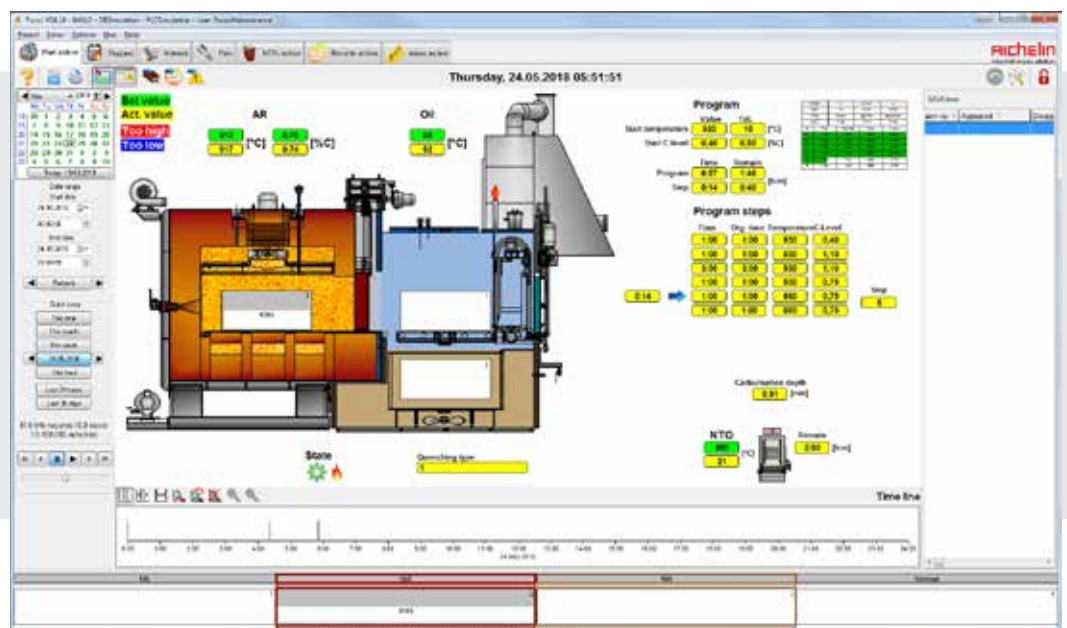
Automatic mode

In this mode, the furnace operates under normal production conditions. After an initial start, all movements of the furnace are run in the correct order and, to optimize time, sometimes also in parallel.

The fully graphical operator panel is the central operation element of the furnace. All limit switch states as well as the states of the step chains can be displayed on it. All those devices that run around the clock (circulators, pumps etc.) can also be controlled through this panel.

The overview image (see below) shows the state of the plant as an animated picture. This way, you always have a complete overview of the plant and the easy operation of your furnace is guaranteed.

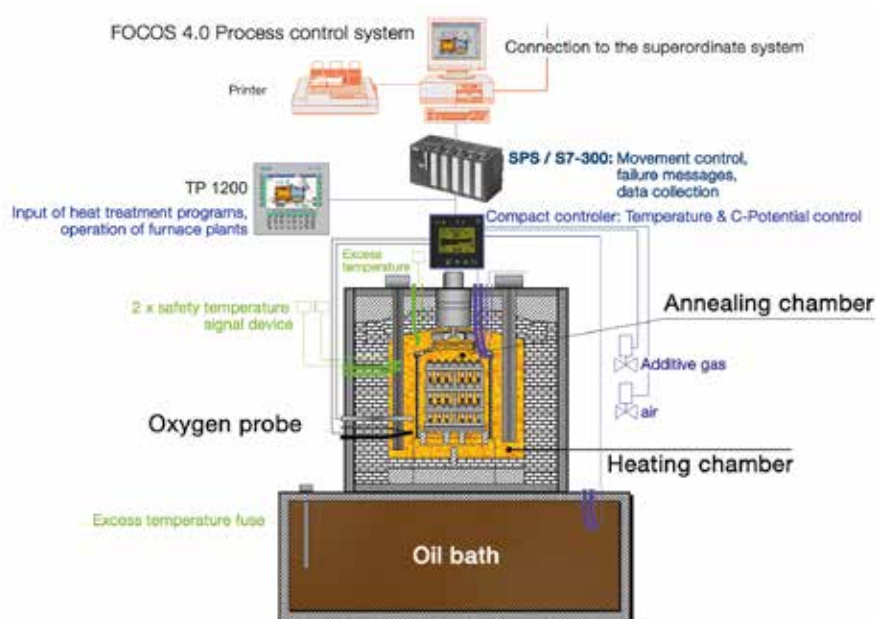
The images show the position of the load and any and all status of the drives; moreover, the actual and set values for C-potentials and temperature are displayed.



8.2 Regulation:

A compact controller is provided to regulate the temperature of the annealing chamber, the oil bath, as well as the C-potential. A bus system enables communication with the programmable logic controller (PLC). During normal operation, the set values are dictated by the PLC, and the actual values are fed back to the PLC. The Operator Panel displays these values.

To safeguard against exceeding the maximum temperature of the furnace, an excess temperature signaler is installed. If the safety temperature falls below its threshold, this is monitored with two safety temperature signalers in gassed furnaces. The oil bath has its own thermocouple to protect it from overheating. The C-potential control of the furnace works with a special software in a compact controller.



Control and activation of the gas addition is independent of the PLC. The Operator Panel allows for a menu-driven operation of complete heat treatment programs.

After batching and after starting the desired heat treatment program, the PLC takes over the programmer function. The set value is then fed to the temperature/C-potential controller, according to the saved program set values. The PLC is also responsible for the control of the quenching processes (oil or gas cooling). The temperature of the annealing chamber, the C-potential, and the temperature of the oil bath are displayed in the FOCOS 4.0 control system.

8.3 C-potential control:

The C-potential, measuring, and control system CARBOMAT S7 with compact controller and extended software for temperature and C-potential time profile is responsible for C-potential control. The actual values are recorded via an oxygen probe (measuring the gas atmosphere in the furnace chamber over zirconium oxide).

Error messages will be displayed in case of sensor failure, exceeding of soot limit, and minimum and maximum thresholds.

As an alternative, the C-potential control can be carried out with software controllers of other selected metrology firms

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9. FOCOS PROCESS CONTROL SYSTEM FOR CHAMBER FURNACES

A FOCOS system lets you control multiple chamber furnaces at once. When starting the heat treatment program, all necessary information is sent to the programmable logic controller (PLC) of the furnace plant. Then the FOCOS system controls the program flow and sends the set values to the PLC. The PLC, in turn, forwards the set values to the compact controller. The updated actual values of temperature and C-potential are then reported back to the FOCOS system. The program flow can be followed online via the Operator Panel. In case of a malfunction of the FOCOS system during a heat treatment phase, the PLC of the furnace plant immediately takes over the programmer functions and the program can continue without interruptions.

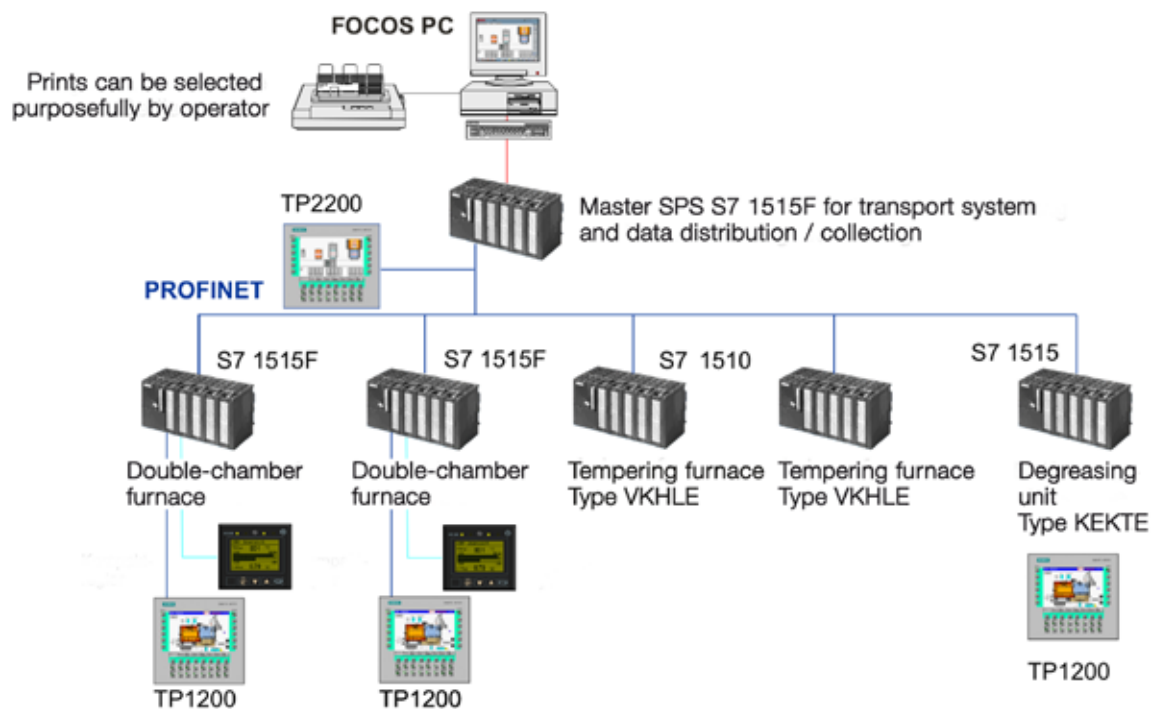
In its standard version, the FOCOS system contains the following program points:

- **OFFLINE DIFFUSION PROGRAM**
for simulating and optimizing carburization programs
- **Program management**
Input of different heat treatment programs; the program flow can be divided into up to 10 sections. Options for time and target quantity control
- **Parts database**
Assigning individual heat treatment programs to certain parts.
- **Programmer**
The set values of temperature and C-potential are determined in line with the heat treatment program data and the graphically displayed.
- **ONLINE DIFFUSION PROGRAM**
During the carburization program, the current carburization profile with the carbon progress can be displayed and printed at any time. If using programs with target quantity control, the carbon progress of the item undergoing heat treatment is calculated with the recorded actual values and then controlled according to the target quantity.
- **Heat treatment documentation**
Available for every load. The documentation is saved on the hard drive and can be displayed on the screen anytime. It includes the heat treatment program displayed as a table with all relevant data on parts, the set values, and actual values of C-potential and temperatures in graphic form for the entire duration of the process, as well as the calculated carbon use in the parts displayed as a table and graphically.
- **Utility programs**
Calculation of the alloy factor from the composition of the material. Different conversion functions such as C-potential in probe voltage, CO content, etc.
- **Fault handling**
Clear indication of malfunctions: with timestamp of start and end time.
- **Help texts**
The existing help texts offer valuable operation support.

Moreover, there are also numerous expansion stages to the process control system, which can be extended to the point of control of a fully automatic multi-purpose chamber furnace plant. But not only the chamber furnace can be controlled with it, but what's more, any auxiliary units will receive specifications from the FOCOS system, thus automatizing the entire treatment cycle of a load. Operating the plant is thus limited to loading/unloading the storage tracks. In addition to the program points described above, there are also numerous software modules, such as teleservice, text message notifications or extended heat treatment documentation with a lab protocol that can be tailored to the respective customers' needs.

9.1 Fully automatic Chamber furnace line:

Data structure and cross-linking



REFERENCES





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