# GASSING SYSTEMS AT HEAT TREATMENT FURNACES

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**ABSTRACT**

*The article presents gassing installations made by IVA Industrieöfen GmbH. For thermo-chemical treatment many different gases are needed. The way of gases beginning from the storage tank through the furnace to the afterburning system is shown. Gassing lances and their function, safety aspects and applications of the installations are presented. Several pictures inform about the guiding of the process gases within different furnaces. Besides, the article contains a list with some important gaseous media for the heat treatment and their task.*

## 1. GAS SUPPLY

For the heat treatment of ferrous materials, e.g. nitriding, carburizing, soldering, many different gases are needed. Table 1 shows the most commonly used media.

| media | application fields, functions |
|---|---|
| nitrogen | neutral gas, security gas, soldering, vacuum hardening |
| earth gas | heating, burning off, carburizing agent, endogas |
| propane | heating, burning off, carburizing agent, endogas |
| air | oxidizing, flushing, cauterizing, lower carbon potential |
| water | oxidizing, oxinitriding, cauterizing, decarburizing |
| carbon dioxide | oxidizing, nitro carburizing, lower carbon potential |
| ammonia | nitriding, nitro carburizing, fission gas |
| endogas | carburizing, nitro carburizing, annealing |
| methanol | carburizing, nitro carburizing, annealing |
| fission gas | lower nitriding potential, annealing, soldering, tempering |
| hydrogen | annealing, tempering, lower nitriding potential, soldering |
| CITROX®-solution | activating for nitriding/ nitro carburizing, post- oxidizing |

*Table 1: different media for heat treatment and their function [1]*

The way of transporting the medium to the furnace depends on the medium itself and on the required quantity. In many cases, gases are stocked in liquid tanks. As they must get into the reaction chamber in gaseous form, they often have to pass a vaporizer.

In other cases, gas generators are used. The gas flows through a heated tube- often filled with a catalyst- and thereby it is split into two other gases, e.g. $2\ NH_3 \rightarrow 3\ H_2 + N_2$ . A generator has the advantage that if hydrogen and nitrogen are needed in addition to ammonia, no additional storage tank for hydrogen has to be erected. The storage of hydrogen can be complicated because this gas requires additional safety precautions.
Beside storage tanks, filled regularly by a gas supply company, some hardening shops are connected to a public supply piping system for earth gas.
Water and CITROX®- solution for the IVA- CITROX®- process are stocked in simple plastic containers just beside the nitriding furnace, see Picture 1. The CITROX®- solution, used for activating the surface before the nitriding process and for post-oxidizing- is brought into the furnace by pumps and a special lance. Especially in case of a slight contamination the CITROX®-solution cleans the surface of the parts that have to be nitrided/ nitro carburized. Thereby the uniformity and the quality of the nitriding layer are improved.


*Picture 1: gas heated, evacuable nitriding furnaces type RH… RV/g, the plastic containers for water and CITROX®- solution can be seen in the left lower corner of the picture*

## 2. GAS FEEDING

Before a medium gets into the furnace, it usually passes a system of many pressure- reducing valves and flow meters. There are existing two possibilities of mounting these regulation components on the heat treatment plant: a gassing table and a gassing cabinet. Table 2 mentions the advantages and disadvantages of both solutions. Picture 2 shows the appearance of them.

| gassing table | gassing cabinet |
|---|---|
| + good accessibility<br>o maintenance, repair<br>o adjustment | + closed unit<br>o protection against pollution<br>o protection against wrong adjustment |
| + good aeration | + clearness (“at a glance”) |
| + easy to transpose | |
| - possible pollution | - aeration required |
| - good accessibility (unauthorized persons) | - long way for gases<br>with gas-feeding from above |
| | - expensive |

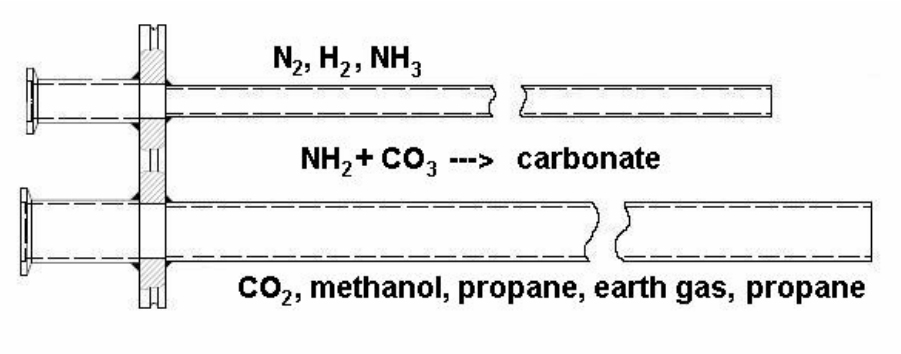
*Table 2: advantages/disadvantages of gassing table/ gassing cabinet*

*Picture 2: left side = gassing table, right side = gassing cabinet*

Process control and regulating electronics control the chronological sequence of the inlet of each medium. The quantity can be adjusted by hand at the flow meter of each branch.
After that, the gas or the liquid gets into the oven through different types of lances.

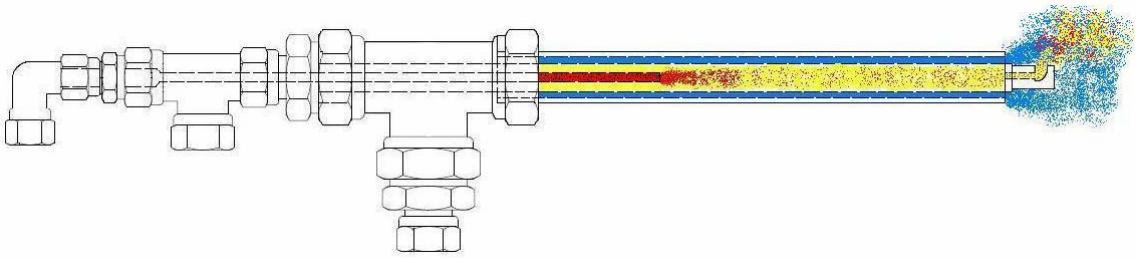
## 3. GASSING – LANCES

As some gases are able to react with each other, these gases should not be blown into the furnace through the same lance. This is only possible for inert gases like $H_2$ and $N_2$ or both together with $NH_3$.
Ammonia and carbon dioxide need different lances because they can react to carbonate which can block the lance. For the process of nitriding and nitro carburizing, IVA evacuable nitriding furnaces type RH… RVe/g are equipped with gassing lances appropriate for reactive gases. This kind of lance can be seen in picture 3. The length of the lance depends on the size of the furnace; it varies between 1000 mm and 1700 mm.




*Picture 3: nitriding- nitro carburizing lance*

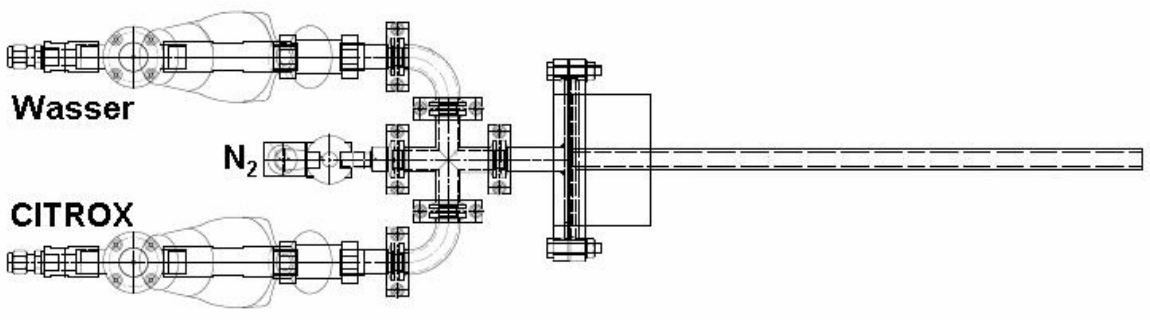
For carburizing, the IVACARB- lance is used. Picture 4 shows this lance and the media going through it. In order to produce a uniform atmosphere in the reaction chamber, a quantity of 4 litre methanol, earth gas or propane per hour should not be exceeded. The optimum mixture of the media is achieved with a quantity between 1,5 and 4 l/h.



| | pressure | medium | function |
|---|---|---|---|
| | high | methanol | carburizing agent, cooling lance |
| | high | nitrogen | pulverizing cooling lance |
| | low | air<br>earth gas, propane | lower Cp, cauterizing lance<br>increase Cp |

*Picture 4: IVACARB- lance (length approximately 1200 mm) for carburizing in IVA multipurpose chamber furnaces and the media flowing through it*

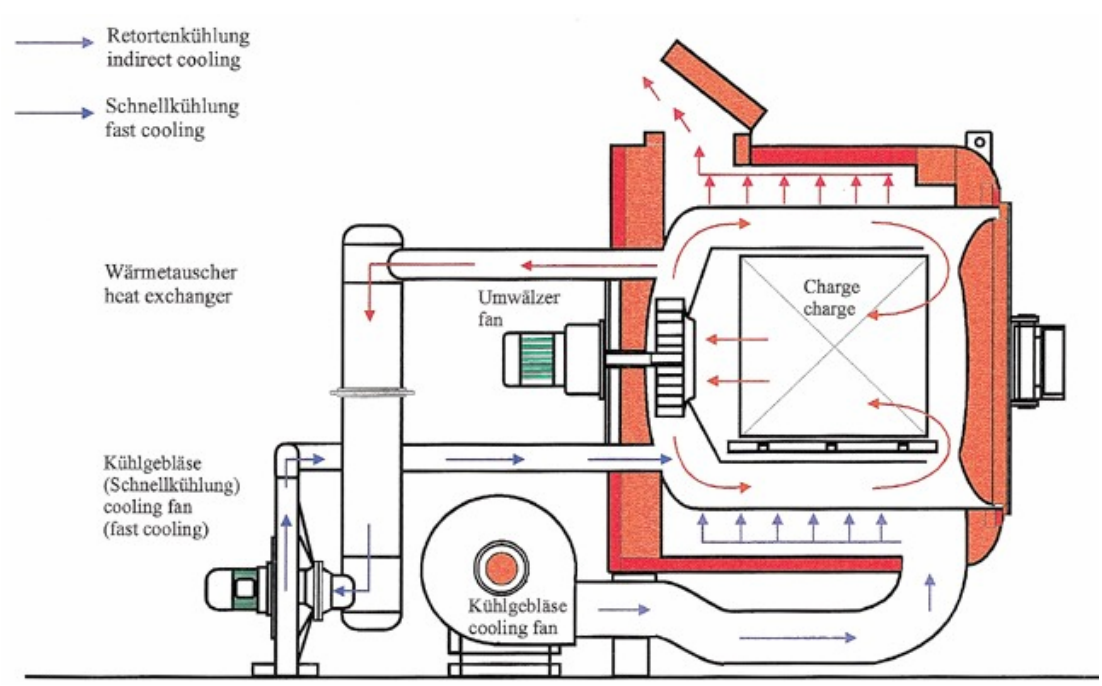
Even if for the CITROX®- process a usual lance consisting only of one tube is sufficient, the behaviour of the citric acid in the CITROX®- solution has to be taken into consideration. As citric acid contains carbon, it can form soot.




*Picture 5: CITROX®- lance, length approximately 1000 mm*

Therefore it should not stay in the lance during the nitriding process that follows directly after the activating with the CITROX®- solution. Flushing with nitrogen blows the rest of the citric acid out of the lance which then stays clean without soot. Besides, using distilled instead of normal water, avoids the formation of lime deposits. A drawing of the CITROX® - lance can be seen in Picture 5.

## 4. GAS GUIDING IN THE FURNACE



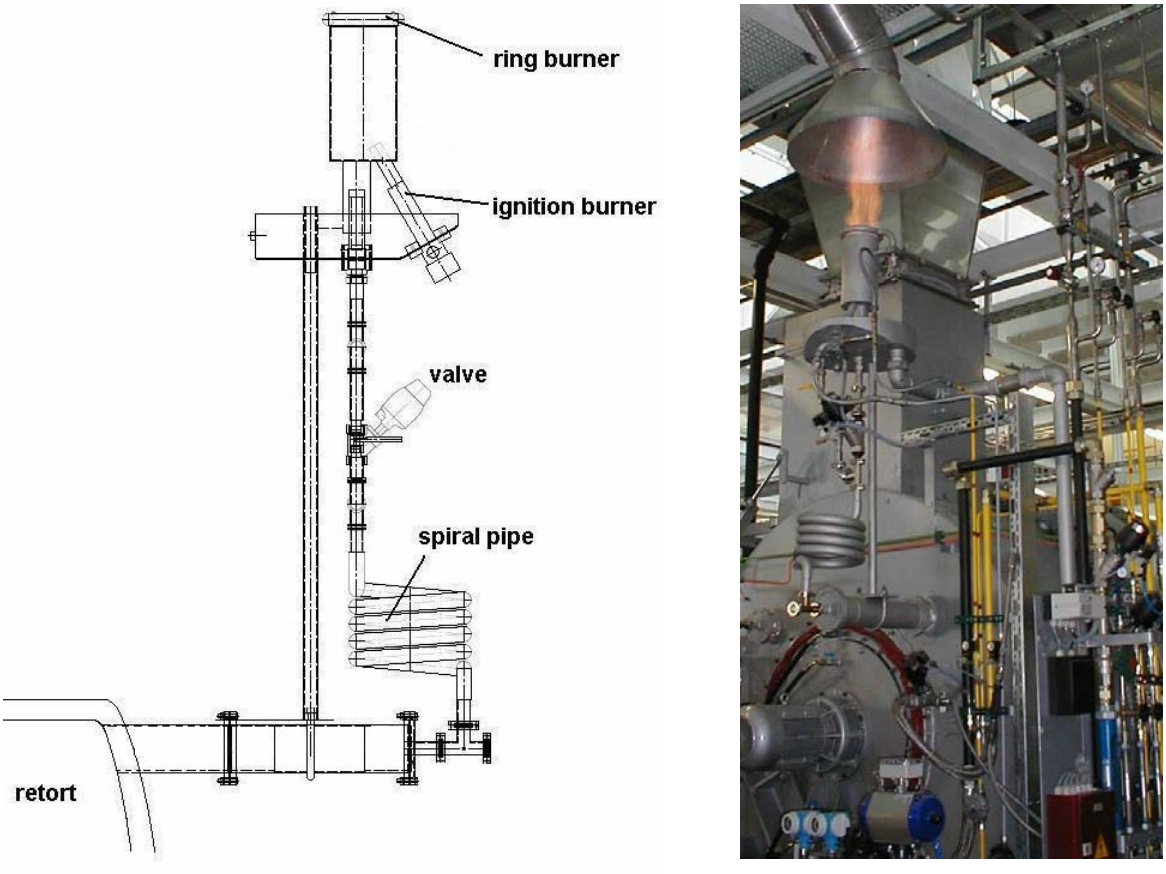

*Picture 6: evacuable nitriding furnace type RH… RVe/g, scheme of the gas guiding and the cooling system*

The efficacy of the media and by this the quality of the heat treatment process does not only depend on the purity of the medium, the quantity or the type of gassing lance. The guiding of the gases within the furnace and the structure of the charge are other important aspects. Picture 6 shows the scheme of an evacuable nitriding furnace type RH… RVe/g.

cylinder, both made of chromium-nickel-steel.
With a vacuum pump the process room (retort) is evacuated. During the heat treatment, the retort pressure is about 50 mbar over the normal pressure. For nitriding nitrogen and ammonia are brought into the furnace. On the surface of the work pieces ammonia splits into nitrogen and hydrogen. Nitrogen in atomic state is able to diffuse into the surface and depending on temperature, time and gas concentration different layers can be produced [2].
The structure of the charge and the size of the surface have to be taken into account. When the reactive gas flows through the charge, at the beginning its concentration is bigger than at the end because a part of the gas has been absorbed by the work pieces. Therefore, the amount of gas in litres or cubic meters per hour has to be adjusted by the operator of the furnace according to the structure of the charge and the required properties of the nitriding layer.
The IVANIT- gassing offers a good solution for both cases. It has two flow meters for ammonia – big quantity for charges with a big surface and small quantity for the ones with a small surface.
As the whole amount of ammonia can never split into hydrogen and nitrogen, nitriding furnaces have to be equipped with an after burn system in order that only negligible quantities of ammonia get into the atmosphere.

## 5. AFTER BURN SYSTEM

Nitriding and carburizing or any other kind of furnaces using poisonous or combustible gases must have an after burner for theses gases. In picture 7 a scheme and photography of a burner for IVA nitriding furnaces is shown.




*Picture 7: after burn system for nitriding furnaces*

The gas leaves the retort through a tube and a spiral pipe. In the spiral pipe the hot gas cools down to a temperature that cannot destroy the valve. When it reaches the ignition burner, the gas is totally burned. In case of ammonia, it is split into hydrogen and nitrogen. An even if there is a small quantity of ammonia left after having passed the ignition burner, the ring burner avoids that this small amount gets into the factory hall.
A hood with a vent pipe, mounted directly above the burner extracts the waste gas and transports it to the outside.
Carburizing furnaces, e.g. multipurpose chamber furnaces, need an after burn system for the gas used, too. Picture 8 shows the burners of an IVA multipurpose chamber furnace type MKG/ MKE. The complete plant can be seen in picture 9.

*Picture 8: burning system at a multipurpose chamber furnace type MKG*


*Picture 9: multipurpose chamber furnace type MKG*

As the name implies, the IVA multipurpose chamber furnaces can be used for a wide variety of applications. Furnaces of this type are supplied in three standard sizes, equipped with oil baths for temperatures up to 200°C. Their heating chamber has a highly uniform temperature because of a modern state-of-the-art burner technology. This leads to a high reproducibility of the heat treatment results. With the possibility of cooling either under gas in the antechamber or by quenching in an oil bath, the multipurpose chamber furnace system, which also can be integrated in existing installations, offers a maximum flexibility.
Process control and instrumentation systems are available as an additional option. The features of these furnaces include high-performance switching and regulating electronics with user-programmable control. On account of their compact design through integration of all important elements such as drives, quenching bath and control electronics, the multipurpose chamber furnaces MKG…/MKE…can be easily operated [2].

The IVA scope of supply includes almost every thermal treatment process:

- Vacuum hardening
- Hardening
- Bainitic hardening
- **Carburizing**
- Case hardening
- Carbonitriding
- Nitriding
- Nitro carburizing
- Vacuum tempering
- Tempering
- Austenitizing
- Oxidizing
- Normalizing
- Coarse-grain annealing
- Recrystallisation annealing
- Stress-relieved annealing
- Soldering
- Aluminum annealing
- Customer-specific special processes (on request)

Literature:

[1] Steinmann, H.; Wethmar, R.; Begasungen und Gasführungssysteme; presentation hold at the “Härterei- Kreis Ruhr”; 8.-9. 06. 2006, Hagen, Germany

[2] Kleffmann, I.: The Equipment for Heat Treatment. Vacuum Heat Treatment and Heat Treatment of Tools; Conference Proceedings, 11.–12. 11. 2003, Slovak Republic, p. 109-116

[3] Kleffmann, Ingo, Wethmar, Richard; Carburizing Installations - Safety and Applications, Conference Proceedings, 22.–23. 11. 2005, Jihlava, Czech Republic, p. 79 - 86