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HICON®

EBNER GROUP Journal for technology and progress

GLOBAL LAUNCH EVENT

GREENBAFx®

NOVEMBER 13, 2024

EBNER GROUP

**Ladies and Gentlemen,
Esteemed readers of the HICON® Journal, dear friends and colleagues of the EBNER GROUP!**

In this edition of the **HICON®** Journal we will take you on a journey across the world, visiting fascinating customer projects from Brazil to China.

We are also addressing a key topic of our time: sustainability. We offer tantalizing glimpses into the groundbreaking developments at **EBNER**, developments that will conserve resources and enable a greener future.

One of the centerpieces of this issue is a detailed report on **GREENBAFx®** furnaces, our latest technological innovation. These furnaces are setting new standards for eco-friendly heat treatment, underlining our tireless commitment to the vision of *DRIVING GREEN TECHNOLOGIES*.

For decades, we have been developing innovative solutions also in the field of burner technologies that constantly set new standards for the industry. In this issue, you can read more about our latest advances.

A significant element in our work is testing our green technologies in practice, paired with intensive exchanges with our customers. In an interview with pewag, you can find a report on the impressive energy savings that can be achieved by using an **EBNER ATMOSPHERE-perfect** software module.

Finally, we would like to introduce the new management team at HAZELETT, where two experienced and visionary managers will continue to push technological progress toward sustainable solutions.

We are convinced that the road toward a more sustainable future can only be traveled if you, our valued customers and partners, are walking next to us.

Your support and collaboration are priceless.

Yours,
Robert Ebner
CEO **EBNER** GROUP

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New Hazelett Management

HAZELETT Strip-Casting Corporation announces leadership transition

DAVID HAZELETT

President Emeritus
HAZELETT

HAZELETT Strip-Casting Corporation announces the retirement of long-time President, David Hazelett, effective December 31, 2024. After decades of dedicated leadership and contribution to the company's success, David will transition his management responsibilities to the offices of Co-Managing Directors, Dave Diederich and Jim St. Germain. Starting January 1, 2025, David will assume the title of President Emeritus, marking the end of an era in Hazelett's storied history.

Robert Ebner and the entire organization extend their sincere gratitude to David for his tireless work and invaluable contributions over the years. His leadership and vision have been integral to Hazelett's growth, expansion, and industry-leading innovations. As he embarks on his well-deserved retirement, the company wishes him many more years of happiness and fulfillment.

A LEGACY OF LEADERSHIP AND INNOVATION

David Hazelett became HAZELETT's second President in 2009. Following in the footsteps of his father, Bill Hazelett, David leaves behind a remarkable legacy. His journey at HAZELETT began in the late 1960's, starting as a laborer in the belt shop while attending high school. After graduating from Dartmouth College in 1972 with a BA degree in environmental policy, David initially worked for the Vermont Natural Resources Council. However, he returned to HAZELETT in 1973, starting with an assignment at M&H Zinc Company at his father's request.

David's professional path also included a detour into law, earning a law degree and practicing in Burlington, Vermont for several years before returning to HAZELETT in 1987. His broad range of experience, both technical and managerial, helped shape his visionary leadership at the helm of the company.

His grandfather, C. W. Hazelett, invented the Twin-Belt Caster in 1948, a pivotal moment that revolutionized continuous aluminum casting. Since then, HAZELETT has become the world's process with the lowest cost and smallest carbon footprint for the production of flat rolled aluminum products. Today, the technology is producing a significant portion of the world's building & construction sheet, foil/fin stock, road signs, truck trailers and slugs for impact extrusions (containers, aerosol cans, fire extinguishers), with improved capabilities of producing automotive and can-end stock. There are now over 100 HAZELETT Twin-Belt Casting Lines operating in 25 countries worldwide, persistently pushing the boundaries of continuous casting.

PIONEERING GREEN TECHNOLOGIES

A passionate advocate for sustainability, David shared HAZELETT's commitment to advancing green technologies in the aluminum industry. Aluminum, with its remarkable versatility and recyclability, is an essential material in the pursuit of a more sustainable world. Under David's leadership, HAZELETT became known for its innovations in aluminum casting, particularly for its more energy efficient and less scrap-generating method of producing aluminum sheet products. His work emphasized the need for reducing inefficiencies compared to traditional aluminum casting processes.

GUIDING HAZELETT TO NEW ACHIEVEMENTS

David led the establishment of HAZELETT's Chinese subsidiary, strengthening the company's global presence and opening up new market potential. He also oversaw the successful introduction of aluminum casting systems for aluminum strip up to two meters wide and the development of CASTechnology™, an extremely promising innovation that has the potential to fundamentally change the industry.

CELEBRATING A CENTURY OF INNOVATION

In 2019, David led HAZELETT in celebrating the company's centennial milestone in continuous casting, commemorating his family's legacy of innovation and excellence. Further cementing his commitment to advancing the company, David initiated a key technical relationship with **EBNER** Industrieofenbau, culminating in HAZELETT joining the **EBNER** GROUP in 2021. David's achievements were recognized in 2023 when he received the prestigious Boultinghouse Award, the highest honor in the North American aluminum industry.

A BRIGHT FUTURE AHEAD

With David Hazelett's move to the role of "President Emeritus", the new Co-Managing Directors Dave Diederich and Jim St. Germain will now take over the management of the company, with a clear focus on sustainable development and energy-friendly solutions.

DAVE DIEDERICH

Managing Director
Finance & Commercial
HAZELETT

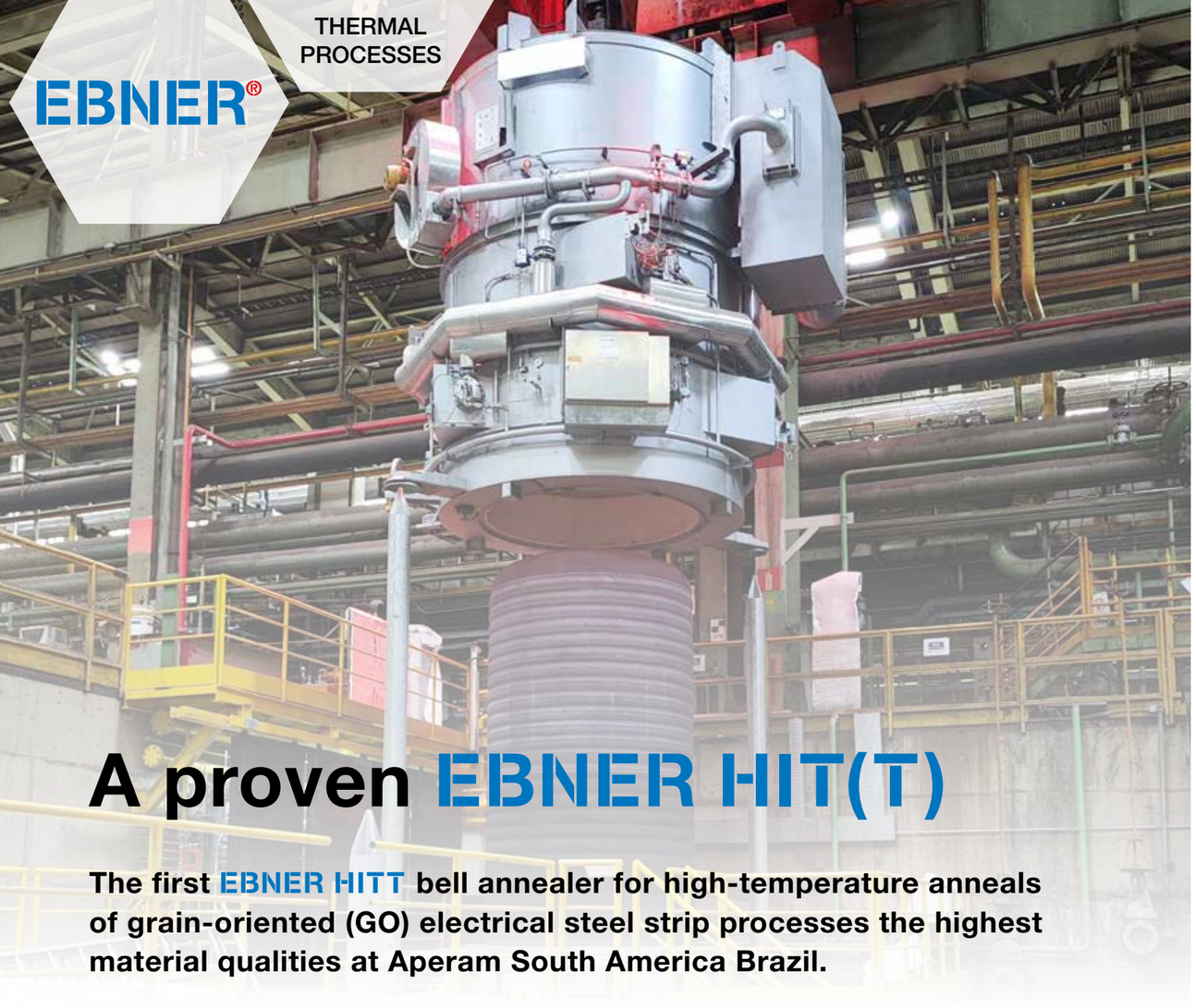
Dave Diederich, who joined HAZELETT in 2003 and has served as its Vice President of Finance for the past 15 years, brings a broad skill set that extends beyond his CPA background. His strategic thinking and leadership in financial management have played a critical role in Hazelett's success, positioning the company for future growth.

JIM ST. GERMAIN

Managing Director
Engineering & Manufacturing
HAZELETT

Jim St. Germain, who joined HAZELETT in 2021 as Vice President of Engineering, has brought a wealth of experience from the automotive and defense industries. His leadership has been transformative for HAZELETT's engineering department, and his technical expertise will continue to drive innovation and excellence in the company's operations.

With the combined leadership of Diederich and St. Germain, and the support of the entire HAZELETT team, the company is well-positioned to continue its tradition of excellence and innovation in the non-ferrous casting industry.



A proven EBNER HIT(T)

The first EBNER HITT bell annealer for high-temperature anneals of grain-oriented (GO) electrical steel strip processes the highest material qualities at Aperam South America Brazil.

ANTON OPPERMANN

Product Manager
EBNER Industrieofenbau

Globally, increasing amounts of electricity are being used for industrial production, transport, electrification and in many other sectors. According to a forecast from the International Energy Agency, an annual increase in electricity consumption of almost four percent is expected by 2027. In addition, global electricity demand will continue to increase at least until 2040.

This increasing demand requires efficient solutions for power distribution networks, networks in which transformers play a central role. That is, transformers are essential components of any power distribution network, as they are needed to convert current into a suitable form before it can be transported or used. The cores of transformers used for this conversion consist of efficient grain-oriented electrical steel strip, which is also known under a variety of names such as silicon steel and transformer steel.

To ensure the quality of this special material, state-of-the-art heat treatment processes are needed - processes such as those carried out in the EBNER HITT® (**H**igh **T**emperature & **T**ight) facility installed at Aperam South America's Brazilian works. This facility was specially developed for high-temperature anneals of grain-oriented electrical steel strip, and provides optimum material quality.

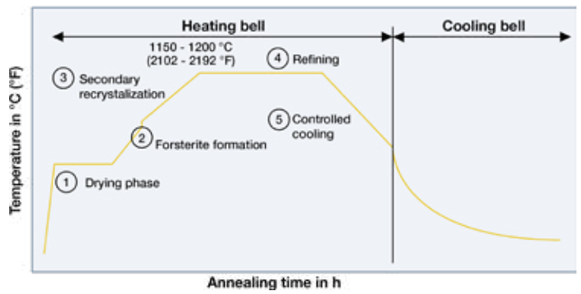
The rising customer demand for increased coil weights and improved temperature uniformity, paired with a need to keep the operating costs for high-temperature anneals of grain-oriented electrical strip as low as possible, are what led Aperam to choose EBNER as the supplier of their new high-temperature bell annealer facility.

In contrast to other existing facility designs (multi-stack furnaces sealed with sand), an EBNER HITT® bell annealer provides a complete, gas-tight separation of the workload space and the combustion chamber.

This separation allows a precisely-controlled atmosphere to be achieved, significantly reducing hydrogen consumption. A special patented coil support enables the coils in the workload space to be heated uniformly and efficiently, leading to a significant reduction in scrap.

Paired with a cooling bell, this system ensures the shortest possible processing times. It provides the highest productivity, paired with the best possible quality and high throughput. The safety concept for processing in hydrogen has been adopted from HICON/H_2® bell annealers, and either an electric or a gas-fired heating system can be installed.

The processing steps (1 - 5) carried out by the bell annealer are schematically depicted in the figure shown below. High-temperature anneals use secondary recrystallization to form grains with the magnetically advantageous Goss texture (3). The high processing temperatures (above 1150 °C) and straight hydrogen atmospheres also remove sulfur and nitrogen from the material (4). At the start of heat treatment, a drying phase (1) is used to dry the MgO coating applied during an upstream process. This inhibits the formation of stickers in the wraps at high processing temperatures by forming a Forsterite layer (2).



The following advantages contributed to Aperam's decision to choose an EBNER HITT® bell annealer over a multi-stack sand-sealed design:

- Lower utility consumption (H_2, N_2), due to the gas-tight encapsulated workload space
- Lower energy consumption (reduced fuel gas consumption)
- Homogeneous temperature distribution within a coil, due to the patented coil supports and symmetrical heating; this ensures
  - homogenous magnetic properties
  - reduced scrap due to reduced amount of strip edge damage
  - shorter annealing cycles (heating-up)
  - long inner cover service life
- Cooling in 100 % H_2 atmosphere and use of a cooling bell provide:
  - significantly increased productivity
  - improved surface finish
  - prevention of further nitriding

TECHNICAL DATA OF REFERENCE FACILITY:	
Diameter	2000 mm
Charging height	3000 mm
Maximum net charge weight	44 t (2 x 22 t)
Heating system	gas-fired
Scope	1 workbase 1 heating bell 1 cooling bell

EBNER sustainability testing it in practice

Austria’s pewag engineering uses ATMOSPHEREperfect to reduce energy consumption.

LUCAS WINTER

Business Excellence and Digitalization
EBNER Industrieofenbau

The ATMOSPHEREperfect software module, developed by EBNER for the VISUALFURNACES® control system, significantly contributes to the implementation of a sustainability strategy. The purpose of this module is to significantly reduce the energy consumption and carbon footprint of the heat treatment industry.

The module regulates the supply of hydrogen gas used to purge contaminants out of the interior of the furnace. This creates an optimal process atmosphere, which is a requirement for ensuring that the surface of the processed material is free of defects. Precise control over hydrogen consumption leads to significant energy savings without affecting the quality of the annealed material.

The Austrian company pewag operates several EBNER-HICON/H_2® bell annealer facilities for steel wire, which have now been equipped with the ATMOSPHEREperfect software module. In a recent interview, pewag’s Christopher Pusnik and EBNER’s Lucas Winter offered insights into the module’s performance and the savings it provides.

Mr. Pusnik, we appreciate your taking the time to speak with us. pewag is well-known for its long tradition and ability to innovate. How important is sustainability to the company?

Pusnik: For us, sustainability is not just a goal - it is a responsibility. We strive to continuously reduce our environmental impact while remaining competitive at the same time. This requires innovative solutions in our manufacturing processes, particularly at our Austrian works.

What challenges do you see for reducing the consumption of energy and hydrogen during heat treatment?

Pusnik: Rising energy prices are creating major challenges. To remain competitive, we have to make our processes more efficient. Optimizing the atmospheres in our bell annealer furnaces is playing a central role in this effort.

How did your cooperation with EBNER Industrieofenbau come about, and why was ATMOSPHEREperfect implemented?

Pusnik: As a team, we have been working hard on both daily and long-term tasks intended to improve our manufacturing processes. In this particular case, we were looking for a thermal processing solution for our bell annealer furnaces that would aid us in reducing our energy and hydrogen consumption without affecting product quality. ATMOSPHEREperfect offered us a chance to refine our processes and reduce environmental impact at the same time.

Mr. Winter, could you tell us a bit more about ATMOSPHEREperfect? How does this technology work?

Winter: ATMOSPHEREperfect is a software solution that optimizes the atmosphere in a bell annealer furnace. It uses the power draw of the fan motor to regulate the purge flowrate of the atmosphere, which leads to a more efficient use of both hydrogen and electrical energy This solution was specially developed for the VISUALFURNACES software suite, and can be employed at HICON/H_2® bell annealers.

Mr. Pusnik, what results have you obtained after implementing ATMOSPHEREperfect?

Pusnik: We have reduced our consumption of both hydrogen and electrical energy by an amount significantly above 20 %. These savings are not just commercially advantageous - they are also an important step forward on our path toward more sustainable production. I am very proud of the business culture at pewag, as it encourages us to focus on improvements and led us to realize that there was still potential to optimize our H_2 and energy consumption. Data, facts and an open-minded approach enabled us to make a significant improvement in one single step. This only increases our motivation to maintain our effort to continuously optimize. If you don’t keep rolling, you start to gather moss!

Mr. Winter, how would you rate the collaboration with pewag and the implementation of ATMOSPHEREperfect?

Winter: From the very beginning, the collaboration was based on a high level of trust. That trust was established extremely quickly, due our shared understanding of the process. By working together, especially with our colleagues Lukas Haberfellner and Martin Ziegler from EBNER, the team was able to generate real value very quickly and adapt the solution to meet pewag’s specific needs. The results show that the solution offers real added value to our customers.

What would you recommend to other companies facing similar challenges?

Pusnik: I find technologies exciting when they do not just provide financial benefits, but also contribute to meeting sustainable production goals. Achieving carbon neutrality by 2030 is one of pewag’s strategic goals.

Winter: I completely agree. In a space where digital and green technologies intersect, solutions can be found that are fast, straightforward and measurably improve both costs and sustainability. This is why I am so delighted with pewag's success with ATMOSPHEREperfect. That success is one of the many examples that can be found among our international customer base of how we are *Driving Green Technologies*.

Mr. Pusnik, Mr. Winter - thank you for the valuable insights, and thank you once again for your time!

FACT CHECK

ATMOSPHEREperfect stands out due to the following features:

- User-friendly operation with VISUALFURNACES.
- Automatic hydrogen purge flowrate control regardless of the lubricant in use, the coil data or the degree to which the surface of the wire is contaminated.
- Atmosphere tracks of annealing programs no longer need to be developed or improved.
- Both hydrogen consumption and electrical consumption by the fan motor reduced by over 20 %.
- Software solution.

THERMAL PROCESSES

Dongkuk Industries

Zero-emission steel strip manufacturing

The Korean steel industry places its trust in green technologies from EBNER.

TCC Steel

KARL WOHLFART

Senior Sales Manager
EBNER Industrieofenbau

SASCHA EPPENSTEINER

VP Product Management
EBNER Industrieofenbau

In a world where electrical energy and energy storage are constantly increasing in importance, battery manufacturing has become a critical industry.

Among the most powerful drivers of growth is the rising demand for battery-powered electric vehicles (BEVs), portable electronic devices and stationary storage systems for renewable energies. The lithium-ion battery (LIB) has emerged as the dominant technology used in these applications, and LIBs are now available in cylindrical, prismatic and pouch cell formats.

Leading BEV manufacturers prefer cylindrical LIB cells due to their high energy density, long service life, high number of charging/discharging cycles, stable performance and the ease of heat management within a battery pack.

NEW FACILITIES SUCCESSFULLY COMMISSIONED

Asian manufacturers currently dominate the global market for battery cells, and further growth can be expected. This situation is underscored by the fact that, over the last two years, two GREENCAL® continuous annealing lines have been successfully started up - one at each of two leading South Korean manufacturers of cold rolled products.

Both high-performance horizontal lines are designed to heat treat nickel-plated steel strip, which is then used to manufacture battery cell casings. The manufacturing process for cell casings requires extremely pure low-carbon steel with a low proportion of alloying elements and excellent deep drawing characteristics. This unique combination of properties is created in a special heat treatment process. The goal of the process is to produce a fine, oxide-free and isotropic grain structure that provides excellent longitudinal and lateral formability and inhibits earing during deep drawing. A diffusion process is then used to create the bond between the nickel plating and the steel substrate. Depending on the thickness of the strip, the desired mechanical properties, the thickness of the diffusion zone and the application of the end product, a variety of routes may then be used to manufacture the strip.

TCC Steel, headquartered in Pohang, South Korea, has already seen success in this market sector and their investment in a high-capacity facility has made them even more competitive.

Dongkuk Industries, also with a manufacturing plant in Pohang, has been strategically diversifying its product portfolio to enable it to enter the most promising markets. By investing in a high-capacity continuous annealing facility for deep-drawn battery steels, as well as in additional equipment, Dongkuk has opened up new markets for itself.

ADVANCED FACILITY TECHNOLOGY

The demands of the future - particularly those posed by e-mobility - are challenging all of us to design processes that are more sustainable, even as they remain competitive. It was with these challenges in mind that EBNER developed the designs for both GREENCAL® continuous annealing lines, designs in which energy efficiency, the elimination of emissions and the maximization of productivity played a central role. At the same time, the facilities had to fulfill the highest demands for quality. A single one of these processing lines is capable of employing every processing technology used in the manufacture of nickel-plated steel strip, from normalizing and diffusion annealing to short anneals.

The combination of extremely pure process atmosphere, high convection and radiant heating leads to extremely precise temperature distribution across the width of the strip, even as it provides reproducible material properties.

The entire facility is exclusively heated with electricity, ensuring that there are no local carbon or NOx emissions. This makes the use of this technology of particular interest to OEMs of batteries or electric vehicles.

TECHNICAL DATA OF GREENCAL® LINES OF THIS TYPE	
Strip width	up to 1220 mm
Strip thickness	0.1 – 1.0 mm
Strip speeds	up to 100 m/min
Throughputs	up to 120,000 t/y
Annealing temperatures	up to 1020 °C

Energy efficiency and flexibility

An EBNER floater furnace facility sets new standards, even as commissioning is completed ahead of schedule.

MICHAEL BLAIMSCHEIN

Sales & Project Manager
EBNER Industrieofenbau

Following successful installation and commissioning of a first floater furnace facility in 2019, we are proud to be able to report on another interesting project for a very valued customer, Chalco Ruimin in China. Over the course of this project a second CASH line was installed, and the line has now successfully gone into operation far earlier than the scheduled date. This expansion does not just underline EBNER's expertise in the implementation of challenging industrial projects - it is also a demonstration of continuing collaboration and the mutual trust between EBNER and Chalco Ruimin.

The new facility will primarily be used to produce aluminum coils for the automotive industry, a sector that demands the highest possible precision, efficiency and quality. With its state-of-the-art technology and innovative solutions, our facility will ensure that Chalco Ruimin is able to fulfill the high expectations of this challenging market. The successful installation of the production line allows our customer to significantly expand production, further strengthening their position in the market.

RAPID PROGRESS THANKS TO A COLLABORATIVE PARTNERSHIP

A significant factor in the success of the project was the outstanding cooperation between the EBNER team, which consisted of experts from EBNER's offices in both Asia and Austria, and the technical specialists at Chalco Ruimin. Thanks to close contact and the collegial exchange of information, any approaching challenges could be identified well in advance and dealt with efficiently. Seamless coordination and the high degree of dedication shown by all those involved contributed significantly to the fact that all project goals were not just met - they were exceeded.

Of particular note is the fact that the project was able to stay on what was already an extremely ambitious schedule. Due to the excellent coordination and focused project management, we were able to start production at the new facility far earlier than originally planned. This early start brought significant benefits to our customer: returns could be generated more quickly, and potential penalties caused by delays could be prevented. This was a clear demonstration of the commercial efficiency of our solutions.

HIGH ENERGY EFFICIENCY, MAXIMUM PRODUCTION FLEXIBILITY

The technology of the facility is state-of-the-art, and is specially tailored to fulfill the specific requirements of the automotive industry. Extremely high energy efficiency, maximum production flexibility and high temperature accuracy (± 2 °C) are hallmarks of the new processing line. It makes a significant contribution to the optimization of our customer's manufacturing processes and increases their competitiveness.

We are proud that this project has made another important contribution to our customer's value-added chain. Its successful conclusion underscores EBNER's ability to complete complex, large-scale projects on time and at a high standard of quality. At the same time, the project reinforced the strength of EBNER's and Chalco Ruimin's partnership and it is expected that this partnership will lead to more collaborative projects in the future.

We are confident that, working together, we will be able to overcome any future challenges and EBNER is looking forward to the next successful collaboration.

GREENBAFx®

The next generation of sustainable HICON/H$_2$® bell annealer facilities

SASCHA EPPENSTEINER
VP Product Management
EBNER Industrieofenbau

PETER SEEMANN
VP Research & Development
EBNER Industrieofenbau

Bell annealer facilities are integral parts of cold rolling mills, where they are used to carry out heat treatment processes. EBNER has been involved in the development of heat treatment processes and the manufacture of heat treatment equipment for decades, constantly introducing innovations that have advanced the industry. For example, EBNER introduced bell annealer technology that combined high convection (HICON®) with straight hydrogen as a process atmosphere (HICON/H$_2$®) all the way back in 1972. The first HICON/H$_2$® bell annealers were designed to process copper base metals, but further development led to designs for the steel industry in 1982. The technology quickly established itself, revolutionizing the heat treatment of semi-finished products.

HICON/H$_2$® bell annealers have been successfully operating for decades. Continuous development has increased their performance even as it has lowered costs, allowing the industry to take decisive steps forward in both quality and economy.

Over 4900 HICON® workbases are in operation today, processing over 80 million metric tons of flat and wire products every year.

Our past and current success is, however, only a starting point. The demands of the future are challenging the entire industry to design processes that are more sustainable, even as they remain competitive. With this challenge shaping our perspective, we invested several years of intensive effort in the development in what we intended to be the next generation of bell annealer furnaces. During development, an emphasis was placed on maximizing energy efficiency, eliminating emissions and simplifying operating sequences.

Our efforts have been rewarded with what is indeed the next generation of sustainable bell annealers, referred to as GREENBAFx® furnaces. These facilities feature innovative systems for inserting thermal energy into the process (direct heating) and for recycling energy released during cooling (heat exchange). During development, two main use cases were taken into account (see figure 1).

- A standard design with direct heating (the "basic case").
- An expanded design with heat exchange (the "advanced" case).

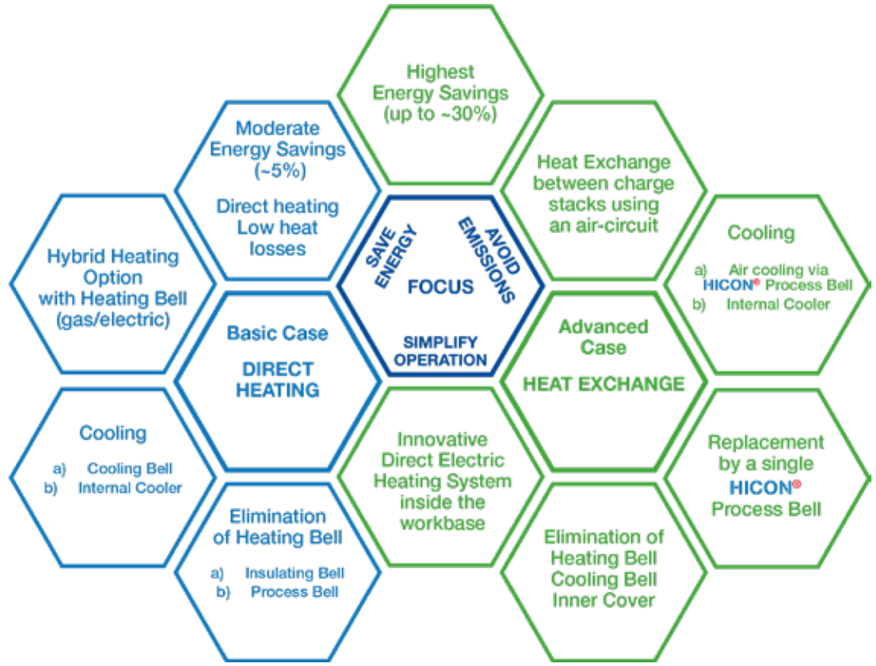


Figure 1: Issues focused upon during development, use cases

GREENBAFx® FACILITY WITH DIRECT HEATING (the "basic" case)

At traditional bell annealer facilities heating is carried out by a heating bell, which is placed over an inner cover. The interior of the inner cover forms the processing chamber, in which is the charge. Thermal (heating) energy is supplied from the heating bell, which radiates heat onto the inner cover. The inner cover then conveys the thermal energy into the processing chamber and atmosphere convection is used to transfer the energy to the charge.

Cooling employs a similar method. A crane is used to replace the heating bell with a cooling bell, which uses cooling air and/or cooling water to subtract the thermal energy. Usually, energy subtracted during cooling either remains unused (is lost) or only recycled in an inefficient manner (e.g. converted to electricity in an ORC process, used to heat water, etc.).

The new, patented GREENBAFx® system takes a different approach. In this design, the thermal energy from heating is fed directly, without detours, into the process atmosphere. To do so, an electric heating system with a high power density is integrated into the workbase itself (in the diffuser).

The workbase fan impeller is designed to ensure an ideal flow of atmosphere to the heating system, with no flow losses. In fact, it was discovered that the heating system has a positive effect on atmosphere distribution - that is, atmosphere flow is even better than that found at a typical bell annealer.

Furthermore, to prevent residual rolling lubricants from collecting on the electric heating elements, a special temperature/atmosphere program was developed. This program cleans the heating elements before every anneal.

All of these features mean that the need for a heating bell is eliminated: it can be replaced with a simple insulated bell (figure 1, option "a"). In this case cooling is still carried out with a standard cooling bell.

Alternatively, the heating bell, cooling bell and inner cover can be replaced by a single "process bell" (figure 1, option "b"). This bell encapsulates and isolates the processing chamber. It allows the entire heat treatment process, from the time the processing chamber is sealed (clamped) to the time it is released, to run fully automatically. In this case, cooling employs a cooling system installed in the workbase (an "integrated cooler" - see figure 1, option "b").

With a process bell, there is no need to exchange heating bells for cooling bells. This greatly simplifies operational and logistical burdens, as significantly fewer crane movements and operator interventions are required. In fact, only two (2) crane movements are needed - one when the process bell is placed, and one when it is lifted off the workbase. Compared to a typical bell annealer facility, where six (6) crane movement cycles are necessary, this represents four (4) or 66 % fewer crane movements per anneal. This also reduces processing times by a small margin.

Another advantage of this design is that less space is required than at traditional bell annealer facilities. That is, as the "passive" process bell has a significantly smaller diameter than a heating bell and no external equipment (ducting, etc.) is required, the longitudinal distance between workbases can be reduced. Furthermore, as each workbase now has its own integrated heating system, there are no waiting times for a heating bell to become available and no throughput is lost.

Heat losses are reduced to a minimum, meaning that the facility can operate extremely efficiently. Zero emissions are created, with both CO_2 and NO_x emissions eliminated. Finally, energy consumption is up to 5 % lower than that at a typical bell annealer facility.

In the "basic" design, an optional possibility is to equip the facility with hybrid heating. If this option is selected, the facility is equipped with a heating bell. Charges can then be processed using either the integrated electric heating system of the workbase or with the gas-fired (natural gas, hydrogen) heating bell (see figure 2).

The advantage of this option is that the user can select the heating method flexibly, for example based on the current availability or price of utilities.

This hybrid heating option can generally be retrofit into existing facilities.

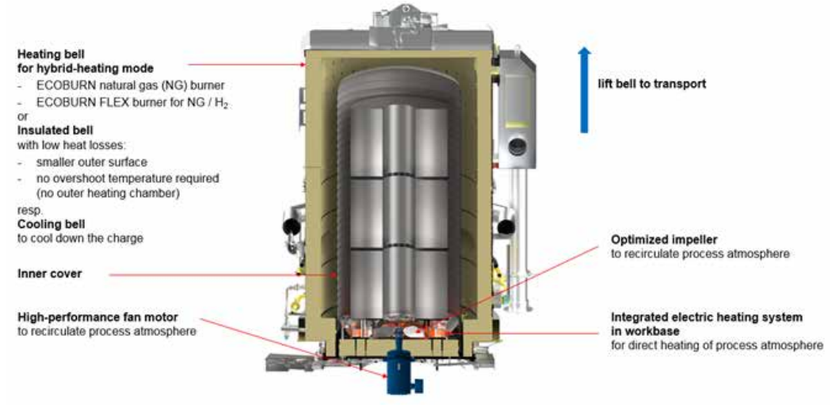


Figure 2: "Basic case" with GREENBAFx® direct heating system; the figure shows an additional heating bell (gas-fired) for hybrid heating (electric/gas)

GREENBAFx® FACILITY WITH HEAT EXCHANGE

(the "advanced case")

The goal of heat exchange is to return the energy released during cooling to the process. This is done by using the energy to preheat a cold coil stack on a neighboring workbase.

A HICON® process bell allows air to be forced through the annular gap around the exterior of the encapsulated processing chamber (the integrated inner cover) at high speed, enabling the air to be used for cooling. This air becomes heated and, as it is now transporting thermal energy, it is fed into an insulated heat exchange circuit. Automatic dampers then lead it to another HICON® process bell, under which another charge is ready for heat treatment, and the air preheats the charge (see figure 3).

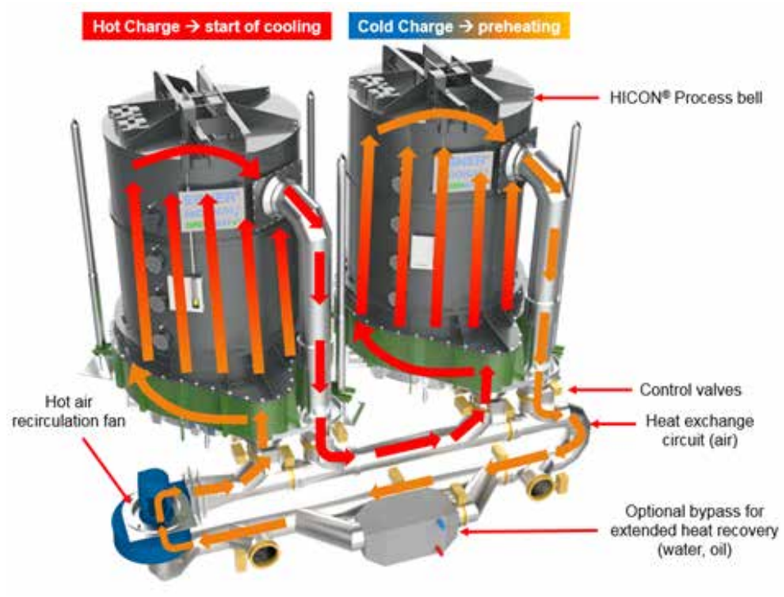


Figure 3: "Advanced case" with GREENBAFx® heat exchange

A crucial element in this design is that heat exchange takes place across the exterior of the integrated inner cover, ensuring that safety (the composition of the atmosphere beneath the inner cover) is not influenced.

As a HICON® process bell transfers the thermal energy collected during cooling to the heat exchange system, heat stored in the mass of the furnace components (tara mass) is also transported. If a slow cooling process is needed to fulfill technological requirements, the energy released during that process is also used.

This amount of heat exchange means that it is possible to return up to 30 % of the total energy of a heat treatment cycle back to the process, providing an excellent financial advantage.

At the end of a heat treatment process, final cooling of the charge can employ either air cooling provided by a HICON® process bell or a heat exchanger ("integrated cooler") installed in the workbase. The thermal energy from air cooling can be supplied to a central pipe end and tied in to another unit, such as an air/water or air/oil heat exchanger. This makes it possible to recycle still more energy by employing it in an external process.

Figure 4 shows the typical time/temperature profile of a 710 °C / 62 t anneal with heat exchange.

In this anneal, thermal energy is drawn out of the exterior of the coils (from the strip edges) by high-convection hydrogen, transported to the interior wall of the process bell (integrated inner cover) and then transferred to the circulating stream of air (high-temperature gas). On the bottom side of thefigure below, it can clearly be seen how the high-convection hydrogen takes thermal energy from the interior wall of the process bell (the integrated inner cover) and transfers it to the exterior of the coil. The temperature of the hot stream of air falls from around 500 °C at the start of heat exchange (when the gas exits process bell 1) to about 250 °C (when it leaves process bell 2).

The energy that is released is that which is used to heat the cold charge, and the drop in the core temperature of the charge that is being cooled and the rise in the core temperature of the charge that is being preheated can be clearly seen. The average coil temperature thus represents the amount of energy that has been transferred to the cold coils. Of particular interest is the fact that the hot stream of air flowing from one process bell to the other remains fairly constant for several hours, even as the temperature of the air being returned gradually increases and the amount of energy that is being transferred falls.

An economical and optimal balance of factors must be found, as while more energy can indeed be collected by extending the duration of heat exchange this reduces the throughput of the facility at the same time.

In the example shown here, the energy consumption of

the heat treatment process with heat exchange is abt. 124 kWh/t. When compared to a typical annealing process, which has an energy consumption of around 178 kWh/t, this means that an energy saving of 54 kWh/t or 30.3 % can be achieved after 8h of heat exchange.

If anneals are carried out at high temperatures (e.g. 850 - 900 °C), even more energy can be recovered.

Note that the heat exchange time is not a pure "loss" that reduces the throughput. Part of the time often runs during a technological slow cooling phase, and the heating time required by the integrated heating system is shorter (as the charge does not start at ambient temperature, having been preheated to around 310 °C).

Furthermore, from a technological point of view a minor extension of the time has a positive effect on coil quality. The slow heating-up rate aids the evaporation of rolling lubricants, while a slow cooling rate helps prevent stickers between wraps.

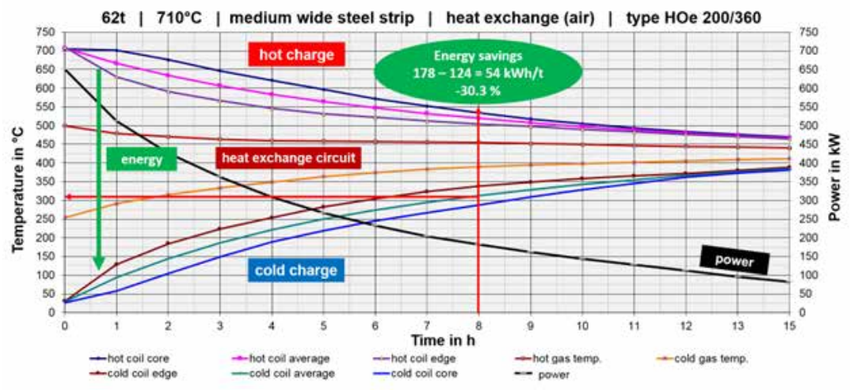


Figure 4: Time/temperature plot of a GREENBAFx® heat exchange anneal

Thermal recovery, alongside other high-efficiency features of the GREENBAFx® design, is an approach that reduces emissions even as it provides significant financial savings.

That is, in comparison to a classic gas-fired facility, a GREENBAFx® annealer allows an enormous reduction in the amounts of CO_2 and NO_x that are expelled. For example, at a facility with a throughput of 250,000 t/y, annual emissions would be reduced by around 9055 t of CO_2 and around 11.8 t of NO_x. The savings in electrical power, when compared to a classic bell annealer with an electric heating system and a throughput of 250,000 t/y, would reach abt. 13,500 MWh/y. Assuming a price for electricity of 0.12 €/kWh, this represents a savings of 1.6 million euros per year.

Figure 5 and Figure 6 show the potential reductions in CO_2 and NO_x emissions, as well as savings in electricity, as a function of the annual throughput.

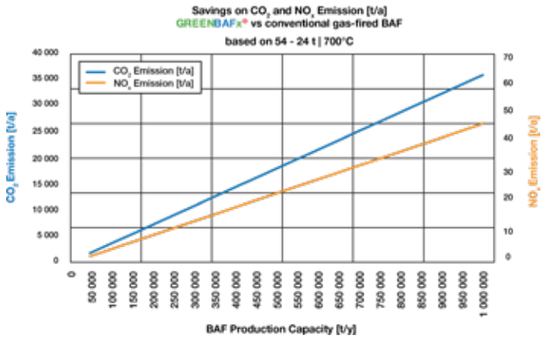


Figure 5: Potential savings in CO_2 and NO_x

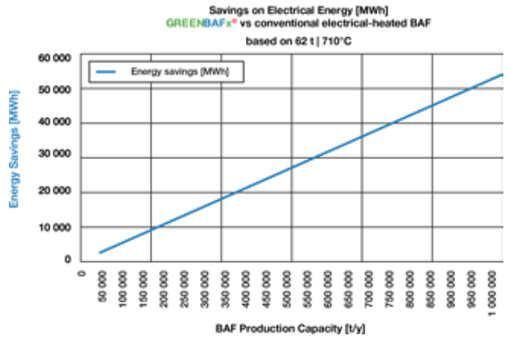


Figure 6: Potential savings in electrical power

WHY CHOOSE GREENBAFx® ?

- **Emission-free process with zero CO_2 and zero NO_x emissions**
  - A GREENBAFx® facility with a throughput of 250,000 t/y reduces emissions by ~ 9055 t of CO_2 and ~ 11.8 t of NO_x per year
- **Significant energy savings due to high energy efficiency**
  - Energy savings of up to 5 % due to direct heating ("basic" case)
  - Energy savings of up to 30 % due to heat exchange ("advanced" case)
  - Reduced power draw (abt. - 5 %) compared to standard bell annealer facilities with electric heating
- **A variety of systems can be provided to recover waste heat, such as**
  - Atmosphere outburner in heat exchanger circuit
  - Air/water or air/oil heat exchanger
  - Direct air heating (hot air is then used to heat the workshop, coil storage area, etc.)
  - Tie-in to energy storage system
- **No temperature peaks in the charge stack**
  - As the gas transferring heat is not at an excessive temperature
- **Optional cooling variants**
  - High-performance air cooling
  - Integrated cooler
  - Fast cooling system: integrated cooler paired with a high-performance air cooler
  - There is no need for a supply of open cooling water, eliminating potential quality issues caused by water droplets on coils
- **A single HICON® process bell replaces the heating bell, cooling bell and inner cover**
  - No utility couplings
  - No bell exchange
  - Operations are massively simplified
  - Heat treatment cycles can be fully automated
- **Reduced number of crane cycles**
  - Only two (2) crane movements are required (place bell, lift bell) instead of the usual six (6)
- **Each workbase is equipped with an independent heating system**
  - No waiting times for "busy" heating bells that may reduce throughput
- **Hybrid-Heating Option with heating bell**
  - The heating type (electric, natural gas, hydrogen) can be freely selected in response to the availability and price of utilities (restrictions in bell handling and heat exchange may apply)
- **Control thermocouple installed in a protected position**
  - Cannot be damaged during charging
- **Extended service life of components (e.g. integrated inner covers)**
  - Due to reduced thermal stresses
- **Extremely low amounts of noise generated**
  - Even during the air cooling phase
- **Low space requirements**
  - Reduced longitudinal distance between workbases
  - Heat shields for valve stands are no longer required
  - The heat exchange ducting requires roughly the same amount of space as exhaust gas ducting
- **Retrofits**
  - Many types of existing facilities can be upgraded with an integrated electric heating system and a heat exchange system

SUMMARY AND CONCLUSIONS

With the innovative development of a new generation of bell annealer facilities, during which a clear emphasis was placed on maximizing energy efficiency, eliminating emissions and simplifying operational processes, a significant step has been made towards creating a sustainable production method for the metals industry.

As stated above, the challenge has been to provide our customers with sustainable production methods, while still allowing them to remain competitive and maintain their positions in the international market.

The different variants in the GREENBAF® line of bell annealers are available as financially appealing new facilities with attractive amortization periods, as well as upgrade packages for existing facilities.

THERMAL PROCESSES

Sustainable heat treatment

The future of EBNER burner technology

PETER SEEMANN

VP Research & Development
EBNER Industrieofenbau

MICHAEL KOLLER

Senior Manager
EBNER Industrieofenbau

Burner technologies play a central role in industrial heat treatment - whether in terms of efficiency, emissions or an ability to be adapted to alternative fuels. For decades, EBNER has been developing innovative burner solutions for heat treatment furnaces, constantly raising the bar for the rest of the industry. In a recent interview, EBNER's Peter Seemann (Vice President Research & Development Ferrous) and Michael Koller (Senior Manager R&D Ferrous) spoke about current developments, current challenges and the future of burner technology.

BURNER TECHNOLOGY AT EBNER

What role does EBNER play in the development of innovative burner solutions for industrial furnaces?

Seemann: EBNER develops its own burner solutions for the majority of its facilities. In-house development allows us to optimally respond when integrating burners into different types of furnaces.

The EBNER product range offers a wide variety of burner technologies - from classic gas burners to flameless burners and hydrogen-powered solutions.

Given that variety, what has been your core approach to development?

Koller: Our feeling of responsibility towards the environment and future generations inspired us early on to begin development of low-emission, sustainable combustion technologies. This produced various innovations, including our own flameless burners, which not only meet increasingly strict NOx emission regulations, but also follow our vision of "Driving Green Technologies". At the same time, there was a need to address future market requirements for carbon-neutral heat treatment solutions. This led to the development of our hydrogen burners. As long as "green" hydrogen is available in sufficient quantities, these burners allow a heating system to be fully carbon neutral – an important step towards a climate-friendly industry.

How do the various EBNER burners differ in terms of technology, efficiency, emissions and area of application?

Koller: EBNER employs heating systems that heat both indirectly (using radiant tubes) and directly. The efficiency of these systems, as well as their emissions, depend on a number of factors. These include the processing temperature, burner output and the temperature to which the combustion air is preheated. The main factors determining their areas of application are first, direct versus indirect heating and second, the type of heat treatment facility - that is, whether it is for steel or aluminum.

Over the last few years, which technological trends have influenced development? Is there a general direction in which all burner designs are headed?

Seeman: A constant effort is being made to increase combustion efficiency, while reducing pollutant emissions at the same time. In addition to that, over the last few years there has been intensive research into the combustion of fuel gases with widely different compositions - mixtures of hydrogen and natural gas, synthetic gases or ammonia. The goal of development is to allow zero carbon or low carbon combustion.

What makes EBNER burners stand out?

Koller: EBNER only develops all-metal burners, which are designed to operate in furnace temperatures up to 1250 °C. In-house design and manufacturing contribute significantly to the exceptionally long service life of our burners.

Are EBNER burners only used for heat treatment, or are they also used in other applications?

Koller: At this time, our burners are only used in facilities we manufacture. Their future use in non-EBNER facilities, as well as in other industries (for example, in equipment used to manufacture cement, bricks, elastomers, glass or carbon) is a major focus of our ongoing research and development work.

CHANCES AND CHALLENGES

Which challenges currently shape the development of burner technologies?

Seemann: One of the greatest challenges is the conflict between the goals of increasing efficiency and reducing NO_x emissions. A solution may be found in intelligent control technology, which allows burners to be controlled very precisely. Additional challenges are posed by the growth of hydrogen as a fuel gas, which remains uncertain.

EBNER has over 43 years of experience in burner development. How has the technology changed over the last few years?

Koller: At new facilities we see an increasing number of measures to reduce NOx emissions, including external exhaust gas admixing and flameless burners. SCR systems for secondary NOx reduction are also installed in particularly strict regulatory environments. Furthermore, a focus is currently being placed on hydrogen-fueled and hybrid burners.

SUSTAINABILITY AND INNOVATION IN BURNER TECHNOLOGY

How does EBNER burner technology contribute to reducing emissions and energy consumption?

Seemann: The use of large recuperators can lead to additional energy savings. Flameless technology already allows extremely low levels of emissions to be achieved.

How does EBNER make sure its burner technologies remain competitive over the long term?

Seemann: Burners are continuously optimized, both in terms of energy efficiency and emissions behavior. Regular testing in our in-house testing facilities allows us to rapidly put new developments into practice. **EBNER** also cooperates with research institutes in both Austria and Germany.

How flexible are EBNER burners when being integrated into existing facilities or switching between different types of fuels?

Koller: During burner development, great care is taken to ensure that the burner can be integrated into existing facilities with minimal effort. That is the case, for example, with our hybrid natural gas/hydrogen burner.

OUTLOOK

Does EBNER see a future for burner technologies that employ electric heating?

Seemann: Direct electric heating will play an increasingly important role, particularly in heat treatment. However, for high-temperature processes plasma burner technology will remain crucial, as it allows very precise temperature regulation. **EBNER** has already developed innovative solutions such as our plate heating system, **GREENBAFx®** bell annealers and electric radiant tubes.

GREENBAFx® furnaces were introduced in 2024, and it was said that they marked a new generation of bell annealers. Why?

Seemann: Many companies are placing their trust in hybrid heating solutions, and in **GREENBAFx® EBNER** has combined electric and gas heating systems in a single facility. This allows fossil fuel and electrical power sources to be used flexibly, reducing both emissions and operating costs.

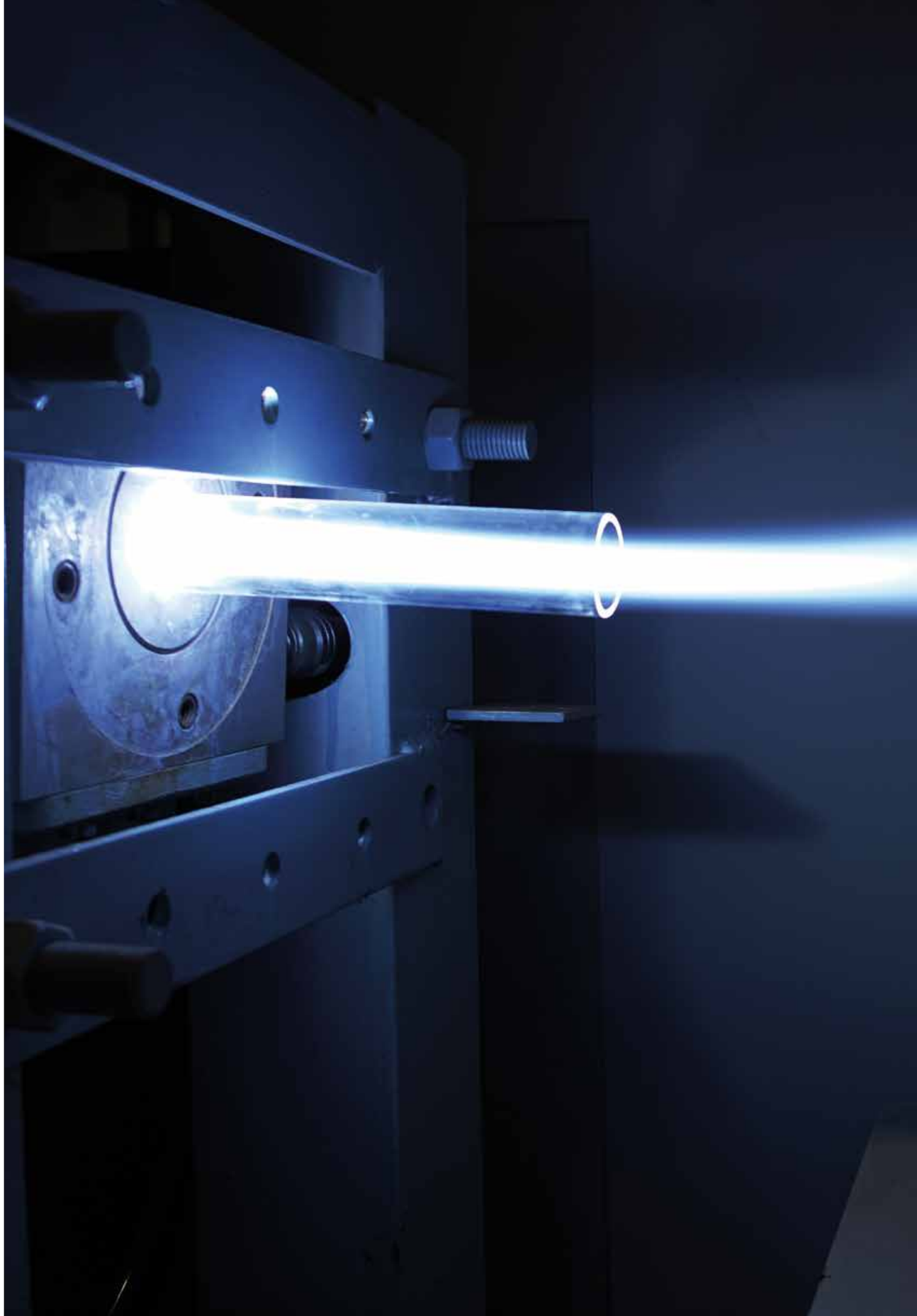
What technological innovations will shape the future of burner technology?

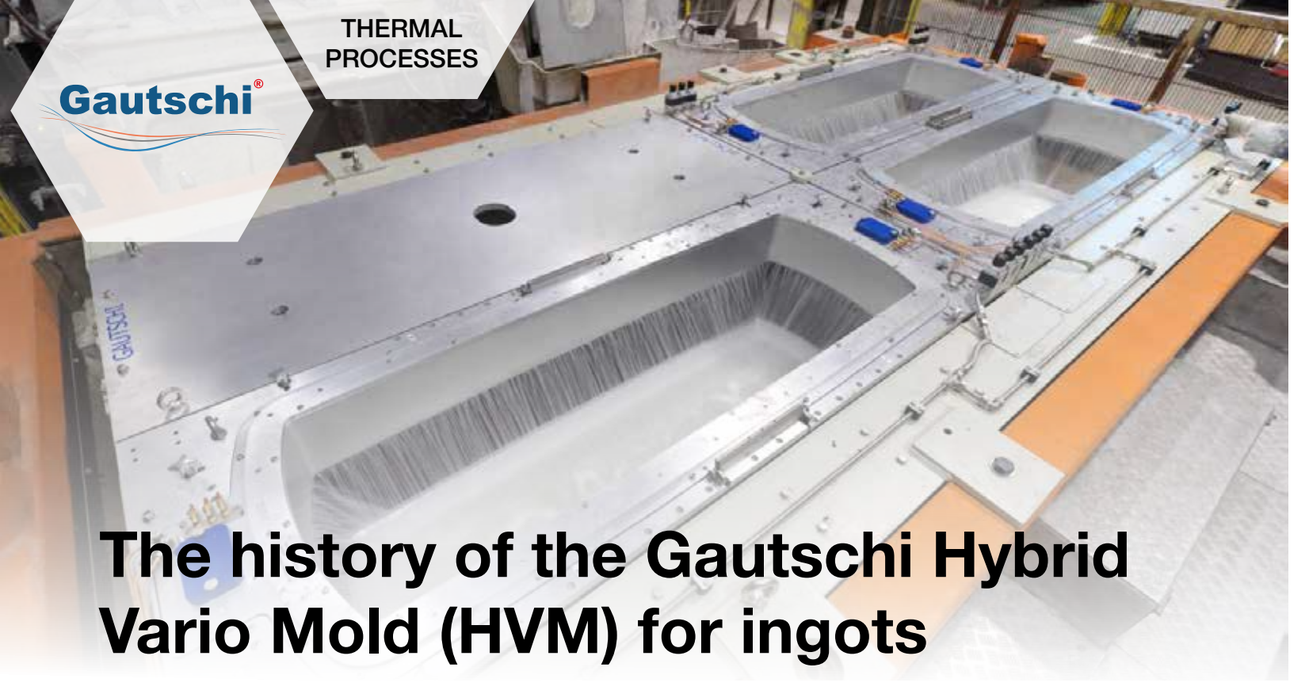
Koller: Of particular importance for the future of burner technologies is the development of solutions for decarbonization, along with carbon-neutral methods of heating.

In this regard we can look back on the years of development work carried out in our in-house TECHCENTER, during which we successfully introduced our hydrogen-fired **ECOBURN** H_2 FLEX burners to the market and made significant progress in the development of plasma burner technology.

> “In-house development allows us to optimally respond when integrating burners into different types of furnaces.”
>
> **- Peter Seemann,** VP Research & Development Ferrous

> “Of particular importance for the future of burner technologies is the development of solutions for decarbonization, along with carbon-neutral methods of heating.”
>
> **- Michael Koller,** Senior Manager Research & Development Ferrous





The history of the Gautschi Hybrid Vario Mold (HVM) for ingots

STEFAN PELECH

Managing Director
Gautschi

Rolling ingots are the starting material used to manufacture aluminum sheet, and are produced in a continuous vertical casting process (VDC). The heart of any vertical continuous casting unit is the mold, which has a significant impact on the quality of an ingot and thus on the end product.

Gautschi Engineering GmbH's Hybrid Vario Mold (HVM), designed for rolling ingots, stands out due to its precision design and high efficiency. These features directly lead to improved product quality and increased production capacity.

THE ROAD TO SUCCESS - MILESTONES IN DEVELOPMENT

2016 THE DECISION TO DEVELOP AN INGOT MOLD

For decades, established manufacturers have been striving to continuously improve and simplify the processes used in mold-based production.
These efforts inspired Gautschi Engineering GmbH to intensively investigate the topic and make it their area of special expertise.

Dedication and a visionary goal led Gautschi to develop an innovative ingot mold, which was introduced in October, 2016. This new technology allowed aluminum to be cast in a continuous and controlled process, and today this ingot mold still stands out due to its advanced cooling technology and the precise control it provides over the casting process.

2017 A NEW TESTING GROUND AND VALUABLE INSIGHTS

In cooperation with Stockach Aluminium GmbH and AS Oxidwerke GmbH, both based in Germany near Lake Constance, Gautschi began to conduct its own series of tests and trials. Gautschi was given access to a large unused casting pit, which the company could then use to conduct testing. Gautschi began to conduct trials with customers from across the globe, allowing valuable data to be collected and know-how to be exchanged. This visionary and practical approach allowed Gautschi to respond to specific requirements of the international market.

2018 THE FIRST STEP INTO A NEW ERA

The first casting unit with the new Hybrid Vario Mold (HVM), in a 535 × 1680 mm format, successfully went into operation at a well-known aluminum manufacturer's works in 2018. This important step demonstrated how traditional production processes could be optimized through innovative technologies - a realization that formed the cornerstone of further development.

2020 EXPANSION AND TECHNOLOGICAL BREAKTHROUGHS

2020 marked a turning point, with two critical developments.

- **Product range expanded:**
  Following successful commissioning of the first casting unit, the same customer installed a second unit at their works that supported ten different formats (ranging from 535 × 1140 to 535 × 1770 mm). For the highest possible quality and greatest possible reliability during every cast, alloys like 6016, 6061, 5754, 5052 and 3003 were used.

- **Patents boost innovation:**
  Alongside expansion of the product range, the design of the new Hybrid Vario Mold (HVM) was further refined and successfully patented. This technical highlight underlined Gautschi's commitment to continuously raising the bar for casthouse technologies.

2020 OPENING OF THE CASTHOUSE (R)EVOLUTION CENTER IN RANSHOFEN, AUSTRIA

Gautschi's close collaboration with HPI High Performance Industrietechnik GmbH, based in Ranshofen, Austria, led to the idea of creating a shared testing center and moving Gautschi's headquarters from Switzerland to Ranshofen.
This test center would incorporate facilities for both horizontal and vertical casting, allowing the entire spectrum of technologies to be covered and an extended range of services to be offered. Following careful planning, construction of the testing center and commissioning of the pilot casters was completed in 2020.

The CASTHOUSE (R)EVOLUTION CENTER, or C-R-C, had become a multi-story testing center that, along with the office building, offered over 1000 m² / 10,700 square feet of space. Construction of this state-of-the-art R&D casthouse has made it possible to test and refine advanced designs under real production conditions, and insights drawn from practical experience are directly applied to optimize processes.

2024 EXPANDING PRODUCTION CAPACITY

The success story of the Gautschi ingot mold was continued in 2024, as a third casting unit designed for HV molds went into operation. A custom design for one of our partners, this new unit is also able to handle additional casting formats such as 35 × 1920 and 535 × 2120 mm. Proven alloys such as 6016, 6061, 5754, 5052 and 3003 continue to be in use, a clear confirmation of the quality and efficiency of the system.

Selected parameters and technical advantages

- **But curl:** varies between 20 and 50 mm
- **Butt swell:** virtually absent
- **Scrap:** less than 1 %
- **Safety:** initial casting is fully automated

These features lead to savings in both materials and costs, as ingots require a reduced amount of machining before any downstream process. Furthermore, the safety of the operators in the production area is improved.

TECHNICAL EXCELLENCE MEETS THE MARKET

The continuous improvement of our ingot molds is founded on the successful give-and-take between our technological know-how and intensive practical experience.

The tireless effort to apply state-of-the-art manufacturing technologies has made Gautschi a leader in the field.

Gautschi's Hybrid Vario Mold (HVM) is the benchmark for:

- **Highest degree of precision**
  Optimized casting processes and customized formats ensure extremely accurate results during production.

- **Flexibility and range**
  The wide variety of aluminum alloys that are supported and the mold's ability to be adapted to different casting formats means that our mold offers tailor-made solutions to the most demanding production requirements.

- **Innovative research**
  By merging in-house expertise with current trends, Gautschi is constantly setting new standards in casthouse technology.

THE FUTURE OF MANUFACTURING - TAKE THE LEAD WITH GAUTSCHI

Gautschi unites decades of experience with pioneering technologies. The Gautschi ingot mold, as well as the Hybrid Vario Mold developed from it, are not just state-of-the-art solutions - they also provide a decisive competitive advantage.

HICON/H_2® SIMCAL

Annealing simulator for continuous heat treatment facilities.

SASCHA EPPENSTEINER

VP Product Management
EBNER Industrieofenbau

Continuous heat treatment facilities are complex systems, with many parameters that can influence a process (heating-up rate, cooling rate, atmosphere composition, dewpoint, strip tension, etc.) and provide a product with particular properties (specific mechanical and magnetic properties, microstructures, phase transformations, etc.).

Efficient manufacturing, optimized processes and the development of new products are critical factors for modern companies as they seek to remain competitive.

When continuous heat treatment facilities are involved, these factors become even more difficult to assess: the facilities, which are typically extremely large, either have to halt production or do not have the flexibility to reliably follow a desired testing program.

For these reasons, simulating heat treatment processes at laboratory scales is far more efficient and much quicker to organize.

This approach provides numerous advantages:

- **The opportunity to analyze and improve the understanding of existing processes**
- **Decisions that affect the process can be made more quickly and accurately**
- **Heat treatment processes and material properties can be optimized**
- **New material grades can be developed and made market-ready more quickly**
- **Annealing cycles can be developed that achieve particular target qualities with different starting materials (e.g. varying chemical compositions / upstream processing steps)**
- **Improvement of throughputs through a better understanding of material-specific process windows and more efficient transitions when strip parameters or formats change**
- **No need for expensive and labor-intensive “full-scale” trials at production facilities**
- **Improve the productivity and profitability of facilities**

When simulating continuous heat treatment processes, the challenge is to recreate the processing conditions within the real facility as accurately as possible.

- The first step is to use strip with an identical thickness. With thick strip this is relatively simple, but the problem becomes increasingly complex as the strip becomes thinner.
- The process atmosphere (composition, dewpoint) must also be a match with that in the real facility. This may mean that some safety-related challenges may have to be met (e.g. when using H_2 as an atmosphere).
- The temperature profile (heating and cooling curves) must correlate with the real ones, as does the temperature uniformity that is achieved.
- In some processes, strip tension can have a significant influence on results. In a simulation, the tension must therefore either match the actual conditions or be dynamically adjusted to match the fictitious travel path of the strip.

In a simulation, comparable material properties can only be achieved if all of these factors are taken into account.

For this application, **EBNER** has developed an extremely flexible, gas-tight annealing simulator with the following specifications:

Strip thickness	0.2 – 3.0 mm
Length of sample	300 – 500 mm
Width of sample	30 – 200 mm
Temperature	up to 1260 °C
Uniformity	± 5 °C to ± 10 °C (depending on the material and its dimensions)
Process atmosphere	100 % H_2 to 100 % N_2, H_2/N_2 mixtures, argon, helium
Dewpoints	+ 20 °C to - 55 °C
Dynamic strip tension adjustment during the entire heat treatment cycle (a perfect representation of a vertical furnace is thus also possible)	
Fast cooling	up to 200 K/s.mm
Slow cooling	5 – 25 K/s

EBNER offers **SIMCAL** simulators as complete facilities for installation in your R&D center, research institute, etc.

EBNER also offers *Simulation as a service*.

This option allows you to use the **SIMCAL** facility installed in our in-house lab in Leonding, Austria for your trial anneals. Our experienced staff is available to assist you. They will carry out the trials for you, and on request can also analyze the samples after testing has been completed.

Our lab is equipped with a wide variety of equipment for analysis and evaluation, including a tensile testing machine, hardness testers, microscopes and sample preparation equipment, equipment to conduct chemical analyses and an Epstein testing device to analyze magnetic properties.

We would be happy to advise you on the services we offer and help you develop a testing plan. Please feel free to contact us at any time!

NEWS

The HICON® Journal is also available by email!

Trade fairs. Conventions. 2025

APRIL 7 - 9, 2025	**CSI**	Brussels	**BEL**		
APRIL 24 - 26, 2025	**INDIA STEEL**	Mumbai	**IND**	Booth no.	**D13**
MAY 5 - 8, 2025	**AISTech**	Nashville	**USA**	Booth no.	**1629**
MAY 13 - 15, 2025	**INTERWIRE EXPO USA**	Atlanta	**USA**	Booth no.	**548**
MAY 28 - 29, 2025	**ALUMINIUM USA**	Nashville	**USA**	Booth no.	**401**
JULY 9 - 11, 2025	**ALUMINIUM CHINA**	Shanghai	**CHINA**	Booth no.	**N1J100-1**
AUG. 27 - 29, 2025	**WIRE SHOW**	Shanghai	**CHINA**	Booth no.	**TBA**
SEPT. 14 - 19, 2025	**ICSCRM**	Busan	**KOREA**	Booth no.	**067**
OCT. 21 - 23, 2025	**STEEL TECH EXPO CONGRESS**	Bilbao	**ESP**	Booth no.	**TBA**
DEC. 2 - 4, 2025	**MTM EXPO**	Shanghai	**CHINA**	Booth no.	**TBA**

We look forward to seeing you there!

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