cunova

FORMERLY KME
SPECIAL PRODUCTS
& SOLUTIONS

Mould Plates
INNOVATION & TECHNOLOGY

MELTING & CASTING
TECHNOLOGIES

CONTENT

The Company

cunova offers a unique combination of know-how and experience in all key technologies for the production of high-performance moulds for casting ferrous alloys.

cunova's corporate goal is to develop and manufacture products that meet customer demands, finding solutions for their specific applications, and providing services as a long-term partner. cunova's strategy for accomplishing this goal is based on a highly skilled and experienced workforce. cunova has the ability to invent and develop new materials and innovative production processes via ongoing advancement and training of our employees and the continual improvement of its organisational structures.

AMT® ADVANCED MOULD TECHNOLOGY

ATSM Advanced Thin Slab Mould

Design Challenge

- Improved thin slab quality
- Lower operating costs and ease of maintenance
- Access to water-cooled copper surfaces for periodic inspection and cleaning
- Maintain operating practices

Solution

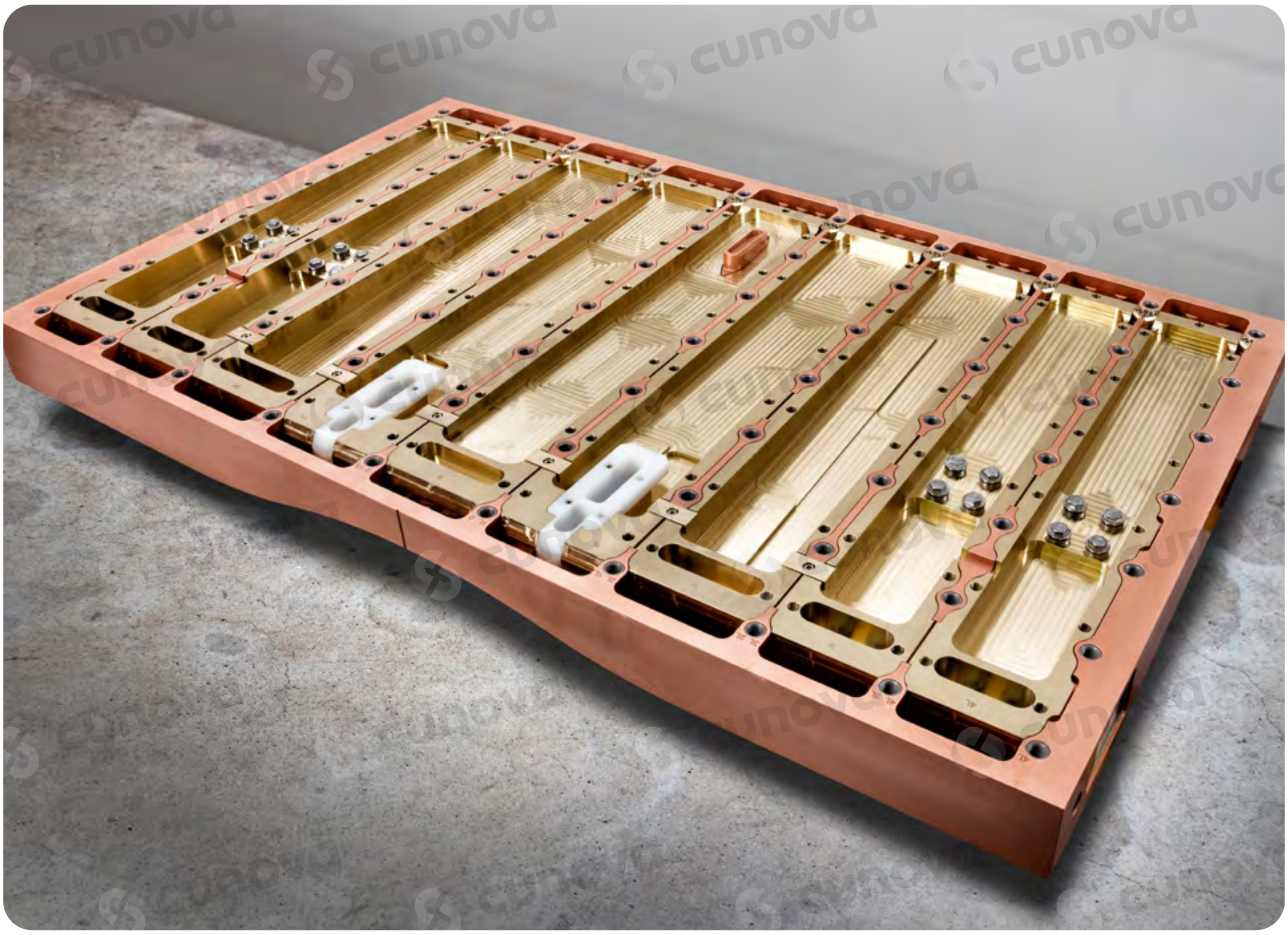
- Improved copper plate design (patent applied)
- Reduced copper mould internal stress (patent applied)
- New anti-bulging system (patent applied)

Application

- All slab mould plates

Advantages

- Homogeneous copper plate temperature resulting in improved
- Thin slab quality
- Reduced meniscus bulging
- Easy installation
- No filler bars
- Complete access to water-cooled copper surfaces
- Compatible with existing water boxes and operating practices



AMT® ADVANCED MOULD TECHNOLOGY

Status Report ATSM Advanced Thin Slab Mould

SDI, Butler, IN, USA

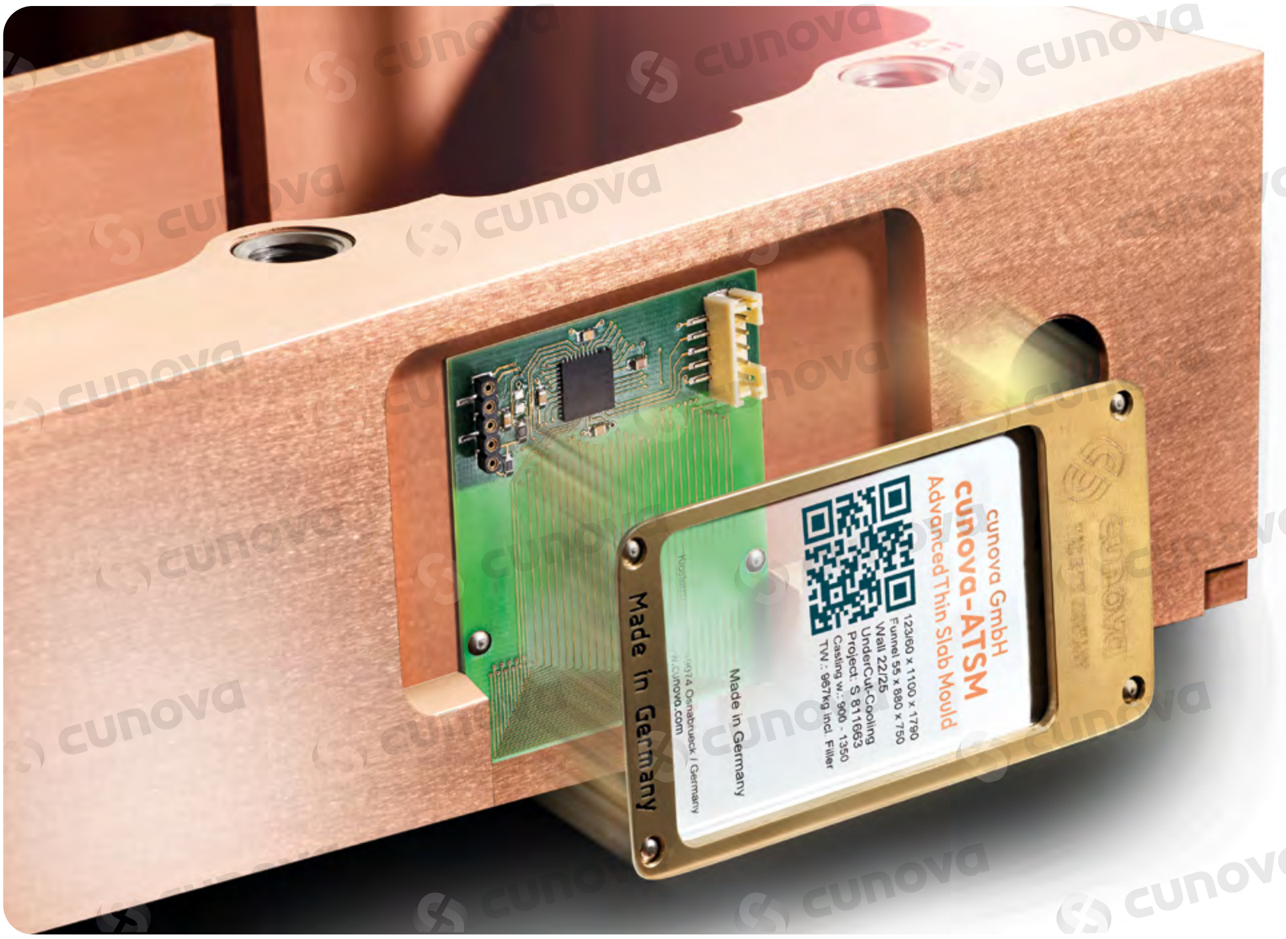
- Trial started Jan.2017, full face Nickel coating 1.0, resp. 0.4-1.2 mm
- Trial finished in March 2018
- Total 8 campaigns with 1.784 heats and 267.800 tons
- Performance excellent, output improvement => 2 more ATSM ordered!

Thyssen Krupp, Duisburg, Germany

- 1 set supplied, Trials started Jan. 2018
- Actually 449 heats, 79.850 tons

Nucor Berkeley

- 1 set supplied, trial started Nov. 2018



AMT® ADVANCED MOULD TECHNOLOGY

ATSM versus existing Designs

SMS Slotted	cunovas's Optimized gun drilled	cunovas's AFM	cunovas's ATSM
Hanging filler bars gun-drills in front of the inserts	Removable and fixed plugs	Adapter plate	Special filler parts, easy maintenance
25 mm hot face distance U-shaped cooling channels	20 – 25 mm 10 mm bores uneven spaced	25 – 22 mm 5/6 mm cooling gap improved meniscus cooling	22 – 25 mm 5/6 mm cooling gap Improved meniscus cooling
None uniform heat transfer in the funnel zone	Special spacing of cooling bores	Uniform cooling with complex adapter plate design	Uniform cooling with new filler parts
931 kg	1.205 kg	381 kg	~ 631 kg
• Limited cooling channel access • Standard cooling	• Limited cooling channel access • Heavy	• Additional adapter costs • No cooling surface access • Standard maintenance	• Full cooling channel access • Filler parts necessary • Maintenance friendly

AMT® ADVANCED MOULD TECHNOLOGY

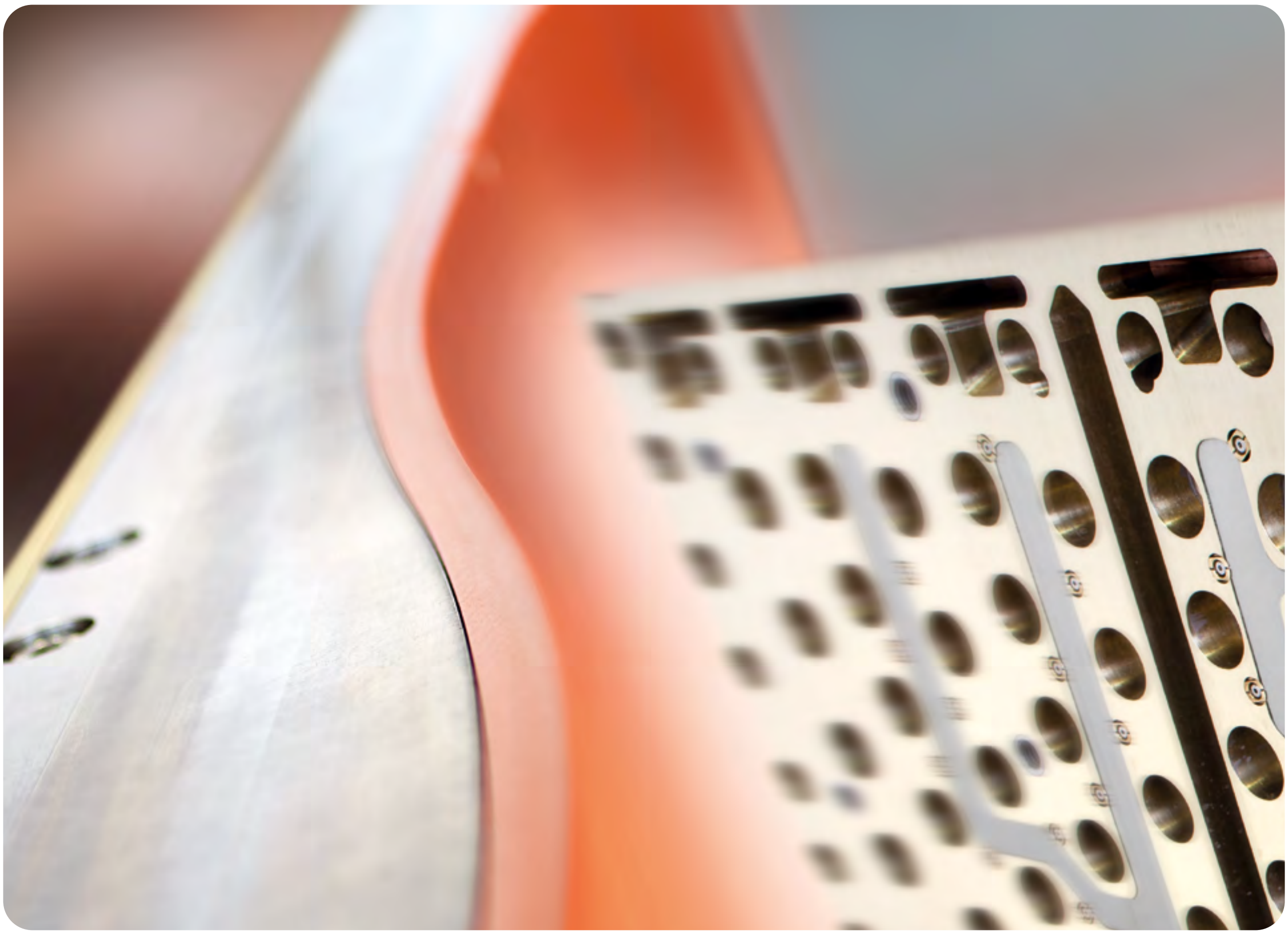
AFM® Advanced Funnel Mould

Challenge
- Improve thin slab quality
- Lower copper weight
- Increase lifetime

Solution
- Thin copper and adapter plate design
- Water gap cooling design
- Low stress AFM® mounting technology (cunova patent)

Application
- Thin slab casting

Advantages
- Improved lifetime
- Homogeneous temperature profile – no hot spots
- No bulging at meniscus area
- Low retrofitting costs
- Compatible with existing waterbox design



AMT® ADVANCED MOULD TECHNOLOGY

Function of the AFM® Mould

This mould system consists of a thin-walled copper plate with a novel water "gap-type" cooling design (instead of cooling slots) and a floating, stress-free attachment to a noncorrosive adapter plate.

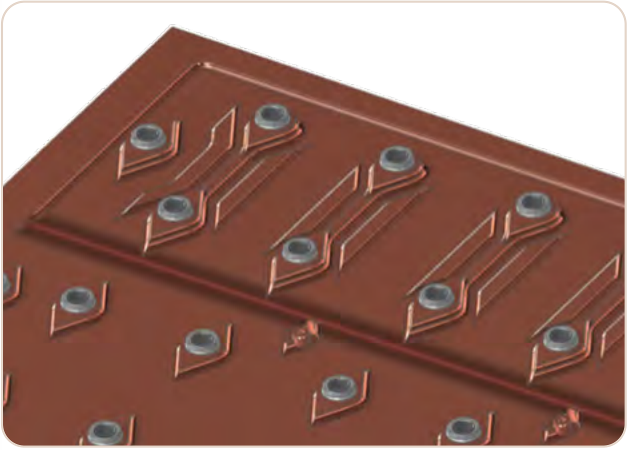
The AFM mould is designed for thin slab casters to work with their existing water boxes to provide a homogeneous cooling and adequate water flow velocity for improved slab quality and longer lifetime. Depending on conditions modifications can be implemented (copper material, AFM II)

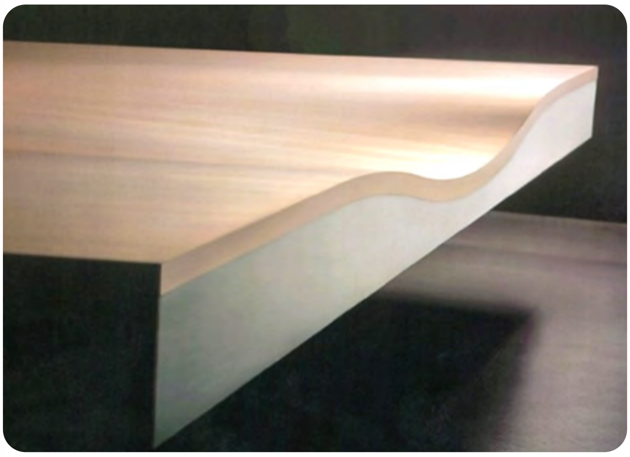
Advantages

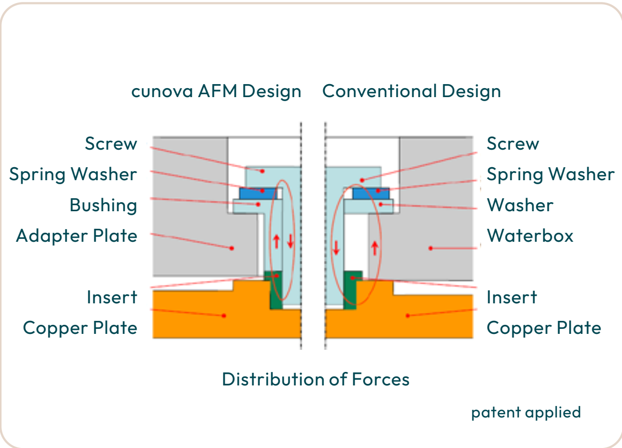
- Improved lifetime
- Homogeneous temperature profile
  - no hot spots
- No bulging at meniscus area
- Low retrofitting costs
- Compatible with existing waterbox design

Results

Strongly depending on casting process parameters, especially on casting speed, cleanliness of steel (Zinc, Sulphur, ..) and remachining cycles. Some customers could nearly double the lifetime and converted completely to the AFM design.







ADVANCED FUNNEL MOULD (AFM)

For Thin Slab Casting: First Results

Wobker, H.-G.; Hugenschuett, G.; Kolbeck, D.; KM Europa Metal AG, Klosterstraße 29, 49074 Osnabrueck, Germany. KME America Inc., 1000 Jorie Boulevard, Suite 111, Oak Brook, ILL. 60523 / USA

Abstract

An update on the progress made in the development of the new Advanced Funnel Mould (AFM) for thin slab casting is presented in this paper. The central elements of this design include: a special copper alloy (Elbrodur® GP), a new type of mould plate fastening system, water-sheet cooling technology, and non-uniform wall thickness to obtain a homogeneous temperature profile.

Trials have already begun at a number of CSP casting plans. Results from these first tests will be presented, along with a discussion on further design improvements planned. Initial indications are that the major goals for the new AFM mould have already been realised in terms of operational compatibility, product quality and mould life. Currently, the AFM mould has been successfully run at casting speeds of up to and including 6 m/min (236 IPM). Further optimisation of the AFM mould is ongoing, using feedback from the first trials. An example of this is additional improvement to the cooling, so as to counter the effect of higher mould temperatures caused by the increase in casting speed. This is especially problematic for steels produced in electric arc furnaces, which may contain high amounts of Cd, Zn, S and Bi, which increase the potential for cracking. Of course, the mould is just one part of the casting machine and in order to make the most of the new design, it is necessary to optimise other key casting components such as the EMBR, SEN, mould powder and cooling water quality.

AMT® ADVANCED MOULD TECHNOLOGY

Introduction

Among the existing near-net-shape casting methods, thin slab casting, a process developed on the basis of conventional continuous casting, has become firmly established as a cost-effective mode of production. Today, more than 45 strands are in operation worldwide, with a capacity totalling more than 45 million tonnes of hot strip per year. Steelmakers and machine builders throughout the world are working on further advances in productivity and performance of thin slab casters, focussing mainly on higher casting speeds, longer machine times and improvements in slab quality.

Crucial to an increase in productivity and performance of the machines is the copper mould, whose basic construction has remained unchanged since the thin-slab technology was introduced. At the same time, as mould constitutes the heart of the casting machine, it determines both cast product quality and the overall economics of the process.

Against this background, a new mould design for thin-slab casting is described. The new development features a thin-walled copper plate with a floating attachment to the water-box and the application of CuCrZr as material for the mould plate. This paper discusses the material and design considerations involved in its development and the first casting trial results at the Thyssen Krupp Casting and Rolling Plant in Duisburg, Germany.

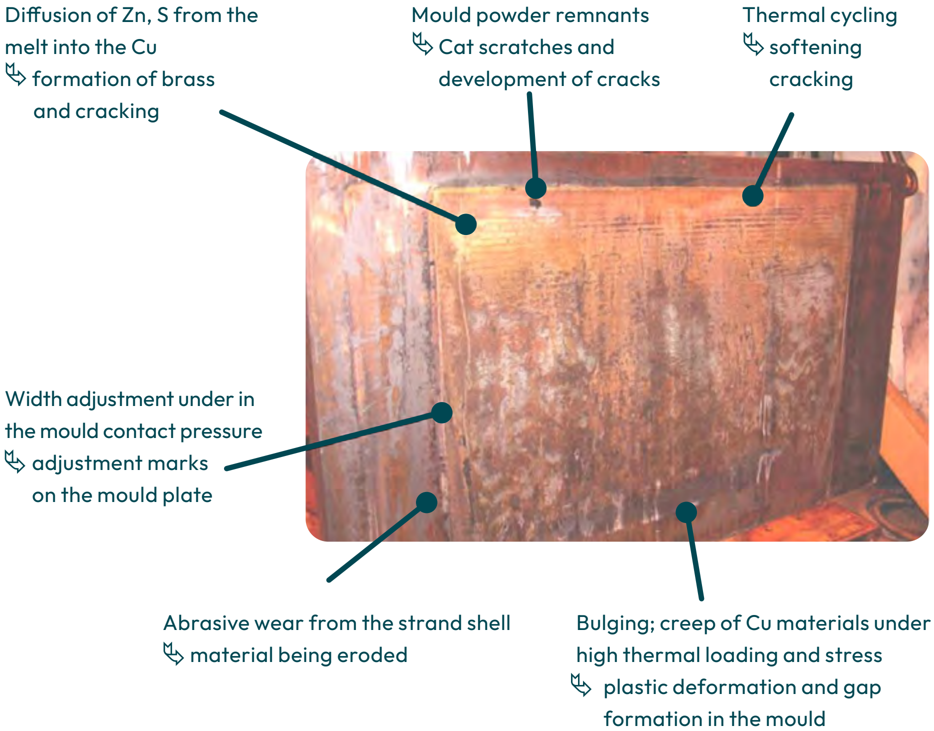
Background

The development of thin slab casting goes back to the early eighties. The prerequisite essential for this new continuous casting technology has been the SMS funnel-type mould, the development of which cunova contributed to with respect to material and manufacturing expertise. Later on, other machine builders also came up with comparable thin slab concepts.

The introduction of near-net-shape thin slab casting for flat products together with the construction of minimills, sparked a surge of innovations in the production of hot-rolled strip in the 80's and 90's and has led to considerable advantages in terms of costs and productivity [1, 2, 3]. Both its economic and ecological advantages have made thin slab casting a technology that has today become firmly established. At the present time, more than 45 strands are in operation worldwide, with a total of more than 45 million tonnes of hot strip being produced each year.

One of the major stumbling blocks to meeting the forementioned objectives has been the current state of mould design, whose basic construction has remained more or less unchanged ever since the introduction of the thin slab casting technology. The objective of this project was to develop an understanding of the limitations with the current thin slab casting mould and work to develop an improved design. It was felt that this approach would hold the greatest promise for meeting the current and future needs of steelmakers. Typical wear phenomena of today's thin slab moulds are shown in the figure 1.

Figure 1
Wear phenomena on thin slab moulds



[1] J. Schönlech, B. Krüger, H.-D. Hoppmann, C. Moffin, "Stand der ISP-Technologie und neue Entwicklungen", Stahl und Eisen, MG (1996)
[2] S. Kollberg, H. Streubel, R. Marracini, "Minimills with thin slab Casting become a real Competition to Minimills", 84th ISS Steelmaking Conference, March 2001
[3] H. Streubel, "LCR, Liquid Core Reduction beim Dünnbrammengießen: Konzepte und Ergebnisse", Stahl und Eisen, 119 (1999)

AMT® ADVANCED MOULD TECHNOLOGY

Weak Points of Thin Slab Moulds

In the early stage of thin slab mould development, the copper plates were made of CuCrZr as this material had superior mechanical properties together with good conductivity, as compared to the commonly used CuAg alloy for conventional slab casting. However operational experience showed that the CuCrZr plates had poor life due to the formation and quick propagation of cracks at the meniscus area. Mould plates of the more ductile CuAg alloy were found to obtain longer life between machining due to slower crack propagation rates. Still, the CuAg mould plates used today have problems at casting speeds above 4.5 m/min, as this is the point where the limit of the material's ability to cope with the thermal stresses involved is reached or exceeded.

A measurable drop in hardness at the meniscus of mould plates after just a short time in service is a clear sign of this. In this case, the temperatures experienced in the mould plate exceed its recrystallization temperature, thereby the strength and the hardness of the CuAg material is greatly reduced.

Other effects of the extreme temperatures experienced in the mould material at high casting speeds take the form of plastic strains, leading to deformations or "bulging" below the meniscus level, as well as the formation of brass phases due to zinc diffusion from the steel. The latter problem is especially problematic for minimills, which often use a scrap-based steelmaking process. The formation of these brass phases causes hot shortness of the copper and, together with the stresses from the high operating temperatures, will give rise to cracks in the material.

Bulging

Bulging of the copper mould will result in gaps developing between the wide-face and narrowface plates. The cause is the extreme temperatures on the inside surface (hot face) which result in thermal expansion of the plate material in the zone below the meniscus. This thermal expansion is constrained on the outer cold face of the mould, with the result that the mould plate deforms macro-elastically/plastically [4]. The degree of such deformation depends mainly on the plate material's creep characteristics and strength. When cooled, the material does not flow back completely, with the result that a depression (concavity) develops in the wide-face plate and a gap forms between it and the narrow-face plate (Fig. 2). The formation of such gaps will very often determine when the mould has to be removed from the casting machine and the copper plates re-machined – which makes it a determining factor with respect to plate life.

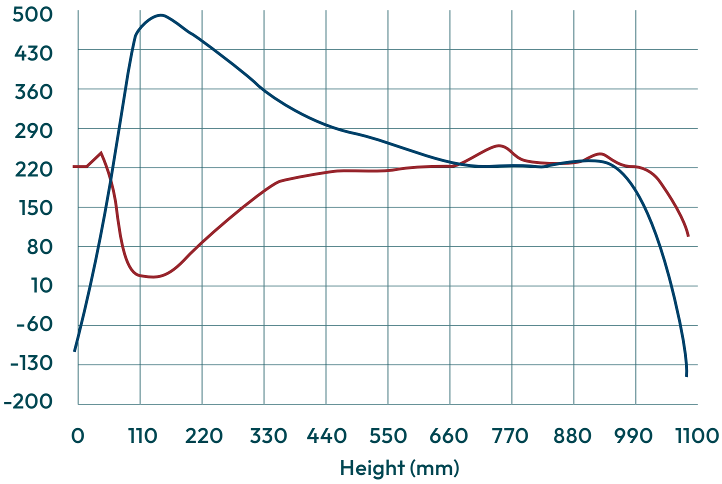
Figure 2

Stresses and strain responsible for bulging of mould plates

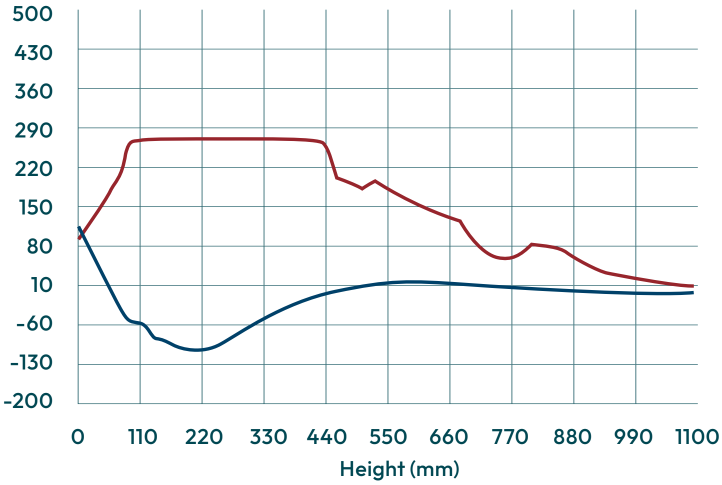
Deformation of Casting Surface [10^{-3} mm]

Equivalent Stress [N/mm²]

During Casting Operation



After Casting Operation



4. J. B. Sears, M. R. Badger, "Improved Product Quality, Increased Cast Speed and Extended Equipment Life with thin slab Cassette Funnel Moulds", Iron & Steel Making Magazine, 2002, pp. 21 – 28

Material Displacement during Width Adjustment

Apart from giving rise to gaps between the wide and narrow-face plates, the bulging described above also leads to material displacement, i.e. material building up in front of the sliding edge of the narrow-face plate during slab width changes. Reducing the clamping pressure on the narrow faces has proved to work well as an immediate countermeasure. Of course there are limits to how far the clamping pressure can be reduced, as the mould will open up due to ferrostatic pressure from the contained liquid steel. Therefore, a mould material with a high degree of hardness is necessary to minimize this damage.

Cracking

The development of cracks at the meniscus is mainly due to extreme levels of heat during casting and the resultant micro-plastic strains/deformations in the surface and sub-surface areas of mould plates. This damage mechanism is enhanced by zones of extremely high temperatures, such as the transition [5] from the funnel to the parallel part of the mould. At that point there are local temperature gradients of several hundred degrees Celsius between the hot and cold face. The casting surface (hot face) is moreover subject to diffusion processes. Elements such as zinc, sulphur, cadmium or fluorine from the steel melt or the powder lubricant diffuse to the surface and subsurface of the copper. These diffusing elements cause hot shortness in the copper mould material, resulting in the formation and subsequent propagation of cracks. Critical factors with respect to this damage mechanism are the maximum temperatures experienced by the mould as well as time in service.

Inhomogeneous Heat Flux in the Mould

The heat flow in the mould wall in both the transverse and longitudinal direction is subject to local variations. In contrast, most of the known conventional mould plate designs provide for only uniform rates of heat extraction, with the result that there are local differences in the mould hot-face temperatures, especially along the meniscus level.

The fact that mould powders are designed to work over a specific temperature range gives rise to local variations in their melting and infiltration behaviour, in particular, between the middle of the mould plate and the parallel-faced areas. Such melting differences will result in thickness variations of the insulating slag film being formed, which in turn will have implications for the rate of heat transfer. The resultant non-uniform rate of heat conduction through the mould is well known to result in "caster folds" or longitudinal cracks in the slab. It can be inferred from this mechanism that it is imperative for the mould to ensure a homogeneous rate of cooling.

Compounding this problem is the formation of a standing wave of incoming steel at the meniscus [1, 6]. The consequence of this effect is that the mould experiences the most extreme temperatures in the location where the standing wave forms (where the metal level is highest). This is because the powder can only form a relatively thin insulating slag film between the strand and copper wall as the melted powder runs to the lowest points of the steel meniscus level, which is at the centre of the mould where it forms the thickest insulating film. The result is a thick insulating slag film formed in the area with lower temperatures while the thinnest slag film is formed where the hottest temperatures are experienced. This fact aggravates the uneven temperature profile in the mould plate. To counter-act this effect, many thin slab casting machines use an electromagnetic brake to regulate and control the liquid metal level and minimize the formation of standing waves.

Wear at the bottom end of Mould Plates

In addition to the points already mentioned, another factor that determines the life of moulds between re-machining is abrasive wear in the lower regions of the mould due to mechanical interaction from the solidified strand shell. The answer to this abrasive wear can be in a partial nickel or nickel alloy coating. At the same time, a partial coating prevents the strand shell from picking up copper particles from the plate surface, which can give rise to star cracks in the surface of the rolled product.

5. B. G. Thomas, U. S. Yoon, J. K. Park, I. Samarasekera, "Mould Crack Formation of the Funnel Shaped Mould during thin slab Casting", Proceedings of the 2002 ISS Steelmaking Conference, pp. 245 – 257

6. R. Dehoff, "Effects on Standing Wave Height in a Continuous Casting Mould Water Model", Senior Design Project Presentations of the Department of Material Science and Engineering, Ohio State University

Objectives of the new AFM Mould Development

Based on the preceding discussion as to the weak points of today's thin slab moulds, objectives for the new AFM (Advanced Funnel Mould) for thin slab casting were determined to be:

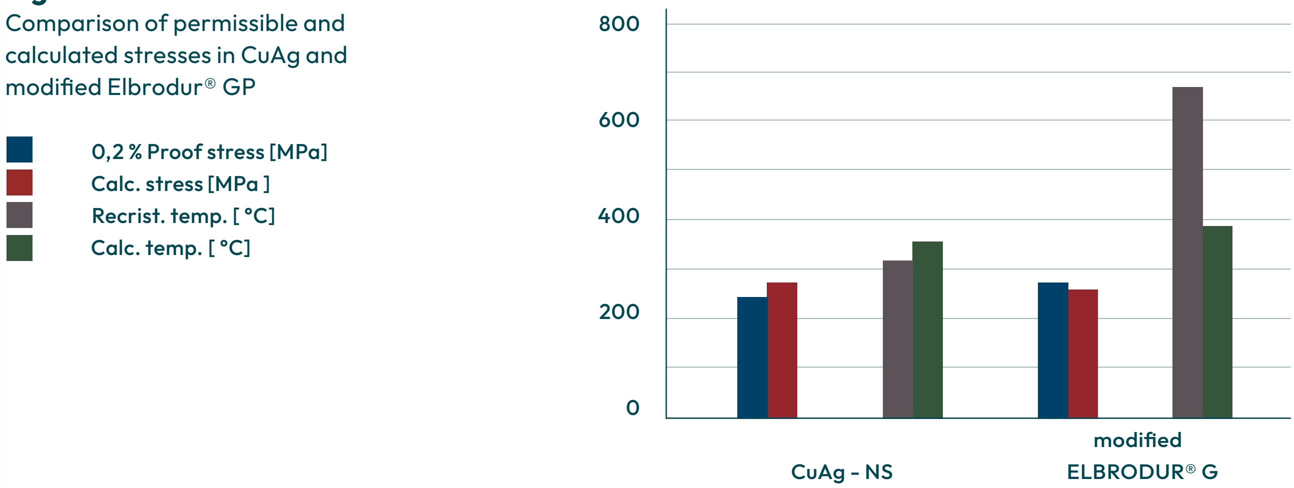
- Longer mould life/service life between re-machining.
- Improved suitability of the mould for casting crack-prone grades of steel.
- Potential for achieving casting speeds of greater than 5 m/min, together with stable process conditions (thermal load).

The paramount objective faced was to increase copper plate life and therefore reduce the mould cost per tonne of steel cast.

To ensure acceptance by the customer, another goal of the new design was to ensure compatibility, both in equipment and established casting parameters. The steel plants' large investment in developing specialized casting practises for different steel grades could not be rendered useless by the new mould design. In addition, it was also important that the steel plants be able to keep on using the existing secondary equipment such as the cooling water supply, EMBR, mould level control and existing TC systems. Furthermore, the new mould had to be sufficiently compatible with the existing machines so as to keep any capital costs to an absolute minimum [7].

Figure 3

Comparison of permissible and calculated stresses in CuAg and modified Elbrodur® GP



	CuAg - NS	modified ELBRODUR® G
0,2 % Proof stress [MPa]	275	365
Calc. stress [MPa]	309	349
Recrist. temp. [°C]	350	700
Calc. temp. [°C]	394	418

7. H.-G. Wobker, G. Hugenschuett, D. Kolbeck, I. Bakshi, "Advanced Funnel Mould for thin slab Casting", Proceeding of the AISTech, Sept. 15-17, 2004, Nashville, Tennessee

Make-up of Mould and Model Calculations

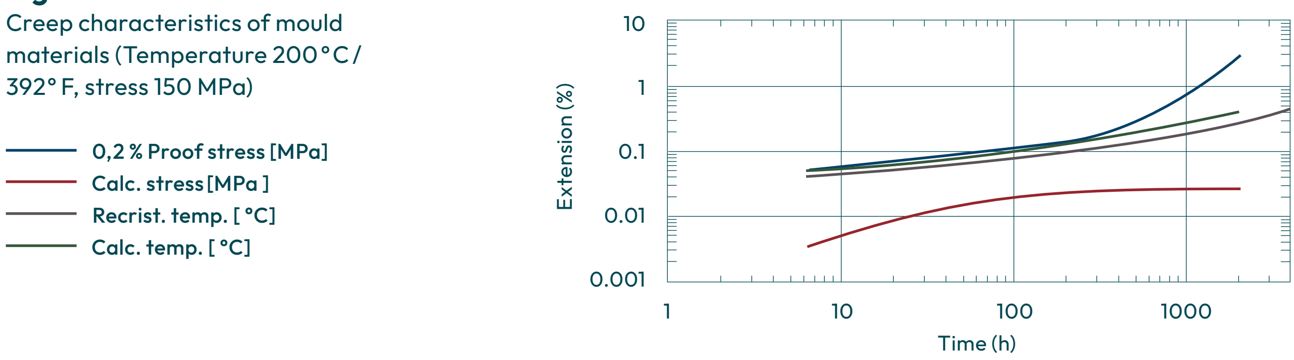
Mould Material

As described above, the extreme thermal stresses which the mould plates experience make enormous demands on the materials of which they are made, as well as being the cause of various wear mechanisms observed in the moulds. To meet these extreme thermal demands, the AFM mould plates are made of the modified CuCrZr alloy, Elbrodur® GP. The new Elbrodur® GP material stands out for its superior mechanical properties at room temperature, together with considerably improved properties at higher temperatures. A comparison of the properties and mould loadings of CuAg versus Elbrodur® GP is shown in the figure 3. This graph illustrates the materials' respective properties at the calculated stresses and temperatures, which the mould plate sees in service. For the CuAg alloy, both the active stresses and temperatures exceed that material's limits. Elbrodur® GP has still considerable reserves, in particular, at the maximum operating temperatures – so that the material can cope with high levels of heat and stress. Another big advantage of Elbrodur® GP consists in considerably improved creep resistance, so that there is a much better chance to avoid bulging. [8]

Figure 4 shows a comparison of the creep characteristics of CuAg, DHP copper and Elbrodur®.

The diagram shows that Elbrodur®'s resistance to creep under the same stress load exceeds that of the other two metals by a factor of about 10. The advantage of this precipitation-hardenable material becomes even more obvious in case of stress loads of longer duration. Whereas the creep in Elbrodur® under 150 MPa comes to a stop (after approximately 100 hours) a continued increase in extension is observed in CuAg, and especially in DHP Cu, where it reaches levels of 0.5 to 1.0 %. Its good resistance to creep plus its superior strength and thermal stability mentioned above are the main reason why this material is being used in the new mould. This makes it possible for the bulging problem in moulds to be considerably reduced [8].

Figure 4
Creep characteristics of mould materials (Temperature 200 °C / 392° F, stress 150 MPa)



[8] KM Europa Metal AG, "AMT® - Advanced Mould Technology", Technical Information of Engineered Products for Melting and Casting, 2003

AMT® ADVANCED MOULD TECHNOLOGY

Design Features of the New Mould

The newly developed AFM mould consists of the actual Cu plate, together with an adapter plate made of a special high-strength, non-magnetic copper-based alloy, which is used for attaching the Cu plate to the water-box (Fig. 5).

The design concept for the copper mould is to have a relatively thin plate, of non-uniform thickness (patent pending), together with the machined funnel geometry. Unlike other mould concepts, the approach of varying the copper thickness will compensate for the non-uniform thermal field being generated in the mould. The desired goal is to achieve maximum possible homogeneity of the temperature on the copper hot face, in order to facilitate the uniform melting and fluxing of the mould powder.

The figure 6 shows the temperature distribution on the hot and cold face of the mould, based on a heat flux distribution of between 1.4 and 4.5 MW/m², which corresponds to a casting speed of about 5 m/min. The calculated temperatures show a maximum difference of 15 °C so that an even melting and fluxing of the mould powder under actual operating conditions is achieved. At the same time, this homogeneous type of cooling offers good chances for the casting of crack-prone steels.

The division of functions in the new AFM system, which comprise the actual mould plate together with the adapter plate (which serves to attach the mould plate to the water-box), makes this system flexible and easily adaptable to different geometries. The material chosen for the adapter plate is a high-strength copper-based alloy having non-magnetic properties, so as to eliminate any adverse effect on the auxiliary equipment of the mould, specifically thermocouple and EMBR systems.

Figure 5
Assembly of adapter plate and Cu plate

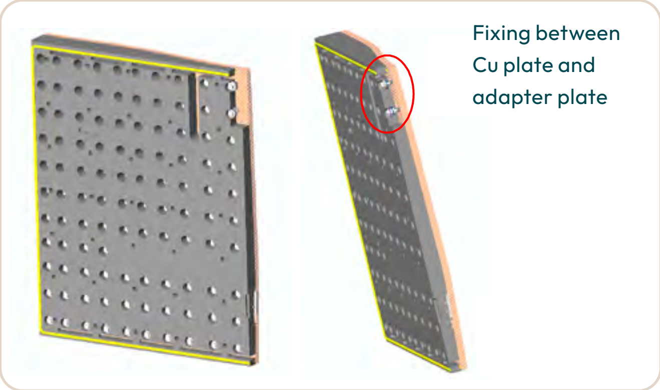
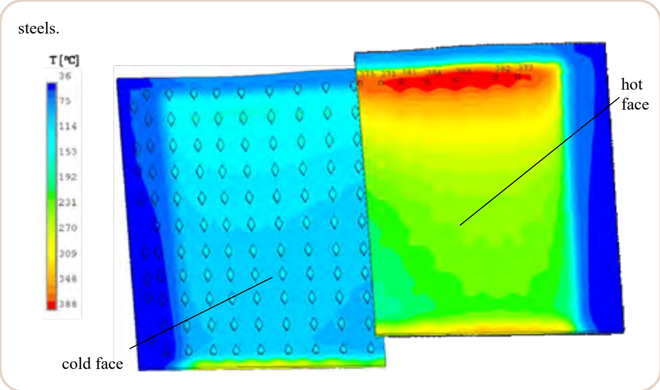


Figure 6
Temperature distribution in thin-walled mould plate



Floating Attachment of the Mould Plate

The plates of today's known types of continuous casting moulds are held in position by locating keys and then fixed in position by means of bolts. In case of thermal expansion, for example during casting, this type of assembly will induce additional stresses in the mould. In that case the operating stress experienced in the mould plate is composed of the existing internal stresses in the plate σ_{RES}, the stresses arising from the casting operation σ_L, and the stresses σ_F induced through the mode of fixing the plate on the water-box. To reduce these stresses and thereby increase the working life, a new fixing system has been developed for attaching the mould plate to the adapter plate.

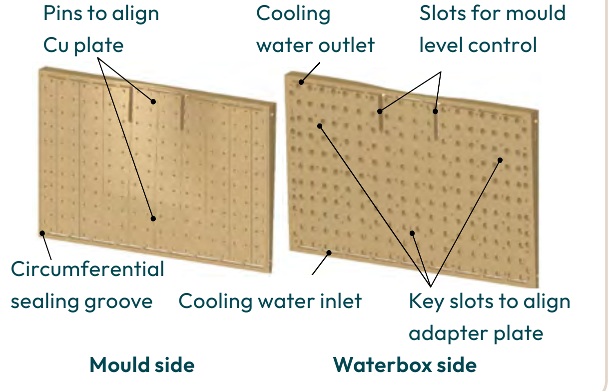
The new joining technique ensures a stress-free (unconstrained) attachment of the copper to the adapter plate. To accomplish this, the copper is carried by small segments on the adapter plate and fastened in such a way that allows a defined amount of movement of the copper relative to the back-up plate. This mode of attachment permits unrestrained thermal hot face cold face expansion of the copper when exposed to the operating temperatures, without any additional stresses being induced in the mould from its fixation.

In the new AFM design, machined cooling slots have been rejected in favour of using a correspondingly thin copper plate. Without any solid, full-thickness lands between cooling slots, this plate is able to expand under whatever heat flow may be applied. In addition, there are much fewer cross-sections that remain cold and impede thermal expansion of the plate. The advantages over the cooling slots also holds true over deep-drilled cooling passages, for similar reasons. The fact that the plate rests on a few fastening points on the adapter plate allows for "sheet cooling" with heat being evenly extracted from a large surface area. Together with the differences in plate thickness, this cooling design contributes significantly toward achieving a homogeneous temperature distribution on the mould hot face.

The cooling water is circulated in a gap between the adapter and the actual mould plate, as shown in the figure 7. Another benefit is that the cooled region of the mould becomes larger, allowing for a wider range of slab widths that can be cast with this mould design. In mould assemblies used today, it is very often the copper area actually being cooled, which limits the maximum cast slab width.

The seal between adapter plate and water-box is not any different from systems in use today, ensuring no assembly problems. It also means that existing devices such as thermocouples for breakout detection, mould level control and/or EMBR systems can continue to be operated as before.

Figure 7
Adapter plate design



AMT® ADVANCED MOULD TECHNOLOGY

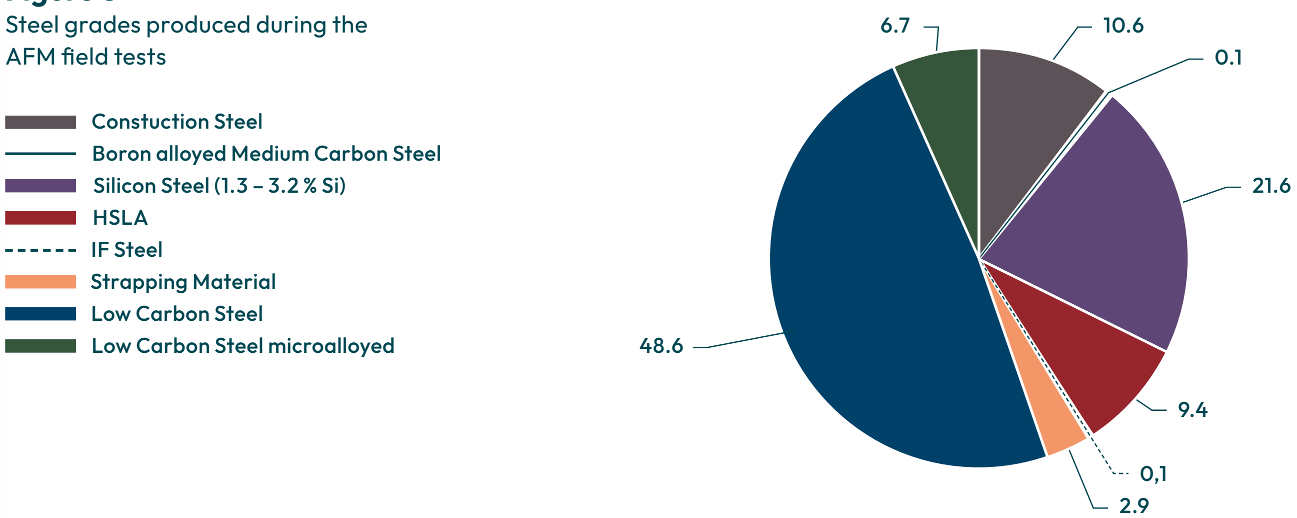
In-Service Behaviour of the new Mould

In April 2003, the AFM mould was used for the very first time at the ThyssenKrupp thin slab casting machine in Duisburg on a two-strand thin slab caster. As this caster is a two-strand caster and is equipped with both an EMBR and a breakout detection system, it offered ideal test conditions. A conventional thin slab mould was installed on one strand and the new AFM mould on the second strand, providing an ideal situation for comparison purposes.

The initial casting results were very promising. There was no increase in cooling water lemperature compared to the conventional mould. Additionally, due to design optimization, the pressure drop of the cooling water was higher with the AFM mould than with the conventional mould.

The first AFM mould has been tested in operation at ThyssenKrupps Casting Rolling Plant from April 2003 to February 2004. In this period the complete product portfolio of the Casting Rolling Plant (Fig. 8) has been produced successfully.

Figure 8
Steel grades produced during the AFM field tests



The adaption of process parameters as casting powder, sensibiliy of BreakPrevention system or others were not necessary. The casting process was stable, there was no break out while using the AFM mould. The lifetime of the copper plates was 60 % higher than the medium lifetime of conventional broad faces. Campaigns of more than 40.000 tons inbetween two remachinings were possible.

The average casting speed during the test was 4.8 m/min. Thyssen Krupp's target is in general to increase casting speeds in order to optimize the overall productivity of the casting and rolling plant. However, with respect to the different steel grades casting speeds were for dynamo grades 4.6 m/min, for high carbon grades 4.7 m/min and for low carbon grades 5.7 m/min. For test purposes also high speeds up to 6.1 m/min were tested in order to better understand the performance of the mould at higher speeds. These tests will be continued in the near future.

Mould life during the first tests was influenced by a series of modifications and corrective measures as a result of which the plates required early remachining. The problem was in particular in a gap developing between the mould plate and adapter plate. These unscheduled early remachinings made it impossible for the mould's full potential to be brought into effective action. Meanwhile these teething troubles have been overcome through certain design changes.

Summary and Future Outlook

The present paper reports on the development of a new mould for thin slab casting. On the basis of systematic analysis of the wear mechanisms in today's moulds, a new mould concept was developed. The central elements of the new development are: the new ELBRODUR® GP material, a newly developed fastening system, water-sheet cooling, and non-uniform wall thickness in order to ensure homogeneous temperature distribution in the mould.

In the course of the more than a year's use of the mould it has been possible to gather a host of knowledge and experience. It has turned out that, compared with the types of mould design used in the past, the AFM mould does make it possible to achieve considerable gains in mould life and performance. It is also for the purposes of using higher casting speeds that the mould appears to have rather good potential. The optimization work under way at present focusses on optimization of the cooling, appropriate coatings, and further improved mould materials.

AMT® ADVANCED MOULD TECHNOLOGY

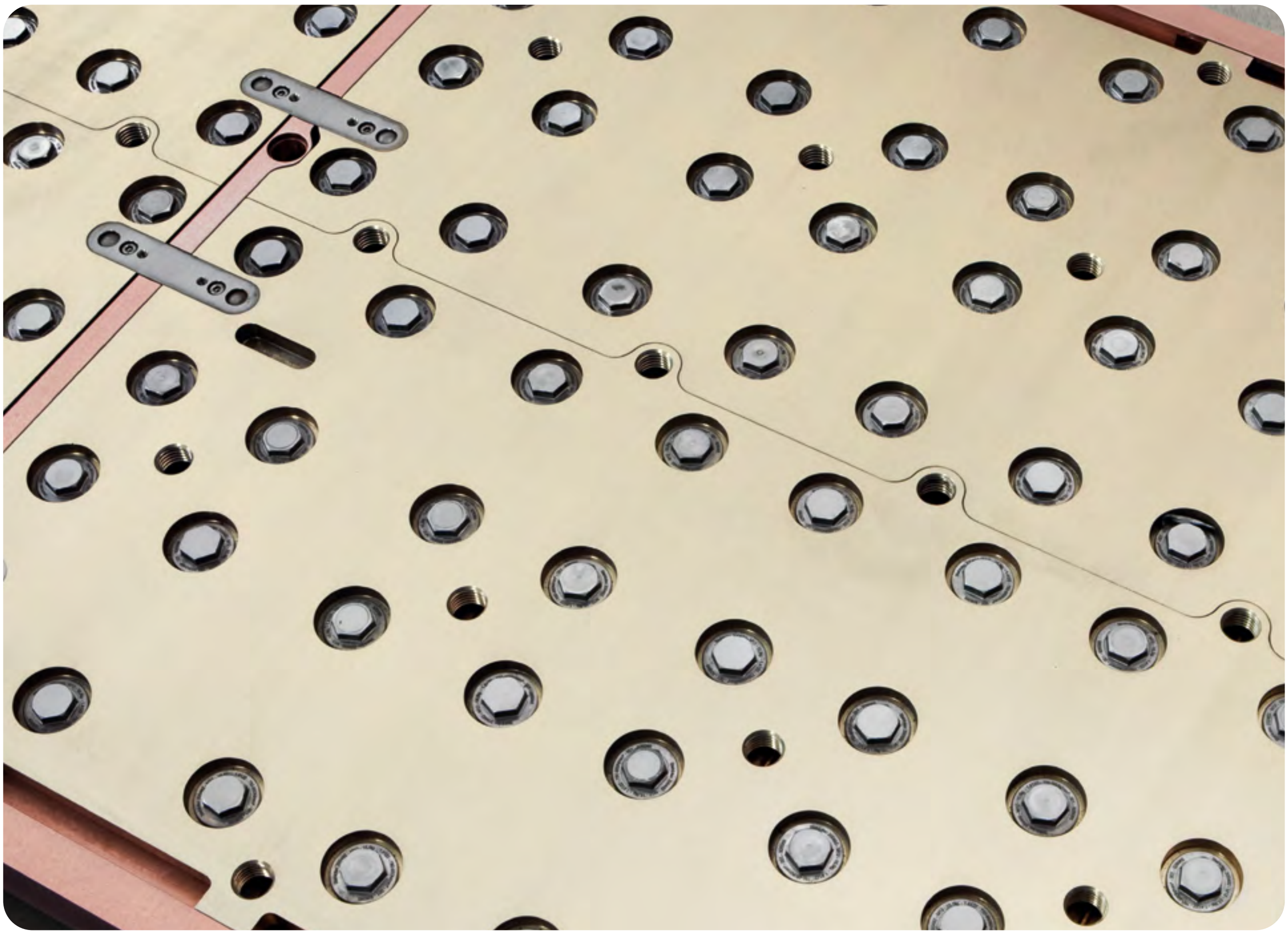
ASM Advanced Slab Mould

Challenge
- Optimize cooling of standard mould plates and improve slab quality

Application
- All slab mould plates

Solution
- Uniform water gap cooling design
- Low stress AFM® mounting technology (cunova patent)

Advantages
- Homogeneous temperature profile – no hot spots
- Higher heat transfer rate
- Higher lifetime due to reduced thermal stress
- Low retrofitting costs
- Compatible with existing water box design



AMT® ADVANCED MOULD TECHNOLOGY

Function of the ASM Mould

This mould system consists of a thin-walled copper plate with a novel water "gap-type" cooling design (instead of cooling slots) and a floating, stress-free attachment to a noncorrosive adapter plate.

The ASM mould is designed for slab casters to work with their existing water boxes to provide a homogeneous cooling and adequate water flow velocity for improved slab quality and longer lifetime. This system can be adapted to customers' needs and conditions as "sandwich version" (adapter-plate behind the copper plate) or as "inlet version" with adapter plates within the copper plate.

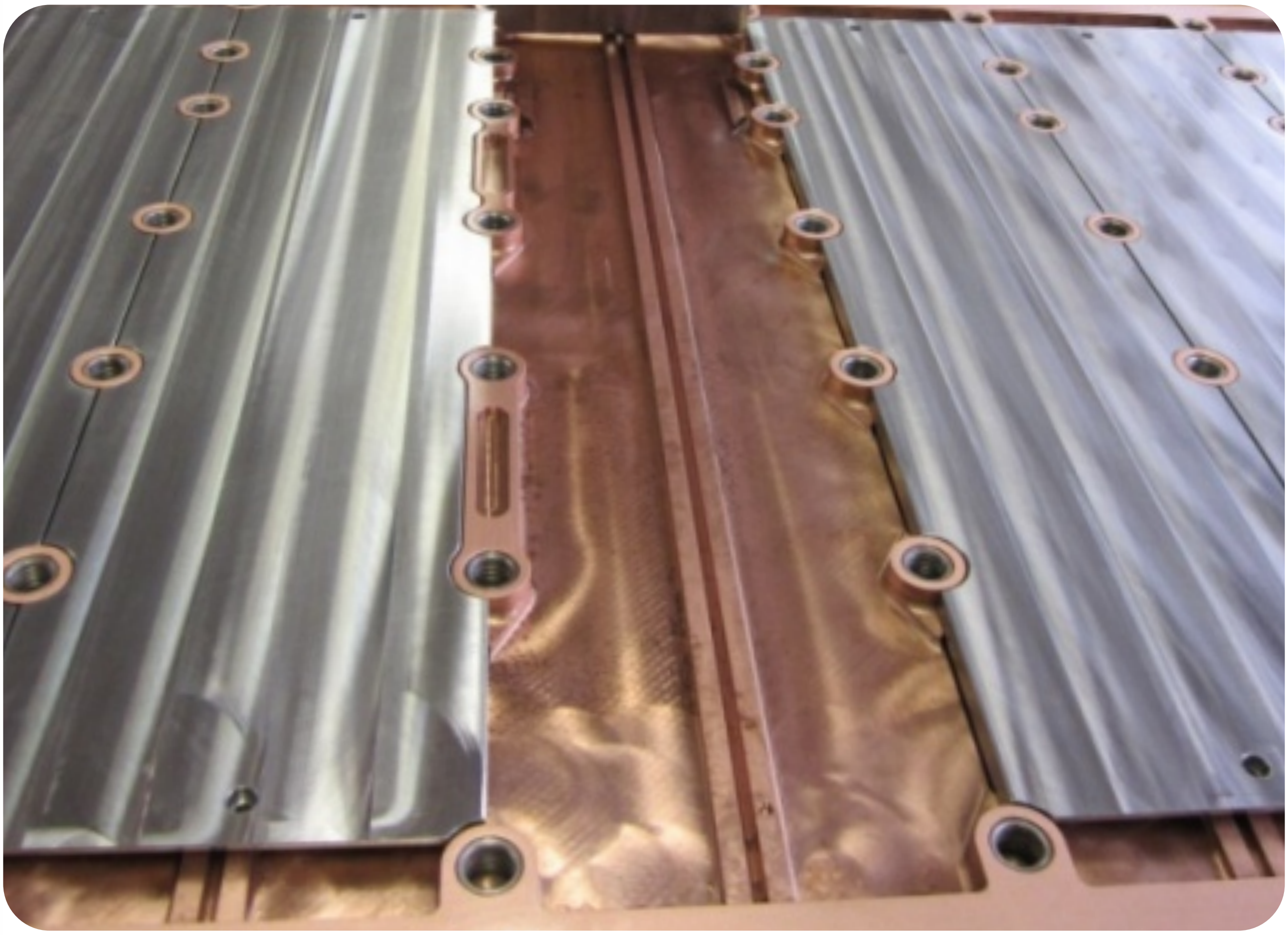
The ASM mould is based on prior cunova developments of AFM (Advanced Funnel Mould) and ABBM (Advanced Beam Blank Mould) designs.

Advantages

- Homogeneous temperature profile - no hot spots
- Higher heat transfer rate
- Higher lifetime due to reduced thermal stress
- Low retrofitting costs
- Compatible with existing water box design

Results

First sets of ASM mould show a lifetime increase of approx. factor 2 and steelgrade-depending improvements in product quality



AMT® ADVANCED MOULD TECHNOLOGY

ABBM Advanced Beam Blank Mould Plate

Challenge

- Improve Beam Blank quality and lower copper weight

Application

- Beam Blank mould plates
- All types of hot face coatings
- Compatible with existing equipment
- For oil and powder casting

Solution

- Thin copper and adapter plate design and water gap cooling design
- Low stress AFM® mounting technology (cunova patent)

Function of the ABBM Mould

This mould system consists of a thin-walled copper plate with a novel water “gap-type” cooling design (instead of cooling slots or bores) and a floating, stress-free attachment to a non-corrosive adapter plate.

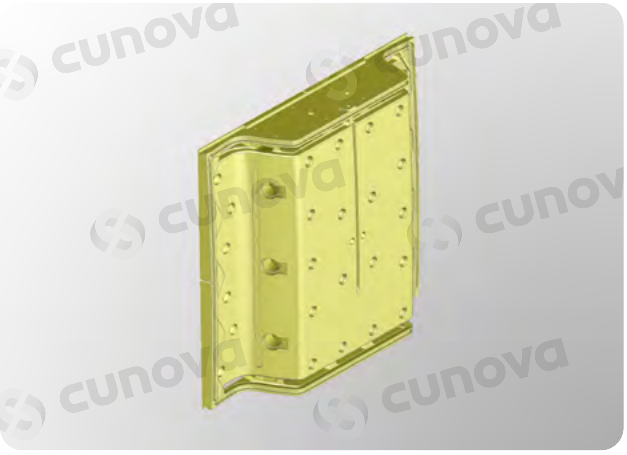
The ABBM mould is designed for beam blank casters to work with their existing water boxes to provide a homogeneous cooling and adequate water flow velocity for improved beam blank quality and longer lifetime.

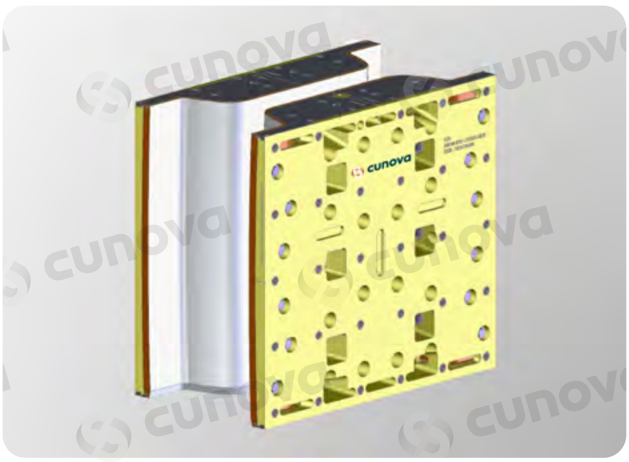
Advantages

- Improved lifetime
- Homogeneous hot face temperature profile
- Improved product quality
- Low retrofittng costs
- Compatible with existing water box design

Results

Customer comments:
“... the product quality with the ABBM is the best of all mould designs currently in use.”
and
“... cast product quality of the ABBM is still the best of all mould designs in use, compares to the next best mould defect rate of 1,4 %.”
Overall appearance of the ABBM continues to be excellent, with reduced wear.





AMT® ADVANCED MOULD TECHNOLOGY

Chamfered Narrow Face Mould Plate

Challenge
- Improvement of slab quality in corner areas

Application
- All kinds of slab, bloom and beam blank sizes

Solution
- Chamfered edges with optimized edge cooling

AMT® ADVANCED MOULD TECHNOLOGY

Function of the Chamfered Narrow Face Mould Plate

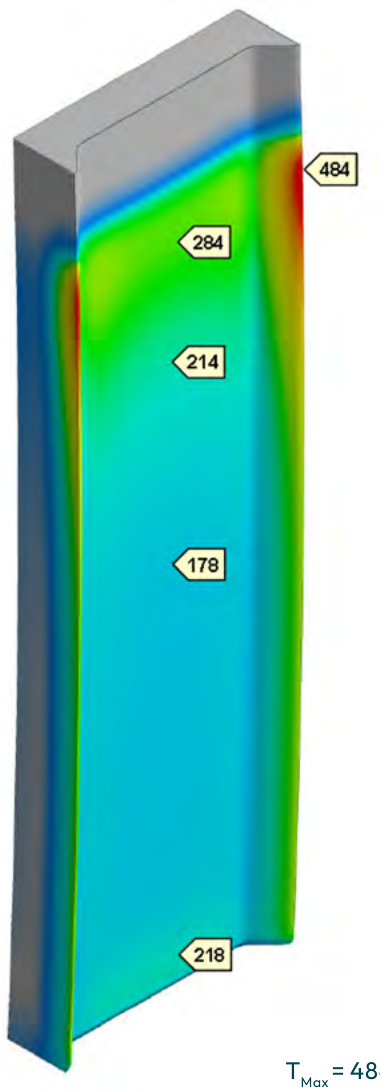
A diversity of cunova developed cooling and chamfer designs following the customers´ requirements of hot face geometry.

Advantages

- Improved slab temperature in corners
- Reduction of slab transverse corner cracks

Results

Improvements in product quality during hot rolling



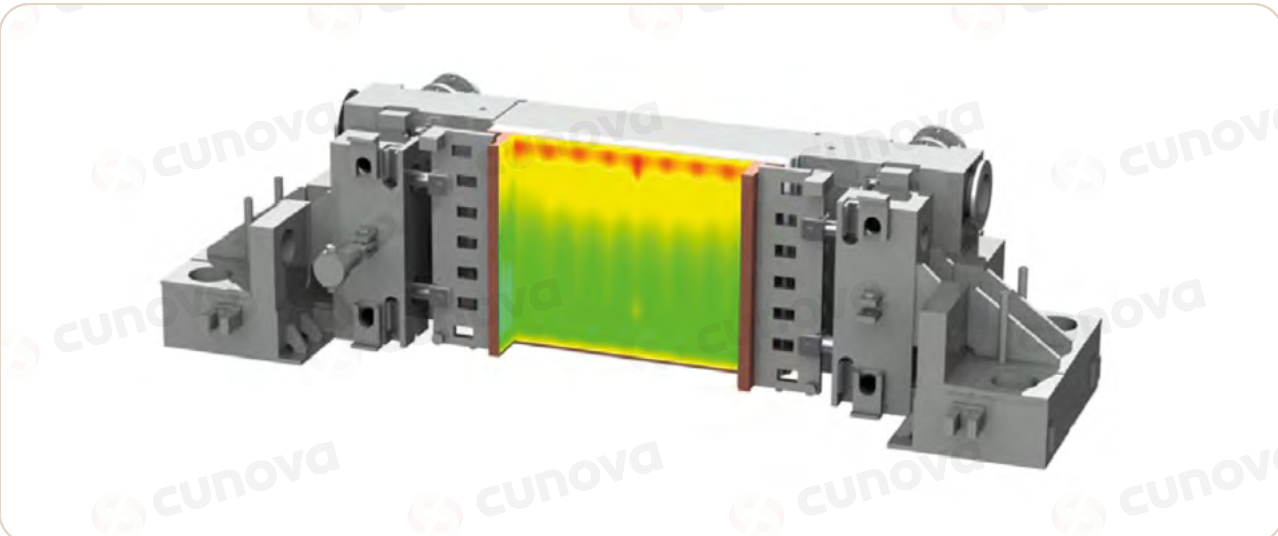
$T_{Max} = 484°C$

AMTM - Advanced Mould Temperature Monitoring

Challenge
- Creation of real-time high resolution thermal mappings to optimize the continuous casting process

Application
- All mould plates
- All mould tubes

Solution
- Fiber-optic temperature measurement technology offers unsurpassed high resolution visualizations and a three times faster detection than conventional systems)



AMT® ADVANCED MOULD TECHNOLOGY

Function of the Advanced Mould Temperature Monitoring

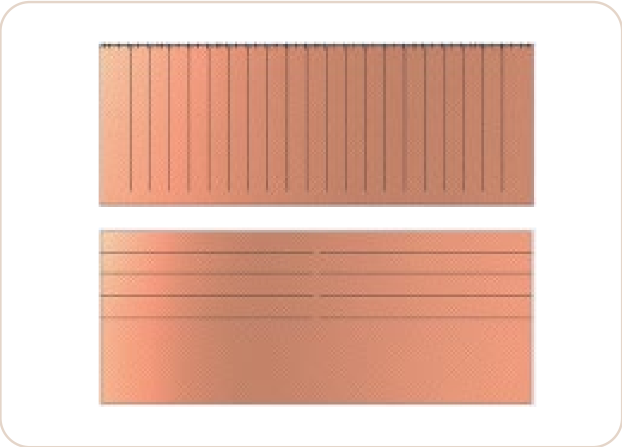
The continuous casting process can be optimized by the innovative “Advanced Mould Temperature Monitoring” which is based on the fiber-optic technology (with fiberbragg-gratings).

The number, length and position of fibers in the mould can be individually adapted to the process demands. Byusing a test configuration with 38 fibers, consisting of 70 measuring points each fiber, a resolution with 2660 measuring points allow a deep insight into the casting process.

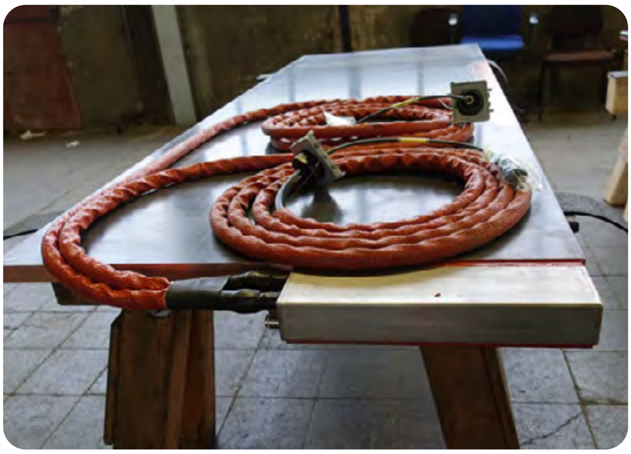
Via an intermediate box and an interrogator the temperature signals are analysed and a real-time visualization is created. The effort for cabling and maintenance is significantly lower compared to conventional systems.

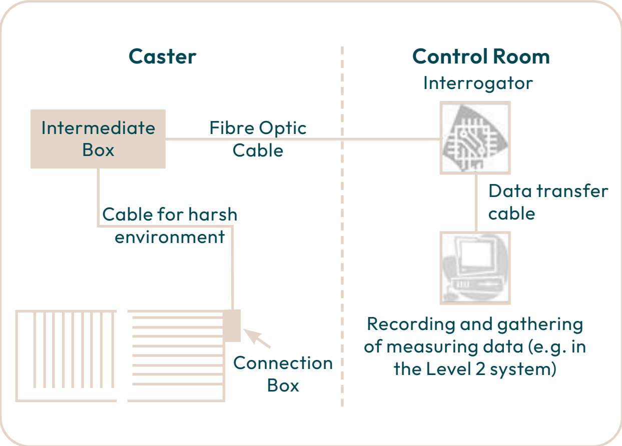
Advantages

- Unsurpassed resolution (up to 20 times more measuring points)
- Improved slab quality by an optimal process insight
- Improved sticker detection to prevent breakouts
- Improved crack warnings
- Improved detection of casting flux changes
- Lower cabling efforts and maintenance-free



Schematic figure of different configurations





System overview

Cabling at the mould

AMT® ADVANCED MOULD TECHNOLOGY

cunova Mould Service Worldwide

Challenge

- Recoating of mould plates with short turn-around time and low volume of plates in circulation

Application

Maintenance in 3 steps:

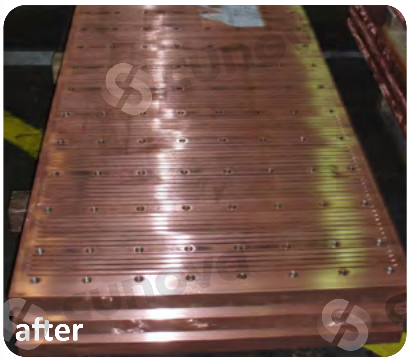
1. Recoating and machining of mould plates
2. Phase 1 including maintenance of water boxes
3. Phase 1 and 2 including engineering solutions for continuous casting and consulting for modernisations

Solution

- Implementation of coating and machining facilities
- Close to the location of purpose

Advantages

- Access to a world wide database of settings and designs of the market leader in mould plates
- Technical support and exchange of information next door
- Simplified implementation and support for trials on new products
- New designs in coatings to be adopted for new plates and repairs
- Close supplier and customer relationship in terms of maintenance and spare products



Principle work steps of next door service

1. Cleaning of mould assembly
2. Water pressure test
3. Disassembly of water box and plate
4. Dimensional check
5. Straightening of plate
6. Machining of worn surface
7. Galvanic coating of plate
8. Final straightening of plate
9. Final machining of plate
10. Assembly of water box and plate
11. Inspection, packing and dispatch

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AMT® ADVANCED MOULD TECHNOLOGY

Customer References for recoating in cunova Stations

TATA STEEL

New Zealand Steel

AHMSA ALTOS HORNOS DE MEXICO

ESSAR

BLUESCOPE LYSAGHT

SSAB RUUKKI

BHUSHAN Bhushan Steel Limited

STOMANA INDUSTRY S.A. SIDENOR GROUP

amet

onesteel

HABAŞ

SALZGITTER AG Stahl und Technologie

sij acroni

ArcelorMittal

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outokumpu

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