

# Hardening, Carburizing, Nitriding, Brazing, MIM



Hot-wall retort furnace NR 50/11 with semi-automatic quenching device for hardening of steel or titanium

## Hardening

Hardening is one of the most common forms of heat treatment of metallic materials, with the aim of increasing mechanical resistance by converting the microstructure.

The hardness and strength increase resulting from the hardening are the main reasons for the increased resistance against wear, tension, pressure and bending.

Hardening is generally understood to mean the transformation hardening, i.e. austenitization of the material followed by quenching. When quenching, the critical cooling rate of the respective material must be exceeded in order to obtain a martensitic structure. The quenching is carried out in different quenching media (water, air, oil or gas).

Depending on the application, the material is allowed to quench, for example to obtain the desired toughness, and the hardness is again reduced.



Protective gas hardening system SHS 41

## Carburizing

Steels with a low content of carbon can usually be poorly cured. By increasing the carbon content to a certain percentage, the hardenability can be significantly improved. This property is used for carburizing. The edge layer is enriched with carbon so that this carburized part of the material can subsequently be cured. The non-edge, non-carburized area of the material remains tough and soft. A known example of this process is the carburizing and subsequent hardening and tempering (case hardening) of gears wheels for all types of gearing. The toothings has the necessary hardness after the hardening in order to minimize wear, but the core of the gear wheel remains ductile and machinable.

## Nitriding

As in carburizing, nitriding is also a thermochemical treatment. During nitriding, nitrogen diffuses into the edge layer. Depending on the steel or cast alloy, an increase in hardness can be achieved. A greater advantage of nitriding is the achievement of a wear-resistant edge layer. For low-alloy steels the corrosion resistance can be significantly increased by nitriding.

Carburizing and nitriding can be carried out with solid, gaseous or liquid media.

The following furnace concepts are suitable for curing, carburizing and nitriding:

### Hardening

- Hardening in the protective gas box/protective gas annealing bag or annealing box in chamber furnaces with or without protective gas atmosphere. The quenching can take place in different media like oil, water or air.
- Hardening in the hot-wall retort furnace with protective gas or reaction gas up to 1150 °C. The quenching is done manually or semi-automatically in oil, water or air.

### Carburizing/Nitriding

- Carburizing/nitriding in the annealing box with appropriate granulates
- Controlled or uncontrolled nitriding/carburizing in the hot-wall retort furnace with combustible reaction gases. The quenching is done manually or semi-automatically in oil, water or air.

### Annealing

- Annealing in a forced convection chamber furnace with or without a protective gas atmosphere
- Annealing in the protective gas box in a forced convection chamber furnace under protective gas atmosphere



Forced convection furnace N 250/85 HA with annealing box



Retort furnace NRA 50/09 H<sub>2</sub>

**Powder-Pack Annealing Processes**

As a cost-effective alternative to the thermochemical processes which take place in a gas atmosphere, the powder packing annealing is suitable for certain processes.

With this method, the parts, which are appropriately prepared, are charged into an annealing box together with the process powder. The annealing boxes are then closed with a cover.

Possible application examples are carburizing, neutralizing, nitriding or boriding.

**Brazing**

In general, when speaking of brazing it has to be distinguished between soft-soldering, brazing and high-temperature brazing. This involves a thermal process for forming substance-to-substance bonds and material coatings during which a liquid phase is generated by the melting of the solder. Based on their melting temperatures, the solder processes are classified as follows:

Soft-solders: T<sub>liq</sub> < 450 °C

Brazing: T<sub>liq</sub> > 450 °C < 900 °C

High-temperature brazing: T<sub>liq</sub> > 900 °C

Beside the right selection of the solder, the flux if necessary, and ensuring that the surfaces are clean, the choice of the right brazing furnace is also key to the process. In addition to the actual brazing process, Nabertherm has furnaces for the preparation process in their range such as for metallizing ceramics in preparation for brazing ceramic-to-metal bonds.

The following furnace concepts are available for brazing:

- Brazing in an annealing box in the forced convection chamber furnace up to 850 °C in a protective gas atmosphere
- Brazing in an annealing box in a chamber furnace up to 1100 °C under a protective gas atmosphere
- Brazing in a hot-wall retort furnace NR/NRA product line under protective gases or reaction gas up to 1100 °C
- Brazing in a cold-wall retort furnace VHT product line under protective gases, reaction gases or under vacuum up to 2200 °C
- Brazing in a salt bath up to 1000 °C salt bath temperature
- Brazing or metallizing in a tube furnace up to 1800 °C under protective gases, reaction gases or in a vacuum up to 1400 °C

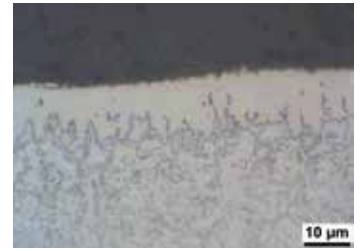
In the Nabertherm Test Center in Lilienthal, Germany, a range of sample furnaces is available for customers testing applications which is the best approach to define the right furnace for a specific application.

**MIM - Metal Powder Injection Molding**

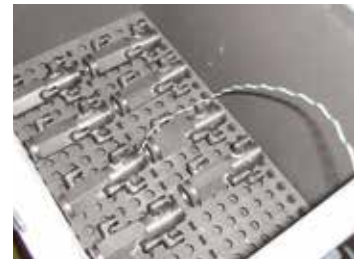
The metal powder injection molding is based on the same principle as the plastic injection molding. At MIM, a metallic feedstock, i.e. a metallic powder with a binder system, is produced by means of an injection molding machine and an injection mold. The result is a so-called green part, which does not yet have its final size and density.

In the subsequent debinding process, which takes place under metallic conditions either under an inert atmosphere, under hydrogen or else catalytically under a nitric acid-nitrogen atmosphere, the green part loses a large proportion of the binder.

In the subsequent sintering process, which is also carried out again in a protective gas or reaction gas atmosphere or in a vacuum, the brown part is sintered to the finished component, which in most cases does not have to be further processed.



Close-up of a metallographic section of a powder-borated hot-work steel



Brazing in annealing box



Retort furnace NRA 40/02 with cupboard for the acid pump



Retort furnace VHT 40/16-MO H<sub>2</sub> with hydrogen extension package and process box