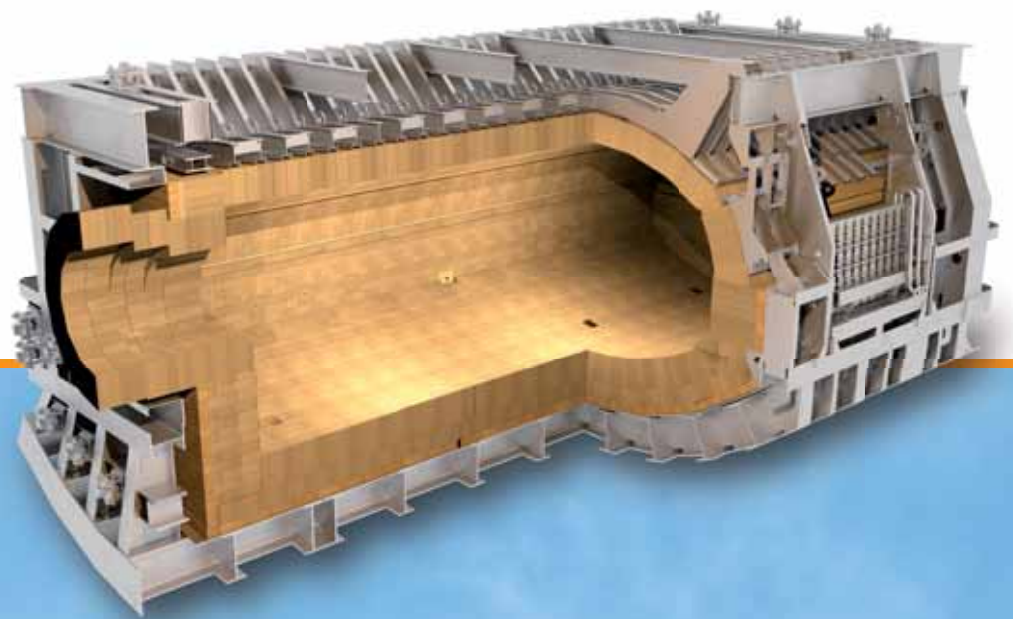




Your Partner for Furnace Integrity Solutions



All you have to know about Furnace Integrity Solutions is us ...



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Andreas & Iris Filzwieser

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In 2010 METTOP GmbH subdivided its activities into pyrometallurgical and hydrometallurgical branches to provide a more focused customer-orientated service.

METTOP FIS is the expert single-source provider for customer-tailored Furnace Integrity Solutions in nonferrous pyrometallurgy.

The name Furnace Integrity Solutions describes our philosophy: To consider the furnace as a whole unit, not single elements, since all parts are interrelated and therefore cannot be changed or optimized without impacting on each other. In addition, with technological advances constantly taking place in this field, it is important to find comprehensive, sustainable solutions for the ever more complex pyrometallurgical systems.

Our unique products and services covers all project and operation stages – from the initial concept to implementation and onsite support. METTOP FIS uses new, alternative approaches and the latest technologies to design customer-tailored solutions. With a highly educated workforce and global academic collaborations, research and development is integral in our company philosophy.

As a single-source provider, we guarantee our customers a problem-free and efficient project-handling.

Customer Benefits

- › Customer-tailored solutions
- › Novel technologies
- › Long-standing worldwide experience
- › One responsible party

innovative system solutions

Your Partner for Furnace Integrity Solutions

Process solutions – plant layout – detailed design

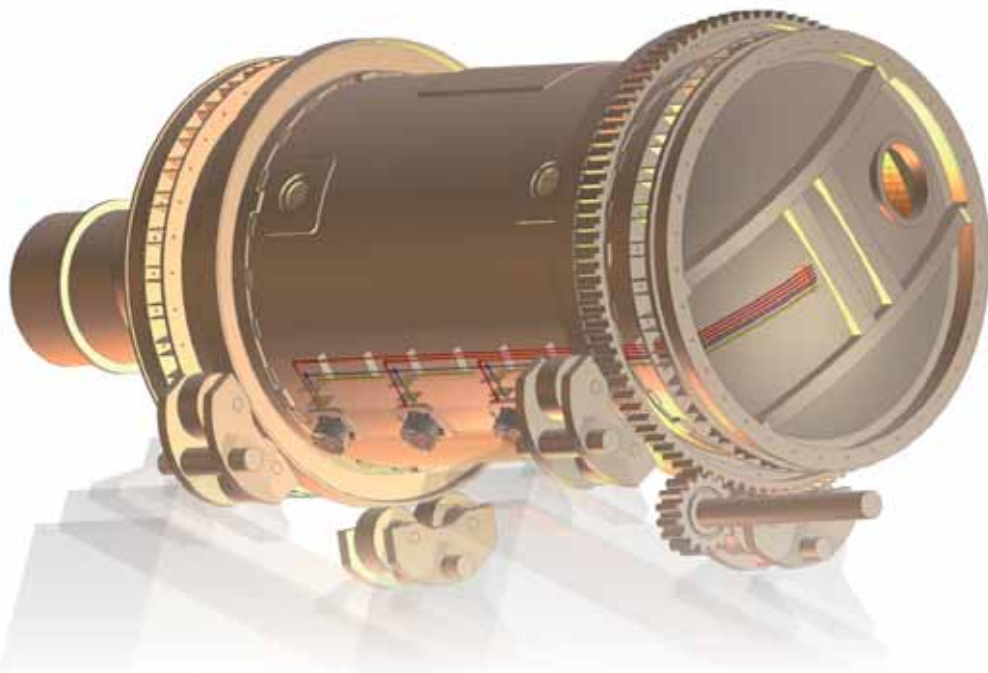
Furnace Integrity for us means a harmonized design of the furnace steelwork, refractory lining, and additional equipment including cooling elements and gas purging systems, in the context of excellent metallurgical process knowledge.

METTOP FIS offers solutions for both new and existing processes; together with our partners we can even provide the layout and design for entire plants.

The furnace must be considered as a whole unit, comprising multiple interlinked parts. Altering one specific feature inherently affects the entire furnace operation; therefore, a holistic approach to changes and optimizations is required.

Solutions

- › Customer tailored
- › Flexible
- › Innovative
- › Metallurgical and engineering expertise





Furnace Integrity – increased productivity and production

For new processes and plants, our comprehensive services range from thermodynamic process modelling to detailed plant design. Thermodynamic modelling software (e.g., HSC Chemistry and FactSage™) is used to define the process layout, process route, and furnaces (i.e., type and size).

This is followed by engineering the furnaces, refractories, as well as additional equipment including burners, cooling technology, and gas purging systems. All the engineering drawings are three-dimensional (3D), and if required computational fluid dynamics (CFD) and finite element method (FEM) modelling and calculations are performed.

When it comes to the actual refractory installation, METTOP FIS can deliver and install the refractories and cooling elements defined in the engineering stage, and also provide heat-up procedures for safe furnace start-up. During the start-up and commissioning, heat-up supervision services are available as well as staff training.

Furthermore, these services continue after the initial stage: Our ultimate goal is a running process and a satisfied customer. Therefore, our metallurgists stay onsite until this goal is achieved.

For existing processes and plants METTOP FIS uses thermodynamic process modelling for process optimization, for example to examine the process parameters like slag and additives.

Our engineering services include 3D drawings of furnaces, refractories, cooling technology, and gas purging systems, also in combination with CFD and FEM modelling and calculations.

Furthermore, we deliver and install the appropriate refractory products, as well as cooling elements. We place special focus on the right combination and optimal design for the refractory/cooler interface. Our services during the start-up and commissioning include heat-up supervision and staff training courses.

In addition, for routine operation, we offer process consulting and optimization (e.g., slag metallurgy, process times, and general operating issues), as well as energy saving packages.

Our working solutions are engineered by metallurgists, applying in-house expertise to optimize process performance. We are not satisfied until we have found the solution for our customer.

Furnace Integrity

Increased furnace operational life and capacity by integrating:

- › Process knowledge
- › Steelwork optimization
- › Proper combination of coolers and refractories
- › Burner optimization
- › Onsite process support

Thermodynamic Process Modelling



Experience has shown us that it is not sufficient to know that something occurs – we need to know why. Therefore, it is important to understand the background of a process and be aware of the fundamental influences and interrelationships. METTOP FIS uses thermodynamic software to model metallurgical processes.

The theoretical model can be extended by integrating operational data, thereby representing the process more accurately. Before practical process variations are performed to optimize operations, the model provides a manipulable tool to examine the effects of any changes theoretically.

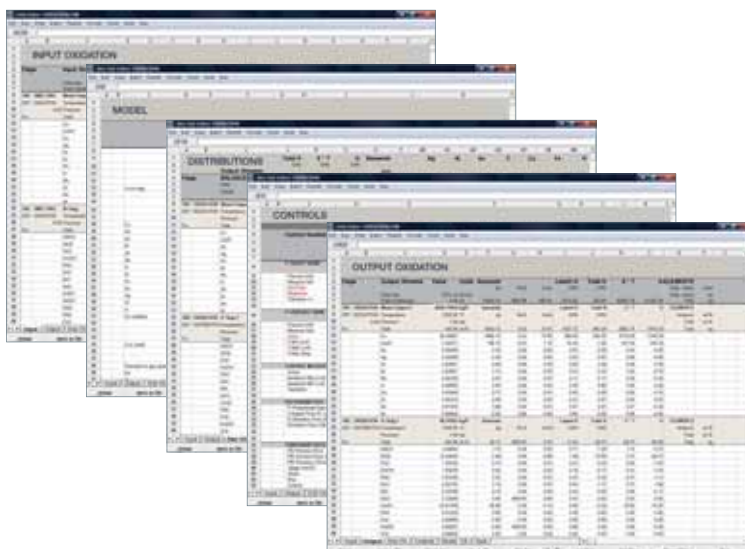
The advantage of thermodynamically modelling pyrometallurgical processes is that decisions are not only made on the basis of experience and estimations but on a combination of founded figures and experience. Entire process streams can be examined in relation to multiple aspects including the chemical reactions, input amounts, and the heat balance.

The model should represent a comprehensive combination of empirical data and thermodynamic calculations that supports planning, ongoing operations, and optimization, and can also be used for training purposes.

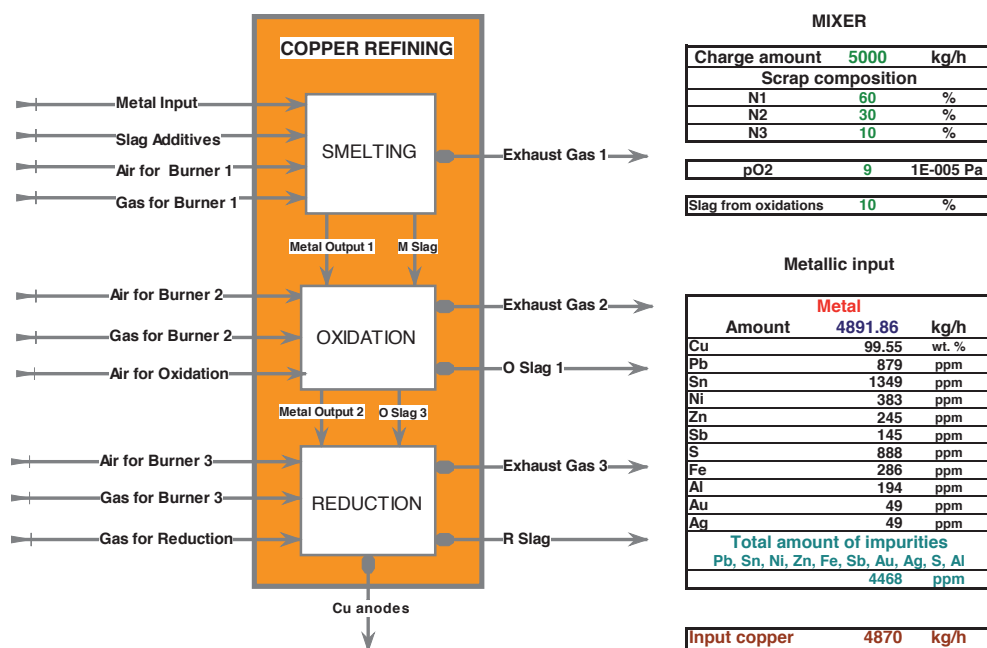
Optimization Tool

The model can be used for:

- › Process design
- › Process optimization
- › Defining furnace sizes and capacities for new plants
- › Process parameter variation
- › Training



Process understanding is fundamental to our optimization approach



MIXER

Charge amount	5000	kg/h
Scrap composition		
N1	60	%
N2	30	%
N3	10	%
pO2	9	1E-005 Pa
Slag from oxidations	10	%

Metallic input

Amount	Metal	kg/h
Cu	99.55	wt. %
Pb	879	ppm
Sn	1349	ppm
Ni	383	ppm
Zn	245	ppm
Sb	145	ppm
S	888	ppm
Fe	286	ppm
Al	194	ppm
Au	49	ppm
Ag	49	ppm
Total amount of impurities		
Pb, Sn, Ni, Zn, Fe, Sb, Au, Ag, S, Al		
4468 ppm		

Input copper	4870	kg/h
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Scrap Processing

- > Customer-specific process information
- > Process model
- > Model validation
- > Theoretical process adjustments
- > Practical process adjustments
- > Optimized process adjustments

Output from 1st oxidation

Amount	Metal	kg/h
Cu	4794.13	wt. %
Cu2O	10.33	wt. %
Pb	317	ppm
Sn	19	ppm
Ni	333	ppm
Zn	0	ppm
Fe	0	ppm
Sb	147	ppm
Oxygen	1.15	wt. %
Total amount of impurities		
Pb, Sn, Ni, Zn, Fe, Sb, Au, Ag, S		
866.31 ppm		
Slag		
Amount	100.97	kg/h
Cu2O	79.14	wt. %
Cu	79.44	wt. %

Output copper	4789.74	kg/h
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Output from 1st reduction

Amount	Metal	kg/h
Cu	4747.50	wt. %
Pb	374	ppm
Sn	156	ppm
Ni	341	ppm
Zn	20	ppm
Fe	22	ppm
Sb	149	ppm
O	100	ppm
Total amount of impurities		
Pb, Sn, Ni, Zn, Fe, Sb, Au, Ag, S		
1164 ppm		
Slag		
Amount	0.68	kg/h
SiO2	73.58	wt. %
Al2O3	26.42	wt. %
Gas		
Ox. from metal	55.36	kg/h

Output copper	4741.50	kg/h
---------------	---------	------

Output from 2nd reduction

Amount	Metal	kg/h
Cu	4620.32	wt. %
Pb	159	ppm
Sn	18	ppm
Ni	303	ppm
Zn	2	ppm
Fe	2	ppm
Sb	152	ppm
O	100	ppm
Total amount of impurities		
Pb, Sn, Ni, Zn, Fe, Sb, Au, Ag, S		
740 ppm		
Slag		
Amount	0.50	kg/h
SiO2	100.00	wt. %
Gas		
Ox. from metal	54.34	kg/h

Output copper	4616.45	kg/h
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3D Engineering

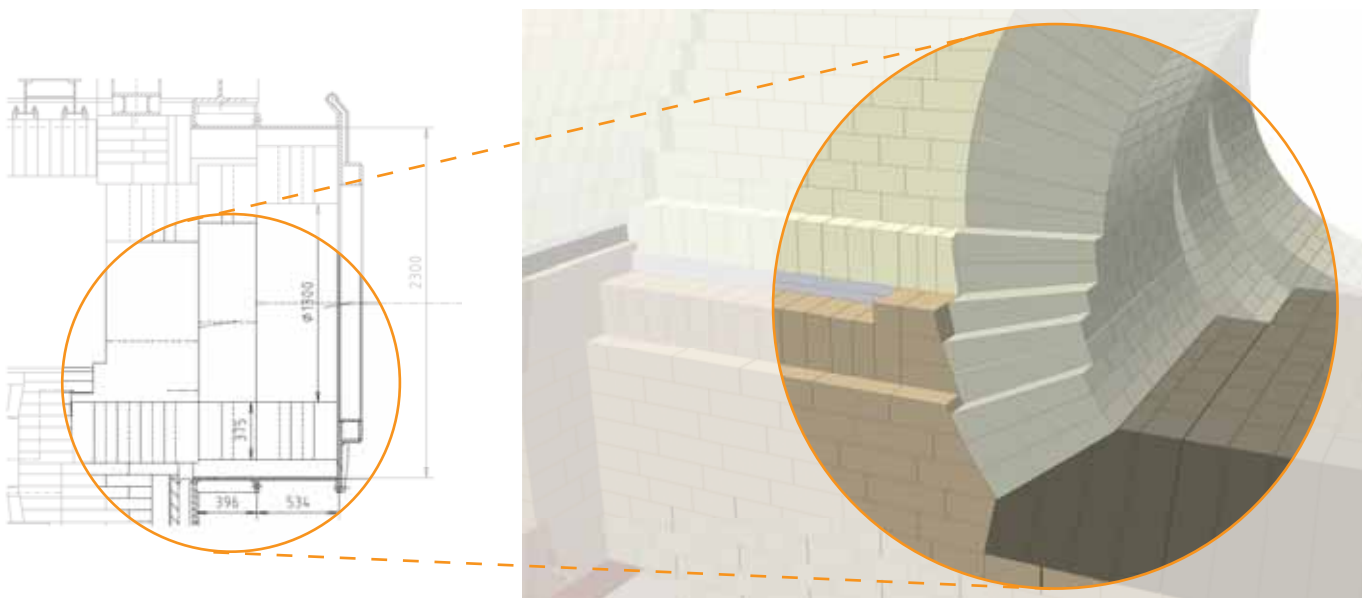


METTOP FIS uses 3D engineering for furnace, refractory, and cooler design. Especially in critical furnace areas, like openings, skewback areas, and transitions the resulting intersections and complex refractory lining geometries cannot be displayed in 2D drawings. This is the significant advantage of 3D drawings: Since the complete detail of all volumes is required in 3D engineering, it is possible to find optimum solutions,

particularly for critical areas. The possibility to premanufacture special areas like arches enables the use of new material types. Furthermore, 3D drawings provide a comprehensive overview of the actual furnace and lining situation.

3D Engineering Benefits

- › Comprehensive overview
- › Solutions for critical areas
- › Advanced installation manuals



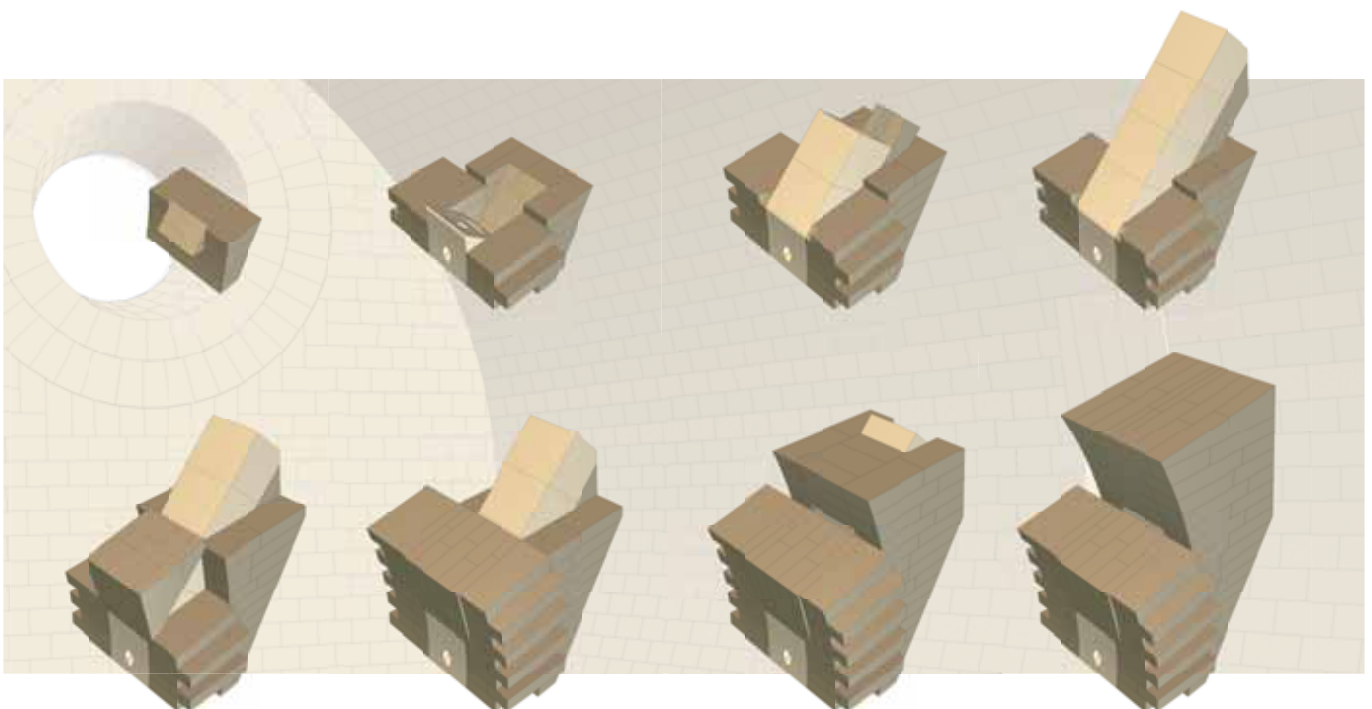
Furnace Integrity – longer lifetime – higher productivity

METTOP FIS also focuses on upgrading existing furnace refractory designs to increase refractory lifetime, speed up installation, and assist the implementation of modern operational systems (e.g., purging systems, cooling systems, and tuyere arrangements). Focused discussions and onsite fact finding missions result in new ideas for lining concepts, which are translated into state-of-the-art 3D designs that provide a

clear understanding of the lining situation. To further facilitate the actual refractory installation, METTOP FIS can provide step-by-step installation manuals as well as animated installation films. Since we are not limited to a single specific refractory producer, the best available options regarding refractory quality and price can be selected to provide an optimal price/performance ratio.

Engineering Package

- › Detailed 3D refractory design drawings
- › Cooler design
- › Steelwork adjustments
- › Delivery and installation



Cooling Technology

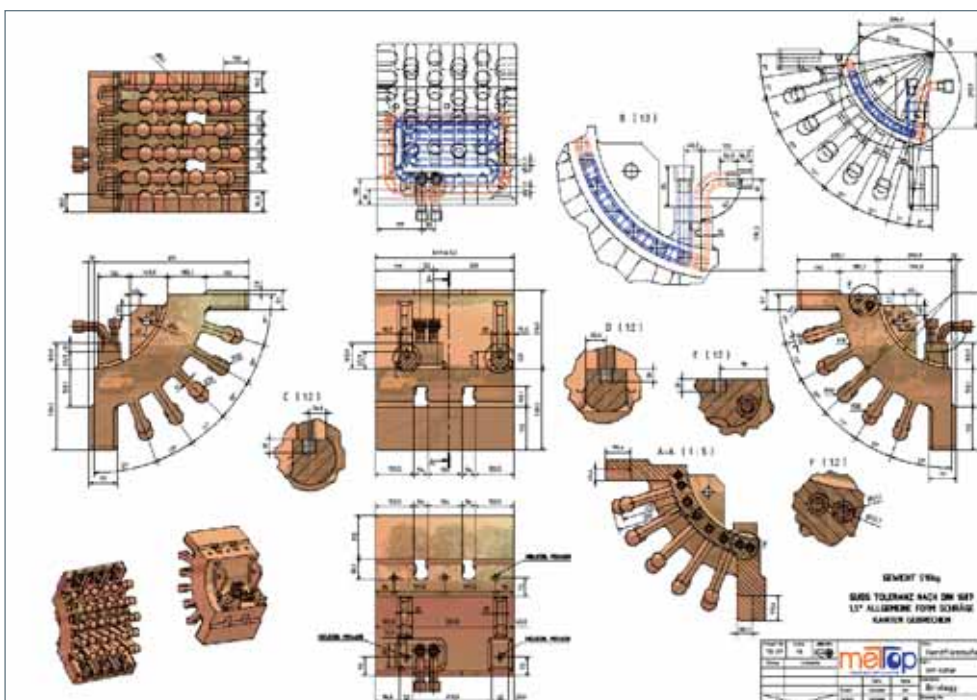


METTOP FIS provides comprehensive solutions, enabling the maximum benefits from cooling to be attained, through the correct integration into the refractory lining. When installing cooling elements, the surrounding brickwork and the general furnace situation always have to be considered.

Modern lining designs require new technologies to reduce operational costs and increase the furnace availability. Cooling element technology, which has been gradually introduced over the years, provides considerable benefits in different furnace lining areas.

Cooling Engineering

- › Basic engineering
- › Specific engineering for implementation in existing smelters
- › CFD calculations for water flow rate and heat balance
- › Complete engineering and cooling system manufacture
- › Installation



Cooling solutions – optimum brickwork integration – longer furnace campaigns – new patented cooling technology

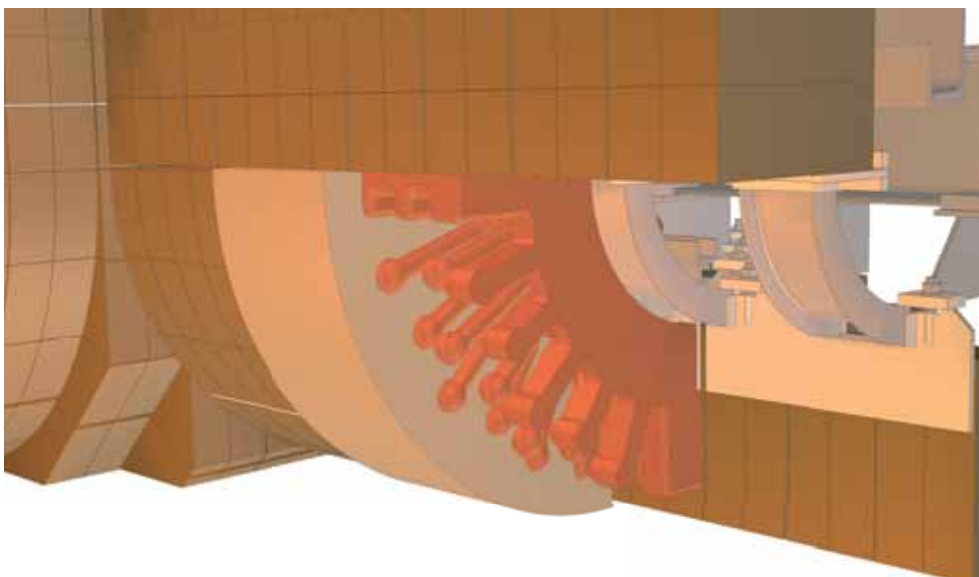
Furthermore, METTOP FIS focuses on optimum solutions for cooling element implementation in the brickwork.

To improve cooling performance and overcome the disadvantages that are inherently associated with the use of water as a cooling medium, METTOP FIS offers a patented, new cooling solution using ionic liquids as the cooling media.

Ionic liquids provide significant advantages compared to water: Higher cooling medium temperatures are possible, which minimizes the risk of hydration during heat-up and avoids corrosion during operations. Additionally, there is no danger of explosions. This increase in furnace availability and safety makes cooling with ionic liquids a revolutionary development in cooling technology.

Patented Cooling

- › No water in the furnace
- › No hydration
- › No explosion risk
- › No corrosion
- › Longer furnace campaigns
- › Safe operation



Gas Purging Systems




METTOP FIS offers gas purging systems to improve the efficiency of different furnace types in nonferrous metallurgy. The system consists of a set of purging elements, such as porous plugs, and a gas control and regulation unit. Porous plugs are used for example to introduce additional gas (e.g., N_2) into the melt. The gas flow for each individual plug is controlled by the gas control unit. Purging programs for different metallurgical processes and single process steps are developed to obtain the maximum benefits from gas purging.

In drum type furnaces, it is also possible to equip the porous plug sets with an exchangeable mechanical system. This enables the plugs to be changed even under hot furnace conditions. The exchangeable system is cooled on the outside with compressed air and each plug contains a residual thickness control, based on thermocouples, that indicates the appropriate time for exchange.

Anode Furnace Benefits

- › Increased bath agitation
- › Uniform chemical composition
- › Bath temperature homogenization
- › Decreased slag overheating
- › Decreased build-ups (accretions)
- › Easier slag skimming operations
- › Higher reaction and process efficiency
- › Overall process time decrease
- › Energy savings
- › Cost savings





Increased agitation – higher efficiency –
improved metal quality – energy savings – cost savings

Two applications for gas purging in copper metallurgy are:

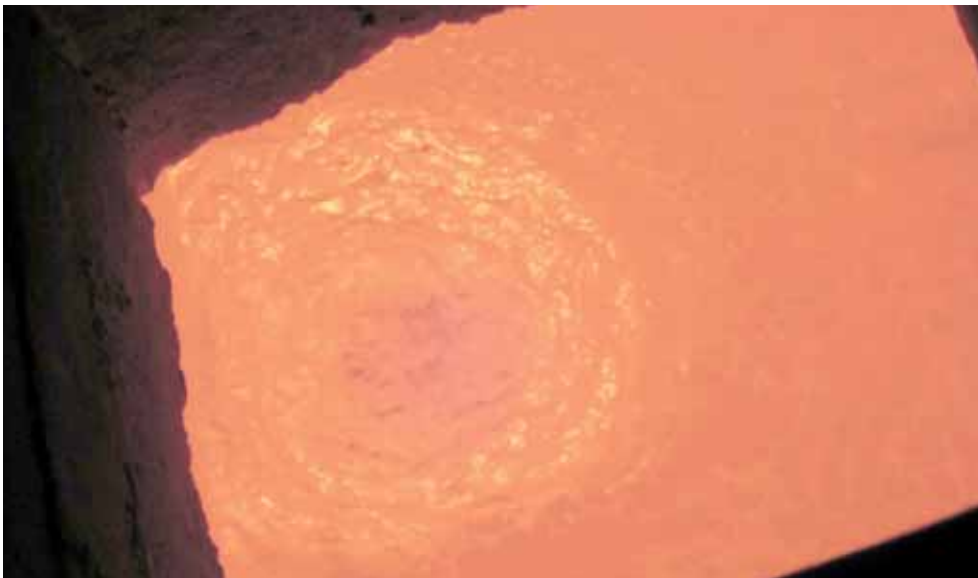
- › Anode furnace
- › Converter

Anode Furnace In copper metallurgy, anode furnaces produce a low oxygen and sulphur containing anode copper, typically through an oxidation and reduction step. However, the reaction kinetics is slow and additional heat is required to maintain the necessary temperature.

Converter During the two step converting process, oxygen enriched air is injected through a row of tuyeres into the copper matte received from a primary smelting unit. In the first step the iron content is oxidized into a fayalitic slag, which is formed by silica addition. During the second step, the remaining copper sulphide is converted into blister copper with a final sulphur content of approximately 200 ppm. The overall efficiency of this process is determined by the total reaction time, the slag quality and quantity and the chemistry of the final blister copper.

Converter Benefits

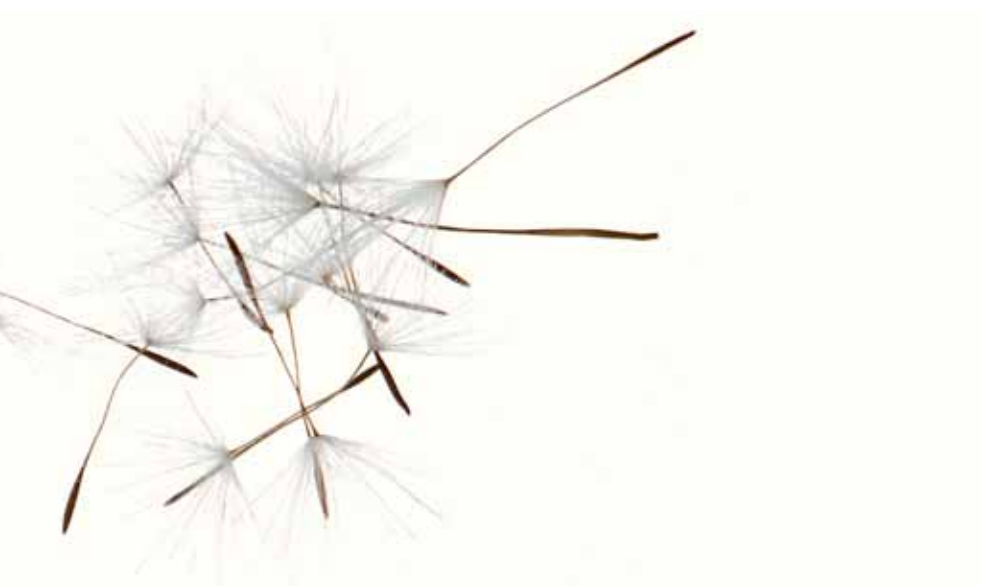
- › Enhanced bath agitation
- › Improved reaction kinetics
- › Lower sulphur content in the blister copper
- › No accretions
- › Easier slag skimming operations
- › Reduced process time
- › Increased refractory lifetime
- › Shorter/no oxidation step in the anode furnace



The seed of an idea

has grown into a whole new branch ...





metopFIS
furnace integrity solutions

... let us improve your growth through our visions

Lining Solutions



Process understanding – refractory knowledge – long-standing engineering experience

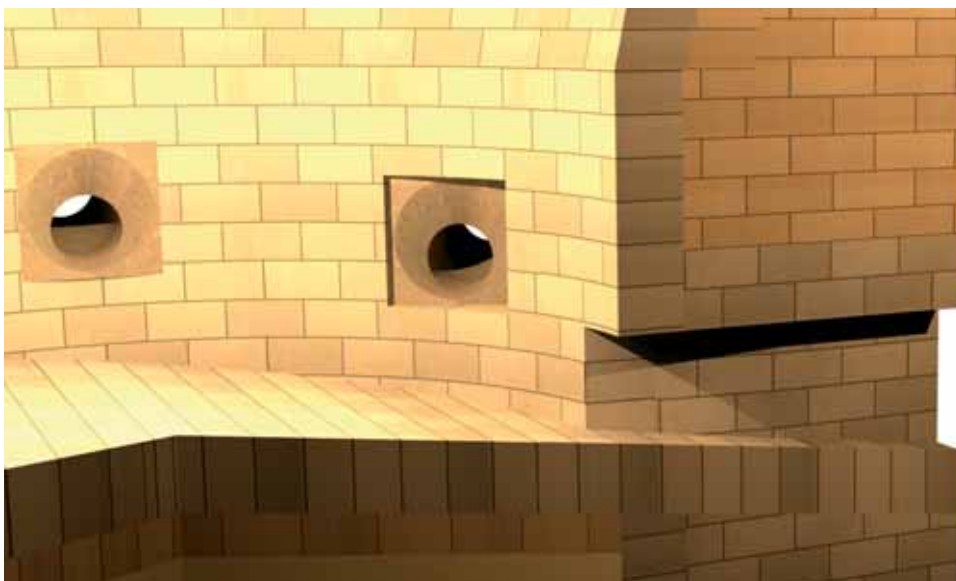
To prolong reactor lifetime to the maximum extent and in a sustainable manner, the individual vessel has to be regarded as a whole, and a comprehensive examination is required. The essential basis is process knowledge: Only when we know why something happens is it possible to make modifications or optimizations to existing systems. An optimized refractory lining is a fundamental contribution to enhanced furnace operations. Besides the appropriate materials, the correct engineering and installation are essential.

As an independent engineering company, METTOP FIS is able to choose the optimum materials and is not limited to specific product brands. Depending on the individual requirements, fired or nonfired, shaped or unshaped refractory products can be used, based on:

- › Magnesia
- › Alumina
- › MgCr
- › AlCr
- › SiC

Focus

- › High refractory quality
- › Optimum combination with cooling technology
- › High furnace availability
- › Long furnace campaigns
- › Harmonized overall furnace design



Lining Solutions Smelting Units

New cooling systems – gas purging – increased productivity

Smelting units, which process concentrates quasi-continuously, can be operated for several years before a complete relining is required. High-wear areas like the reaction shaft or slag zone can be reinforced with cooling elements.

The high wear in specific regions, like the tapping area, is the reason why otherwise long-lasting smelting vessels have to be shut down for repair at least once a year. The corresponding standstill times are highly cost intensive. Therefore, the optimization goal is an increase in furnace availability.

New cooling technologies using ionic liquids can prolong the life of high wear areas, like the tapping area, without risk.



Innovation

- › Ionic liquids as cooling medium in critical areas
- › Longer furnace campaigns
- › Minimized risk
- › Gas purging system

Lining Solutions Converter

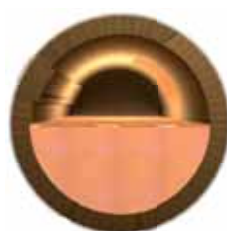
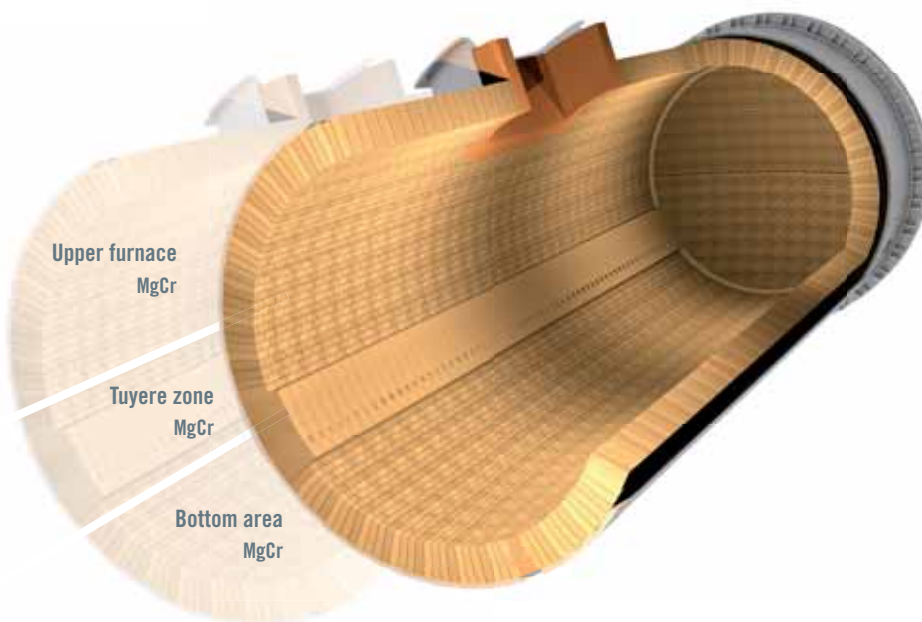
Optimum results with batch converting – gas purging

There is a trend in modern smelters towards using continuously operating reactors for converting. However, existing batch-type vessels can be optimized and the advantage of the batch process can be exploited: Converting in two steps,

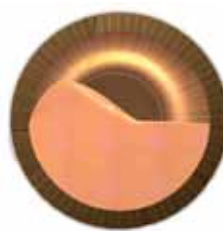
using a fayalitic slag that is removed after the first stage and a high oxygen potential in the second stage, results in minimum sulphur levels in the blister copper and a subsequent productivity increase in the whole process flow.

Gas Purging

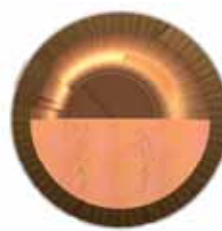
- › Lower sulphur and oxygen levels
- › No oxidation in the anode furnace
- › Shorter process times
- › Longer refractory lifetime
- › No SO₂ in the anode furnace offgas
- › Significant cost savings



Charging



Fe / Cu blow



Purging



Slag skimming / Tapping

Lining Solutions Pyrometallurgical Refining

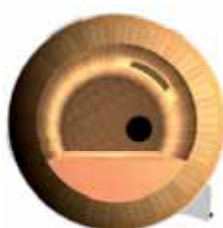
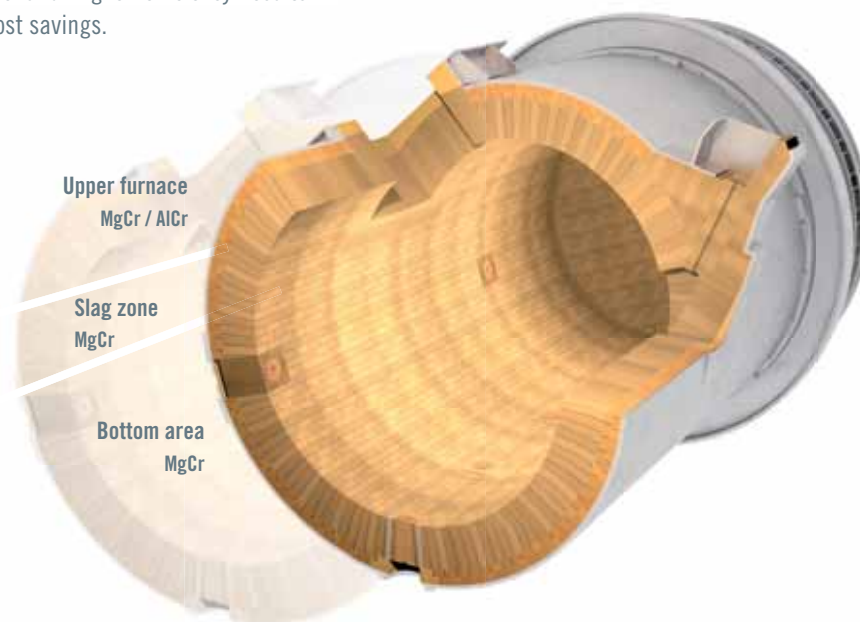
Higher productivity – purging – new burner technologies

Gas purging in the anode furnace is used to improve the oxidation and reduction reactions through increased bath agitation. In addition to the higher melt homogeneity, purging also facilitates deslagging operations. The overall process time decrease and higher efficiency results in energy and cost savings.

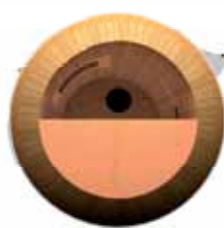
The operational costs can be further reduced by using a new generation of burners and modern refining systems.

Savings

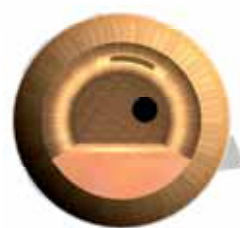
- › 30% shorter oxidation
- › 50% shorter deslagging
- › Less reductant
- › Less refractory wear
- › Time savings
- › Cost savings



Charging



Oxidation / Reduction



Tapping

Lining Solutions Slag Cleaning

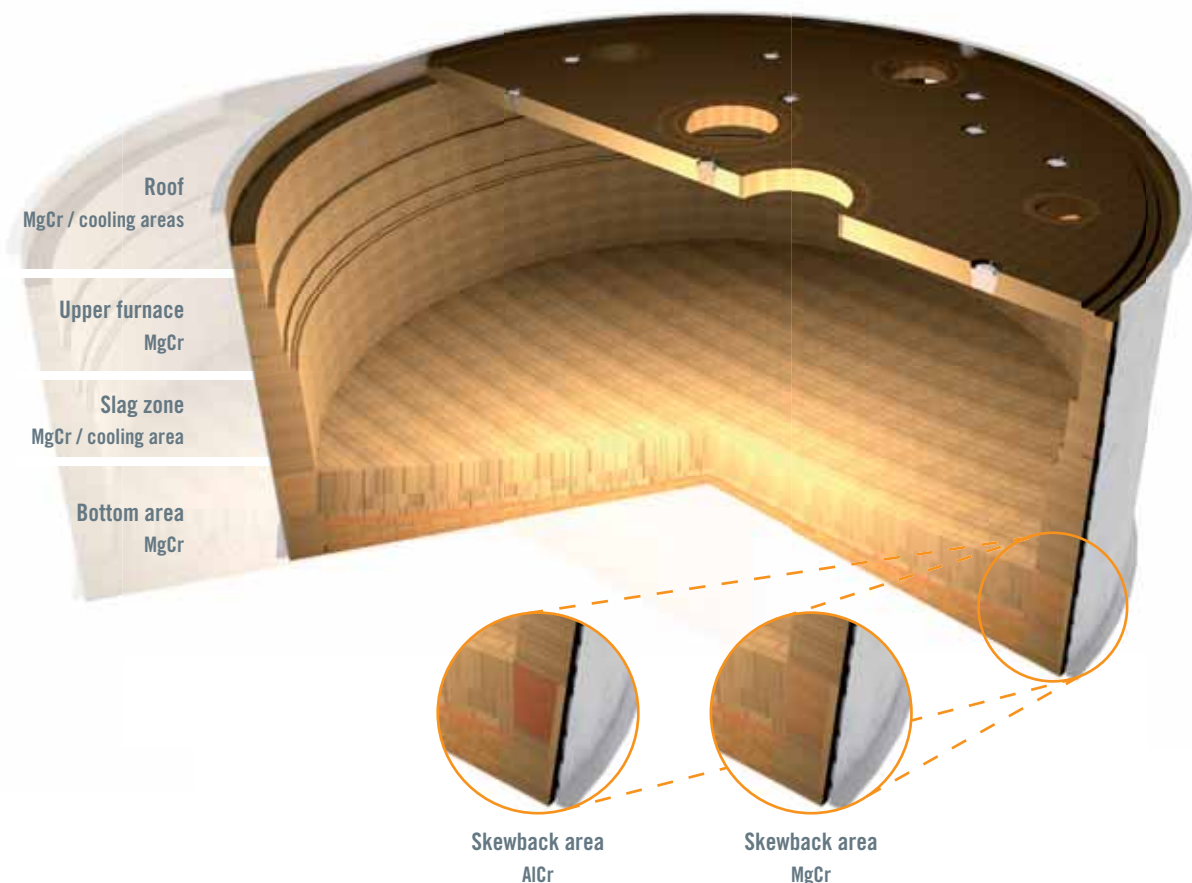
New cooling technology for critical parts

Slag cleaning furnace repair cycles have to be adjusted to the lifetime of the smelting units. However, slag zones can be cooled in a suitable way to prolong furnace campaigns. Areas

like tapholes and electrode openings can be optimized by implementing new cooling technologies that use ionic liquids, thus prolonging the lifetime of these areas.

New Cooling Technology

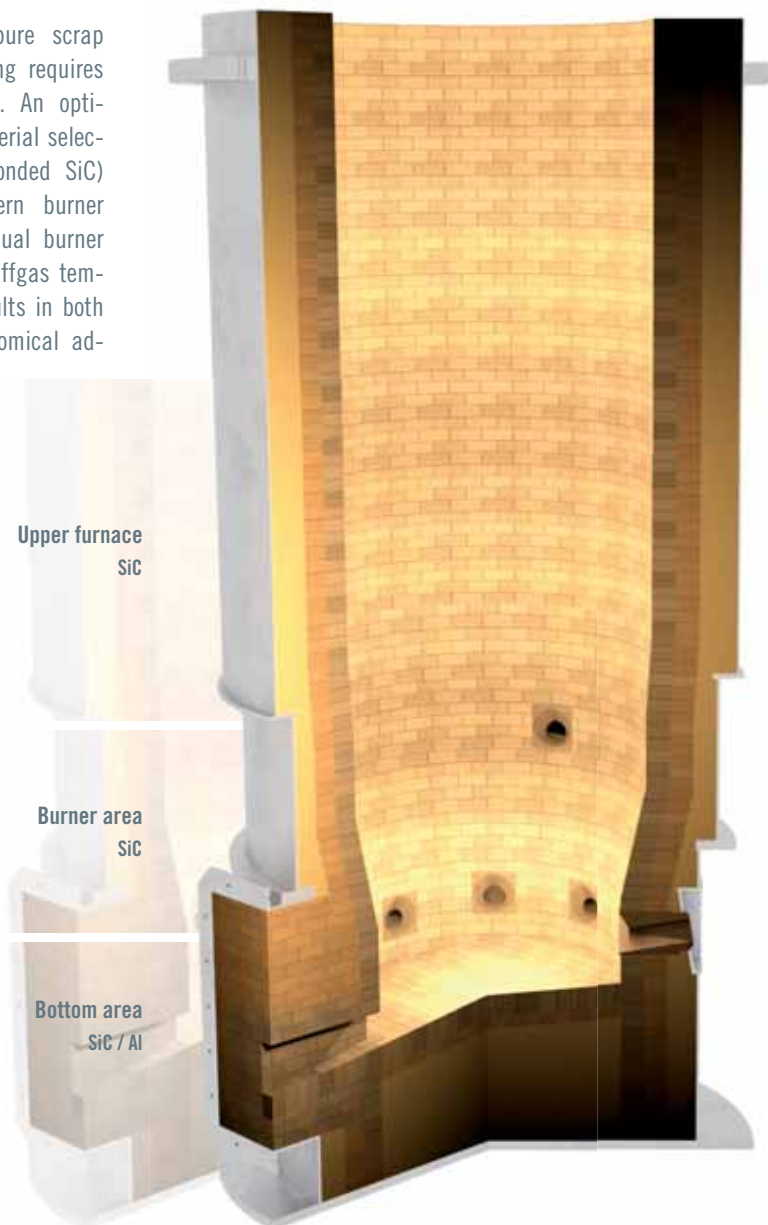
- > No hydration
- > No corrosion
- > No explosion risk



Lining Solutions Smelting Cathodes

Minimized downtime – optimized refractories –
exchangeable burner blocks

Optimizing pure scrap and cathode smelting requires a holistic approach. An optimized refractory material selection (e.g., nitride-bonded SiC) together with modern burner systems and individual burner control, as well as offgas temperature control results in both ecological and economical advantages.



Single Burner Control

- Precise lambda control, resulting in lower oxygen levels in the shaft furnace
- Individual burners can be switched off in the case of failure or special operational situations (e.g., cathode in front of burner) without influencing the other burners
- Energy saving

Lining Solutions Smelting Different Scrap Grades

Exploiting vessel capacities – process modelling – metallurgical expertise

Flexible reactors provide numerous possibilities for processing scrap. However, thorough process knowledge is required to achieve the maximum benefits from these vessels. Thermodynamic modelling provides a comprehensive overview of a specific process, and the way it is affected by the different process parameters.

The possibility to rapidly change the furnace atmosphere or use different slag systems is a considerable advantage of these very flexible vessels. Aggressive slag additives may also require new refractory materials or a special design.

Optimization Potential

- › Process knowledge
- › Refractory materials
- › Lances
- › New slag systems



Lining Solutions Scrap Smelting

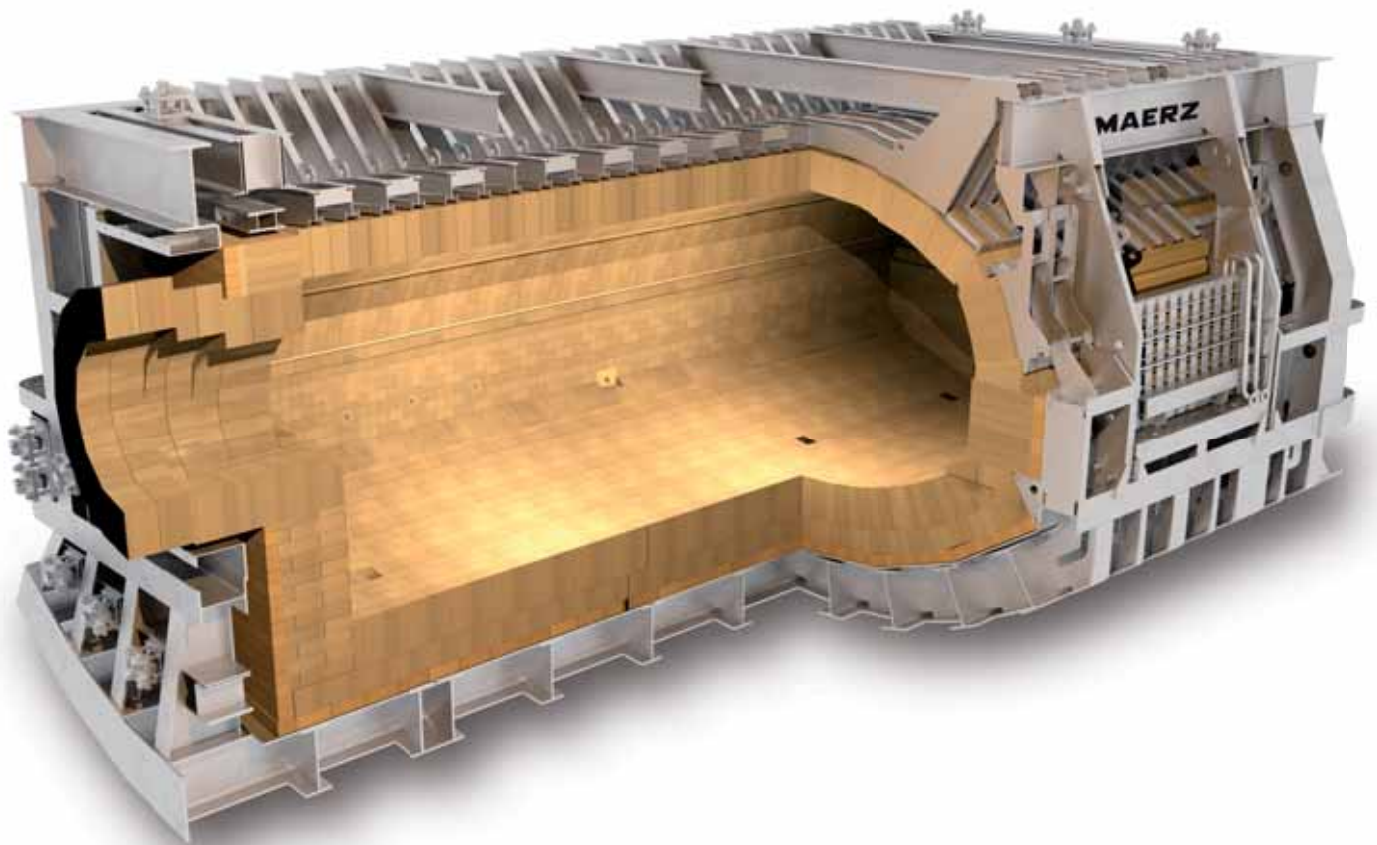
Exploiting metallurgical possibilities –
cooling – refractory optimization – purging

Tilting furnaces are widely used for scrap smelting and processing. The possibilities of this furnace type can be extended by using modern technologies and equipment, like cooling elements, gas purging, oxygen burners,

modern refining systems, and lining concepts. With these improvements, totally new process routes become possible, for example producing copper rod directly from scrap without additional electrorefining.

Furnace Optimization

- › Modern refining system
- › Gas purging system
- › New burner technology
- › Cost savings



Supervision, Commissioning, and Consultancy

Single source supplier – experience – experts

METTOP FIS offers supervision, commissioning, and consultancy services to enable successful start-up, improved operations, and optimized processes. The greatest customer advantage is provided in the knowledge management of refractories and cooling, chemistry, metallurgy, furnace operation, and new technologies. All project stages are covered by one competent partner, guaranteeing efficient and easy communication.

Our main goal is a running process and customer satisfaction. Therefore, we provide extended start-up phase services, process support, and consultancy. During commissioning, the customer benefits from onsite experts to deal with the complex process, equipment, and operational issues.

Our metallurgists do not leave before our goal has been achieved.

Philosophy

- › Considering the furnace as a whole unit
- › A commitment to R&D is vital for successful solutions
- › We take great pride in after-sales customer support and optimization
- › Whilst others might leave – we stay.



Anode Casting

Optimized cooling – longer mould life – improved electrorefining

METTOP FIS provides copper anode casting process monitoring and anode quality optimization to improve the casting process and the subsequent electrorefining step.

The casting process, which is the link between copper pyro- and hydrometallurgy, has a significant influence on anode quality. Since anode quality in turn directly affects the tankhouse operations, optimizing anode casting is a vital step towards improved tankhouse operations and output. The anodes need to have certain chemical and physical qualities to meet the electrorefining requirements. In order to dissolve evenly, a certain

homogeneity across the anode thickness is required. Typically, elemental and structural variations are found between the air- and mouldside, resulting from inhomogeneous cooling conditions.

Optimizing the cooling conditions, especially through watercooling and anode mould design, can result in more homogenous anodes with an improved dissolution behaviour during electrorefining. This can be achieved by combining experimental investigations and measurements with calculation of heat flow and solidification modelling.

Effects on Anode

- › Smooth surface
- › Uniform weight and thickness
- › Minimal edge effects
- › Minimal distortion of the body and lugs
- › Homogeneous structure
- › Elemental distribution as homogeneous as possible



Training Courses and Seminars



Basics – customer tailored – knowledge transfer – worldwide

METTOP FIS offers a wide range of practice-orientated training courses and seminars on different pyrometallurgical topics, which combine experience and knowledge with current research.

These courses and seminars are offered at different levels. Trained personnel are beneficial for both new and already running systems. METTOP FIS's trainers are highly experienced in copper metallurgy, not only on a theoretical level but also as result of worldwide industrial practical experience.

The basic courses consolidate a better understanding of copper production in general, and the specialized courses focus on more detailed information about certain production processes.

In addition to the general and special courses, customer-tailored seminars and training programs are also available that are designed according to specific customer requirements. The courses can be organized at any desired location, including onsite.

Courses

- › Process technology of copper production
- › Refractory materials
- › Cooling technologies
- › Furnace operations
- › Customer-tailored courses



Innovative System Solutions



The essential elements for creating novel solutions are highly-motivated personnel with an open-minded approach.

We are convinced that our innovative ideas are only possible with such a well-educated and flexible workforce, who are willing to examine issues in an unconventional manner. We have to think differently to provide customer-specific solutions instead of standard approaches.

To realize our ideas and provide the best product quality we have committed partners who extend our product and service range.

Our collaboration with expert partners enables maximum customer benefit: We work together with well-known, experienced partners in the fields of burner technology, furnace building, and plant design.

In the field of converting and pyrometallurgical refining we are proud of our exclusive partnership with Andritz MAERZ.



Innovations

Innovative System Solutions means:

- › Complete plant layouts
- › Design of new plants and production processes
- › Optimization of existing plants and production processes
- › New developments
- › Unconventional solutions



Getting more for less

Optimized processes increase productivity and decrease costs

