



# Gas Purging

Metallurgical Optimisation by Mettop

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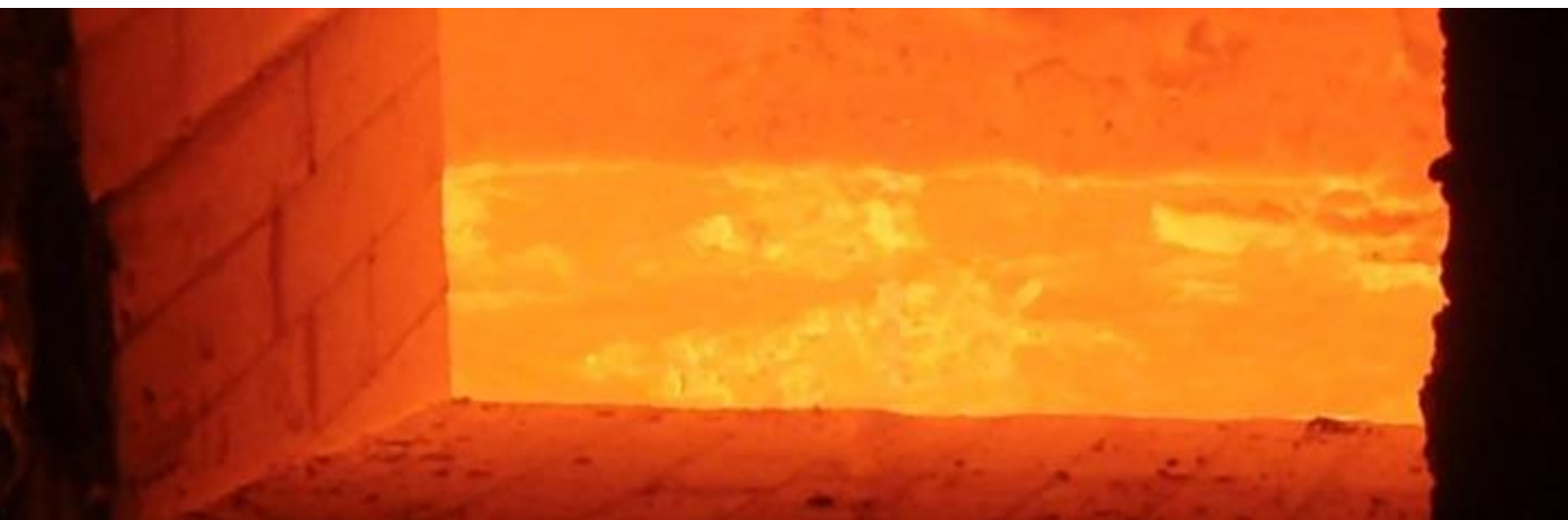
# 1 EXECUTIVE SUMMARY

The implementation of gas purging in new applications or as an upgrade of existing furnaces can lead to a wide range of improvements:

- Homogenisation of the temperature and bath chemistry in the molten bath
- Better kinetics due to increased bath movement and turbulence
- Decrease of slag overheating
- Easier deslagging when installing purging plugs at certain positions
- Decrease of slag coatings and accretions
- Lower sulphur and oxygen contents due to lowering the partial pressure when introducing nitrogen or noble gases
- Extended refractory lifetime

Especially in copper industry, the following advantages within different aggregates can be emphasised:

- Anode furnace: Gas purging in the anode furnace results in 30 % less oxidation time, 50 % less time for deslagging, less reductant consumption, less refractory wear, time savings and finally cost savings
- Peirce Smith converter: Gas purging can also be applied in the converter to achieve lower sulphur content, lower oxygen content, decreased process time and decreased deslagging time. Furthermore purging in the converter may change the process in the subsequent anode furnace.



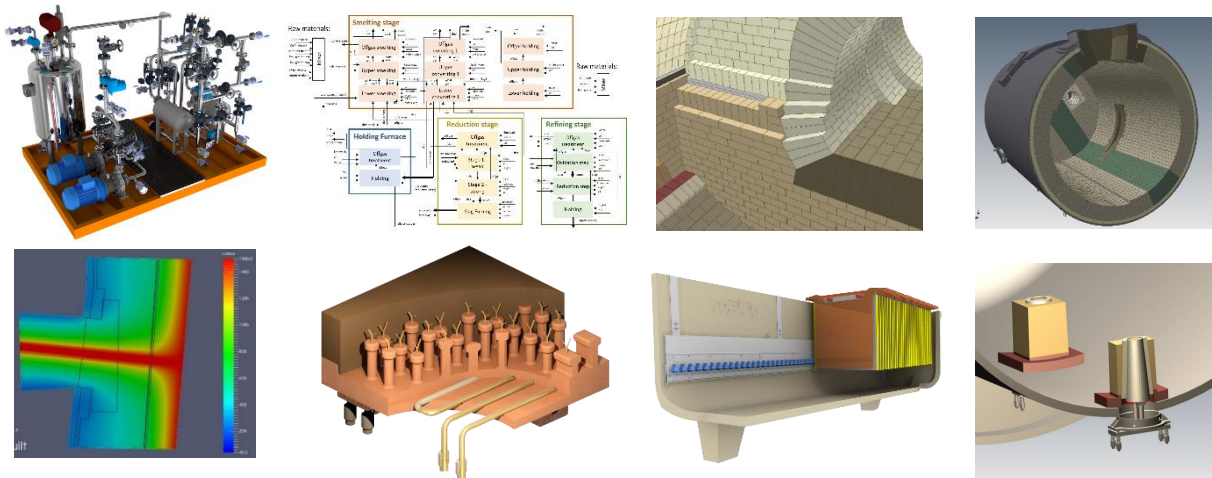
## 2 METTOP AT A GLANCE

Mettop GmbH, founded in 2005, is an independent Austrian engineering company, specialised in the design, optimisation, and engineering of technologies for metallurgical processes. It is active in the field of pyro- as well as hydrometallurgy of non-ferrous metals and recently also started with innovative cooling systems for the iron and steel industry. Special topics can be highlighted:

- Feasibility studies on metallurgical processes
- Basic and detail engineering of metallurgical processes
- Technical and metallurgical process optimisation
- New tankhouse technology, i.e. the METTOP-BRX Technology
- Water-free and safe cooling technology, i.e. the Ionic Liquid Cooling Technology (ILTEC)
- Cooler design and integrated solutions for cooler, refractory and process conditions
- Gas purging systems
- Refractory management comprising of refractory engineering, delivery and supervision during lining on site
- Project management, monitoring and risk analysis
- Staff-training to implement the provided technical innovations

The scope of services comprises optimisation solutions in the area of furnace integrity, combining refractory selection and layout, gas purging systems and cooling elements. In the field of hydrometallurgy, a new electrolysis technology - the METTOP-BRX Technology - was developed and is in operation to allow an acceleration of the electrolytic refining of up to 50 percent. For all metallurgical aggregates and equipment, Mettop developed the new and water-free cooling technology ILTEC, which uses an ionic liquid as cooling medium, for creating new pathways towards safe and efficient cooling for the entire metallurgical industry.

In addition, Mettop is internationally active in terms of technical consulting (process optimisation) and operator training for customers in the non-ferrous metals industry, and also assists in the optimisation of risk management in metallurgical plants.



### 3 METALLURGICAL OPTIMISATION VIA GAS PURGING IN ANODE FURNACES

Gas purging improves metallurgical work and can result in a significant reduction of process time. The introduction of inert gas bubbles into the liquid melt influences both, the kinetics and the thermodynamical processes.

The advantages of gas purging systems can be summarised:

Thermal and analytical homogenisation of the molten bath leads to

- reduction of fuel and auxiliary material consumption
- decreased slag overheating and refractory wear
- uniform chemical purity

Increased surface layer between slag and metal bath will cause

- decreased boundary layer
- enhanced diffusion controlled reaction
- increased metal recovery
- decreased highly oxidised slag

Inert gas bubbles in the molten bath for

- decreased partial pressure for  $\text{SO}_2$ ,  $\text{H}_2\text{O}$  and  $\text{CO}$
- a system reaching equilibrium more quickly

The principle of the sulphur and oxygen removal in the anode furnace is shown in the left diagram in Figure 1 and can be described as follows. During the anode furnace process, two sequential process steps are conducted, at first the desulphurisation followed by the deoxidation step, as marked in the figure with red lines. Within the first step (1), oxygen is introduced and hence the sulphur is decreased to the final desired level of < 50 ppm (whereas the oxygen level is increased). At the second reduction period (2) the oxygen is removed to the desired final extent of < 1,500 ppm.

In Figure 1 the equilibrium lines (black lines) for the solubility product of  $\text{SO}_2$  between the liquid copper melt and the gas phase are given, depending on the partial pressure of  $\text{SO}_2$  ( $p_{\text{SO}_2}$ ). It can be seen that with decreasing partial pressure (as a result from the gas bubbles, partial pressure of  $\text{SO}_2$  within the nitrogen bubbles is zero), lower overall levels of oxygen and sulphur in the melt can be achieved.

On the right side of Figure 1 the difference caused by decreasing partial pressure is obvious. To realise comparable sulphur contents, the oxidation level of the melt is significantly decreased, exemplary given in the figure from 6,000 ppm to 4,000 ppm. The process time decrease for the oxidation process is around 30 %.

Consequently the second step, the reduction period, can be cut down too.

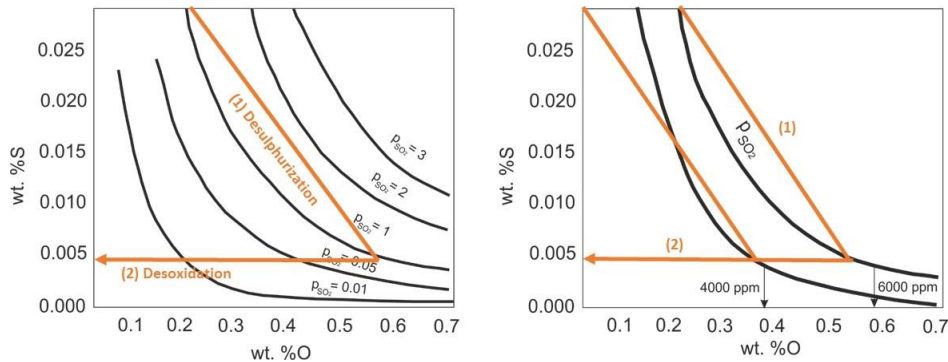


Figure 1 – Fundamental principle of the two process periods during the anode furnace process (left) and fundamental principle of gas purging, decrease of partial pressure (and shifting the lines of the solubility product of  $\text{SO}_2$  towards lower levels) due to introduction of nitrogen or noble gases

In Figure 2 a drawing of an anode furnace with altogether eight purging plugs is shown. The number and the position of the gas purging plugs influence the metallurgical performance of a reactor and have to be considered for an optimised process and output.

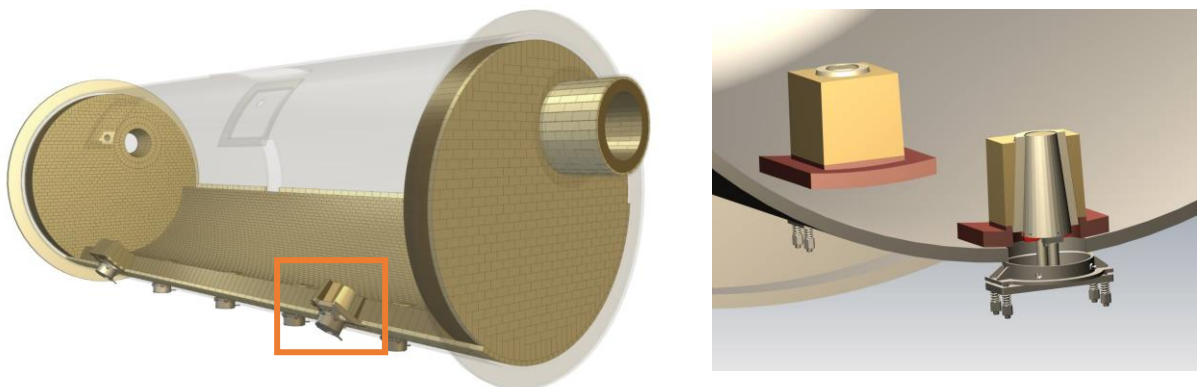


Figure 2 – Installation situation of purging plugs in an anode furnace

As an example, the experience with the  $\text{N}_2$ -gas purging system from industrial partners is as follows (data from the 1<sup>st</sup> year of installation):

- Reduced oxidation time: installation of the porous plugs reduces oxidation time for 70 minutes
- Time for slag skimming: reduced deslagging time: 5 to 10 minutes are saved per batch
- Time for poling: reduced reduction time: 12 minutes are saved per batch
- LPG savings: reduced LPG consumption: 0.3 kg/t-anode LPG is saved with the porous plugs
- Longer tuyere lifetime: tuyere lifetime is extended accordingly

## 4 GAS PURGING IN PEIRCE SMITH CONVERTERS

Caused by the improved kinetics, but especially by the thermodynamical changes via the decreased partial pressure of  $\text{SO}_2$  within the inert gas bubbles, gas purging in the converter process can result in an optimised process. However, while it is already commonly used in anode furnaces, there are only a few converters that are equipped with a purging system.

Figure 3 shows a Peirce Smith converter equipped with altogether eight purging plugs. A detailed picture of the complete purging plug unit (well block, inset layer and porous plug) is given on the right side.

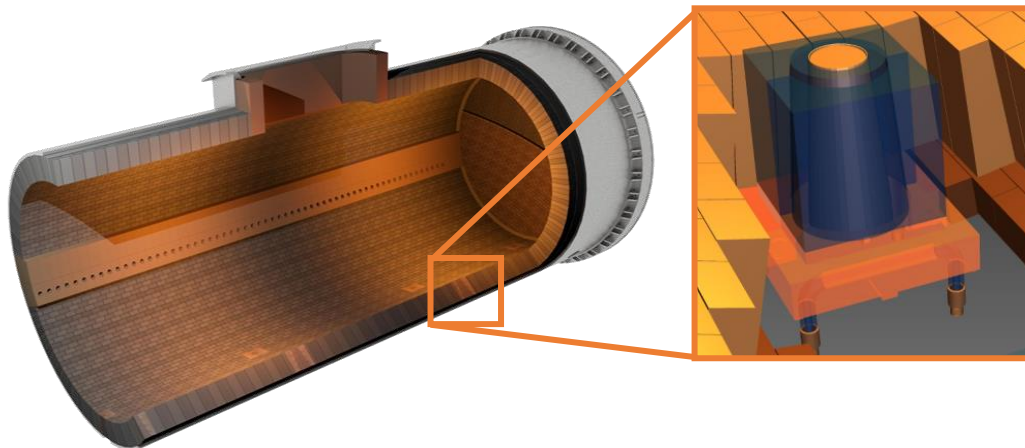


Figure 3 – Peirce Smith converter equipped with purging plugs and a detailed picture of the purging plug unit

Whereas during the charging, the iron blow, the copper blow and the tapping step only minor influence can be realised, there are strong process improvements achievable during the marked process steps:

- (1) **Slag skimming:** By pushing the slag more towards the converter mouth, an optimisation of the slag skimming process can be realised. This will result in 50 % less time for deslagging and also avoids that fayalithic slag will remain in the converter vessel. It further prevents that magnetite is formed from the iron within the fayalithic slag and hence no fuming can occur.
- (2) **Purging step prior to tapping:** With a so-called waiting step after the copper blow, prior to the tapping and between the tapping steps (Figure 4) a notably decrease of the sulphur and oxygen content can be realised. Due to the introduction of inert gas bubbles, the partial pressure of sulfur and oxygen is decreased.

It can be seen from Figure 5 that the decreased partial pressure because of nitrogen introduction leads to significant decrease in both, oxygen and sulphur content of the copper melt. Especially the decreased sulphur content below < 100 ppm enables a skipping of the oxidation step within the anode furnace

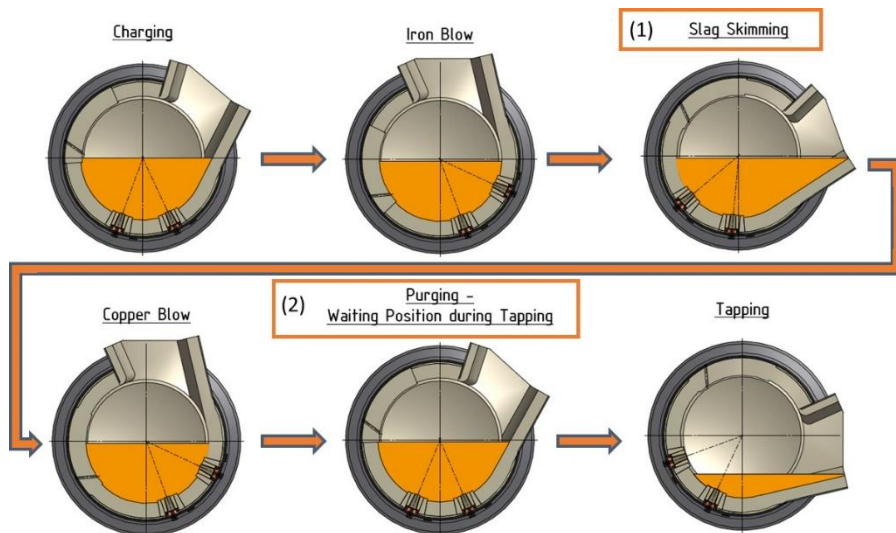


Figure 4 – Sequence of process steps within the converting process and marked steps where purging leads to significant changes in productivity and product quality

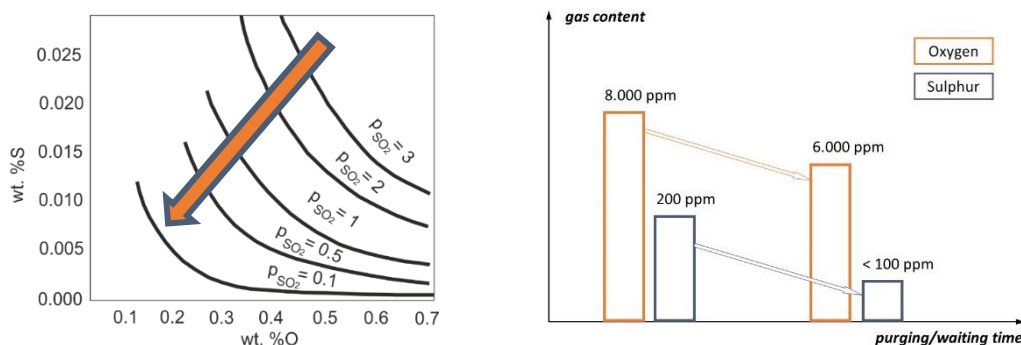


Figure 5 - Achievable lowering of oxygen and sulphur levels because of the decreased partial pressure

In addition to the possibility of adapting the installation situation for a tailor-made and optimised process, there can be generally distinguished between two different procedural cases, depending on the overall situation on site:

- **Change of process control:** As a result of the lower partial pressure, resulting from the gas, and the enhanced kinetics the process time to reach the desired oxygen and sulphur contents is decreased. Especially since the converting process is considered the “bottle neck” this fact can help to increase the entire output of the process chain as process time is shortened.
- **Change of anode furnace process:** If the time needed for the converting process is not the limiting factor, an additional purging and waiting step can completely change the process within the anode furnace. Since the sulphur level can be lowered below < 100 ppm the oxidation step within the anode furnace can be skipped. This leads to a significant reduction of process time in the anode furnace and, additionally, to a significant increase in furnace lifetime due to the lack of atmosphere change between oxidising and reducing.

## 5 SCOPE OF SERVICES BY METTOP

The scope of services of Mettop comprise of the following:

- Purging Plugs:

The delivered and installed purging plugs comprise of the inner porous plug, the ceramic inlay and the well block.

- Gas control unit:

The technical realisation of the gas control unit for every application is shown in Figure 6. On the left side the gas control unit as constructed, built and delivered by Mettop can be seen, in this case there are 8 supply lines for the nitrogen purging of each plug. On the right side an example of the visualisation (HMI – human machine interface) is shown.

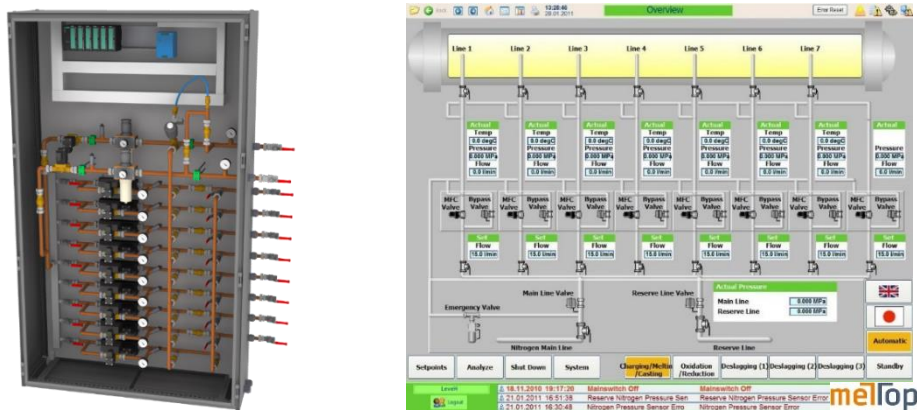


Figure 6: Gas control unit and user interface (HMI) for operation

- Installation on site:

The entire installation on-site will be supervised by Mettop personal.

- After Sales Service:

Mettop provides after sales service for both planned maintenance as well as unlikely events.

- Training courses

For optimised profit from the benefits, and using the entire metallurgical potential of gas purging, it is of interest to fully understand the metallurgical background of the processes. Therefore Mettop provides detailed and comprehensive training courses on site to teach the operators metallurgical know-how combined with operational instructions.



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