Cooling Solutions
Tailor-made cooling concepts by Mettop
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1 EXECUTIVE SUMMARY

Since the demand towards more and more economic and cost optimized processes is steadily increasing, an optimized process performance can be achieved by installing and optimizing cooling solutions:

- Cooling of refractory is inevitable for smelting operations to intensify their performance
- Intensified cooling of the refractory leads to a steeper temperature gradient within the lining
- Steeper temperature gradient means less area for possible infiltration of liquid slag or metal
- Less infiltration leads to better wear performance of the refractory material
- Better performance of refractory leads to increase in furnace lifetime, increase in campaign lifetime and furthermore to a more cost saving and economical production route

In order to provide optimized and tailor-made solutions, the product portfolio provided by Mettop not only comprises of coolers but of a holistic concept:

- Individually designed and dimensioned coolers for being capable of heat removal exactly as desired (with the aid of manifold thermal and thermodynamic computation tools)
- Independent and process orientated optimized concept
- Most modern construction and engineering tools
- Consideration of different available cooling media for additionally increasing safety
- Transport, installation and supervision on site for a quick and smooth start-up
- After sales service on site for the best possible operational result for the customer

Since Mettop combines substantiated knowledge about refractories with profound metallurgical and process know-how, it is intended to be part of the entire process concept. On letting Mettop be part of the process, optimized cooling solutions can be achieved.
2 METTOP AT A GLANCE

Mettop GmbH is an independent Austrian engineering company, which was founded in 2005. Mettop is specialized in process design, process optimization, and process engineering with the focus on:

- Feasibility studies on metallurgical processes
- Basic and detail engineering of metallurgical processes
- Technical process optimization
- New tankhouse technology, the METTOP-BRX Technology
- New cooling technology, the Ionic Liquid Cooling Technology (ILTEC)
- Cooler design, integrated solution for cooler, refractory and process conditions
- Delivery of coolers
- Refractory engineering
- Delivery of refractory
- Staff-training for realization of the provided technical innovations
- Trading technical devices and equipment in the frame of the above described company subjects
- According to the specific customer and project, the above-mentioned products and services are provided as either complete package or single parts

Mettop’s activities include the field of the pyro- and hydrometallurgy of non-ferrous metals as well as the iron and steel industry. The scope of service comprise optimization work in the area of furnace construction (furnace integrity), like refractory linings, gas purging systems, and cooling systems. In the field of hydrometallurgy, a new electrolysis technology - the Mettop-BRX Technology - was developed, which is already used commercially. For all metallurgical aggregates and equipment, Mettop developed a new cooling technology ILTEC, which uses an ionic liquids as cooling medium instead of water.
3 COOLING BY METTOP

In industrial scale application, there is a huge variety of different approaches to cooling with even more different cooler geometries available and practicable. For achieving the major aim of increasing refractory and furnace lifetime, Mettop provides standardized coolers as well as individually designed special cooling solutions for each application.

3.1 Standard cooling solutions

For almost every conceivable application, there can be the right cooling solution provided. For more or less standardized cooling concepts, standardized cooling solutions are offered from cooler producers. But on taking a closer look to the specific applications and issues of each customer, hardly any concept comprises only of a standard product without any special needs and requirements.

Therefore, when talking about standard cooling solutions, it not meant that there is no close look to the specific problem and the entire furnace and process behind it. It only refers to cooling solutions where cooling is common praxis. Since Mettop combines substantiated knowledge about refractories and cooling concepts with profound metallurgical know-how, it is intended to be part of the entire process concept for tailor-made and optimized cooling solutions.

In the two figures, Figure 1 and Figure 2, two examples of a modified standard cooling solution are shown.

Figure 1 – Copper cooler (stave) for a blast furnace shaft cooling solution

Figure 2 – Different solutions for side wall cooling of an electric arc furnace, plate coolers at the outer wall, behind the brickwork (upper pictures) and plate coolers in between the layers of the bricklining for an even better cooling performance (lower pictures)
3.2 High intensity cooling – freeze lining concept

The basic concept of high intensity cooling is a freeze lining concept. This freeze lining concept is attributed to the fact that the removed amount of heat is high enough for creating a frozen slag/metal layer upon the castable refractory. The slag/metal bath is locally (at the contact face melt and castable refractory) cooled to such an extent that the temperature of the liquid falls below the liquidus temperature. Consequently, a solid slag/metal layer is formed.

Once this slag/metal layer is created there is no further wear and, thus, consumption of the refractory material since an there is an equilibrium established between melting of the frozen layer and freezing of a new layer is formed.

The initial thickness of the refractory material will be reduced during the first couple of heats due to non-sufficient heat removal within the refractory. By and by the refractory material will be partly consumed and infiltrated by liquid slag/metal, which increases its thermal conductivity. With the thinning of the refractory the heat removal becomes more and more prominent. Once it has reached a certain level the local cooling of the melt becomes sufficiently strong to create the freeze line accretion layer.

The fact that the refractory material is not consumed at that certain point because of generating a self-protective slag/metal layer is the main concept behind this high intensive cooling concept.

3.3 Heat removal and heat transfer limitations

It is known from calculations as well as lab scale tests, that the limiting factors for sufficient heat transfer are the thermal conductivity of the accretion layer and the refractory as well as the heat transfer coefficient between accretion layer and refractory (marked red in the picture). The limiting factor is neither the heat transfer coefficient between copper and cooling medium nor the thermal conductivity of the cooling medium. This means that particular

![Diagram](https://via.placeholder.com/150)
attention has to be payed to the entire system refractory/copper coolers/cooling medium for providing a sufficient cooling result.

### 3.4 CFM Cooling Elements

The new approach to improved cooling is via composite furnace module cooling. The advantages are:

- Effective and adjustable cooling
- Homogeneous hot face temperature
- Steep temperature gradient
- Accretion layer/freeze lining for protection of the refractory
- Extended refractory lifetime and furnace campaigns
- Increased furnace capacity because of less thick refractory lining

The design can be describes as a compound of a copper cooling element and the refractory material, a visualization is given in Figure 4. The casted copper coolers consist of a copper back plate with copper fingers at the surface. Within the copper plate, the cooling pipes (made of either copper or Monel alloy) are casted for an optimized flow of the cooling medium. The cooling medium might be water; for a further improving a cooling with ionic liquid (ILTEC) can be realized.

The copper fingers are covered with refractory mass. The height of the copper fingers as well as the thickness of the castable refractory can be adjusted for each case. Due to the increased remove of the heat because of the better cooling, an accretion layer of frozen metal or slag is supposed to form onto the refractory, which acts as a protection and hence can increase the lifetime of the refractory.

The calculation of the removed heat from this special copper cooling element for using as a side wall cooler beneath the liquid melt/slag level (as given in Figure 4) at a melt temperature of 1600 °C revealed that with this concept the heat removal is sufficient and the system is capable of creating a freeze lining. The CFD modeled heat removal can be seen in Figure 6.
3.5 Examples of industrial scale use

Mettop has several customers and references all over the world, the following examples are only a small excerpt of the installed cooling solutions.

Figure 6 – CFD modelling of the temperature distribution at a furnace temperature of 1600 °C (left) and resulting steep temperature gradient within the refractory mass (right)

Figure 7 – Off-gas opening for an electric arc furnace

Figure 8 – Off-gas junction of an anode furnace

Figure 9 – Charging mouth of a tilting furnace
4 SCOPE OF SERVICE

Mettop provides full engineering service for the perfect tailor-made cooling concept. The scope of service comprises of the full concept, starting from considering the process itself, the prevailing furnace and plant situation, via engineering and construction to the finally the installation and start-up. Moreover, Mettop provides supporting after-sales service for ensuring a perfect functionality.

Dimensioning of the capacities

The starting point for every cooling solution is taking a close look to the entire process. The tools used by Mettop comprises of:

- Thermodynamical modelling with HSC
- CFD modelling
- Optimized construction
- Optimized refractory design for less wear

Design, layout and detail engineering of the coolers

Mettop creates individual and tailor-made cooling solutions including modelling and basic engineering:

- 3D engineering
- Construction plans
- Complete list of parts
- Independent and process orientated optimized concept
- Technical documentation

Casting moulds and copper cooling elements

The copper cooling element is delivered including piping for cooling medium, either of Monel alloy or copper piping whereas the casting of the copper coolers is executed at our suppliers’ site.

Refractory mass including refractory concept

The service regarding casting and drying upon the copper coolers is provided by Mettop as well as considerations regarding choosing the best available refractory mass. The casting of the refractory mass is done either at the casting shop, at the refractory supplier or on customers’ site.

Transport, installation and supervision on site

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

After Sales service:

In case either any unlikely event or planned maintenance, Mettop provides after sales service and special support.
5 CONTACT

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