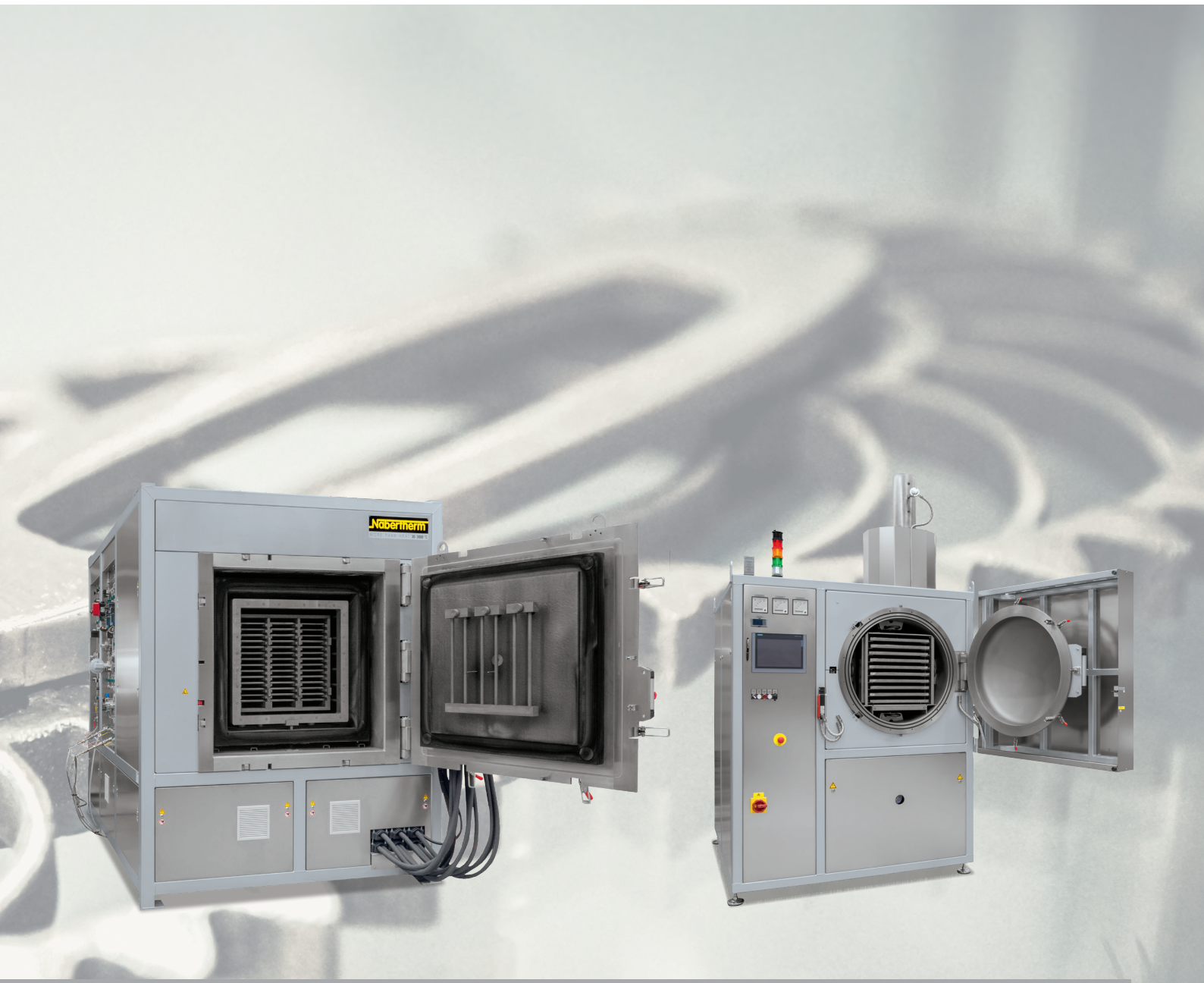
Nabertherm

MORE THAN HEAT 30-3000 °C



METAL INJECTION MOLDING (MIM)

Furnaces for Debinding and Sintering

Made
in
Germany

www.nabertherm.com

Facts

- Production of Arts & Crafts furnaces, laboratory furnaces, dental furnaces and industrial furnaces since 1947
- Production site in Lilienthal/Bremen - Made in Germany
- 600 employees worldwide
- 150,000 customers in more than 100 countries
- Very wide product range of furnaces
- One of the biggest R&D departments in the furnace industry
- High vertical integration

Global Sales and Service Network

- Manufacturing only in Germany
- Decentralized sales and service close to the customer
- Own sales organization and long term sales partners in all important world markets
- Individual on-site customer service and consultation
- Fast remote maintenance options for complex furnaces
- Reference customers with similar furnaces or systems close to you
- Secured spare parts supply, many spare parts available from stock

Setting Standards in Quality and Reliability

- Project planning and construction of tailormade thermal process plants incl. material handling and charging systems
- Innovative controls and automation technology, adapted to customer needs
- Very reliable and durable furnace systems
- Customer test center for process assurance

Experience in Thermal Processing

- Thermal Process Technology
- Additive Manufacturing
- Advanced Materials
- Fiber Optics/Glass
- Foundry
- Laboratory
- Dental
- Arts & Crafts

Furnaces for MIM Applications

Metal Injection Molding (MIM) is a manufacturing process that allows for the rapid and cost-effective production of small, geometrically complex, metallic components in large quantities.

In MIM, several identical parts are typically produced in a single operation using a metal-based feedstock, which is a metallic powder with a binder system, injected into a mold by a molding machine.

In the subsequent debinding process, this green part loses a large amount of the binder, which was needed only for shaping, and becomes what is known as the brown part. Debinding can be carried out in several ways, either thermally in an inert atmosphere or under hydrogen, catalytically in a nitric acid-nitrogen atmosphere, or in a system containing water or solvent. The basis of a thermal or catalytic debinding furnace is a gas tight hot-wall retort furnace from the NR product line.

Retort furnace VHT 40/16-MO H_2 MIM

In the subsequent combined debinding and sintering process, which takes place in a process gas atmosphere or in a vacuum, the brown part is sintered into the finished part.

Due to the high sintering temperatures, this process step is typically carried out in a cold-wall retort furnace from the VHT model series. The furnace can be tailored specifically to the material for this process step in various configurations. For sintering stainless steels under a hydrogen atmosphere, furnaces with heaters and insulation made of molybdenum and heating elements made of tungsten, for example, are used. Furnaces with graphite heaters and insulation made of graphite felt are excellent for low-alloy steels that can be sintered in a non-reducing process gas atmosphere.

The Nabertherm MIM product lines, consisting of NR for debinding and VHT for sintering, are extremely flexible and compatible. Four furnaces each are available for thermal and catalytic debinding and sintering, all of which are optimally matched to each other in terms of size. As a result, the charge can be transferred directly from the debinding furnace to the sintering furnace or can also be manufactured with different furnace sizes independently of working or shift times.

Catalytic debinding furnace	Thermal debinding furnace[1]	Solvent debinding system[2]	Sintering furnace[3]	Volume	Work space in mm			Quantity	Number of shelves 170 x 250 mm total (level)	Shelves Work space in m²
				in l	w	d	h	levels		
NRA 40 CDB	NR 40/11..	EBA-200NT EDA-200NT	VHT 40/15 .. MIM	40	340	500	240	6	24 (2x2)	1
NRA 80 CDB	NR 80/11..	EBA-250NT EDA-250NT	VHT 80/15 .. MIM	80	340	750	320	8	48 (2x3)	2
NRA 160 CDB	NR 160/11..	EBA-450NT	VHT 160/15 .. MIM	160	500	680	480	12	96 (2x4)	4
NRA 320 CDB	NR 320/11..	EBA-900NT	VHT 320/15 .. MIM	320	680	750	640	16	192 (4x3)	8

[1]IDB (debinding in non-flammable process gases), H_2 (debinding in hydrogen)
[2]Models from Lömi GmbH, designed to work together with Nabertherm sintering furnaces, specifications according to Lömi GmbH
[3]MO: Molybdenum, GR: Graphite

Hot-Wall Retort Furnaces for Catalytic Debinding

The hot-wall retort furnaces are ideal for heat treatment processes that require a defined process gas atmosphere. The furnace chamber consists of a gas tight retort.

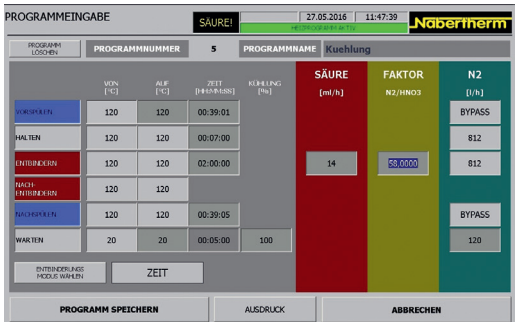
Equipped with the corresponding safety technology, these retort furnaces are suitable for catalytic (CDB) and also thermal (IDB, H_2) debinding of MIM components.

Retort furnace NRA 40/02 CDB with separate cabinet for the acid pump

Hot-Wall Retort Furnace for Catalytic Debinding (CDB)

The hot-wall retort furnaces NRA .. CDB were developed especially for catalytic debinding of ceramic and metal powder injection molding components. They are equipped with an internally-heated gas tight retort.

The catalytic debinding furnaces are designed and built so that the nitric acid is fed into the furnace by means of an acid pump where it evaporates and is distributed evenly throughout the furnace chamber through the atmosphere circulation. The evaporated nitric acid debinds the components by chemically decomposing the polyoxymethylene-based binder (POM) to form formaldehyde. To minimize emissions to the atmosphere, the furnace is equipped with a thermal post-combustion system. Formation of explosive gas mixtures is prevented with monitored flow of the nitric acid and a constant, monitored flow of nitrogen. The design and construction of the furnace with gas tight retort ensures that no oxygen can enter. The door is kept closed during the entire debinding process.



Heating program input screen of the CDB furnace

Standard Design

- Safety package for safe operation with nitric acid
- PLC process control with safety monitoring (F-PLC) and graphic touch panel
- Retort made of acid-resistant stainless steel 1.4571 with swing door
- Heating inside the retort via chrome steel tubular heating elements
- Horizontal circulation for even distribution of the process atmosphere
- Acid pump in separate cabinet
- Gas-fired exhaust gas torch with flame monitoring

Model	Volume	Work space in mm			Quantity	Number of Shelves 170 x 250 mm	Shelves Work space	Outer dimensions in mm			Weight	Heating power
	in l	w	d	h	Levels	total (level)	in m²	W	D	H[1]	in kg	in kW
NRA 40 CDB	40	340	500	240	6	24 (2x2)	1	1400	1700	2400	1000	2
NRA 80 CDB	80	340	750	320	8	48 (2x3)	2	1600	2000	2500	1200	13
NRA 160 CDB	160	500	680	480	12	96 (2x4)	4	1800	2200	2600	1600	20
NRA 320 CDB	320	680	750	640	16	192 (4x3)	8	2300	2400	2800	2800	35

[1]Including exhaust gas torch

Hot-Wall Retort Furnaces for Thermal Debinding

Retort furnace NRA 80/11 IDB

Thermal post combustion with optional condensate trap

Retort furnace NRA 300/09 H_2 for heat treatment in hydrogen

Hot-Wall Retort Furnaces for Thermal Debinding in Non-Flammable Process Gases (IDB) and for Presintering

In the IDB version, the retort furnaces are equipped with a safety concept in which the furnace chamber is inerted with a protective gas. Exhaust gases are incinerated in a thermal afterburner. Both the purging and the torch function are monitored to ensure safe operation.

Standard Design IDB

- Safety package for handling flammable gas releases
- Process carried out with monitored overpressure of 10-50 mbar relative
- PLC process control with safety monitoring (F-PLC) and graphic touch panel
- Monitoring of all process gas input pressures
- Bypass for safe purging of the furnace chamber with inert gas
- Thermal post combustion of the exhaust gases

Hot-Wall Retort Furnaces for Thermal Debinding in Hydrogen (H_2) and for Presintering

If flammable process gases, such as hydrogen, are used, the retort furnace is also equipped with the required safety technology.

Standard Design H_2

- Safety package for operation in hydrogen
- Flammable process gases with controlled overpressure of 10-50 mbar relative
- PLC process control with safety monitoring (F-PLC) and graphic touch panel
- Redundant gas inlet valves for hydrogen
- Monitoring of all process gas input pressures
- Hydrogen sensor/hydrogen gas warning sensors in the furnace housing
- Bypass for safe purging of the furnace chamber with inert gas
- Torch for thermal post combustion of the exhaust gases
- Protective gas emergency flood container for purging the furnace in case of malfunction

Additional Equipment

- Condensate trap (for IDB and H_2 models), which is dependent on the quantity and condensation behavior of the type of binder that is used

Cold-Wall Retort Furnaces for Residual Debinding and Sintering

The cold wall retort furnaces of the VHT series are designed as high-temperature furnaces, including graphite or molybdenum/tungsten heating. The vacuum-tight retort allows heat treatment processes either under flammable or non-flammable process gases or in a vacuum.

Two variants, tailored to different sintering processes, are available for debinding and sintering MIM components.

Retort furnace VHT 100/16-MO MIM with automatic package

Retort furnace VHT 100/18-GR MIM with CFC process insert box and extension package for operation with hydrogen

Gas management system

Basic Design of Both Product Lines

- Switchgear and controller integrated in the housing (from VHT 160/15 .. MIM separate switchgear)
- PLC process control with safety monitoring (F-PLC) and graphic touch panel
- Automatic pre-program, including leak test and safe inertization of the process chamber
- Redundant safety-relevant sensors and valves
- Process gas management with mass flow controllers (MFC)
- Single-stage rotary vane pump for pre-evacuation
- Water-cooled, stainless steel process chamber
- Over-temperature limiter with manual reset as over-temperature protection
- Inner process box with shelves
- Automatic door lock
- Heated, controllable exhaust gas line with condensate trap
- Exhaust gas torch (gas-fired) for post combustion
- Protective gas emergency flood container for purging the furnace in case of malfunction

Cold-Wall Retort Furnaces for Sintering in Hydrogen

The VHT ../15-MO MIM design is based on the product line with molybdenum/tungsten heating unit and insulation and a hydrogen safety package. The core of this design is a tried and tested safety package that enables safe operation at all times and initiates an appropriate emergency program in the event of a malfunction.

This design is the best choice for sintering stainless steel.

Standard Design MO MIM

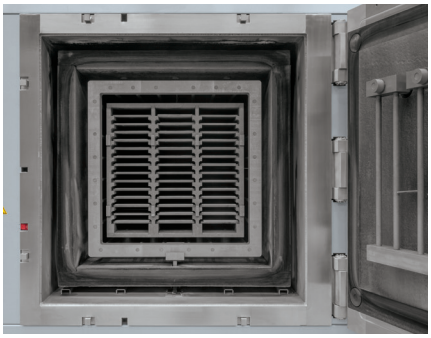
- Can be used for sintering processes in flammable and/or non-flammable process gases or in high vacuum
- Tmax 1500 °C (optional to 1800 °C)
- Max. vacuum, depending on type of pump used, to $2x10^{-6}$ mbar
- H_2 introduced into the furnace with controlled overpressure (10-50 mbar relative) from room temperature
- Underpressure operation (optional): Hydrogen introduced into the furnace with controlled under pressure from 750 °C furnace temperature

Cold-Wall Retort Furnaces for Sintering in Inert Gas

Furnaces in the VHT ../15-GR MIM range are equipped with graphite heating and insulation as well as a safety package for residual debinding and sintering with non-flammable process gases.

This design is a very good choice for sintering low-alloyed steel.

Molybdenum insert box, split



Graphite insert box, split

Heated exhaust gas line with binder trap

Standard Design GR MIM

- For sintering processes in non-flammable process gases or in vacuum
- Tmax 1500 °C (optional to 2400 °C)
- Max. vacuum, depending on type of pump used, to 2 x 10^{-4} mbar

Inner Process Box for Residual Debinding

Due to the release of residual binders before the sintering process, the furnace chamber is equipped with an additional inner process box through which the exhaust gas is directly vented to the exhaust stack. This system significantly reduces contamination of the furnace chamber by gases generated during the debinding step. In addition to optimizing temperature uniformity, the process inner box ensures excellent gas flow across the components due to the gas distribution plate on the rear wall. For a graphite furnace, the inner box is made of graphite, while for a metallic-heated furnace, a box made of molybdenum (potentially tungsten-reinforced) is used.

The standard equipment for sintering furnaces includes a complete set of carrier shelves, as listed in the table. Adjustments to the usable space and the inner process box when using carrier shelves with different dimensions are optionally possible.

Heated Gas Outlet

To minimize binder condensation in the exhaust gas line as much as possible, the area of the gas outlet between the outlet from the inner process box and the torch is heated with heating tapes and, if necessary, is also insulated.

For optimum temperature management of the exhaust gas to the torch, depending on the size of the furnace, the exhaust gas line is divided into different zones. In these zones, the temperatures of the heating tapes can be controlled differently depending on their position.

Additional Equipment

- Condensate trap (for IDB and H_2 models), which is dependent on the quantity and condensation behavior of the type of binder that is used

Model[1]	Volume	Work space in mm			Quantity	Number of shelves 170 x 250 mm total (level)	Shelves Work space in m²	Outer dimensions in mm			Weight GR/MO in kg
	in l	w	d	h	levels			W	D	H²	
VHT 10/15 .. MIM	10	170	250	240	6	6 (1x1)	0,25	1600	2600	2700	1600/2300
VHT 20/15 .. MIM	20	250	340	240	6	12 (1x2)	0,50	1600	2600	2700	2000/3000
VHT 40/15 .. MIM	40	340	500	240	6	24 (2x2)	1,00	1900	3300	2850	2700/3500
VHT 80/15 .. MIM	80	500	510	320	8	48 (2x3)	2,00	2000	3500	3000	3000/4000
VHT 160/15 .. MIM	160	500	680	480	12	96 (2x4)	4,00	2300	4100	3400	7500/8500
VHT 320/15 .. MIM	320	680	750	640	16	192 (4x3)	8,00	2500	4300	3500	9000/10000

[1]MO: Molybdenum, GR: Graphite
[2]Including exhaust gas torch

Nabertherm

MORE THAN HEAT 30 - 3000 °C

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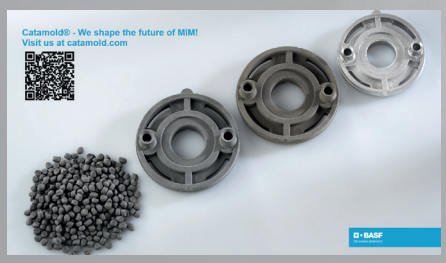

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