Cooling Solutions

Tailor-made cooling concepts by Mettop

mettop

TABLE OF CONTENT

1 EXECUTIVE SUMMARY

As the demand towards more and more economic and cost-optimised processes is steadily increasing, an improved process performance can be achieved by installing and optimising 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 optimised and tailor-made solutions, the product portfolio provided by Mettop not only comprises of basic coolers but of a holistic general concept:

- Individually designed and dimensioned coolers for heat removal exactly as desired (with the aid of manifold thermal and thermodynamic computation tools)
- Independent and process-orientated optimised concepts
- Most modern construction and engineering tools
- Consideration of different available cooling media for additional 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

Combining substantiated knowledge about refractories with profound metallurgical and process know-how, Mettop is intended to supervise the entire operating concept. On letting Mettop be part of the process, optimised cooling solutions can be achieved.

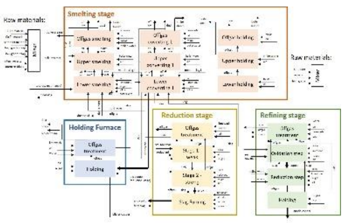
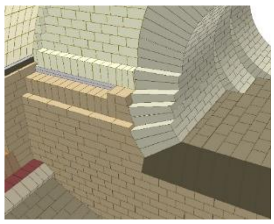
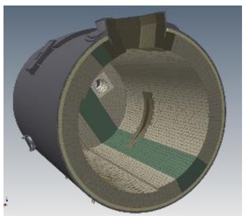
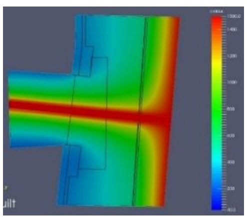
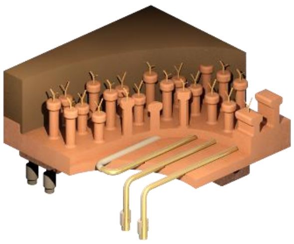
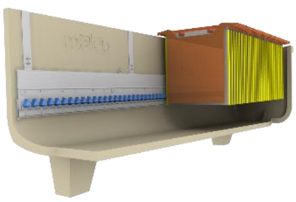
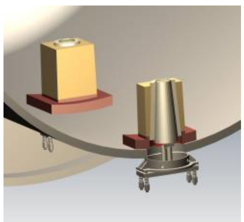
2 METTOP AT A GLANCE

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 COOLING BY METTOP

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

3.1 Standard cooling solutions

For almost every conceivable application, the right cooling solution can be provided. For more or less standardised cooling concepts, producers offer standardised cooling solutions. But on taking a closer look to the specific applications and customer issues, there is hardly a concept that comprises of standard products only, without any special needs and requirements.

So when we speak of standard cooling solutions, this does not mean that the specific problem, the whole furnace and the process behind it, are not being exactly considered. It only refers to cooling solutions where cooling is a 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 optimised cooling solutions.

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

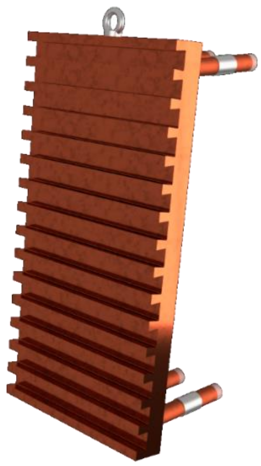


Figure 1 – Copper cooler (stave) for a blast furnace shaft cooling solution

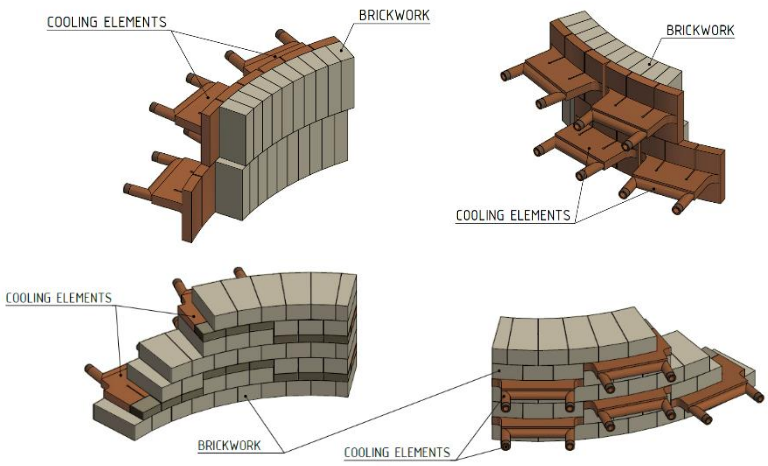


Figure 2 – Different solutions for side wall cooling of an electric arc furnace, plate coolers at the outer wall, behind the brickwork (upper pictures) and plate coolers in between the layers of the bricklining for an even better cooling performance (lower pictures)

3.2 High intensity cooling – freeze lining concept

The basic concept of high intensity cooling is a freeze lining concept (see Figure 3). This freeze lining concept is attributed to the fact that the removed amount of heat is high enough to create a frozen slag/metal layer upon the castable refractory. The slag/metal bath is cooled to such an extent that the temperature of the liquid falls below the liquidus temperature. This is carried out locally at the contact between face melt and castable refractory. Consequently, a solid slag/metal layer is formed.

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

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, increasing 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 strong enough to create the freeze line accretion layer.

The fact that at this specific point the refractory material is not being consumed but generates a self-protective slag/metal layer, shows the main idea behind this high intensive cooling concept.

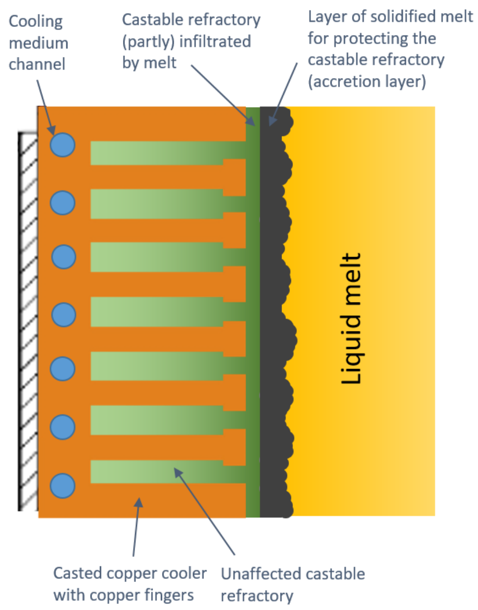


Figure 3 – Schematic picture of the freeze lining

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 attention has to be payed to the entire system refractory/copper coolers/cooling medium in order to provide an effective cooling result.

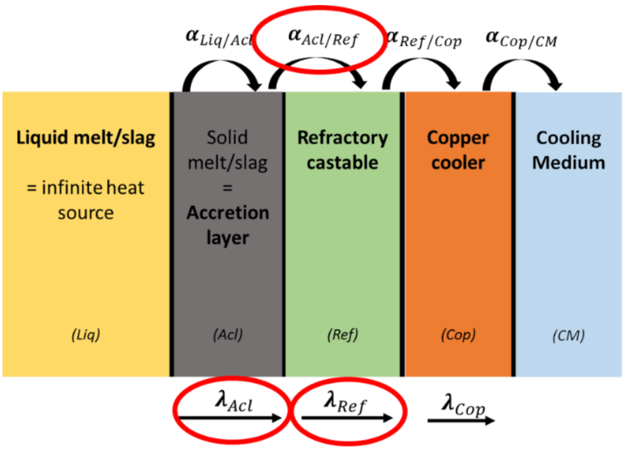


Figure 4 – Removed heat and limitations

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, as shown in Figure 5. 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 optimised flow of the cooling medium, being water in most cases; to further improve the system a cooling with ionic liquid (ILTEC) can be realised.

The copper fingers are covered with refractory mass, the height of both can be adjusted for each individual case as needed. Due to the increased removal of heat resulting from a better cooling, an accretion layer of frozen metal or slag will form onto the refractory, acting as a protection and hence increasing the lifetime of the refractory. The geometry can be adjusted to special demands and applications, Figure 6 shows a tailor-made design of a high intensity cooler.

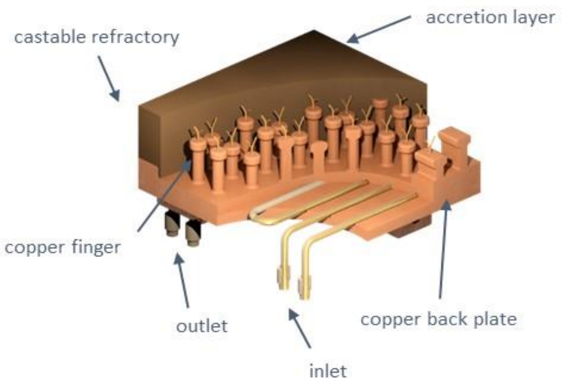


Figure 5 – Design of a CFM cooling element

A calculation with thermal modelling tools shows that by using this concept of a special copper cooling element as a side wall cooler beneath the liquid melt/slag level (as given in Figure 7) at a melt temperature of 1600 °C the heat removal is sufficient and the system is capable of creating a freeze lining. The CFD modeled curves for heat removal for a CFM cooler can be seen in Figure 7.

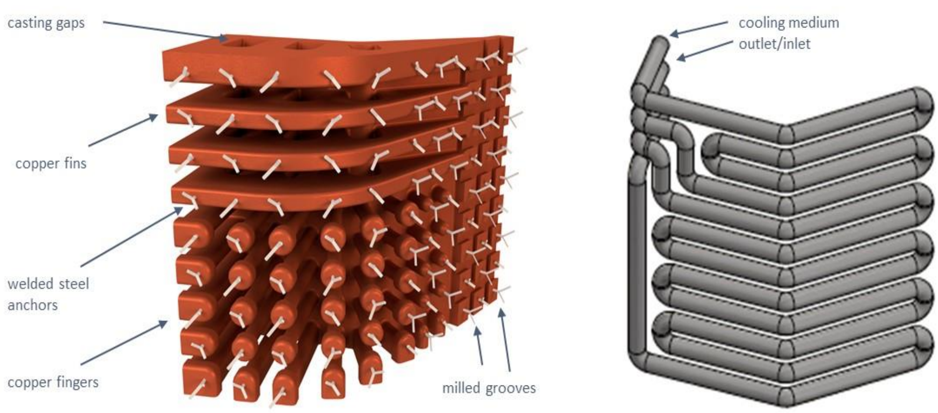


Figure 6 – Specially designed high intensity cooling element for a slag tapping mouth of an EAF

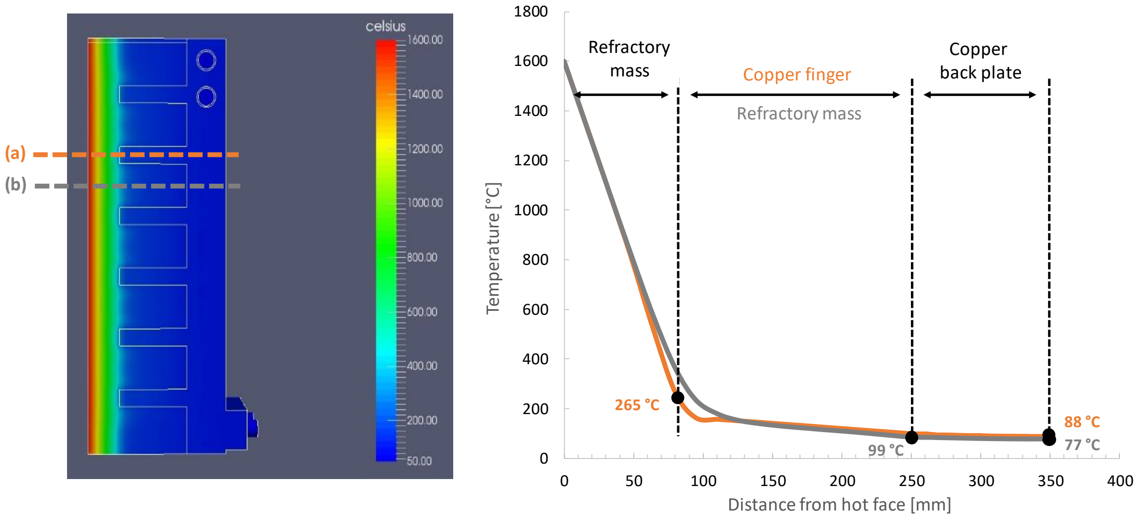


Figure 7 – CFD modelling of the temperature distribution at a melt temperature of 1600 °C (left) and the resulting steep temperature gradient within the refractory mass (right)

3.5 Examples of industrial scale use

Having several customers and references all over the world, the following examples can only be a small selection of cooling solutions successfully implemented by Mettop.

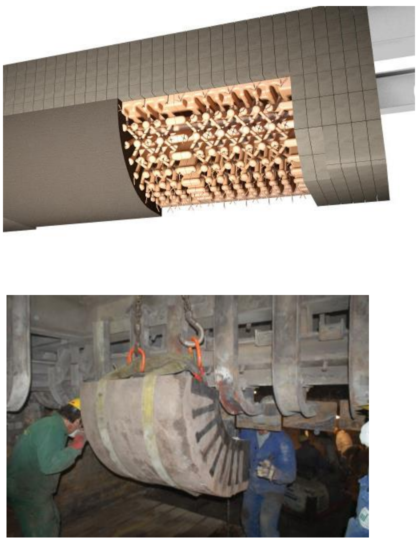


Figure 9 – Off-gas junction of an anode furnace

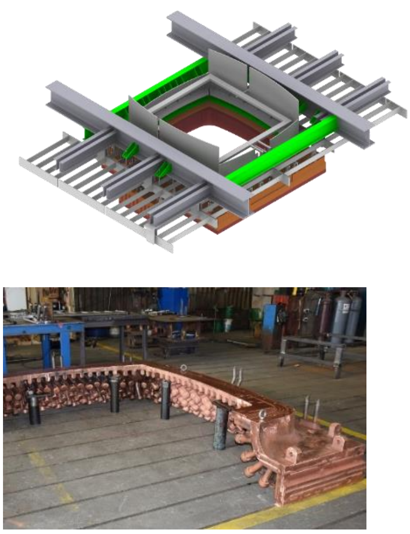


Figure 8 – Off-gas opening for an electric arc furnace

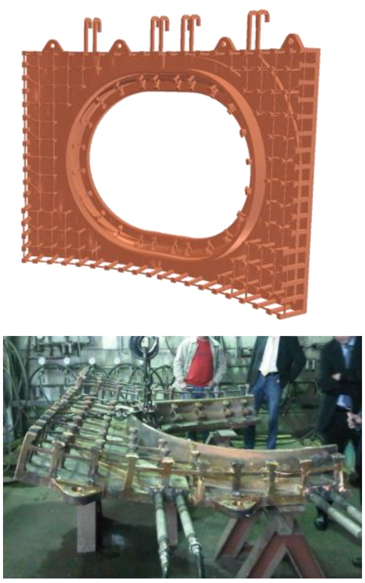


Figure 10 – Charging mouth of a tilting furnace

4 SCOPE OF SERVICES

Mettop provides full engineering service for the perfect tailor-made cooling concept. The scope of services comprises the full concept, starting from consideration of the process itself, the prevailing furnace and plant situation, via engineering and construction to the final installation and start-up. Moreover, Mettop provides supportive after-sales service to ensure 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 comprise of:

- Thermodynamical modelling with HSC
- CFD modelling
- Optimised construction
- Optimised 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 optimised concept
- Technical documentation

Casting moulds and copper cooling elements

The copper cooling element is delivered with the complete piping - made of either Monel alloy or copper piping - for the cooling medium, being casted at our suppliers' sites.

Refractory mass including refractory concept

Mettop provides both, service in respect to casting and drying upon the copper as well as considerations regarding the choice of the best available refractory mass. The casting of the refractory mass is done either at the casting shop, the refractory supplier or at the customer´s site.

Transport, installation and supervision on-site

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

After sales service

Mettop offers after sales service and special support for planned maintenance as well as for unlikely events.

Mettop GmbH
Peter-Tunner-Str. 4
8700 Leoben
Austria
www.mettop.com

Dr. Iris Filzwieser: +43 664 88 60 45 41 iris.filzwieser@mettop.com
Dr. Andreas Filzwieser: +43 664 88 60 45 40 andreas.filzwieser@mettop.com
DI Stefan Wallner: +43 664 88 60 45 53 stefan.wallner@mettop.com