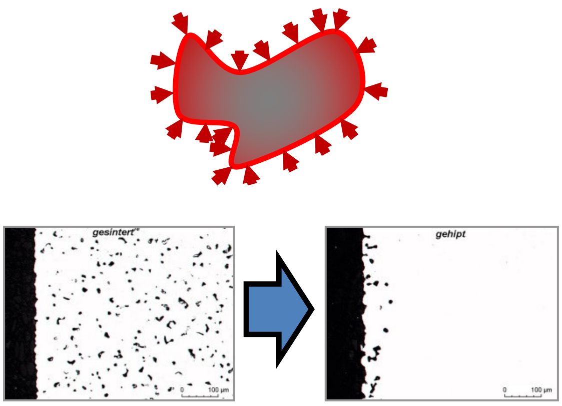
CREMER HIP - Systems

1 Overview HIP Technology

During Hot Isostatic Pressing (HIP), the material to be processed is heated up in special plants (HIP plants) under argon atmosphere and high gas pressure from all sides and under high temperatures exceeding its yield point so compact it. For most materials, process pressure is approx. 1000bar = 100MPa and temperatures are up to 1400°C.

The HIP process serves for removing internal cavities, e.g. residual pores in cast or sintered metal or ceramic parts in order to obtain properties comparable to those of forged materials.



Usually, Argon is used as pressure transmitting medium at material-specific sinter temperatures, i.e. approx. $0.7 * T_S$.

Depending on the material, the applied pressure varies between 300 and 1500 bar. This pressure is generated by means of a compressor as well as due to the thermal expansion of the gas.

2 Applications

HIP-produced or treated components show the following properties:

- isotropic, homogeneous, and pore-free microstructure (100% density)
- no internal material defects as a matter of principle resp. their avoidance and recovery (cavities, cracks, pores) considerably improved mechanical properties, especially fatigue strength
- considerably improved polishability

Therefore, the HIP process is successfully used in the following sectors:

- Redensification of ceramic components (also CIM-parts[1])
- General redensification of cast or forged parts to increase their performance or to recover defects
- Redensification of PM-parts (conventional sinter parts, MIM-parts[2] or AM-parts[3]) to eliminate pores
- Near-net-shape production of powder metallurgical (PM) parts and semi-finished products by means of the container method
- Processing and densification of materials, which can only be processed by means of powder metallurgically, e.g. carbides and various superalloys

[1] CIM: Ceramic Injection Molding
[2] MIM: Metal Injection Molding
[3] AM: Additive Manufacturing

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3 HIP Systems - Makeup

A Hot Isostatic Press (HIP) can be understood as a high-pressure furnace:

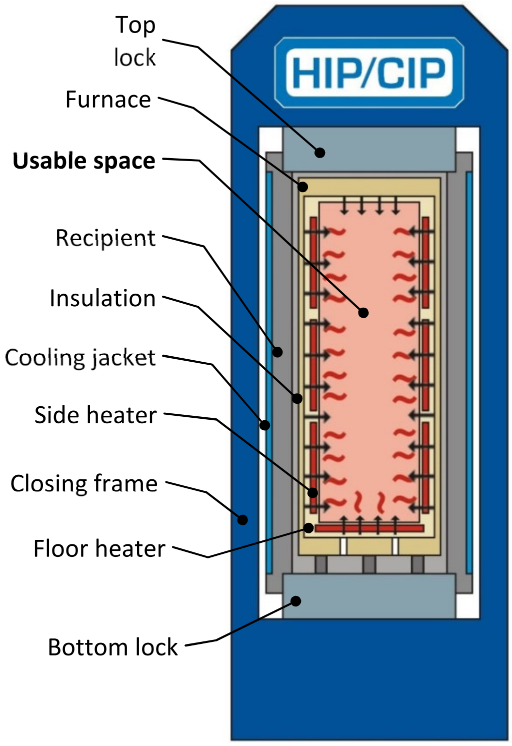
This furnace accommodates the product to be processed, heats it up to the desired temperature, and at the same time shields the outside against this temperature by means of its insulation.

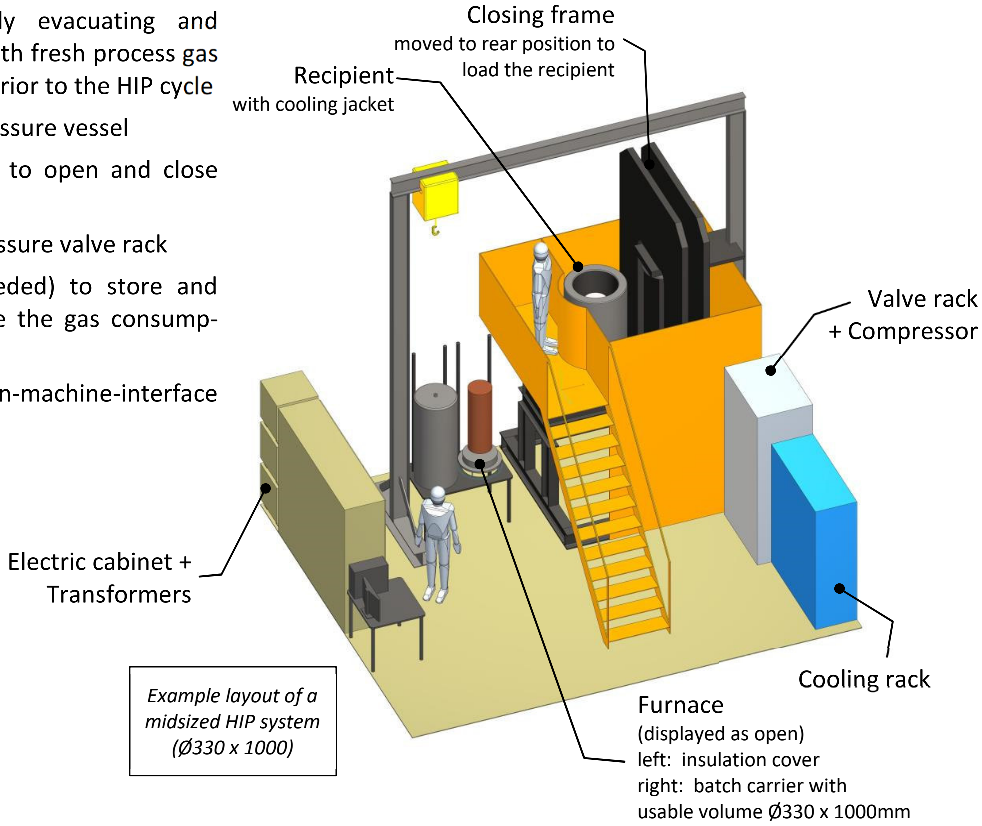
This happens under very high pressure (up to 2000bar). The furnace itself could not withstand the pressure. Consequently, the complete furnace is located inside a pressure vessel (= recipient, top and bottom lock + closing frame). Thus, the furnace resp. its individual components receives only isostatic pressure, i.e. from all sides at the same time. Therefore, mechanical forces cannot impact the furnace components. As a result, the furnace can neither explode nor implode.

The pressure vessel is responsible for accommodating the furnace and to withstand the process pressure. At the same time, the furnace insulation protects it against the process temperatures.

Sub-systems of a Hot Isostatic Press are:

- **compressor** pressurizing the process gas to the desired process pressure inside the pressure vessel
- **vacuum system** alternatively evacuating and purging the pressure vessel with fresh process gas to remove undesired oxygen prior to the HIP cycle
- **cooling system** to cool the pressure vessel
- **hydraulic system** (if needed) to open and close the pressure vessel etc.
- **gas supply system** as high-pressure valve rack
- **recycling gas deposit** (if needed) to store and recycle process gas to reduce the gas consumption of the system
- **system control** (PLC) with man-machine-interface (visualisation)





Example layout of a midsized HIP system (Ø330 x 1000)

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4 Furnace Types

The HIP System can be equipped with various furnace types, which are distinguishable by their individual properties.

Graphite Furnace G200

The graphite furnace attains highest temperatures up to 2000 °C. It is used e.g. to process ceramics or tungsten.

Its CFC and Isographite design make it robust and allow varied applications.

Due to the material, carbon dissolutes in the process gas. Therefore, processing sensitive materials (e.g. stainless steel) is possible but under certain precautions.

Molybdenum Furnace M140

The molybdenum furnace attains temperatures up to 1400 °C (after individual examination up to 1600 °C).

It is the alternative to the graphite furnace whenever high temperatures are necessary while carbonic atmospheres are prohibited.

Ideal e.g. for materials like stainless steels which require high process temperatures, but which are sensitive to carbonic atmospheres at the same time.

Steel Furnace E105

The steel furnace E105 is designed for maximum operating temperatures of 1050°. After individual examination, up to 1100 °C is possible.

Its cost-efficiency makes it highly recommendable to process materials at low temperatures, e.g. aluminium.

In addition to that, the basis material is very resistant against oxygen. Therefore, depending on the application, oxygen can be added to the process to activate certain chemical or metallurgic reactions. Under certain circumstances, it is even possible to use air instead of inert gases for the entire HIP process.

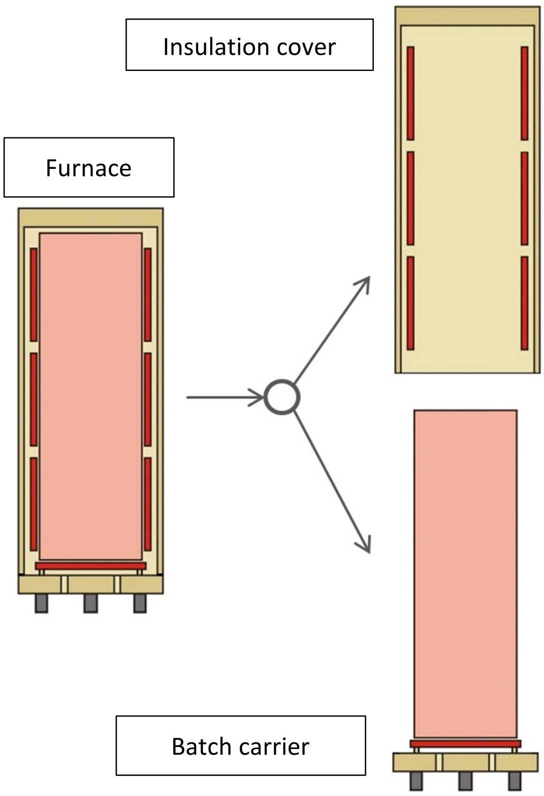
5 CREMER HIP Furnace System

Furnace functionality is of particular interest for the operating company in many respects because he respectively his staff handles this system component frequently.

Therefore, we attach top priority to reliability, operational safety, maintainability, and ergonomy.

One fundamental feature of our furnace system is that it is not firmly fitted into the pressure vessel. Therefore, it is removable from the HIP line for loading and unloading.

For this purpose, the furnace unit is removed from the HIP line by means of a crane and put onto a parking device. Now, the operator unlocks several locking mechanisms between insulation cover and batch carrier. In the next step, the operator takes the insulation cover off the batch carrier, which is now ready for loading and unloading.



At first sight, removing the complete furnace out of the pressure vessel seems to be more laborious than simply taking off the process product. Nevertheless, our design has various decisive advantages:

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For ergonomic aspects, it makes sense to move the batch carrier to comfortable working height for loading and unloading instead of having to handle the product bending down to reach the opened pressure vessel. Depending on the application (e.g. aerospace, medical technology) the furnace thermocouples must be replaced frequently for maintenance or quality assurance. The detached furnace allows the operator quick and easy replacement of thermocouples or individual heating elements. Furthermore, checking or cleaning of the furnace and the interior of the pressure vessel between process cycles is completely barrier-free possible. Moreover, a second furnace can be prepared i.e. loaded, while the HIP line is still under process.

One major point crediting our furnace system is the interchangeability of the furnace.

Various materials demand varying process temperatures, thus stipulating miscellaneous requirements to the furnace.

Consequently, our product range offers a graphite furnace (G200), a molybdenum furnace (M140), and a steel furnace (E105). Each individual furnace features different properties, refer to point 4.

Generally, the issue with changing the furnace lies in the fact that each furnace is equipped with proper thermocouples (type K, S, C, etc.) depending on its process temperature.

The possibility of changing from one furnace type to another at any desired time is the outstanding feature of our system. Changing the type of thermocouple for temperature measurement is no issue in our system. Mechanical refurbishment is not necessary. The operator simply changes the system control to the desired furnace.

Consequently, the operating company is not tied to a certain material group. On the contrary: various materials can be processed with different furnace types.

Our system allows maximum flexibility, top capacity, and optimum economy.

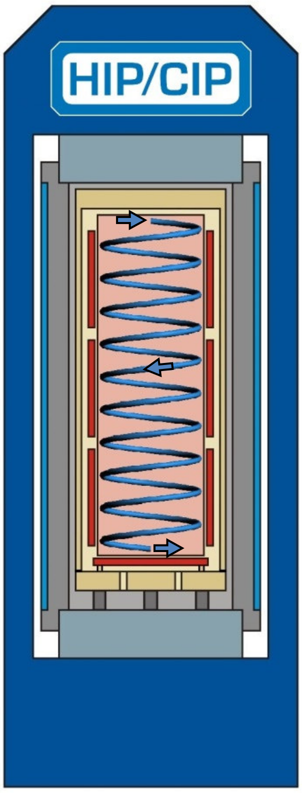
6 Rapid Cooling

In HIP systems, rapid cooling is a common means to increase productivity because it allows effective reducing of cycle times. Therefore, our system always provides rapid cooling. The operator can activate it if desired to reduce the cooling down phase.

Basically, cooled process gas is conducted into the batch basket to cool down the batch as quick as possible. Obviously, the batch must be cooled evenly and uniformly. Cooling some parts of the batch quicker than others will result in noticeably negative effects on process material quality.

The specific feature of our rapid cooling system is excellent temperature homogeneity during the cooling process and over the complete usable height of the batch basket.

This uniformity is achieved by generating a rotating swirl of cold process gas inside the batch basket. Thus, the processed product is not impinged by one concentrated cold gas jet, but the cold process gas mixes homogeneously with the hot process gas to full extent and full batch basket height.



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