CARBOLITE GERO 30-3000°C

HEAT TREATMENT / DEBINDING & SINTERING FOR

ADDITIVE MANUFACTURING OF METALS METAL INJECTION MOULDING

part of VERDER scientific

VERDER scientific

ENABLING PROGRESS.

HEAT TREATMENT
ELEMENTAL ANALYSIS
MATERIALOGRAPHY & HARDNESS TESTING
MILLING & SIEVING
PARTICLE CHARACTERIZATION

Under the roof of VERDER SCIENTIFIC we support thousands of customers worldwide in realizing the ambition we share. As their technology partner behind the scenes, we deliver the solutions they need to make progress and to improve the everyday lives of countless people. Together, we make the world a healthier, safer and more sustainable place.

www.verder-scientific.com

LEADING HEAT TECHNOLOGY

CARBOLITE GERO – OVER 80 YEARS OF INNOVATION

The Carbolite Gero brand is synonymous with high quality, leading heat technology in the design and manufacture of laboratory and industrial ovens & furnaces ranging from 30 °C to 3000 °C which are sold globally to over 100 countries.

On 1st January 2016 Carbolite (UK) and Gero (Germany) merged to become one company under the name of Carbolite Gero. With the combined product lines, the company is strengthening its market position locally and globally. In the past, both companies acquired strong, established reputations for engineering expertise in applied heating technology.

Carbolite Gero has two manufacturing and sales sites. One is based in Derbyshire in the United Kingdom, where Carbolite manufactures laboratory and industrial ovens and furnaces up to 1800 °C; the second facility is located in Neuhausen, southern Germany, where high temperature furnaces up to 3000 °C with a large variety of solutions for vacuum and other modified atmospheres have been manufactured since 1982.

In addition to the extensive range of standard products as shown in this catalogue, Carbolite Gero is an expert in the development of customized equipment for complex heat treatment processes. Solving customers' individual application requirements has given Carbolite Gero an important place in aerospace, engineering, materials science, heat treatment, medical, bioscience and contract testing laboratories globally. Not only can Carbolite Gero supply products with Standards-compliant furnace and oven designs (e.g., Nadcap heat treatment processes (AMS2750F)), but also fully traceable certification for control, measurement, recording and data acquisition devices, issued by an independent UKAS accredited laboratory.

All products, and more, featured in this catalogue are available through your local Carbolite Gero office, Verder Scientific office or an extensive network of 3rd party dealers and sales organisations.

Carbolite Gero,
Neuhausen (Germany)

Carbolite Gero,
Hope (United Kingdom)

1938
Carbolite founded in Sheffield

1966
Production moves from Sheffield to Bamford Mill

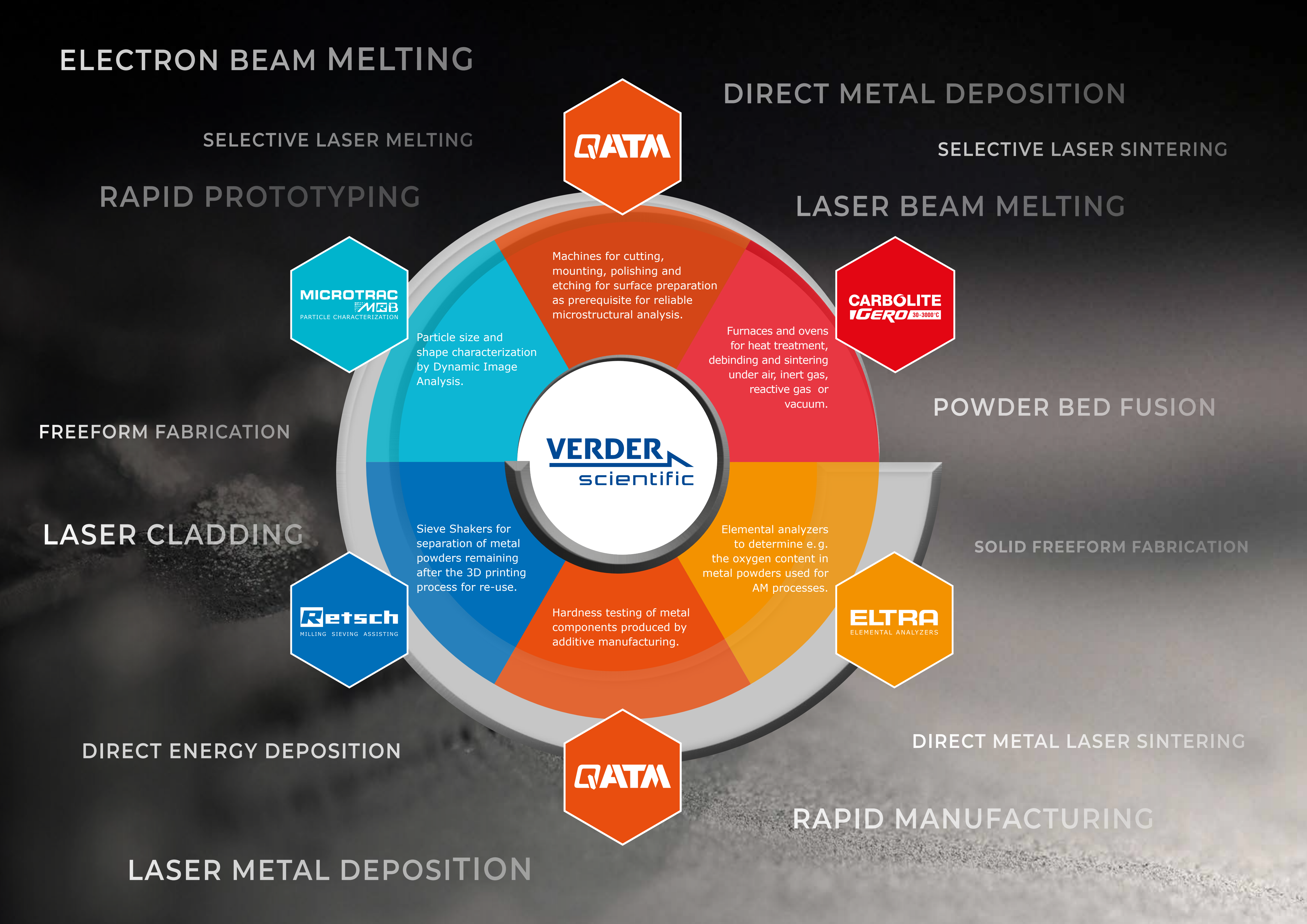
1982
Gero founded in Germany

1993
Carbolite relocates to a new site in Hope as Gero relocates to Neuhausen

2012
Carbolite acquired by Verder Group

2013
Gero acquired by Verder Group

2016
Companies merged as Carbolite Gero

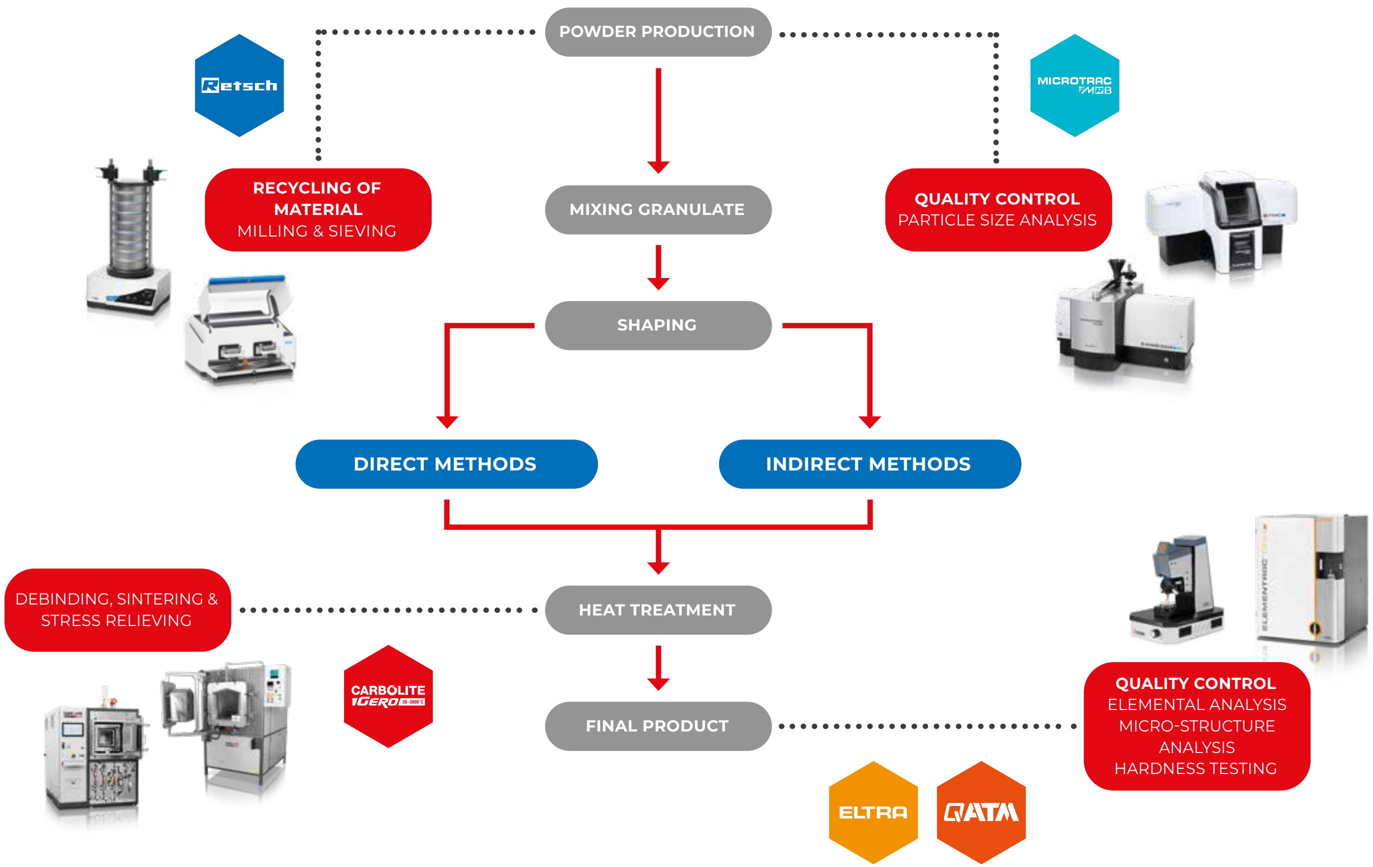

ELECTRON BEAM MELTING
DIRECT METAL DEPOSITION
SELECTIVE LASER MELTING
SELECTIVE LASER SINTERING
RAPID PROTOTYPING
LASER BEAM MELTING
QATM
Machines for cutting, mounting, polishing and etching for surface preparation as prerequisite for reliable microstructural analysis.
MICROTRAC MRB
PARTICLE CHARACTERIZATION
Particle size and shape characterization by Dynamic Image Analysis.
CARBOLITE GERO 30-3000°C
Furnaces and ovens for heat treatment, debinding and sintering under air, inert gas, reactive gas or vacuum.
POWDER BED FUSION
FREEFORM FABRICATION
VERDER scientific
LASER CLADDING
Sieve Shakers for separation of metal powders remaining after the 3D printing process for re-use.
Elemental analyzers to determine e.g. the oxygen content in metal powders used for AM processes.
SOLID FREEFORM FABRICATION
Retsch
MILLING SIEVING ASSISTING
ELTRA
ELEMENTAL ANALYZERS
Hardness testing of metal components produced by additive manufacturing.
QATM
DIRECT ENERGY DEPOSITION
DIRECT METAL LASER SINTERING
RAPID MANUFACTURING
LASER METAL DEPOSITION

VERDER SCIENTIFIC

SOLUTIONS FOR ADDITIVE MANUFACTURING & METAL INJECTION MOULDING

All manufacturing companies under the roof of Verder Scientific provide solutions for Additive Manufacturing and MIM technologies. Everything starts with the powder and ends with the finished product, and with many production steps along the way. The equipment of CARBOLITE GERO, ELTRA, QATM, MICROTRAC MRB and RETSCH helps you to implement a variety of production processes and ensure quality control.

Particle size and shape analysis, elemental analysis, heat treatment, microstructural analysis and hardness testing: the Verder Scientific companies offer innovative, efficient solutions for your Additive Manufacturing or Metal Injection Moulding process – combined with expert advice and service support worldwide.



CARBOLITE GERO
HEAT TREATMENT

ELTRA
ELEMENTAL ANALYSIS

QATM
MATERIALOGRAPHY & HARDNESS TESTING

RETSCH
MILLING & SIEVING

MICROTRAC MRB
PARTICLE CHARACTERIZATION

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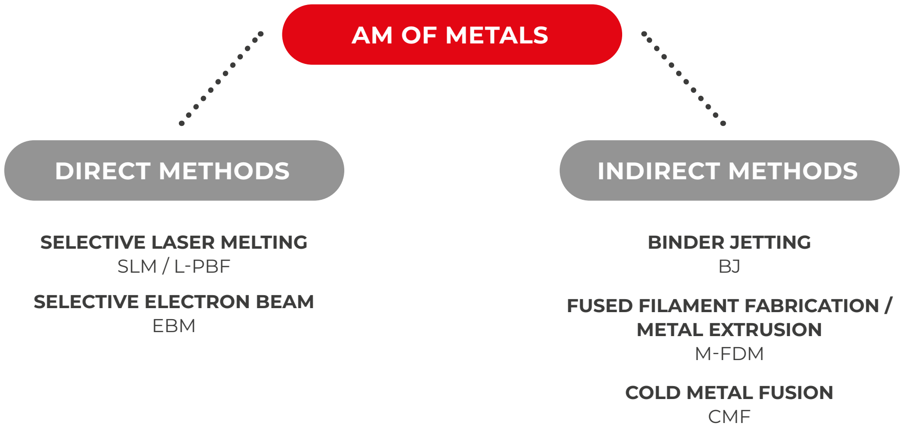
OVERVIEW: ADDITIVE MANUFACTURING PROCESSES

DIRECT AND INDIRECT PROCESSES

Additive methods can be divided into two categories. Direct methods, such as SLM and EBM, are very well known and have reached a broad market acceptance in the industrial environment.

However, indirect methods have become more important in recent years. With these methods a green part is produced in the first process step, which is debinded and sintered in the second step.

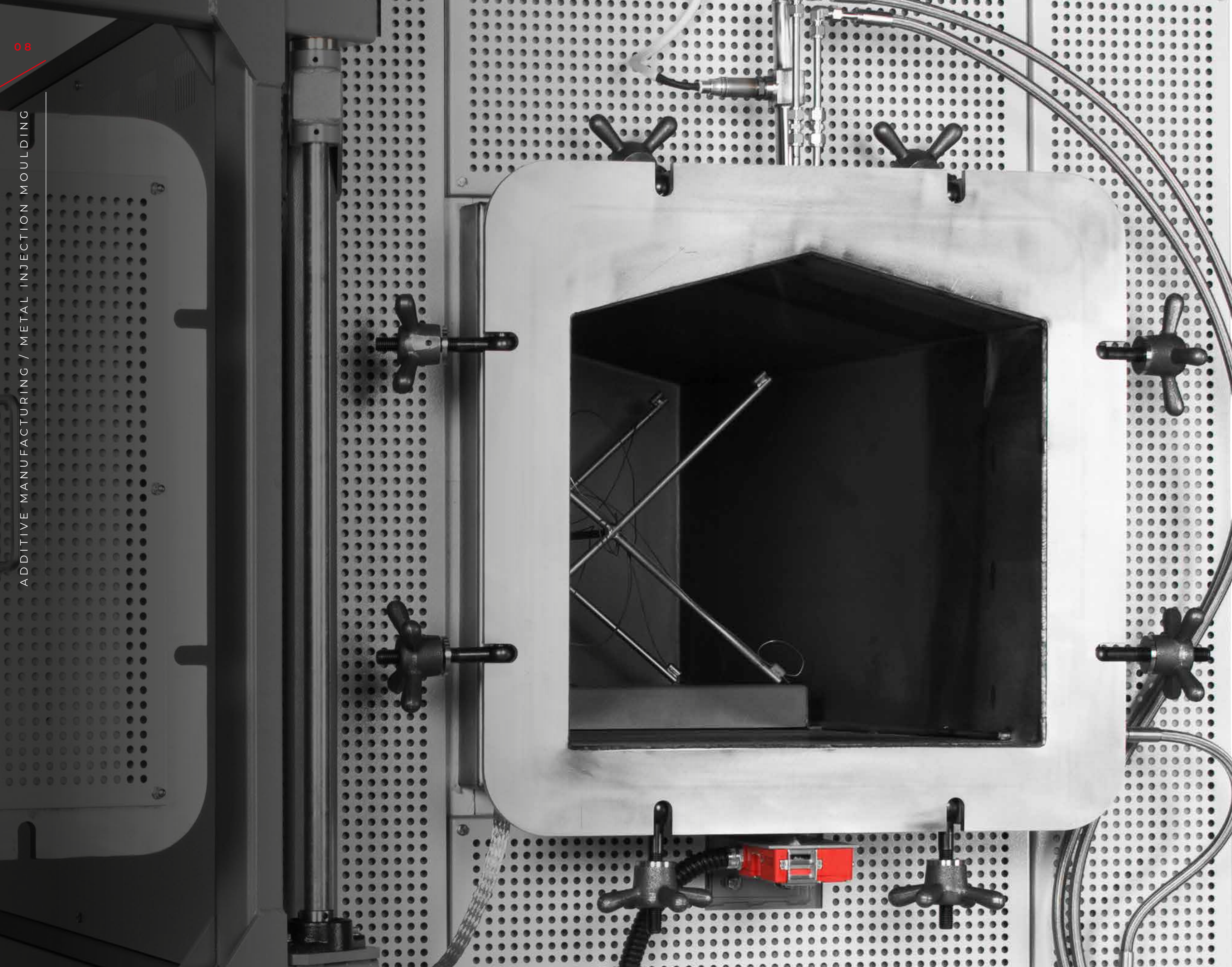


* Examples of direct and indirect Additive Manufacturing methods

	DIRECT AM METHODS	INDIRECT AM METHODS
METHOD	**L-PBF, EBM** One-step process Direct production of components through welding processes	**BJ, CMF, M-FDM** Two-step process In the first step: Production of green parts In the second step: Debinding and sintering of the green parts
ADVANTAGES	- Material can be applied to existing structures - High degree of development - High reproducibility	- Wide variety of materials possible, materials can be processed that are also not weldable - Component properties comparable to MIM components - Highest ratio of the volume of all printed parts to printer volume (even stacking is possible)
DISADVANTAGES	- Rough surfaces - High thermal stresses are introduced into the components as a result of the process - Support structures are required for complex geometries - Surface porosity - Reworking of components required, removal of support structures always necessary - High heat input - Powder handling	- Sintering distortion of the components possible - More complex process chain compared to direct AM methods

HEAT TREATMENT FOR EVERYONE

QUALITY
CUSTOMER FOCUS
EXPERIENCE



FURNACES & OVENS

FOR DIRECT ADDITIVE METHODS

In direct additive processes high thermal stress is often generated by high heat input during the printing process. CARBOLITE GERO provides customers with two suitable furnaces to achieve the best possible component properties.

GPCMA – MODIFIED ATMOSPHERE FURNACE

The GPCMA modified atmosphere chamber furnaces are equipped with a metallic retort to provide a heated volume with a controlled atmosphere. They are floor-standing models with a smooth action hinged door arrangement.

Available with a range of maximum temperature from 1000 °C to 1150 °C depending on the selected retort material. Retort working volumes range from 37 to 245 litres.

Oxygen levels can be reduced to 30 ppm depending on the application. Perfect for stress relieving additive manufactured components particularly those produced via DMLS. This range of furnaces can be optionally specified for compliance to AMS2750F Nadcap class 1 for aerospace applications.

APPLICATION EXAMPLES

- General heat treatment, stress relieving 3D printed additive manufactured parts

GPCMA

- Stress relieving
- Argon, nitrogen, forming gas
- Large usable volume for many parts, big parts
- Precise temperature uniformity
- Oxygen levels down to 30 ppm

V-L – TOP HAT FURNACE

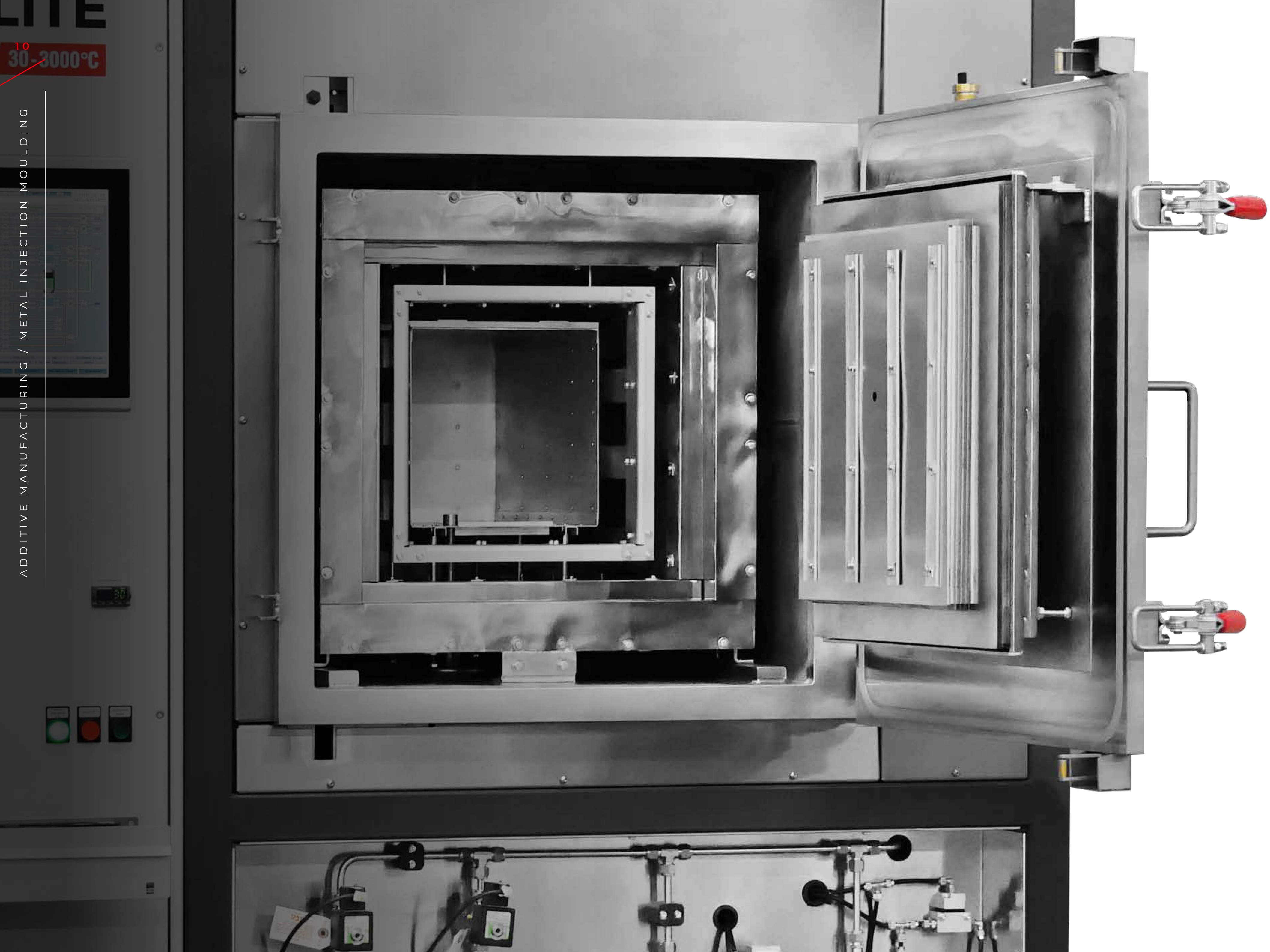
The V-L furnace is suitable for generating the lowest achievable operation pressures. Due to this vacuum capability, the highest purity gas atmosphere can be achieved.

APPLICATION EXAMPLES

- Annealing, brazing, degassing, quenching, rapid prototyping, sintering, soldering, synthesis, tempering, stress relieving 3D printed additive manufactured parts

V-L

- Stress relieving
- Argon, nitrogen, forming gas, high vacuum
- Oxygen levels <<30 ppm
- Precise temperature uniformity


30-3000°C

DEBINDING & SINTERING FURNACES

FOR INDIRECT ADDITIVE METHODS

GLO 8 LITRE – ENTRY-LEVEL FURNACE

With the GLO 8/13 Carbolite Gero provides a small versatile furnace for Additive Manufacturing. The furnace features rotationally symmetrical heating elements that surround a cylindrical retort, ensuring uniform heating along the entire length.

The furnace can be operated either with nitrogen, argon or forming gas (N_2/H_2 95/5 % or Ar/H_2 98/2 %).

APPLICATION EXAMPLES

- Thermal debinding, sintering, pyrolysis, synthesis, annealing, tempering

GLO

- Up to 1300 °C
- ⌀ 180 mm
- Gas tight
- Robust and reliable

HTK 8 TO 120 LITRE – ADVANCED FURNACES

The high temperature furnace range HTK of Carbolite Gero consists of several metallic heated furnaces made of molybdenum and tungsten.

These furnaces can be operated up to 2200 °C with hydrogen, nitrogen and argon, or even in vacuum, depending on the customer's requirements. The concentration of the gases is freely adjustable.

The HTK 8 and HTK 25 chamber furnaces are widely used for indirect Additive Manufacturing applications. The usable space, precise temperature control and uniformity are beneficial characteristics for indirect Additive Manufacturing processes.

APPLICATION EXAMPLES

- Thermal debinding, sintering, pyrolysis, synthesis, annealing, tempering

HTK 8 & HTK 25

- Up to 2200 °C
- 8 to 320 litres volume
- Fine or high vacuum
- Suitable for all materials

HISTORY FACTS

In 1909 Bakelite became the first injectable man-made polymer, changing the face of manufacturing forever. Since then, plastic injection moulding has been further developed and is nowadays one of the most common methods used to produce polymeric parts.

This breakthrough in manufacturing sparked the idea of applying the injection moulding process to different materials. The first studies on ceramic injection moulding (CIM) originated in the 1920s, making ceramic material available for the injection process.

In 1970 metal injection moulding (MIM) was invented by Dr. Raymond and E. Wiech Jr. Subsequently, it has become a standard industrial process. Early in these developments, the required furnaces were not dedicated to this process had to be modified to meet the requirements for MIM.

The direct manufacturing method Laser Powder Bed Fusion (LPBF) was first demonstrated in 1995 at the Fraunhofer institute in Aachen by Dr. Schwarze and Dr. Fockele.

Since the beginning of the 21st century, the Additive Manufacturing (AM) or 3D printing methods further expanded the field of direct and indirect manufacturing methods. Regardless of the process, heat treatment is a vital manufacturing step, often overlooked.

With over 80 years of furnace engineering experience, Carbolite Gero have developed furnaces specifically for debinding and sintering processes. Our latest generation of MIM furnaces is now available to customers all over the world.

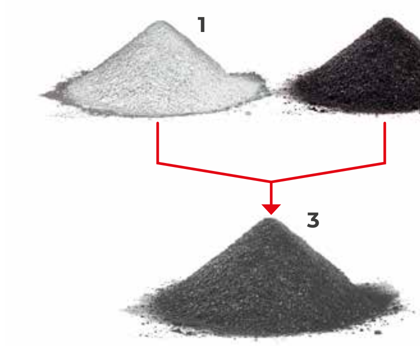
INTRODUCTION TO METAL INJECTION MOULDING (MIM)

PROCESS OVERVIEW

MIM (Metal Injection Moulding) is a near net-shaping process technology for the production of complex shaped devices with high throughput. For MIM technology a polymer is mixed with a metallic powder. The so called “feedstock” is formed, that can be injected into moulding cavities afterwards to form the “green part”. A typical injection moulding machine is the ALLROUNDER® from Arburg. With this technology it is possible to obtain very complex geometries with high reproducibility. After shaping the “green part” the polymeric binder is removed either chemically (with catalytic additives, solvents, water) or by heat treatment dependent on the used feedstock. This procedure is followed by sintering, i.e. densification by heat treatment.

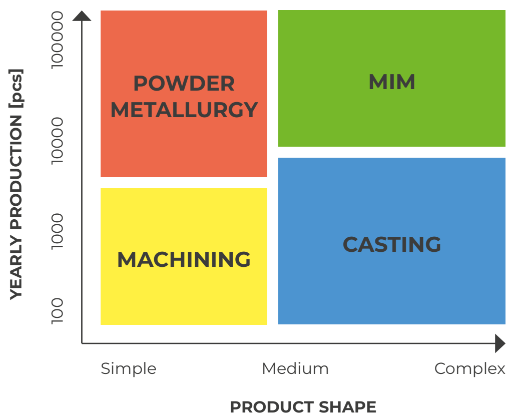
MIM PROCESS STEPS

1. FEEDSTOCK MIXING AND GRANULATING
2. MOULDING
3. FIRST STAGE BINDER REMOVAL
4. SECOND STAGE BINDER REMOVAL AND SINTERING
5. FINISHING

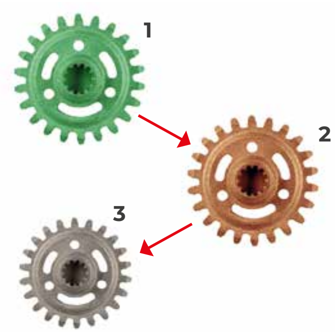


ARBURG

FEEDSTOCK MIX
Binder (1) and metal powder (2) are combined to result in the feedstock (3)



MASS PRODUCTION
Incorporation of existing manufacturing technologies for mass production



PARTS THROUGHOUT HEAT TREATMENT
Green part (1) formed by Metal Injection Moulding, brown part (2) after binder removal and finished part (3) after sintering

CARBOLITE GERO

FURNACES FOR ADDITIVE MANUFACTURING & METAL INJECTION MOULDING

FURNACES ARE OUR PASSION

HIGH QUALITY GREAT PERFORMANCE

FURNACES FOR METAL INJECTION MOULDING

MORE THAN 30 YEARS OF EXPERIENCE

EBO**MIM** **3**

CATALYTIC DEBINDING

The EBO-MIM was specially developed to meet the strict requirements of **catalytic debinding** of MIM parts. This oven is an ideal solution for debinding green parts from **Catamold® - made by BASF** feedstock.

Nitric acid (HNO_3) is vaporized and introduced into the furnace with the carrier gas nitrogen, where a recirculation fan delivers the acid around the green parts. The nitric acid cracks the main binder, creating formaldehyde (CH_2O), which is gaseous and explosive in concentrations between 7 % - 73 %.

The gas flow directs the formaldehyde towards the furnace gas outlet where it is then safely combusted using an active torch afterburner.

GLO**MIM** **3**

REST DEBINDING & PRE-SINTERING

For MIM technologies the **thermal debinding** process should guarantee the binder decomposition, safe removal of volatile substances and protection of metallic powder from oxidation.

All requirements can be fulfilled by our GLO-MIM furnaces. Each furnace is equipped with a gas-tight retort and a continuous gas flow guides the volatiles to the exhaust system. No oxygen gets into the furnace, which means the sample is protected, does not oxidize and no dangerous atmosphere is created.

These furnaces are designed to enable the use of a controlled atmosphere up to 1100 °C, allowing the **pre-sintering** process to take place.

HTK**MIM** **3**

REST DEBINDING & FULL SINTERING

Sintering of the brown parts for MIM technologies requires vacuum furnace technology. The ideal solution for this is the HTK-MIM vacuum furnace. It is equipped with all relevant features for debinding and sintering.

HTK-MIM series is suitable for thermal **rest debinding** of the backbone binder of MIM parts (typically 1 % backbone binder).

The final sintering step can be performed at a maximum temperature of 1450 °C. In each process step, all required gas atmospheres and vacuum levels are possible.

HEAT TREATMENT SOLUTIONS FOR MIM

INDIVIDUAL, RELIABLE SOLUTIONS

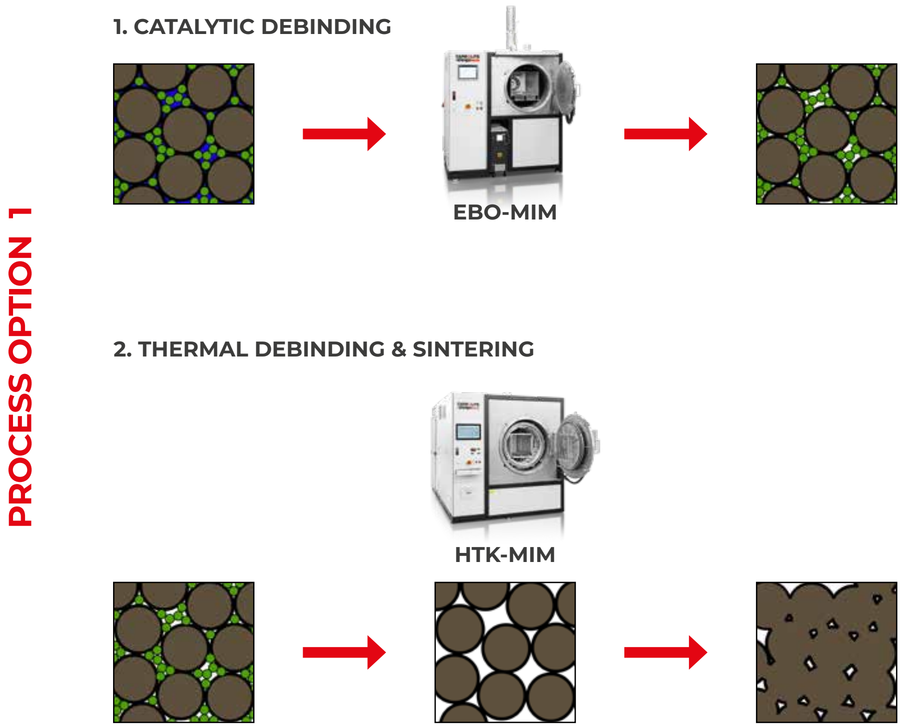
Carbolite Gero offers two main multi-step solutions for the heat treatment of Metal Injection Moulding (MIM) parts:

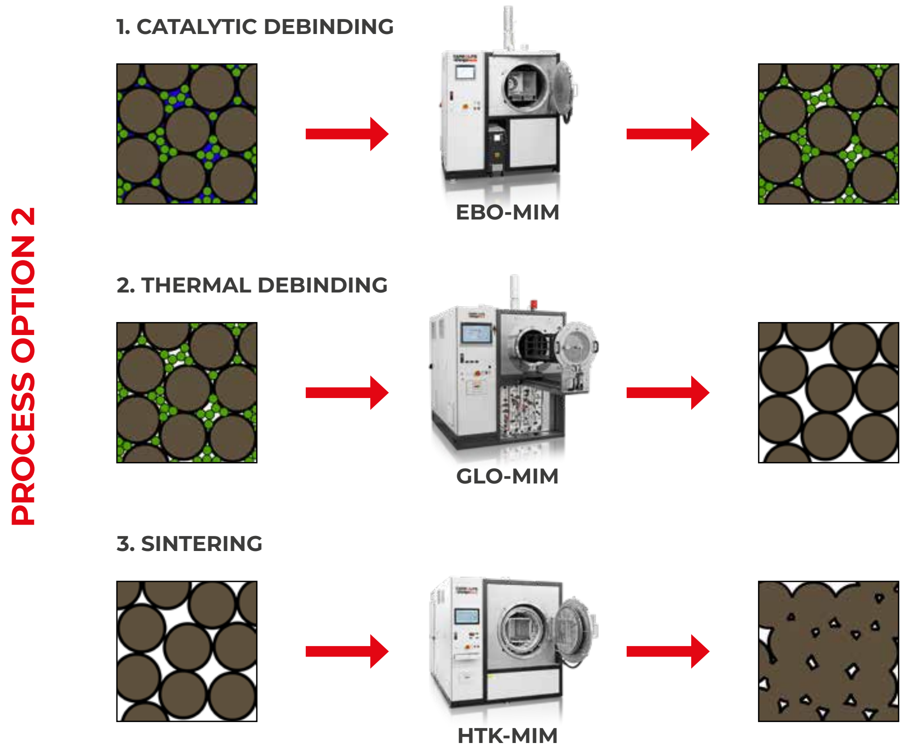
For the most widely used feedstock systems, i.e. **Catamold® - made by BASF**, the Metal Injection Moulding process requires catalytic debinding, thermal debinding of the backbone binder, and sintering. Carbolite Gero provides customers with two different process options consisting of two or three furnaces.

The first option is a combination of the **EBO-MIM** and **HTK-MIM** furnaces. Catalytic removal of the binder is carried out in the EBO-MIM, whilst both thermal debinding of the backbone binder and sintering can be performed inside the HTK-MIM. The main benefit of this solution is that the entire process can be carried out using only two furnaces.

The second option is a combination of the **EBO-MIM**, **GLO-MIM**, and **HTK-MIM**. Catalytic removal of the main binder is carried out in the EBO-MIM, thermal rest debinding of the backbone binder and pre-sintering in the GLO-MIM, and main sintering in the HTK-MIM furnace.

Whilst this solution incorporates an additional furnace into the process, overall it can prove a more cost-effective solution because the molybdenum / tungsten parts of the HTK-MIM furnace are protected from contamination, thus maintenance costs are reduced.



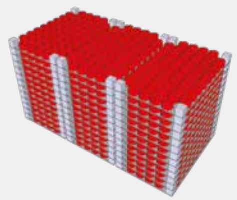


EBOMIM3 → GLOMIM3 → HTKMIM3

THE BEST SOLUTION FOR YOUR PRODUCTION

Carbolite Gero offers a whole range of furnaces for the MIM process, starting with small units for R&D, up to industrial scale furnaces. But the most widely used MIM debinding and sintering furnaces are made for a total of **three sinter stacks**. Three stacks (380 x 240 mm) with 20 trays each as sample support are the maximum capacity of the **EBO 120**, **GLO 260** and **HTK 120**. That's why we call them **EBOMIM3, GLOMIM3** and **HTKMIM3.**

The working space in all **MIM3** furnaces is almost identical, which makes it convenient to move samples from one furnace to another. This is especially important for the MIM process, since both green and brown parts are still fragile before sintering, and re-sorting between process steps is very undesirable.



	TWO FURNACES		**THREE FURNACES**		
	EBO	**HTK**	**EBO**	**GLO**	**HTK**
Cycle time, hours	8	22	8	12	12
Total hours	30		32		
Maintenance	Slightly higher, due to debinding in the sintering furnace		Low, since the sintering furnace is kept clean.		
Hydrogen partial pressure debinding	Yes		Not in the GLO, only in the HTK		

BENEFITS OF CARBOLITE GERO FURNACES

OUR EXPERTISE

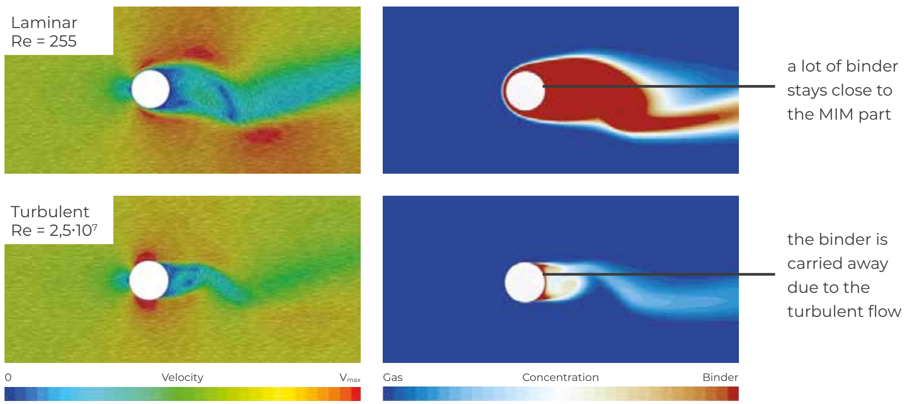
SAFETY FIRST

Since the debinding and sintering process requires hydrogen for many high quality materials, safety is paramount. Carbolite Gero has a full TÜV certified safety concept for the whole furnace series, including hydrogen partial pressure operation over the full temperature range. Throughout the product range we are using Siemens PLC hard- and software, which is a modern industrial standard.

GAS FLOW MANAGEMENT

In order to achieve the best possible conditions to remove the binder of MIM components, the gas flow needs to be **continuous and turbulent** to enable it to reach all samples placed within the furnace. The turbulence assists in the removal of binder from green parts during the process.

Carbolite Gero has worked closely with academic institutions to carry out CFD (Computational Fluid Dynamics) simulations to test and improve gas flow inside furnaces typically used for MIM applications.



TEMPERATURE UNIFORMITY

Temperature uniformity is the maximum temperature deviation within the usable volume of the furnace chamber. For example, if the furnace is set to 600 °C and it has a stated temperature uniformity of ±5 °C, then temperature within the usable volume cannot drop below 595 °C or exceed 605 °C.

Temperature uniformity is crucial during the sintering of MIM parts, as the aim is to ensure that all parts have an equal amount of shrinkage and density.

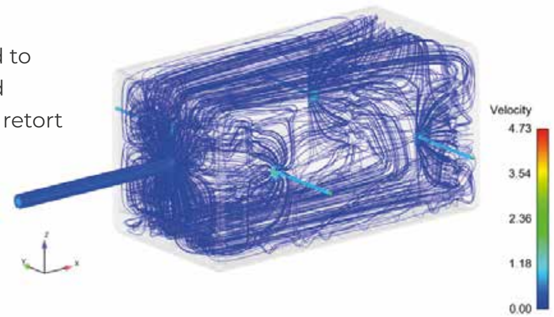
Carbolite Gero furnaces are available with multiple heated zones to ensure the temperature inside the chamber is uniform over the entire usable space.

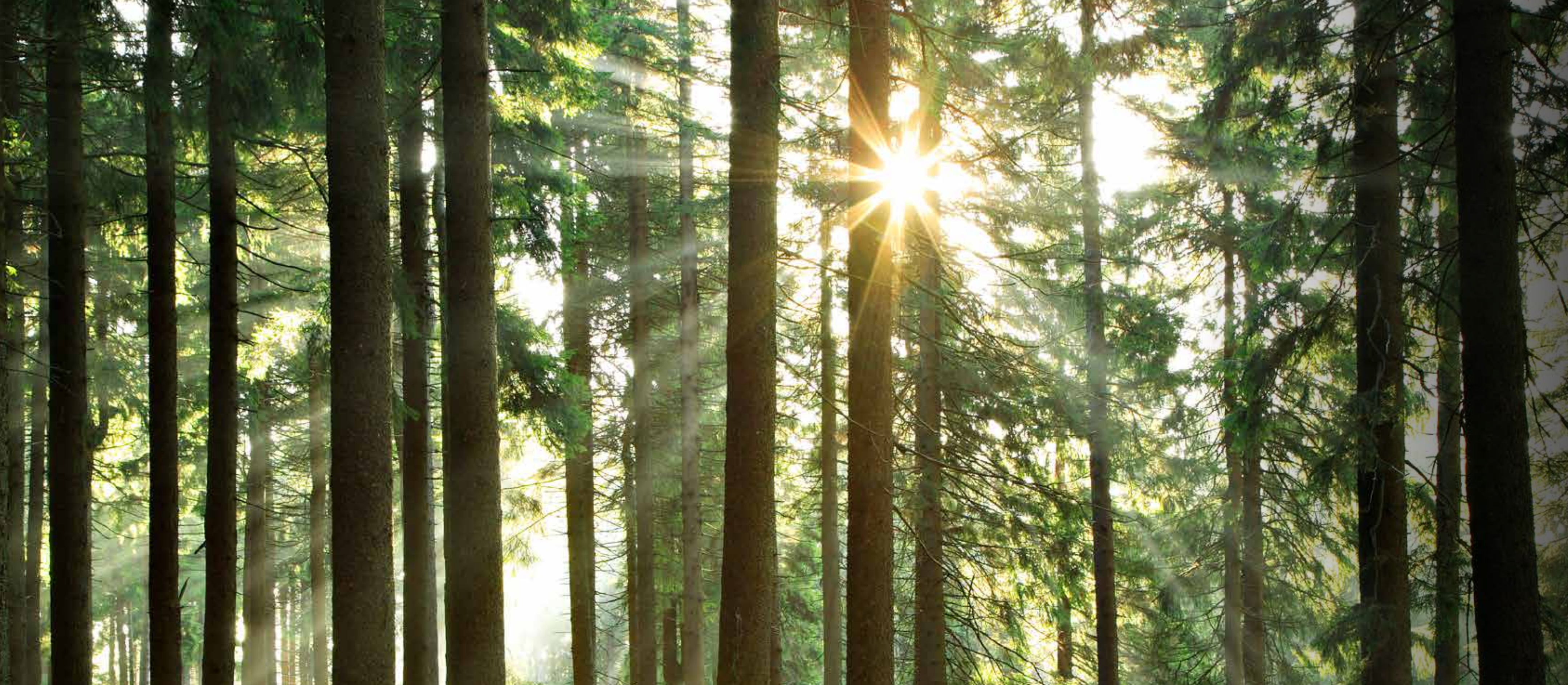
Partial pressure with Ar, N_2 or H_2 is possible in HTK-MIM furnaces. The pressure can be adjusted in the HMI and set between 50 - 1000 mbar. The opening angle of a pneumatic valve is set to ensure the pressure within the furnace vessel is kept at a constant level.

Partial pressure increases the efficiency of debinding and reduces the temperature due to the additional pressure exerted by the vapourised backbone binder.

The design and configuration of the rack enables gas to flow through each layer and around each MIM part. To achieve this, four special gas inlets diffusors direct the flow horizontally through the layers of racking. Each inlet is connected to a separate gas flow, the rate can be individually set to maximise performance depending on the individual requirements.

A special gas outlet plate is fitted to ensure that the gas is distributed uniformly throughout the whole retort of the furnace rather than solely through the centre.





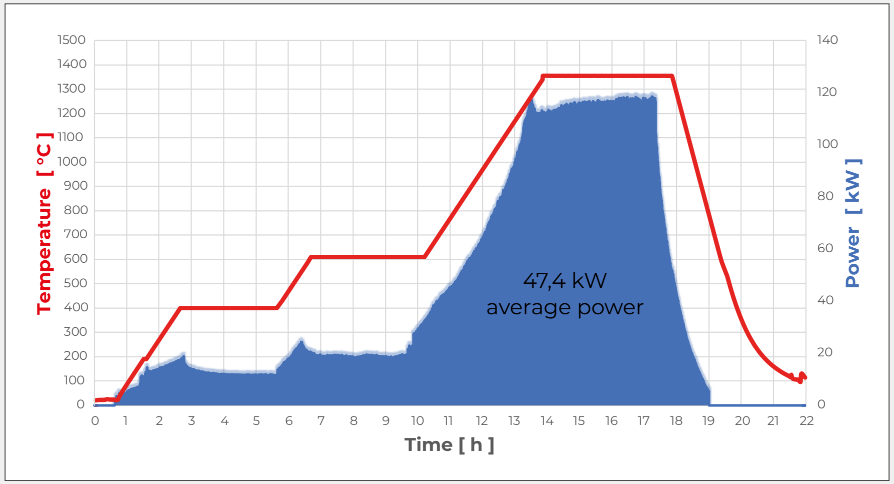
LOW ENERGY CONSUMPTION

Carbolite Gero MIM furnaces are very energy-efficient. Due to our design of the heating cassette energy consumption is drastically reduced, which is an important fact, mainly for production units, and results in reduced costs per MIM-part.

Using a Carbolite Gero furnace reduces your energy cost as well as the carbon footprint.

For instance a full 22 hours rest-debinding / sintering run with typical load of an HTKMIM3 required a total of 900 kWh. Usual values in the market are more than twice as high.

UP TO 50 % LESS ENERGY REQUIRED!
COMPARISON WITH EQUIVALENT COMPETITOR PRODUCT



CARBOLITE GERO 30-3000°C

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VERDER SCIENTIFIC

SCIENCE FOR SOLIDS

Verder Scientific is a business field belonging to the Verder Group and sets standards in the development, manufacture and sale of laboratory and analytics devices. Used in quality control, research and development for test-piece preparation and the analysis of solids.

For several decades our companies have supplied production plants and research institutes, laboratories for quality testing and analytics, all kinds of technical specialists and scientists with modern, reliable devices to solve the many and varied challenges they face.

CARBOLITE GERO 30-3000°C
ELTRA
Retsch
QATM
MICROTRAC MRB