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STEEL+ TECHNOLOGY

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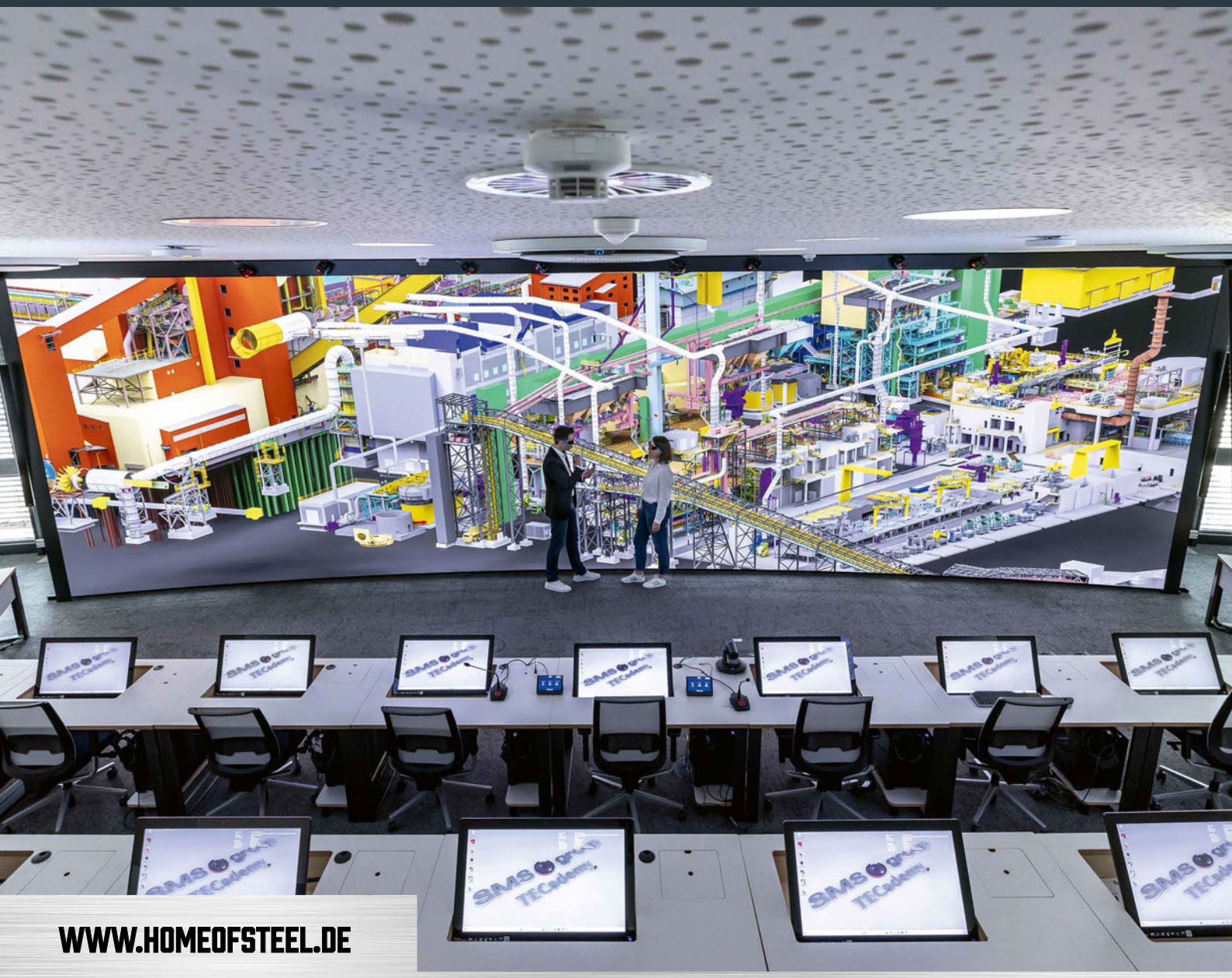
THE TECHNICAL MAGAZINE FOR IRON AND STEEL PROFESSIONALS AROUND THE WORLD



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GLOBAL ECONOMY

OECD Steel Committee discussed the current steel crisis and potential solutions

STEELMAKING

Electric arc furnace long arc operation and its relation to flicker

HEATING TECHNOLOGIES

Electrification of high-temperature heating zones in strip processing lines

STEEL PROCESSING

Clutch-operated screw presses produce components for turbine applications

HÜTTENTAG

GET-TOGETHER OF THE STEEL INDUSTRY

MESSE ESSEN | NOVEMBER 13, 2025

THE STEEL INDUSTRY FACES A TURNING POINT

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Steel is innovative

As global politics are increasingly dominated by military conflicts, previous megatrends such as decarbonisation, the digitalisation of society and the globalisation of the economy seem to be taking a back seat. The conclusions of the OECD Steel Committee on a possible solution to the global steel crisis (**page 24**) are also unlikely to receive the attention they deserve. Many steel companies have been recognising the situation and have adapted their corporate strategy to the new circumstances yet. The primary goal: investments must be profitable. Of course – one would think.

Research and development play an important role here, for example when it comes to reducing CO_2 emissions from the blast furnace process (**page 30**). Also, in order to significantly reduce the carbon footprint of stainless steel, a new low-CO_2 nickel extraction process could represent a quantum leap (from **page 34**).

The CO_2 reduction potential of industrial heating processes has also long been the focus of technological development. More and more it is being concluded that the countless natural gas burners in hot blast lines, in the reheating furnaces upstream of the hot rolling mills or in the conti and bell annealing lines in strip processing may not be able to cover their costs if they are converted to burn green hydrogen. Consequently, developments for electrical alternatives to industrial process heat are running at full speed (**pages 32 and 49**).

Last but not least, the focus is once again shifting to electric steelmaking technology. As part of the transformation projects of numerous steelworks, there is a need for information in many places on how this technology works and what details need to be considered. This is not something that can be learnt in one afternoon. STEEL + TECHNOLOGY will therefore regularly publish articles on how a modern EAF works (from **page 38**).

Arnt Hannewald,
Dipl.-Ing., Editor

In the field of steel processing, we would like to emphasise the Swedish Steel Prize. It honours a special development in car body construction, more precisely in the field of press hardening (from **page 55**). Although neither the process nor the steel required for it are fundamentally new, the targeted development of the pressed part properties as a result of the interplay between the material and processing parameters is very impressive.

Steel is innovative. This is evident not least at industry events – such as the recent AISTech conference and exhibition in Nashville, TN/USA (from **page 22**). Next, the German steel industry will meet in Essen on 13 November. Save the date and register online now. Don't miss out on this event. See you in Essen.

18 The new meltshop in Oxelösund, Sweden, will play a vital role in realizing SSAB's transition plans towards fossil-free production

32

STEEL PROCESSING

COLUMNS

DIGIMELTER®

Q-ONE® HYBRID POWER FEEDER

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ENDLESS CASTING-ROLLING

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BAR SPOOLING

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IN OPERATION
WORLDWIDE

With the order placed by CMC Steel for its fourth new, MIDA QLP hybrid-ready minimill, the Danieli scorecard hits 26 plants for long-product endless casting-rolling, out of 115 total minimills.

26
PLANTS

LARISA GYLLENRAPP IS NEW HEAD OF GLOBAL SALES AT OVAKO

Larisa Gyllenrapp will assume the role as EVP Global Sales in November this year (Picture: Ovako)

Larisa Gyllenrapp has been appointed as Executive Vice President Global Sales for Ovako Group. She will join the Executive Management Team and lead Ovako's international sales organization with a focus on driving growth, strengthening customer value, and strengthening commercial execution across key markets.

Larisa brings over two decades of global leadership experience in industrial companies, with a strong track record in strategic sales, market expansion, and organizational development. Most recently, she led the Wood Division at Bruks Siwertell, overseeing operations across Europe, the Middle East, and Africa. Prior to that, she held senior commercial and leadership roles at BillerudKorsnäs, further building her expertise in customer-centric, international business environments.

Her appointment marks an important step in Ovako's continued ambition to build a high-performing, growth-oriented sales organization. Larisa will assume the role in November this year. Until then, Marcus Hedblom, President and CEO of Ovako, will continue to serve as acting EVP Global Sales.

Ovako

NUCOR APPOINTS HUMAN RESSOURCE EXECUTIVES

Nucor Corporation has promoted Thomas J. Batterbee to the position of Executive Vice President of Human Resources and Talent and appointed Elizabeth Bledsoe to President of Human Resources and Talent.

In their new roles, Thomas J. Batterbee and Elizabeth Bledsoe will focus on Nucor's enterprise talent development and human resources strategy. Batterbee began his Nucor career in 1989 at Nucor Building Systems Indiana. He currently is president of Nucor's Vulcraft Verco division, producer of steel joists, decking and grating.

Elizabeth Bledsoe's position of President of Human Resources and Talent has been newly created. She joins Nucor from MSC Industrial Direct, a distributor of metalworking and maintenance, repair and operations products and services.

Nucor

SANDVIK APPOINTS NEW GENERAL COUNSEL

Sandvik has appointed Johanna Kreft as Executive Vice President and General Counsel, effective October 2025. She currently holds the corresponding position at Alleima.

Johanna Kreft has a long background from within Sandvik spanning over 15 years. In her role as general counsel, she has played an essential part in the successful spin-off process leading up to the listing of Alleima on the stock exchange in 2022. Before the spin-off of Sandvik Materials Technology (SMT) as Alleima, she was business area general counsel for SMT.

Johanna Kreft replaces Asa Thunman, who as previously announced is leaving Sandvik for a similar position at the Swedish project development and construction group Skanska.

Sandvik

Johanna Kreft will be the new general counsel at Sandvik (Picture: Sandvik)

THYSSENKRUPP MATERIALS SERVICES APPOINTS CEO OF BUSINESS UNIT PROCESSING

Thyssenkrupp Materials Services has appointed Dr. Heather Wijdekop as the new CEO of the Business Unit Processing, effective July 1, 2025. In addition, Dr. Wijdekop will head the Operating Unit Processing North America as CEO.

In both roles, she will succeed Norbert Goertz, who will remain interim CFO of the Business Unit Solutions and lead the corporate functions for the thyssenkrupp Materials North America headquarters in Southfield, Michigan.

Dr. Wijdekop led various international roles with Tata Steel Europe and the Corus Group, which was acquired by Tata Steel Europe in 2007. Most recently she served as Director Commercial at Tata Steel IJmuiden. She holds an engineering doctorate in materials engineering.

The Business Unit Processing of thyssenkrupp Materials Services is represented in both Europe and North America and specializes in the customized processing of flat-rolled metals to meet specific requirements. North America is a key growth region for thyssenkrupp Materials Services due to its significant market potential and strategic advantages. In the last year, the company opened major new sites in Mexico and Texas and invested in new processing capabilities.

thyssenkrupp Materials Services

Dr. Heather Wijdekop, CEO of the Business Unit Processing of thyssenkrupp Materials Services (Picture: John de Koning)

SMOOTH HANDOVER OF SALES AND PURCHASING AT WUPPERMANN STAHL

Jasmin Niehof is now responsible for flat steel sales at Wuppermann Stahl
(Photo: Wuppermann AG)

Jasmin Niehof has joined Wuppermann Stahl as a new member on the management board responsible for flat steel sales and will – from November 1, 2025 – also assume responsibility for purchasing.

Jasmin Niehof, who joins Wuppermann from thyssenkrupp Steel Europe, will report directly to Oliver Rechtsprecher, spokesman of the executive board of Wuppermann AG. "With her many years of experience in the steel industry, Jasmin Niehof brings in-depth expertise to our company. It is particularly pleasing that we are able to ensure a smooth and gradual handover of the sales and purchasing department thanks to the close cooperation with her predecessor during the transition phase," says Oliver Rechtsprecher, CEO of Wuppermann AG.

Carl Swoboda will continue to be responsible for hot-rolled strip and zinc purchasing until his planned retirement on October 31, 2025 and, in addition to Jasmin Niehof, Andreas Kersch will remain on the management board as head of supply chain management.

Wuppermann

SENIOR LEADERSHIP TRANSITIONS AT STEEL DYNAMICS, INC.

Glenn Pushis, Senior Vice President Special Projects, will be retiring from Steel Dynamics on October 1, 2025, while Miguel Alvarez will assume responsibility and oversight for the company's aluminium operations, including the new strategic aluminium investments which are currently being commissioned under Mr. Pushis' leadership.

Most recently, Glenn Pushis was responsible for the successful design and construction of the company's new 650,000 t/year lower-carbon, recycled aluminium flat rolled products mill in Columbus, Mississippi, with two satellite recycled aluminium slab centres in the Southwestern United States and North-central Mexico. He is retiring from Steel Dynamics to pursue a position as the chief executive officer of McBride Capital Partners "Project Aero", a U.S. based company that plans to construct a titanium manufacturing facility in North Carolina. Glenn Pushis will continue to provide consulting services to Steel Dynamics through commissioning of the company's new aluminium flat rolled facilities during the year.

Miguel Alvarez will assume responsibility for Steel Dynamics' aluminium operations as Senior Vice President Aluminum Group. Miguel Alvarez joined Steel Dynamics in 2019 as Senior Vice President, Southwest U.S. and Mexico to support the company's steel and metals recycling growth strategy in that region. In 2022, he was promoted to lead the company's metals recycling platform.

Steel Dynamics, Inc

WUPPERMANN APPOINTS NEW HEAD OF COMPETENCE CENTRE IN HUNGARY

Dr. Thomas Angerer is the new head of Wuppermann's competence centre for research & development and process technology in Hungary. He takes over from Phillip Weilguni, who is leaving Wuppermann at his own request.

Wuppermann opened its competence centre in Győr-Gönyű in 2022 to bundle know-how in process technology and optimization. Equipped with extensive metallographic systems, modern scanning electron microscope and a corrosion laboratory, Wuppermann uses the competence centre for quality assurance analyses of both primary material and galvanized strip.

Iron and steel metallurgist and thermal process engineer Thomas Angerer, holds a doctorate in non-ferrous metallurgy. He has profound expertise in process management and optimization as well as in materials development and project implementation in the field of metallurgy.

Wuppermann

Dr. Thomas Angerer took over as the new head of the competence centre in May 2025
(Photo: Wuppermann AG)

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EUROPE – FINLAND

Outokumpu Stainless grants FAC for Steckel mill modernization

Outokumpu Stainless has granted SMS group the final acceptance for the comprehensive modernization of its Steckel mill at the Tornio facility. The project involved a downtime of just four weeks.

Outokumpu Stainless has been operating a Steckel mill at its Tornio works in Finland since 1988. The long-standing technology partnership with SMS has ensured that the mill has continued to be state of the art. Most recently, SMS group renewed the entry and exit sections of the mill, including the implementation of roller tables with new side guides and state-of-the-art motors. The new pinch roll unit was fitted with a drive train and motors. The side guides and the pinch roll unit are controlled by hydraulic valve stands. The upgraded equipment has been mounted on a new steel structure, replacing the former concrete blocks. A particular challenge of the project was to integrate the new equipment into the plant's limited available space. Operations were resumed in November 2024, following a test phase of eight weeks during which all contractually agreed performance parameters were met.

SMS group

EUROPE – FRANCE

ArcelorMittal confirms intention to invest in Dunkirk to decarbonize

ArcelorMittal remains committed to decarbonizing its operations in France. The company is working closely with the French Government, whose leadership has been key in the defence of the steel industry in France and Europe.

Uncertainty about the future of the European steel industry has led ArcelorMittal to delay its European decarbonization projects. However, the European Commission's Steel and Metal Action Plan, announced in March 2025, provides optimism that the European Commission will implement efficient trade defence and carbon border adjustment mechanisms (CBAM) soon.

The revised steel safeguard measures that entered into effect on April 1st, 2025, are a first step in the right direction. The European steel industry now requires effective limitation of imports at 15% of market demand as well as an effective CBAM that notably prevents resource shuffling. That would restore a level playing field on the European steel market.

In this context, ArcelorMittal is confident all the conditions will be in place, soon after the summer, to be able to relaunch its decarbonization plan and, as such, confirms its intention to invest in a first electric arc furnace in Dunkirk. This EAF will require an investment of approximately EUR 1.2 billion. This, together with the recent investments announced in Dunkirk and Fos, and the new electric steels production unit under construction in Mardyck, totals EUR 2 billion of investment and demonstrates ArcelorMittal's intention to maintain a thriving and sustainable steel-making business in France.

ArcelorMittal

EUROPE – GERMANY

Salzgitter invests in new walking beam furnace and heat recovery system

Salzgitter Flachstahl will be receiving a new walking beam furnace and waste gas heat utilization system for its hot strip mill. The furnace will be supplied by Tenova Italimpianti, the heat recovery system by DSD Power.

"With the new furnace, we will be reducing our energy requirements for slab heating in hot flat production by up to 30 %. This is another significant step towards reducing the CO_2 footprint of flat steel products," says Thomas Routschek, Operations Director, Hot Flat Products Division, Salzgitter Flachstahl. The walking beam furnace to be supplied by Tenova Italimpianti will heat the slabs subsequently rolled in the rolling mill to up to 1,300 °C. During this process, combustion gases are generated. The thermal energy from these gases is converted into steam in the waste gas heat recovery system to be supplied by DSD Power. "The entire project is all about energy efficiency. The high-quality steam generated in the process will be distributed throughout the plant for efficient use," says Felix Iwanowski, Project Management Hot Rolling Mill, Salzgitter Flachstahl.

Salzgitter AG / Tenova Italimpianti / DSD Power

EUROPE – GERMANY

Pre-FEED study for possible CO_2 terminal in Bremen

Following the successful completion of a pre-FEED study, Ambrian Energy and Messer are planning a strategic partnership to jointly implement a CO_2 terminal in the port of Bremen.

Ambrian Energy had assigned industrial gas specialist Messer with a pre-FEED study to investigate the technical and economic feasibility of a facility for the delivery, storage and shipping of liquefied CO_2. The planned infrastructure should make a decisive contribution to the implementation of carbon capture & storage (CCS) in Germany.

The CO_2 terminal is to be built on an unused area of around 12 hectares on the Ambrian Energy site. The location offers ideal logistical conditions: An existing rail connection enables CO_2 to be transported by train, while a port jetty for ships with a capacity of up to 40,000 t ensures onward transport to geological CO_2 storage facilities in the North Sea. The planned terminal capacity is initially 2 million t/year of CO_2.

The scope of the pre-FEED study included the feasibility of constructing a specialized tank farm for liquefied CO_2, which will have an integrated quality assurance system and a gas recovery facility. In addition, a modern unloading facility for transport by train is to be built. Another key element is the ship loading facility, which will enable the safe and loss-free transportation of the CO_2 to geological sinks in the North Sea.

Industrial gases specialist Messer has decades of experience in CO_2 recovery and processing. ZeCarb®, a new offering in the field of Carbon Capture as a Service (CCaaS) launched by Messer, helps to decarbonize industries with high CO_2 emissions. Ambrian Energy, on the other hand, has extensive expertise in the logistics of fuels. Together, the two companies are pursuing the goal of offering customers a complete value chain from CO_2 recovery from industrial emitters to transportation by train and loading onto ships for CO_2 sequestration.

Ambrian's port infrastructure for a future CO_2 terminal in Bremen
(Photo: Ambrian Energy GmbH)

Ambrian Energy / Messer

EUROPE – GERMANY

WS Group inaugurates new buildings

Almost 500 guests attended the celebration at the headquarters of thermal process technology group WS in Renningen on April 30, 2025.

Guests from industry, universities and politics, as well as the employees and their families joined in to celebrate the inauguration of the two newly erected buildings at the headquarters of WS. The programme started with a tour of facilities and a keynote speech by Professor Dr.-Ing. Herbert Pfeifer from the Department for Industrial Furnaces and Heat Engineering at RWTH Aachen University. The new buildings will be mainly used by the team of the WS subsidiary e-flox GmbH. FLOX®, which stands for flameless oxidation, is a combustion technology developed by Joachim A. Wünning, the founder of WS.

WS Wärmeprozesstechnik

Celebrating the opening of the new buildings: Professor Dr.-Ing. Herbert Pfeifer, Department for Industrial Furnaces and Heat Engineering at RWTH Aachen University; Dr. Martin Schönfelder, Managing Director WS; and WS founder Dr.-Ing. Joachim A. Wünning (left to right) (Photo: WS Wärmeprozesstechnik GmbH)

EUROPE – ITALY

Alfa Acciai orders new spooler line

Alfa Acciai has awarded Danieli the order for a latest-generation spooler line to be installed at its Brescia works, in northern Italy. This will allow Alfa Acciai to produce rebar in coils weighing from 2.4 to 8 t.

The new line will replace existing equipment and overcome the current coil weight limitation of 3 t. With the new line it will be possible to produce torsion-free, quality rebar in compact coils weighing up to 8 t. The mill will initially produce rebar in diameters from 8 to 16 mm. This range may be extended to 18 and 20 mm in future. The hot start-up of the new spooler line at Alfa Acciai is scheduled for the beginning of 2026.

Bar spooling is an ideal technology for endless rolling processes, such as casting-rolling and billet-welding rolling. While enhancing productivity, the process also achieves superior metallurgical characteristics of the final product. Using Danieli billet welding and spooling technologies, Alfa Acciai was the first steelmaker to produce spooled bars in coils in endless mode, in 2007.

Danieli

Spooler technology for the production of compact rebar coils (Photo: Danieli)

EUROPE – ITALY

Marcegaglia to modernize cold rolling mill with advanced digital solutions

Marcegaglia Gazoldo Inox has awarded Tenova the order to modernize and restart the 20-high cold rolling mill at its plant in Mantua. The project is set to integrate advanced automation, digital solutions, and machine learning for improved efficiency and performance.

The revamping will include the implementation of advanced Level 1 and Level 2 automation, a next-generation human-machine interface, and machine learning applications for optimizing the rolling pass schedule. Additionally, Tenova's advanced roll cluster configurator, a system designed to automatically select the optimal roll sizes required for specific rolling configurations, will provide automated roll management, while vibration monitoring will improve process stability and control.

The upgraded mill will achieve higher rolling accuracy, improved process stability, and enhanced operational reliability. The integration of automation and digital tools will enable Marcegaglia to increase production and its product portfolio. The revamped mill is expected to be operational by early 2026.

Tenova

Marcegaglia and Tenova representatives after signing the modernization contract
(Photo: Tenova)

EUROPE – THE NETHERLANDS

Tata Steel Nederland launches new planning and scheduling solution

Tata Steel Nederland BV has successfully launched the PSImetals solution for planning and production execution at its cold rolling mill. Thus, planning and scheduling is now consolidated within a single database, the PSI Factory Model.

With PSImetals for planning, production execution, and production quality now in place, Tata can efficiently meet the requirements of its diverse customer portfolio while enhancing production performance. Previously, the cold rolling mill operated on a legacy system that posed challenges in production planning and execution. With the included line scheduler, order scheduler and schedule execution management, Tata can now optimize production schedules to ensure on-time and specification-compliant deliveries. Additionally, PSImetals production execution and quality solutions bring new functionalities, such as improved product quality and the capability to process joined coil parts. Erik Hermans, Project Leader at Tata Smart Steel Factory, says: "Replacing the current MES systems is critical for Tata Steel IJmuiden to stay competitive in high-value markets and avoid production disruptions. A modern, unified IT solution will simplify maintenance and reduce operational risks. It will also create a shared knowledge base, minimize knowledge loss, enable standardized work methods and speed up implementation of changes."

PSI

EUROPE – SWEDEN

SSAB concludes early services agreement for new cold rolling complex in Luleå

Teams from SSAB and SMS group attending the signing of the Early Services Agreement at the SMS Campus in Mönchengladbach (Photo: SMS group)

SSAB has awarded SMS group an Early Services Agreement for the delivery of the cold rolling complex at its steel production facility in Luleå. The complex will have a production capacity of 1.3 million t/year.

This project marks a significant step towards sustainable steel production, underscoring SSAB's commitment to green technologies and processes. With an annual production capacity of approximately 1.3 million t, the equipment will enable SSAB to meet the growing demand for third generation advanced high-strength steels (AHSS), particularly serving the automotive sector. The project encompasses sophisticated technology, including a pickling line/tandem cold mill with CVC® technology, a continuous galvanizing line, a continuous annealing and galvanizing line, and a recoiling and inspection line, all being key components to achieve the final quality of SSAB's specialty products.

Fully electrically heated Drever furnaces will utilize a combination of induction and electrical radiant tubes, thus ensuring a minimal carbon footprint. For optimal surface quality, Duma-Bandzink air-knives will precisely control the coating thickness. Amova robotics applications and logistics systems will optimize material flows and streamline logistics processes within the new cold rolling complex. Comprehensive automation and digitalization solutions will assure production efficiency, process stability and product quality. Also included in the scope are major auxiliary plants like an acid regeneration plant, roll shop, coil logistics and water treatment plants.

The cold rolling complex will enable the processing of strip widths up to 1,900 mm and thicknesses ranging from 0.30 to 2.5 mm, ensuring versatility in product offerings.

SSAB / SMS group

EUROPE – SWEDEN

SSAB secures green financing for fossil-free mini-mill

SSAB has secured EUR 2.3 billion of green financing for the transformation project to build a state-of-the-art fossil-free mini-mill in Luleå. The transformation project is key to enable SSAB to re-position SSAB Europe as a maker of premium products, lower production costs, and reduce CO_2 emissions from operations.

The financing package is covered by the Swedish National Debt Office (Riksgälden), the Italian Export Credit Agency (SACE) and the Nordic Investment Bank. Crédit Agricole CIB structured the transaction. The loans are structured under the Green Loan Principles, in line with SSAB's green and sustainability-linked finance framework.

"The great interest to participate in the financing underscores our partners' strong confidence in our transformation plan. We managed to secure favourable terms and the package gives us the financial flexibility we need for robust implementation of the transformation, in line with our financial targets," says Leena Craelius, CFO of SSAB.

The new steel mill will be able to use a flexible mix of fossil-free sponge iron, pig iron and recycled scrap. It will have a capacity of 2.5 million t/year with two electric arc furnaces, advanced ladle metallurgy and an integrated rolling mill. The investment also includes a cold rolling complex, advanced galvanizing, as well as continuous annealing. When the new mini-mill is completed, SSAB will close the current blast furnace-based production system in Luleå, which will largely remove the CO_2 emissions from existing operations.

SSAB

EUROPE – UNITED KINGDOM

Tata Steel signs contract for new pickle line at Port Talbot

Tata Steel has signed contracts with Clecim and ABB to supply the new pickling line for its Port Talbot site in Wales. The partnership marks a significant milestone in the company's journey to green steelmaking at Port Talbot.

As leader of the consortium, Clecim will design and supply mechanical and process equipment, while ABB, will supply essential equipment and expertise needed to power the site's new 1.8 million t/year pickle line. With the pre-engineering phase of the project completed, both companies are now moving forward with detailed engineering.

Tata Steel CEO Rajesh Nair said: "Our new and advanced pickle line will form a major part of our green steelmaking facility at Port Talbot, ensuring we can supply downstream businesses with the high-quality, low CO_2 steel products our customers are demanding."

Left to right: Stephen Winkley, ABB's UK sales manager; Rajesh Nair, CEO of Tata Steel UK; and Thomas Comte, CEO of Clecim, signing the contracts (Photo: Tata Steel)

"This is yet another positive step towards securing a bright future for steel in South Wales, following the improved deal for Port Talbot's transition we agreed with Tata Steel and the next phase of our steel plan," said UK Industry Minister Sarah Jones

Tata Steel / Clecim / ABB

GROWING DEMAND FOR CO_2-REDUCED STEEL

SSAB to shorten lead times for sustainably produced steel products

The Oxelösund mill in Sweden is the first in the green transition of SSAB's entire Nordic production system

> Since we will be using mostly recycled steel scrap as the raw material in Oxelösund, we will also be able to offer our customers "closed loop" solutions.
>
> *Thomas Hörnfeldt, VP Sustainable Business at SSAB*

SSAB will substitute the blast furnaces in Oxelösund, Sweden by an electric arc furnace and associated raw material handling. The aim is for the new production system to be up and running towards the end of 2026. The Oxelösund mill in southern Sweden is the first in the green transition of SSAB's entire Nordic production system.

"The change in Oxelösund is great news not only for the environment but also for our customers. An electric arc furnace means we will be able to deliver large volumes of SSAB Zero™ to our main European markets with much shorter lead times than today. SSAB Zero™ is made using recycled steel and fossil-free energy – resulting in steel with virtually zero fossil carbon emissions," explains Thomas Hörnfeldt, VP Sustainable Business at SSAB.

SSAB Zero™ already commercially available

The demand from our customers in various segments led SSAB to start making SSAB Zero™ back in 2023 at SSAB's Iowa plant in the United States. However, having an electric arc furnace in Oxelösund will enable SSAB to offer a much wider product portfolio than the company has to date. The conversion of Oxelösund is proceeding according to

The blast furnaces in Oxelösund will be replaced by a more flexible and cost-efficient meltshop that runs on electricity
(Picture: SSAB)

New meltshop currently under construction

One of the world's most powerful electric arc furnaces is being built for SSAB's strategic unit for green steel production in Oxelösund. SSAB has chosen SMS group for the construction of this new 190-ton EAF, which is set to be one of the largest installations in the world with an upper shell diameter of 9.3 meters.

Powered by a 280 MVA transformer, an installation such as this requires highly advanced technology to meet the limitations imposed by the grid authority in terms of flicker, power factor, and harmonic distortion. The modular multilevel converter (MMC) based direct feed system, supplied by GE Vernova's Power Conversion business, is an indirect power supply built on IEGT (injection-enhanced gate transistor) technology and designed specifically for EAFs, which seeks to ensure that the new EAF operates smoothly and efficiently without disrupting the grid.

This system uses advanced technology to maintain high levels of power quality and reliability. To achieve the desired EAF power quality contribution and grid performance requirements, the system includes two parallel converter lines installed at 300 and 400 meters from the EAF, directly connected to the 34 kV bus. This setup mitigates flicker, maintains very low harmonics, and ensures a unified power factor.

The new EAF in Oxelösund has its first heat scheduled for the fourth quarter of 2026 and will not only play a vital role in realizing SSAB's transition plans towards a fossil-free production, but also lower total CO_2 emissions in Sweden by three percent.

SMS group

plan and SSAB has obtained all the required permits and secured the availability of sufficient amounts of fossil-free electricity.

"We have customers in many market areas and various industries. One typical customer group consists of large, listed companies with clear sustainability targets and strategy. Other customers make it their niche to be at the very forefront of the green transition, doing everything as sustainably as possible. And some of our customers choose to label part of their product portfolio as low-emission products," Hörnfeldt explains.

"Since we will be using mostly recycled steel scrap as the raw material in Oxelösund, we will also be able to offer our customers "closed loop" solutions, where we utilize scrap from our customers' production as a raw material and deliver our high-quality steel back to the same customer again," Hörnfeldt adds.

SSAB has created a platform for zero emissions to support steel processing companies to drastically reduce greenhouse gas emissions as well as to support them in building an entirely fossil-free value chain, all the way to the end customer. Thus SSAB has already teamed up with several large companies, such as Volvo Group, Alfa-Laval, Mercedes-Benz, and Cargotec, to create joint projects.

Some facts about the transformation programme

Steelmaking globally remains a major source of CO_2 emissions – and time is running out. This is why SSAB is reinventing steelmaking by addressing the root cause of CO_2 emissions in the industry. Reinventing steelmaking means rethinking the whole production system.

SSAB has taken a policy decision to transform all production sites to fossil-free steel production. In June 2023, the company decided to invest in an electric arc furnace in Oxelösund. And in April 2024, the investment decision was made for the transformation of the Luleå site in Sweden. The third step planned is for the transformation of Raahe, Finland. The Raahe project timing will depend on SSAB's financing and execution capacity, as well as the learnings from the Luleå project.

SSAB

METALLURGICAL PLANT BUSINESS

SMS Group improved its operating result

SMS Group sees itself in a solid position, thanks to effective diversification. With earnings before taxes at 153 million euros, the 2024 fiscal year has seen a significant increase on the previous year. The service business is expected to be key to a further increase in profitability.

SMS group has continued its positive development in the 2024 fiscal year. While order intake dropped from 5.0 billion to 3.6 billion euros, it remains above the average over the last ten years. The exceptionally high order intake in the previous year (2023) was the result of a single major order from thyssenkrupp Steel. Sales, on the other hand, rose by around 600 million euros last year (+17.6 percent). Net liquidity also remained high.

"Despite geopolitical tensions and a challenging market environment, 2024 was a successful year for us. We benefit from our diversified position and the globally sustainable trends towards decarbonization and the circular economy. We are therefore confident that we will achieve our short and medium-term profitability targets," says Jochen Burg, CEO of SMS group.

> We benefit from our diversified position and the globally sustainable trends towards decarbonization and the circular economy.
>
> *Jochen Burg, CEO of SMS group*

Looking ahead with optimism (from left): Fabíola Fernandez, CFO, and Jochen Burg, CEO of SMS group (Picture: SMS group)

SMS significantly improved its earnings before taxes, which, at 153 million euros, were clearly above the previous year's figure of minus 20 million euros.

"We have cut our costs, closed non-profitable areas, and made the organization more efficient. This puts us in a good position," says Fabíola Fernandez, CFO of SMS group.

SMS has successfully strengthened its service business, encompassing the servicing, modernization, digitalization, and expansion of plant and equipment. One example of this is the twelve-year service agreement concluded with Swedish company Stegra, for which SMS is building the world's first steel plant to be operated entirely with green hydrogen. In addition, last year SMS group acquired IMS, a electrical engineering company for electrical and automation systems, which is based in the US and has around 130 employees. Going forward, the plan is to generate up to 50 percent of sales from the service business.

Driving the transformation of the steel industry worldwide

SMS is advancing the transformation of the steel industry with its range of innovative technologies. This autumn, SMS will undertake the construction of a direct reduction plant at thyssenkrupp Steel in Duisburg, Germany. In Sweden, Stegra will launch climate-neutral steel production using technology from SMS at the end of 2026. In addition, SMS has received an order from German Saarstahl for one of the world's most powerful AC electric arc

furnaces for CO_2-neutral steel production. "We are involved in many leading projects around the world aimed at decarbonizing the metals industry. This highlights the key role we play," says Jochen Burg.

India and the USA as growth markets. Against the backdrop of global uncertainty and increasing trade barriers, SMS's regional diversification is paying off. Sales and project handling activities are organized in the Americas, Europe, China, and APAC & MEA regions. In India, especially, SMS is expecting to see a growing number of orders in the years ahead. The company is currently investing in the construction of another production site in Ahmedabad in the Indian state of Gujarat. While Europe is leading the way in green steel projects, the focus in the Americas is on expanding the service business. In the USA alone, SMS operates numerous service workshops directly on the customers' premises.

Figures of SMS group's financial years 2023 and 2024

	2023	2024	Change
Order intake	5,044	3,62	-28.2%
Order backlog	6,938	6,336	-8.7%
Revenues	3,431	4,033	+17.6%
Earnings before taxes (EBT)	-20	153	173
Net liquidity	906	929	+2.5%
Investments / R&D	151	155	+2.7%
	in million Euro		

SMS firms up ESG strategy

SMS group has continued to firm up its environmental, social, and governance (ESG) strategy and embedded it in the organization. In 2023, a sustainability framework was developed in line with the UN Sustainable Development Goals and is being operationalized on an ongoing basis. The signing of the UN Global Compact in 2024 underlines the central importance of ESG in the way the group operates.

In the social sphere, binding targets on gender diversity have been set. "ESG is a strategic success factor for us. This also includes taking responsibility for our employees and promoting diversity and ethical corporate governance," adds Fabíola Fernandez. SMS technologies are helping to reduce customers' ecological footprint. At the same time, SMS is working intensively on improving its own ecological footprint and setting comprehensive CO_2-reduction targets. Concrete measures to achieve climate neutrality by 2030 have already been set out for the major locations. Since March 2025, SMS has also been a member of the Stiftung KlimaWirtschaft (German CEO Alliance for Climate and Economy), working actively with other sponsor companies to promote climate protection and sustainable economic practices.

Outlook

For the 2025 fiscal year, SMS expects a slightly higher order intake, with sales at the same level as the previous year. Earnings are expected to rise again, with a target earnings margin of around seven percent by 2027.

SMS group

PREMIER TECHNOLOGY EVENT FOR THE STEEL SECTOR IN NORTH AMERICA

AISTech 2025 – a gateway to innovation in steel technologies

AISTech 2025 was another record-breaking event. Spanning four days, it offered non-stop inspiration, education and collaboration, making it a truly unique experience. This year, Nashville set the stage – and what a show it was! With an impressive attendance, an enthusiastic audience and continuous innovation on display, this year's event once again demonstrated the strength of the steel industry.

Even before AISTech 2025 opened its doors in Nashville, TN, USA, on 5–8 May 2025, it was clear that the 2025 Iron & Steel Exposition was set to make history with its unprecedented level of participation. More than 700 exhibiting companies took over the Music City Center, filling its halls with innovations never before seen and showcasing the steel industry's latest cutting-edge solutions and technologies.

Of the more than 8,300 registered attendees, 2,352 participated in the conference. They seized the opportunity to connect with decision-makers, discover new business opportunities, and find innovative solutions to help them stay ahead in this rapidly evolving industry. After four days, they left with fresh insights and practical takeaways.

Golf classic. AISTech 2025 kicked off on Sunday 4 May with the AIST Foundation Golf Classic held at the beautiful Towhee Golf Club in Nashville! With a full roster of 144 players, the event brought together the iron and steel community for a day of connection, competition, and giving back. Thanks to the incredible support of everyone involved, AIST was able to raise US$25,000 toward scholarships that will directly impact deserving students.

Young professionals. This year marked the launch of the AISTech Young Professionals Development Program, introduced to educate and inspire confidence in early-career iron and steel professionals by way of two unique sessions. Own Your Path: Navigating Challenges, Embracing Growth and Finding Balance featured a panel of steel industry leaders who shared strategies for identifying opportunities, finding mentors, pursuing impactful projects, thriving in stretch roles and turning setbacks into stepping stones toward success. The second session, Networking — The Secret Sauce of Career Success was presented by Jamie Lewis Smith, chief executive officer and leadership psychologist, Pixel Leadership Group. Jamie led the attendees through an interactive workshop designed to help master the art of networking through hands-on activities and real-world techniques. These two sessions collectively empowered young professionals to take ownership of their professional growth.

Women in steel. The Women in Steel Development Program was implemented this year to empower and uplift women in

(Pictures: Markus Winterhalter, STEEL + TECHNOLOGY)

the steel industry through two unique sessions. From Groundwork to Greatness: Empowering Women in Steel Manufacturing featured a panel of trailblazing women who shared real-world strategies for overcoming challenges and building fulfilling careers in steel. The second session, Risk-Taking and Mistake-Making: How Fear Is Holding You Back From Innovating, educated participants on conquering fear and perfectionism to unlock innovation, with practical tools for embracing risk, learning from failure, and celebrating success. Together, these sessions inspired confidence, resilience and bold leadership in the traditionally male-dominated industry.

Conference highlights. On Monday 6 May, the conference opened with the Howe Memorial Lecture, delivered by Tadashi Furuhara of the Institute for Materials Research at Tohoku University in Sendai, Japan. The title of his lecture was: 'The Roles of Thermomechanical Processing in the Control of the Microstructure of High-Strength Steels'. He found that the importance of reheating processes in utilising microstructure inhomogeneities has recently been emphasised in the research of advanced high-strength steels. This lecture discussed the importance of such technology and its future prospects from the viewpoint of fundamental physical metallurgy.

On Tuesday 7 May, the President's Award Breakfast programme consisted of the presentation of the prestigious AIST Board of Directors Awards, including the AIST Steelmaker of the Year Award. This was followed by a keynote presentation entitled 'Tales from the Vault', given by Richard P. Teets Jr., co-founder and director of Steel Dynamics Inc.

Wednesday 8 May was the day of the Town Hall Forum dedicated to the topic: "Steel 2025 - shake, battle and roll". In his return to the White House, U.S. President Donald Trump is swiftly reorienting U.S. trade policy as he attempts to expand domestic manufacturing, particularly steel. The goal is defensible, but the means are controversial, and success is far from certain. During the Town Hall Forum, the panel of distinguished industry representatives discussed the new paradigm and shared their perspectives on steel policy, decarbonization, markets, workforce and more.

On Thursday 9 May attendees had the opportunity for plant tours to CMC Rebar Fabrication in Nashville or the Nissan Smyrna Assembly Plant.

Conclusion

AISTech 2025 was another record-breaking event. Spanning four days, it offered non-stop inspiration, education and collaboration, making it a truly unique experience. Nashville set the stage – and what a show it was – with an impressive attendance, an enthusiastic audience and continuous innovation on display.

AIST - Association for Iron and Steel Technology

Impressive figures of AISTech 2025

- 8,313 total attendees
- 2,352 attendees with full conference registration
- 133 student attendees
- 519 technical presentations
- 40 countries represented
- 691 assigned booths at the expo
- 722 exhibiting companies
- 12,221 m² (131,550 sqft) of booth space

OECD STEEL COMMITTEE

Co-operation needed to end the steel crisis

The OECD Steel Committee brought together 293 government and industry delegates from 41 major steel-producing economies on 31 March and 1 April 2025 to discuss the current steel crisis, its root causes, and the need to deepen international co-operation to improve prospects for their steel industries

Non-market policies and practices continue unabated in some economies where steel-making capacity is growing rapidly (Picture from the archives: worldsteel / Baotou)

The global steel industry crisis has deepened due to growing global steel excess capacity and resulting surge in exports of low-priced steel, threatening Steel Committee members' production. Chinese steel exports have more than doubled since 2020, surging to 118 million t in 2024 (more than total North American steel production and not far from that of the European Union last year), while the country's steel imports have plunged by almost 80%, to 8.7 million t. Steel prices and industry profitability continued to decline during 2024, hitting historically low and unsustainable levels in some regions. These negative developments have disrupted international markets resulting in trade actions across a growing number of countries that are likely to persist in the light of increasing excess capacity and sluggish market growth.

Non-market policies and practices. The root cause of the current crisis continues unabated in some economies where steel-making capacity is growing rapidly. The Committee reviewed its latest subsidy monitoring work, concluding that significant Chinese subsidisation in 2024, including grants, tax incentives, differentiated electricity pricing and below-market borrowing to steel companies in China and other countries, will worsen steel excess capacity problems and trigger further trade disruptions for Steel Committee members going forward. Without policy adjustments in countries that are fueling the excess capacity, or disincentives for them to export their surplus steel, global steel industry problems will intensify. The Committee called for accelerating work on the root causes of the global steel crisis and to feed the results into international efforts to develop solutions to the situation, including the Global Forum on Steel Excess Capacity.

Market outlook faces significant risks. Global steel demand is projected to grow only modestly in the medium term, impacted by the steep downturn in the Chinese construction sector. Global steel excess capacity is expected to continue rising, with 165 million t of new capacity additions projected for 2025-27, fuelled by cross-border investments by Chinese steel companies. Global excess capacity is expected to increase to 721 million t by 2027, from an estimated 602 million t in 2024, putting enormous pressures on the viability of even highly competitive steelmakers.

Decarbonisation efforts are facing headwinds. The ongoing excess capacity problem is reducing the steel industry's profitability and the capital available for investing in new technologies, hampering the industry's efforts to decarbonise. The Committee discussed recent initiatives and exchanged their national experiences on ways to reduce those headwinds, including ways to foster and expand markets for lower-carbon steel and seizing opportunities from rapid developments taking place in green iron markets.

Co-operation needed to end the crisis. Despite the increased market difficulties and heightened trade policy reactions thereto, participants welcomed the OECD Steel Committee as an essential multilateral platform for discussion and promoting mutual understanding. As key action points moving forward, the Steel Committee will, as soon as practicable, host a workshop during which members, experts, and other participants will discuss best practices and evidence related to tools and policies of relevance on how countries can urgently address challenges for the steel industry. This would include assessing why certain trade measures are being taken, and explore where solutions to common problems can be found amongst the Committee's members. The outcome of discussions could feed into the work of the Global Forum on Steel Excess Capacity and other relevant fora.

Ulf Zumkley, Chair of the OECD Steel Committee

THE AMERICAS

AM/NS Calvert to upgrade automation of hot strip mill

AM/NS Calvert has commissioned SMS group to carry out a major upgrade of the automation control system at its high-capacity hot strip mill in Calvert, Alabama. Scheduled to commence in phases from 2025 to 2027, SMS group's automation solution will elevate the mill to a new technological level, providing modern and reliable high-speed control.

The aim of the project is to bring the automation technology up to the state of the art and increase the operational efficiency of the hot strip mill. As well as installing advanced X-Pact® embedded controllers, the core of this upgrade is the X-Pact® ProBAS software platform, which ensures the plant's high-speed control capabilities. The integration of an EtherCAT real-time Ethernet network for high-speed technological sensors and a Profibus remote I/O system for standard sensors ensures robust and reliable real-time data communication.

This technological advancement provides numerous benefits, including an enhanced graphical programming environment, high-speed control, and improved diagnostic capabilities, which are crucial for maintaining seamless plant operations. The new automation system guarantees digital readiness, which is essential for getting production units and automation systems ready for digitalization with a minimum of effort.

The project continues a longstanding collaboration between SMS and AM/NS Calvert. Over the years, SMS has played a vital role in various upgrade activities at the plant, ensuring that operations remain efficient and aligned with the latest technological advancements. AM/NS Calvert's decision to partner with SMS underscores the latter's expertise in delivering advanced technological solutions tailored to metallurgical plant needs.

Matt Korzi, Vice President of Automation, Digital and Service Solutions at SMS group Inc., stated, "As a lifecycle partner of AM/NS, we are committed to ensure a reliable automation solution that not only addresses immediate technological needs of the hot strip mill but also sets a foundation for future operational improvements." AM/NS Calvert's seven-stand hot strip mill, with an annual capacity of 5.3 million t, is a key player in the USA, producing flat carbon steel to the highest specifications.

SMS group

Nucor California Steel orders continuous galvanizing line

Nucor Corporation has awarded Fives a contract for a continuous galvanizing line to be installed at California Steel Industries, a joint venture between Nucor and JFE Steel.

California Steel Industries is investing in a new line at its Fontana facility to meet the growing demand for high-quality, high-value-added products to support the strong need for construction materials in the Western United States. "The California Steel team selected Fives for this project based on the development of confidence between our two teams as well as the past Nucor collaboration with Fives in the two high-end galvanizing lines in our West Virginia facility", says Drew Linder, General Manager of California Steel Industries. Guillaume Mehlman, President of Steel & Glass Division at Fives, adds: "This project is a testament to the strength and resilience of our ongoing partnership with Nucor."

Fives

Electra raises three-digit million amount in funding round for clean iron plant

Electra's high-purity iron technology drives investment from across the value chain as the company prepares to build its first demonstration plant in 2025. A Series B funding round has recently raised US$ 186 million, bringing Electra's total funding to US$ 214 million.

The recent funding round features investors including financial investors such as Capricorn Investment Group and Temasek Holdings, strategic investor BHP Ventures, global iron ore suppliers Rio Tinto and Roy Hill, electric arc furnace steelmakers Nucor and Yamato Kogyo, and organizations including Interfer Edelstahl Group and Toyota Tsusho Corporation, who are committed to reducing the environmental impact of iron and steel in their supply chains.

Electra's modular, patented process uses the most flexible and cost-effective iron ores and intermittent renewable energy as inputs while producing the highest-value 99% pure iron. Strategic partnerships spanning mining, steelmaking, and consumer sectors reflect confidence in Electra's approach to producing clean iron. Last year, Electra signed several MoU agreements with leading companies, including ZF Group and Interfer Edelstahl, to supply high-purity iron for steel and battery applications.

The capital raised in the Series B funding round will support the construction of Electra's demonstration plant in Colorado, starting later this year. The demonstration plant will produce Electra's clean iron for partner testing and qualification and lay the foundation for a commercial plant by the end of the decade.

Electra

ASIA – BAHRAIN

Bahrain Steel adopts energy-centred maintenance solution

Bahrain Steel, producer of high-quality iron-ore pellets, is implementing an energy-centred predictive maintenance solution from Nanoprecise to tackle energy waste and optimize maintenance costs.

Bahrain Steel has embarked on a digital transformation journey for its operations to meet evolving business and market demands. With prior experience in both wireless and wired condition monitoring technologies, Bahrain Steel has decided to adopt a transformative technology that aligns with its goal to sustain its leadership in manufacturing efficiency. The AI-powered energy-centred predictive maintenance solution from Nanoprecise Sci Corp combines IoT sensor technology with artificial intelligence and machine learning to improve efficiency of machines and contribute to sustainability.

Commenting on this strategic partnership, Bahrain Steel's General Manager of Operations, Mr. P.M. Edwin, said: "Integrating Nanoprecise's energy-focused maintenance has been a key milestone in our digital journey at Bahrain Steel. Their dashboard will give our teams clear, real-time insights into energy use and quickly identify anomalies related to machine health. By proactively tackling these machine health issues and energy inefficiencies, we're strengthening our commitment to operational excellence and sustainability."

Nanoprecise

ASIA – MALAYSIA

Oryx Stainless opens new facility in Malaysia

Oryx Stainless Group, suppliers of recycled stainless steel raw materials headquartered in the Netherlands, has officially opened its latest facility in Johor, Malaysia.

Opening ceremony for the new stainless steel recycling facility (Photo: Oryx Stainless)

Oryx specialises in creating precise blends of recycled raw materials for various stainless steels, addressing the need for over 150 different alloys. Their process involves analysing, storing, and producing high-quality recycled materials to meet specific metallurgical compositions. This ensures consistent quality and reduces the use of high carbon footprint primary raw materials like ferronickel, ferrochrome, and ferromolybdenum. "Malaysia is key to our strategy of bringing high-quality, low carbon footprint stainless steel raw materials closer to the production centres of Asia," said Mr. Tobias Kämmer, CEO of Oryx Stainless Holding.

As phase 1 begins, the facility will process 150,000 t/year of stainless steel, marking a significant step forward in regional resource conservation and sustainable manufacturing. New stainless steel – with no loss in quality – can be produced from up to 90% of the materials processed on the new site. The prerequisite is smart recycling as practiced by Oryx Stainless. Local talent development stands central to the facility's mission. Malaysian employees have already completed advanced training in Thailand, learning to operate specialised equipment including Malaysia's first special Sennebogen material handlers.

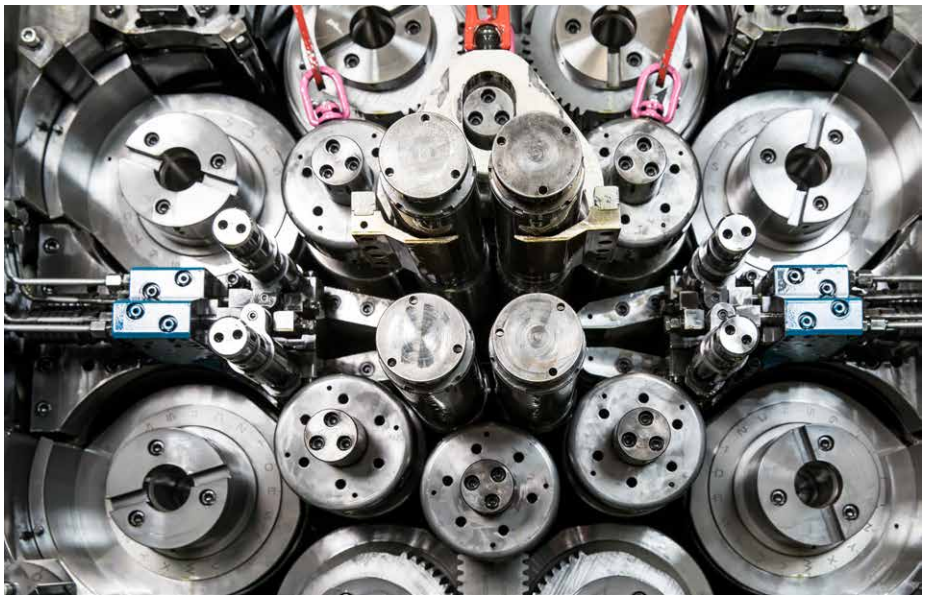
Oryx Stainless

ASIA – CHINA

Shagang orders 20-high cold rolling mill

Shagang has placed an order with Fives for the supply of a cold rolling mill to produce electrical steel. The new mill is set to produce 80,000 t/year of high-grade non-grain-oriented electrical steel.

Fives DMS, a Fives subsidiary specializing in mechanical equipment and cold rolling mills, will supply a DMS 20Hi EcoMill featuring best available technology, including increased rolling speed and strip tension, advanced roll gap lubrication for higher product quality, enhanced fume extraction, better strip wiping efficiency and an innovative concept for flatness actuators. The new mill will be the second cold rolling mill Fives supplied to Shagang in the last four years. It will enable the strip to be rolled down to 0.1 mm over the full width of 1,350 mm, while maintaining excellent surface quality and flatness. These steel grades are mainly dedicated to high-performance electrical motors that require high-quality electrical steel.



Shagang has ordered a 20-high cold rolling mill of the latest design (Photo: Fives)

Fives

Angang upgrades plate mill automation

Angang has awarded the final acceptance certificate (FAC) to Primetals Technologies for a comprehensive automation upgrade at its 3.8-m plate mill in Bayuquan, Liaoning province.

Primetals Technologies has supplied and implemented full Level 1 and 2 automation systems as well as a process camera system and a new human-machine interface (HMI). The modernization enables Angang to produce new types of steel, such as the high-performance X60MO subsea pipeline special steel, known for its stringent shape and surface quality requirements. Primetals Technologies' newly implemented advanced process models enable rolling with increased flatness and profile quality, as well as the production of thinner plates down to a thickness of 5 mm. Following the successful modernization, Angang is planning a further expansion of its product portfolio with new steel grades, thereby increasing the proportion of high value-added products. With a capacity of 1.4 million t/year, Angang's 3.8-m plate mill produces high-quality medium-thick plates and special steel products. The plate thicknesses vary from 5 to 50 mm, and widths from 1,450 to 3,600 mm.

Complete Level 1 and 2 automation systems have been implemented at Angang's 3.8-m plate mill (Photo: Primetals Technologies)

Primetals Technologies

ASIA – VIETNAM

Hoa Phat to build new casting and rolling line for long products

Hoa Phat has awarded Primetals Technologies a contract for the supply and implementation of a long product caster and rolling line. The rolling line is expected to commence operations in the third quarter of 2026, and the casting line in the fourth quarter.

Contract signing for the new casting and rolling line at Hoa Phat (Photo: Primetals Technologies)

Primetals Technologies will design, supply, and install a billet/bloom/beam blank casting machine. The one million t/year caster will feature a wide range of advanced solutions, including DynaGap soft reduction, which ensures superior internal strand quality. The casting area includes a standby solution for large-section-size casting, enabling the production of blooms and beam blanks for steel profiles up to 800 mm wide, ideal for the structural steel industry. A comprehensive Level 1 and 2 automation system will enable precise control of and influence over the entire casting process.

Primetals Technologies will also provide Hoa Phat with a comprehensive scope of high-quality wire rod rolling line equipment. The technology comprises a complete state-of-the-art long rolling processing line, including 18 no-housing stands and mill shears, a 10-stand eDrive no-twist mill, and a Morgan reducing/sizing mill with integrated single-family rolling to ensure high product quality. Additional production advantages include optimal coil packages enabled by metallurgical in-line heat treatment, Morgan water boxes, and a Morgan Stelmor controlled cooling conveyor.

Primetals Technologies

ASIA – INDIA

Jindal places order for hot-strip mill modernization

Jindal United Steel Limited (JUSL), a part of Jindal Stainless, has awarded Primetals Technologies a contract for the comprehensive upgrade of its hot-strip mill at the Jajpur facility in Odisha. The upgrading project is scheduled for completion by December 2026.

Representatives from Jindal United Steel and Primetals Technologies on the occasion of contract signing (Photo: Primetals Technologies)

The hot-strip mill, originally supplied by Primetals Technologies in 2012, produces plates up to 1,650 mm in width with thicknesses ranging from 11 to 80 mm, as well as strip up to 1,650 mm in width and thicknesses from 1.5 to 12.7 mm. As part of the upgrade, Primetals Technologies will extend the mill's heavy plate processing area by modernizing cooling bed No. 1, installing a new heavy plate shear with a hydraulic pump station, and adding cooling bed No. 2. The scope also includes a new coil box, an upgraded work roll cooling system across all seven finishing mill stands, and a new automation system for the cooling beds. Additionally, the upgrade will incorporate a Level 1 automation system as well as Level 2 automation system adaptations, advanced measurement equipment, and a human-machine interface system for heavy plate handling.

To accommodate increased productivity and prevent bottlenecks, the mill's plate production area will be expanded. The installation of a heavy-plate shear, designed to reduce cutting times, along with the new cooling bed, will support higher output. The new coil box is designed to handle evolving market requirements, including a wider range of steel grades and products.

The modernization will also focus on improving strip quality. The work roll cooling system in the finishing mill will be upgraded to ensure better distribution of cooling water while maintaining current consumption levels. This enhancement is expected to improve surface quality of the rolled materials.

Primetals Technologies

ASIA – INDIA

ArcelorMittal's new renewables project starts supplying steel plant with clean electricity

ArcelorMittal's largest renewable energy venture has recently started providing clean electricity to AM/NS India, ArcelorMittal's 60/40 Indian steelmaking joint venture with Nippon Steel.

The 1 GW solar and wind project located in Andhra Pradesh, developed, constructed and commissioned by AM Green Energy, a wholly owned ArcelorMittal subsidiary, is expected to reduce AM/NS India's carbon emissions by 1.5 million t/year. Now fully commissioned and running at nameplate capacity, approximately 1.5 million solar panels and 91 wind turbines will generate 2.5 billion kWh of power annually. The renewables project has been developed as a hybrid project, integrating the 1 GW of solar and wind capacity with a third-party hydro pumped storage solution, ensuring the project will ultimately deliver at least 250 MW of round-the-clock power - critical for continuous energy production. It will provide over 20% of the existing energy requirements at AM/NS India's steel plant in Hazira, Gujarat.

Commenting, Aditya Mittal, CEO, ArcelorMittal, said: "Investing in renewable energy generation is an exciting new business area for ArcelorMittal. It provides cost effective clean energy security for our steelmaking operations and supports our decarbonisation objectives." In total, ArcelorMittal has 2.3 GW of renewable energy projects underway, in India, Brazil and Argentina.

ArcelorMittal

ADVERTISERS' INDEX

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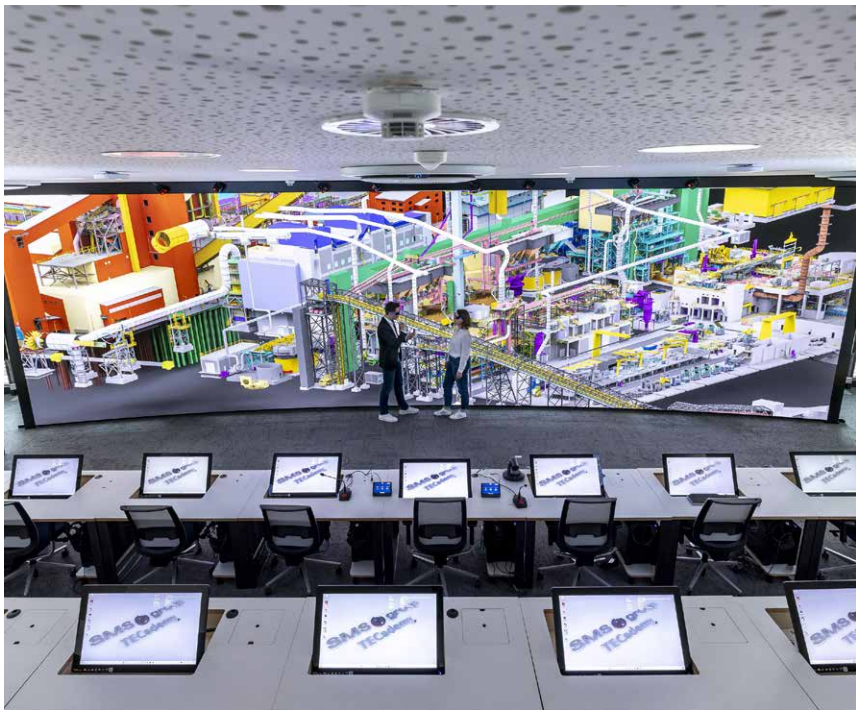


SMS group has opened a state-of-the-art digital workshop at its Mönchengladbach site, which not only offers plant operators practical learning experiences with the latest technical equipment but also opens up new possibilities for early fault detection and efficient project management. Using stereoscopic displays, participants can explore entire systems on the multi-tracking LED powerwall, which has a size of approximately three by twelve meters. This innovative setup enables detailed 3D animations of maintenance tasks as well as access to component documentation. This revolutionizes the efficiency and effectiveness of SMS TECademy sales support and training.

RAW MATERIALS

British Steel trials greener iron ore pellets in blast furnace test

British Steel and Binding Solutions Limited successfully completed a 250-tonne industrial trial of Cold Agglomerated Pellets in the Queen Bess blast furnace at Scunthorpe, UK

Binding Solutions Limited (BSL), a fast-growing UK technology company, has developed a patented and proprietary process to produce blast furnace pellets with significantly reduced carbon emissions relative to standard pellets and sinter, contributing to greener steel production at scale [1].

Binding Solution's cold agglomeration technology uses proprietary binders and agglomeration processes to produce Cold Agglomerated Pellets (CAPs) without using high temperatures – reducing process complexity, lowering capital requirements, and significantly cutting emissions of carbon dioxide, nitrogen oxides, and sulphur oxides by replacing traditional technologies (induration and sintering) in ironmaking. The technology can also be used to convert milled low-grade iron ore ('fines') to a form that can be physically charged to the blast furnace.

Using cold-bonded pellets has the potential to significiantly reduce CO_2 emissions in ironmaking (Picture from the archives: Binding Solutions Limited)

Traditionally and widely common, one of the raw materials required to produce iron is Indurated pellets. They are created by mixing iron ore fines with additives, shaping them into ovals/balls with a pelletiser and then hardening them by heating to around 1,300°C to create pellets. In comparison, the Cold Agglomerated Pellets are cured at below 150 degrees Celsius, driving reductions of up to 80% in energy usage at the production stage and also driving down carbon dioxide emissions by up to 70%.

The trial proved the operational effectiveness of BSL's Cold Agglomerated Pellets in a blast furnace, with blast furnace stability maintained whilst continuing to meet the plant's required performance parameters. BSL's Cold Agglomerated Pellets can therefore replace up to 8% of indurated pellets in a blast furnace, offering a viable and near term opportunity for the steel industry to reduce emissions from primary steel making. BSL and British Steel will publish more detailed results of the test soon.

Commercial CAP production facilities on the horizon

The successful results of this trial will enable investment in BSL's planned commercial Cold Agglomerated Pellets production facilities. BSL is currently reviewing locations in the UK, Europe and Canada for its first production plant in cooperation with a range of commercial and government partners.

Jon Campbell, Health, Safety and Environment Director for British Steel said: "We are delighted to have worked with BSL to enable this first large scale trial of BSL's innovative, low emission Cold Agglomerated Pellets. The successful trial clearly demonstrates British Steel's commitment to exploring new ways of reducing the carbon footprint of our ironmaking operations. We are excited by the results and look forward to working with BSL to review options for using their technology as and when we are able."

Jon Stewart, CEO of Binding Solutions also said: "After a decade of development, the successful trial with British Steel is a huge milestone in BSL's development. This collaboration validates the potential of our Cold Agglomerated Pellets and reinforces our confidence in scaling our technology to commercial production."

Russell Kaschula, COO of Binding Solutions said: "The tests confirm our technology's effectiveness, with no impact on the blast furnace, having closely monitored all parameters to ensure a successful result in collaboration with British Steel. It has been a pleasure to have worked alongside the Scunthorpe production and technical team and we're thrilled with the results and proud to have proven our pellets as a viable replacement for indurated pellets."

Binding Solutions has spent more than a decade developing its patented and proprietary process to convert primary iron ore into high value pellets. Its dedicated Technology Centre located on Teesside on the Materials Processing Institute's campus is a world-leading European research facility. Its Technology Centre includes a sophisticated pilot plant, where it is working with leading iron ore miners and steel producers to test various iron ore types and refine its patented low-energy, cold binding process.

> The tests confirm the effectiveness of the technology, with no impact on the blast furnace, having closely monitored all parameters to ensure a successful result in collaboration with British Steel.
>
> *Russell Kaschula, COO of Binding Solutions Limited*

Feasibility study of a cold pelletising plant at the Port of Rotterdam

In May this year, HES International B.V. ("HES") and Binding Solutions Limited signed a Memorandum of Understanding to assess the potential for a state-of-the-art iron ore cold pelletising plant at HES's HBTR terminal in Rotterdam, the Netherlands. HES is a leading European provider of bulk handling services for industrial customers across the continent. The HBTR terminal is the largest dry bulk terminal in Europe.

The parties' aim is that the project at HBTR will produce high value iron ore CAPs. The envisaged first phase of the project involves the construction of a 400,000 tons per year capacity plant, with future expansions envisioned to increase capacity to between 1 and 3 million metric tons per year.

The pelletising plant aligns with HES's long-term vision to solidify HBTR's position as an important hub in the European steel supply chain, enhancing its capacity to support sustainable steel production and logistics.

British Steel / Binding Solutions Limited

References

[1] Cold-bonded iron ore pellets. In: STEEL + TECHNOLOGY, 2023-3, pp. 36-37

IRONMAKING

Electric process gas heater for commercial use in DRI production

Alleima's Kanthal division and Danieli will supply a pilot-scale electric process gas heater to be installed at Emsteel's Direct Reduced Iron (DRI) plant in Abu Dhabi, UAE, to electrify a part of their existing heating system. It will be the first electric process gas heater for DRI that Kanthal supplies for commercial use – an important step in the ongoing development project.

Electric process gas heater (Picture from the archives: Alleima)

Emsteel is UAE's largest steel and building materials manufacturer. The Emsteel plant in Abu Dhabi produces quality long products – heavy sections, bars and wire rods – and features an Energiron DRI plant. By installing a 1-megawatt size electric process gas heater, supplied by Kanthal and Danieli, the company will take another step towards making this low-emission plant even more environmentally friendly. Delivery is planned for the beginning of 2026.

The heater is based on Prothal® DH technology. Prothal® DH has been developed and tested by Kanthal and is now being prepared for commercialization together with the strategic partner Danieli. When fully scaled up, this technology has the potential to completely remove the CO_2 emissions from the heating process while enhancing energy efficiency.

"This pilot is an important step in the development and industrialization of full-scale electric process gas heaters for DRI and other ironmaking applications. We're proud to see that the technology is now being implemented in an end-user production setting, which will enable further opportunities for future sales and commercialization," says Robert Stål, President of the Kanthal division.

Kanthal and Danieli signed a strategic partnership agreement to develop and industrialize full-scale electric process gas heaters for DRI and other ironmaking applications in 2024. The heating solution is being developed for hydrogen, natural gas and combinations, thereby enabling retrofitting of existing DRI plants. By installing this technology in Energiron hydrogen-ready DRI plants, fully emission-free DRI production can be achieved. Even for natural gas based DRI plants, a more than 30% reduction of CO_2 emissions will be achieved when electrifying the heating system.

> We're proud to see that the technology is now being implemented in an end-user production setting
>
> *Robert Stål, President of the Alleima's Kanthal division*

Alleima / Danieli

Reference

[1] Electric process gas heaters. In: STEEL + TECHNOLOGY 3/2024 (October), p. 44

RAW MATERIALS

Global nickel production monitoring

Earth-i, a leading provider of advanced geospatial data analytics, has launched the next release of its SAVANT platform in early April, offering enhanced insights into global nickel production. This second major release of Nickel significantly bolsters the platform's capabilities, enabling stakeholders to monitor 95% of the world's nickel output with high accuracy in near real time.

Nickel West fully integrated mine in Kalgoorlie, Western Australia (Picture: BHP Group)

Analysts forecast the global nickel mining market to reach approximately US$100 billion by 2034, driven by the escalating adoption of electric vehicles and energy storage solutions. To monitor global nickel production SAVANT uses cutting-edge satellite technology to detect activity signals from nickel smelting plants worldwide. By analysing these activity signatures, the platform delivers data on smelting operations, enabling accurate production level estimates without the need to wait for and rely on self-reported figures from operators and industry reports. This is especially crucial in the nickel industry, where the build out of privately owned capacity since the beginning of the decade has meant that production figures are in many cases never reported. This scientific approach ensures objective, unbiased and near real-time intelligence for users.

Beyond nickel, SAVANT continues to monitor global copper production, cementing its role as a high-value tool for investors, physical traders, and smelter operators aiming to track competitor activities and anticipate global supply fluctuations.

Nickel plays a pivotal role in the global economy. Approximately 65% of primary nickel consumption is attributed to the stainless-steel industry, confirming its importance in producing durable and corrosion-resistant materials. In addition, the electric vehicle (EV) market relies heavily on nickel for battery production, with demand projected to increase substantially in the coming years.

The nickel industry has witnessed significant shifts recently. Notably, Indonesia has emerged as a dominant force, now accounting for 61% of the global refined nickel supply. This surge results from strategic export bans and substantial investments in processing facilities. Conversely, other regions have faced challenges. In Australia, the nickel sector has seen the closure of several operations. The competitive pricing from Indonesian producers, backed by lower production costs and technological advancements, has intensified these pressures.

The enhanced SAVANT platform arrives at a critical juncture for the nickel industry. By offering detailed monitoring of pig iron, ferronickel, and pure cathode nickel production, users can make informed decisions on this fast-moving, but opaque, market.

About Earth-i. Earth-i is a geospatial intelligence company providing advanced analytics using automated interpretation of a range of geospatial Earth Observation data sources including colour imagery, colour video, infra-red and radar from a range of sources including satellite, drone, aerial and ground-based sensors. This data is fused with additional data sources to extract factual understanding and generate predictive insights across a range of markets such as commodities, supply chain, agriculture, infrastructure and defence.

About SAVANT. Earth-i's SAVANT platform provides indicators of smelter activities around the globe, in an easy-to-understand format, covering multiple metals and minerals. Three types of indices are provided: smelter activity levels, production levels and periods of shutdown or inactivity. With up-to-date monitoring capability, SAVANT provides data on a near real-time basis for up to 95% of global smelting capacity, including China, about individual smelters, regions, countries and companies.

Earth-i

RAW MATERIALS

CO_2-free produced nickel as a resource for sustainable stainless steel and superalloys

The production of nickel, a key material in the manufacture of stainless steel and superalloys, is responsible for a significant carbon footprint. Scientists at the Max Planck Institute for Sustainable Materials have developed a carbon-free and also energy-saving technology to extract nickel from ore.

Ubaid Manzoor using an electric arc furnace to reduce low-grade nickel ores with hydrogen plasma
(Picture: Max-Planck-Institut für Nachhaltige Materialien GmbH)

Nickel is an essential raw material for batteries, but also for stainless steel and superalloys. The demand for nickel is expected to double by 2040 due to the increasing electrification of infrastructure and transport systems, as well as the batteries needed for them.

Yet, producing one ton of nickel currently emits around 20 tons of CO_2. As for batteries, there are raising concerns about shifting the environmental burden from transportation to nickel metallurgy. Also, due to the high nickel content, this alloying metal currently contributes significantly to scope 3 emissions in the production of stainless steel and consumer products made from it.

Researchers at the Max Planck Institute for Sustainable Materials (MPI-SusMat) have now developed a carbon-free, energy-saving method for nickel extraction. Their approach also enables the use of low-grade nickel ores, which have been overlooked due to the complexity of conventional extraction processes. The researchers from MPI-SusMat now published their results in the journal Nature [1].

One single step to green nickel

"If we continue producing nickel in the conventional way and use it for electrification, we are just shifting the problem rather than solving it," explains Ubaid Manzoor, PhD researcher at MPI-SusMat and first author of the publication. Manzoor and his colleagues have developed a new method to extract nickel from ores in a single step, using hydrogen plasma instead of carbon-based processes. If the CO_2 emissions generated during the mining of nickel ore and its transport are con-

> By using hydrogen plasma and controlling the thermodynamic processes inside the EAF, we are able to break down the complex structure of the minerals in low-grade nickel ores into simpler ionic species – even without using catalysts.
>
> *Prof. Isnaldi Souza Filho, Max-Planck-Institut für Nachhaltige Materialien GmbH*

sidered, the new process reduces CO_2 emissions by 84%. In addition, the process is up to 18% more energy-efficient when renewable electricity and green hydrogen are used, as the repeated heating and cooling of the ore, which is common in conventional processes, is avoided.

Traditionally, industry relies on high-grade ores, as extracting nickel from lower-grade ores is far more complex due to their chemically intricate composition. Unlike iron, which can be reduced in a single step by removing oxygen, nickel in low-grade ores is chemically bound within complex magnesium silicates or iron oxides. Conventional extraction involves multiple stages like calcination, smelting, reduction, and refining, which are energy-intensive and have a large carbon footprint. A breakthrough of this method is its ability to process low-grade nickel ores (which account for 60% of total nickel reserves) in a single reactor furnace, where smelting, reduction, and refining occur simultaneously, producing a refined ferronickel alloy directly.

"By using hydrogen plasma and controlling the thermodynamic processes inside the electric arc furnace, we are able to break down the complex structure of the minerals in low-grade nickel ores into simpler ionic species – even without using catalysts", explains Professor Isnaldi Souza Filho, head of the group "Sustainable Synthesis of Materials" at MPI-SusMat and corresponding author of the publication.

Towards industrial application

The new method not only reduces emissions and energy consumption, but also broadens the spectrum of usable nickel ores, making extraction more cost-effective and sustainable. The next step for the Max Planck team is scaling up the process for industrial applications. "The reduction of nickel ores into simpler ionic species occurs only at the reaction interface, not throughout the entire melt. In an upscaled system, it is crucial to ensure that unreduced melt continuously reaches the reaction interface," explains Manzoor. "This can be achieved by implementing short arcs with high currents, integrating an external electromagnetic stirring device beneath the furnace, or employing gas injection." These are well-established industrial techniques, making integration into existing processes feasible.

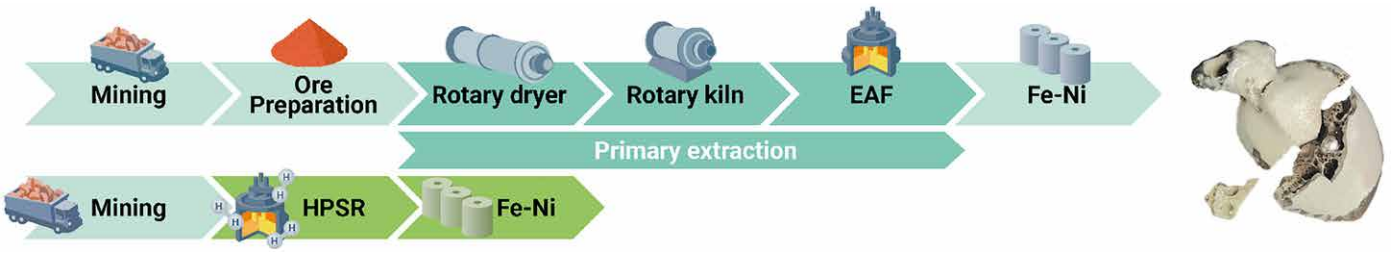
The green nickel production route opens the door to more sustainable value chains. The reduced nickel alloy can be used directly in stainless steel production and, with additional refinement, as a material for battery electrodes. Additionally, the slag produced during the reduction process can serve as a valuable resource for the construction industry, including brick and cement production. The same process can also be applied for cobalt, which is used in electric vehicles and energy storage systems.

The research was funded by an Advanced Grant of the European Research Council.

Max-Planck-Institut für Nachhaltige Materialien GmbH

Reference

[1] U. Manzoor, L. Mujica Roncery, D. Raabe, I.R. Souza Filho: Sustainable nickel enabled by hydrogen-based reduction. In: Nature (2025), DOI: 10.1038/s41586-025-08901-7

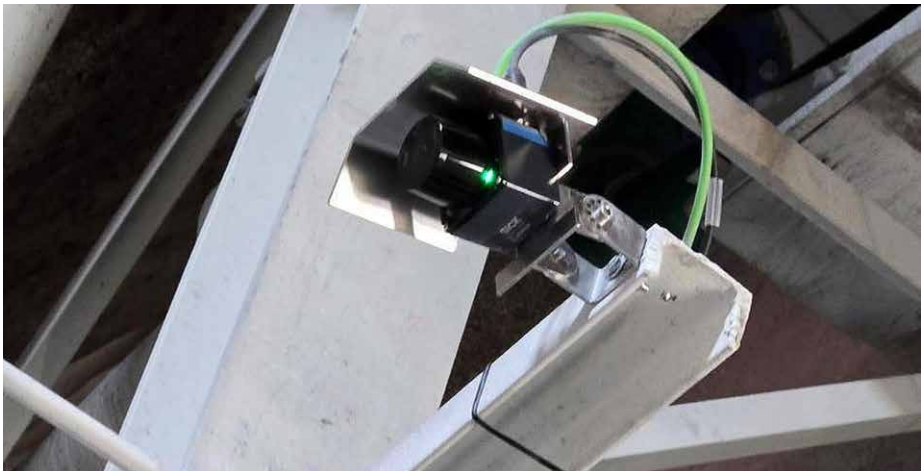


While conventional production (above) involves multiple stages from ore preparation to drying steps, the newly developed method (below) relies solely on the reactions taking place during the hydrogen plasma smelting reduction (HPSR)
(Picture: Max-Planck-Institut für Nachhaltige Materialien GmbH)

RAW MATERIALS – AUTOMATION

Material flow monitoring along the entire process chain

In modern bulk material processes, precise monitoring of material flow is essential – from extraction and processing to logistics. The OWL EYE® system, developed by Sachtleben Technology, is a modular platform offering a comprehensive solution for non-contact volume and mass flow measurement across the entire process chain – from stockpiles to conveyor belts, from mobile machines to silos. The system combines precise sensor technology with intelligent data analysis and condition monitoring.



Permanently installed LiDAR or 3D sensors periodically record stockpile growth or reduction (Picture: Sachtleben Technology)

Mining and bulk material logistics revolve around the movement of mass – the economic value lies in the material that must be transported, stored, and processed. However, extraction, processing, and logistics rarely operate in perfect synchrony. Extraction volumes fluctuate, plant capacities are limited, and transport is subject to external factors. The result: temporary stockpile buildup, material bottlenecks, or unused storage capacity.

A precise and continuous monitoring of material quantities provides the necessary transparency. It allows operators to identify bottlenecks early, better coordinate processes, and make data-based decisions – whether it's planning loader usage, optimizing transport routes, or evaluating plant efficiency. Ultimately, accurate knowledge of the current material flow is essential to ensure economical, reliable, and well-controlled operations.

One System – multiple measurement points

OWL EYE® is not a single-purpose device, but a scalable and integrative system designed to monitor mass flows at various points within an operation. The platform includes several specialized modules:

Static stockpile volume measurement. Permanently installed LiDAR or 3D sensors periodically record stockpile growth or reduction. Data is processed into 3D models to document material movement and provide reliable inventory levels.

Mobile stockpile scanning. Specialized units mounted on discharge conveyors, rotary stackers, or bucket wheel excavators continuously measure material buildup at the discharge point. The system helps monitor remaining capacity on the stockpile and determine when a wheel loader is needed to redistribute the accumulated material – improving storage space utilization and internal logistics.

Wheel loader mapping. 3D LiDAR units mounted on wheel loaders scan the environment during normal driving operations. A dynamic 3D representation of the stockpile is created without interrupting regular workflows – ideal for progress tracking, stockpile management, or documentation.

Bin and hopper monitoring. OWL EYE® can also be used for volume measurement in closed or semi-open containers such as feed hoppers, crushers, silos, or chutes. The system continuously detects fill levels and volume changes, even in dusty or low-light conditions.

Conveyor belt volume flow measurement. A core component of the platform is the non-contact volume flow module for conveyor belts. A 2D LiDAR sensor,

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mounted above the belt, continuously scans the cross-sectional profile of the material. In combination with belt speed, the throughput is calculated in m³/h or t/h, with a typical deviation of ±1%. In addition to volume measurement, the system also detects material shifts, belt misalignment, large foreign objects, and anomalies in the loading profile, making it a vital tool for automated process control.

Advanced conveyor diagnostics: integrated condition monitoring

Beyond conventional throughput measurement, OWL EYE® provides real-time conveyor diagnostics. By analyzing the material profile, the system can detect deviations and potential damage early on. These include:

- belt misalignment due to uneven loading or roller defects,
- asymmetrical or unstable loading, indicated by shifting mass centres,
- large foreign objects (detection of big rocks) that may damage mechanical parts or downstream processes,
- profile anomalies that indicate material buildup, belt damage, or upstream feed issues.

These events are recorded continuously and evaluated against predefined thresholds. This allows for targeted maintenance before failures occur, increasing operational reliability and minimizing downtime.

System integration and data access

Designed for industrial continuous operation, OWL EYE® integrates seamlessly into existing automation and control systems using standard protocols:

- REST API for cloud or software connectivity,
- OPC UA for SCADA and MES system integration,
- analogue outputs for conventional PLCs.

A browser-based dashboard displays all operational data – accessible from any location or device. Key features include:

- real-time throughput in m³/h or t/h,
- historical data with 2D cross-sectional visualization,
- real-time alerts when limits are exceeded,
- customizable data export for reports and further analysis.

An optional automatic air-cleaning unit ensures sensor reliability even in highly dusty environments.

Mounted above the conveyor belt, the LiDAR sensor continuously scans the cross-sectional profile of the material (Picture: Sachtleben Technology)

Adaptable to all types of bulk materials

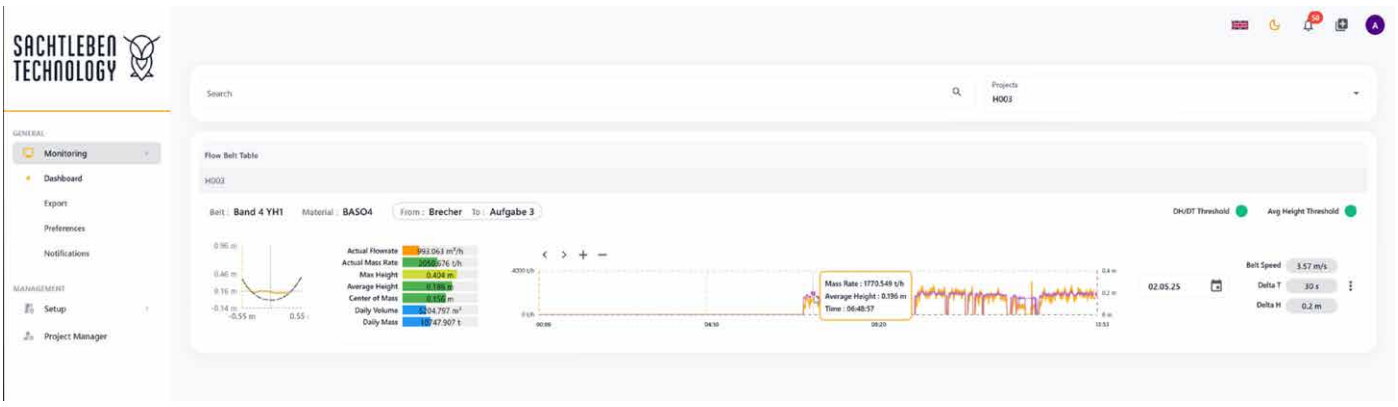
OWL EYE® is material-agnostic and suitable for a wide range of bulk materials – regardless of density, particle size, or moisture content. Practical applications include:

- wood products: wood chips, pellets, sawdust,
- industrial minerals: silica sand, limestone, gypsum, kaolin,
- ores: iron ore, copper ore, bauxite,
- aggregates: gravel, crushed stone, sand, clay,
- chemical materials: fertilizers, plastic granulates, powders,
- organic materials: beet pulp, wheat, maize.

Conclusion

OWL EYE® delivers a robust and flexible solution for volume flow measurement and condition monitoring – from extraction sites to final logistics. The combination of precise sensor technology, modular system architecture, and full IT integration provides operations with real-time transparency, early fault detection, and reliable data for strategic and operational decision-making.

Sachtleben Technology GmbH



The OWL EYE® dashboard: volume flow measurement (Picture: Sachtleben Technology)

STEELMAKING

Electric arc furnace long arc operation and its relation to flicker

Long arc operation is a very efficient way to melt scrap. A prerequisite is a well performing electrode regulation system enabling dynamic electrode movements. Based on the example of the performance of a BSE-Elarc electrode regulator installation at a 120 MVA, 140 t conventional scrap melting AC-EAF, the influence of regulating performance in combination with an optimized power profile and a serial reactor is examined and the measured effect of regulator performance and reactor value on flicker is pointed out.

EAF operation usually strives for the best productivity in terms of tonnes per hour. An essential factor for EAF performance is the electrode regulation system in combination with a proper power profile (i.e. setpoint table). The setpoints are determined by the transformer tap voltage, the current setpoint and the serial reactor tap. The serial reactor is required for long arc operation. The system reactor + transformer + high current system + arcs must have a certain reactance value that sustains arc stability for a melting setpoint [1]. Arc stability is to be understood in terms of active power input. Less arc stability means less active power input on average. Long arcs are efficient because of their intense radiation power that melts the scrap. Also long arcs keep a larger distance of the electrode tips to the charge material. Less overcurrents and more steady melting currents are to be expected (less sensitivity to scrap movements).

It is important to understand that a high current arc as it appears in an overcurrent event in scrap melting has high active power but produces less radiation power for scrap melting. Thus frequent overcurrents at large active power do increase the heat average MW but do not result in less power-on time. Therefore steady melting currents are benefitial because of more steady radiation power. That this „long arc effect" is benefitial for scrap melting has also been demonstrated by the author at BSW. Important for productivity is further that the serial reactor value is adjustable onload, like operated at Badische Stahlwerke BSW. The additional arc stability provided by the reactor is only required in scrap melting, not in refining. Its value shall be adjustable step by step depending on the progress of melting. Shorter arcs with larger currents are benefitial in refining to get the energy into the liquid steel and avoid radiation losses by arc coverage with foaming slag in the best case. Addi-

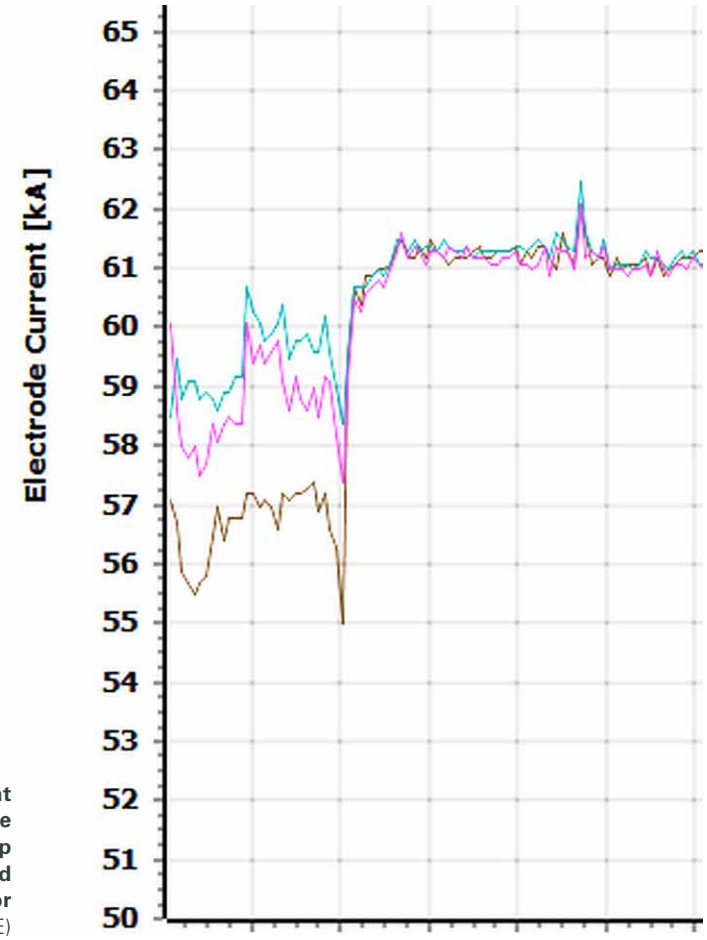


Figure 1. Heat average electrode currents of backup (unsteady) and BSE-Elarc regulator (steady) (Picture: BSE)

Dirk Riedinger, Badische Stahl-Engineering GmbH, Kehl, Germany – Contact: dirk.riedinger@bse-kehl.de

Table 1. Results of BSE power input optimization campaign and related flicker values

	Pp_av/MW	Delta	Wp_av/kWh	Delta	POT_av/min	Delta	P_{st95}
Backup 40% Reactor 2020							1.20
Backup 70% Reactor 2013							1.07
BSE Campaign 2025							
Backup 70% Reactor	83.41		46125		33.17		
BSE-Elarc 70% Reactor	86.47	3.05	47013	887	32.62	-0.55	1.01
BSE-Elarc 55% Reactor	89.94	6.53	45492	-633	30.35	-2.82	0.94

Pp_av: transf. primary side active power of the average heat
Wp_av: transf. primary side active energy of the average heat
POT_av: power-on time of the average heat
P_{st95}: 95% of all measured P_{st} values are below the P_{st95} value, P_{st} measured at the PCC

tional reactance would then only reduce active power input by unnecessary voltage drop.

Expectations on the electrode regulation system

There are certain features that are prerequisites for a good regulator performance. The core of the regulator must be an impedance (Z) regulator, thus using electrode voltages and currents. This is because the impedances of the three phases are significantly less coupled than for example the electrode currents. Their sum is zero instantaneously: $i_1 + i_2 + i_3 = 0$. If one current changes then both others do instantaneously. A pure current regulator suffers from this strong coupling. However, a pure impedance regulator suffers from electrode current drift. The cause of that is the variation of the apparent system reactance (the so called operating reactance X_{op}) during the melting process from solid to liquid. In scrap melting the conditions for the arcs cause a significant harmonic level, the curve shapes of electrode voltages and currents being very non-sinusoidal. This leads to more reactive power Q which in turn results in a reactance value $X_{op} = Q / I^2$ that is significantly larger than the short circuit reactance X_{sc} of the furnace high current system without arcs.

The pure impedance regulator tries to keep the impedance setpoint (that includes the variable X_{op}), thus there are no defined current setpoints. The load conditions of the transformer vary accordingly. The BSE-Elarc overcomes this drawback by an additional current control, i.e. an automatic adaption of the impedance setpoints that keeps the desired current setpoints on average under all melting conditions. This control strategy is very benefitial and allows to keep well defined transformer load conditions over the complete heat (**figure 1**). This function combined with an adaptive proportional gain allows the best regulating performance for any EAF. The adaptive proportional gain is very useful to damp unnecessary electrode movements in unsteady scrap melting and to make movements more sensitive in steady melting conditions. The result of these advanced functions is a very steady scrap melting with lowest current setpoint deviations. It also simplifies the setup of the setpoint tables. For example just the rated transformer currents are set, no calculations are required like with pure impedance regulators.

It is worth mentioning that the BSE-Elarc measures the correct primary side active power and energy. The typical electrode regulator measures the more or less wrong secondary side power and energy, influenced by unavoidable induction into the electrode voltage measuring loops. How the optimal electrode voltage measurement is to be installed is discussed in detail in [2].

Influence of the electrode regulation system on process parameters and flicker

BSE is a worldwide consultant for EAF steel plants. A frequent finding is that the existing electrode regulation system is not well adjusted and low performing. Reasons are typically obscure parameters, a non-user friendly HMI (no useful trending and reporting) and a low performing regulator core. Also the power profile is often not optimal. Lower than possible active power input results. An advanced regulator like BSE-Elarc with impedance+current (Z+I) strategy and using an optimized power profile increases active power input and thus decreases power-on time. But any regulator has practically no influence on the energy consumption. This is completely determined by the process, i.e. scrap quality, chemical energy input, slag conditions, process delays, etc. An initially unexpected effect of the BSE-Elarc installation under consideration here was that the P_{st95} flicker value decreased slightly due to more dynamic electrode movements and less reactor value and thus with more steady, longer and more powerful arcs. This effect is very interesting. The thesis of the author is:

- Proper high power long arc operation is generally benefitial for flicker containment during scrap melting. Prerequisite are dynamically regulated electrodes.

A certain reactor value is required to support stable long arc operation but too low reactor value results in less stable long arcs in scrap melting, i.e. less active power input. The optimal setting depends significantly on the transformer impedance and the short circuit reactance of the high current system. If especially this is large already then more reactor value is just too

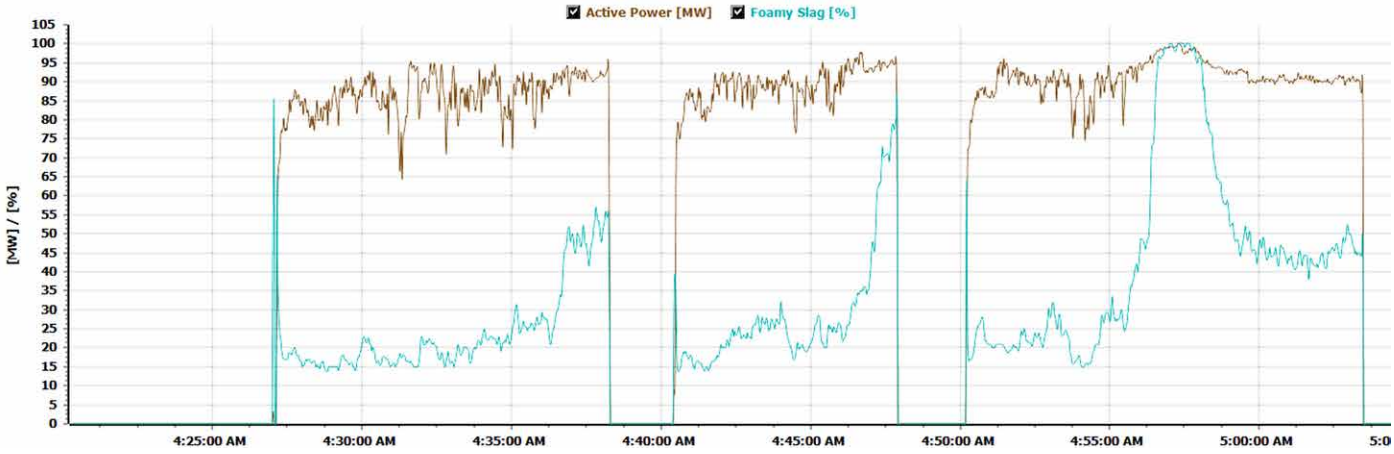


Figure 2. Primary side active power and foaming index of a 3-basket heat (Picture: BSE)

much to be efficient and not required for arc stability. The 140 t EAF under consideration here has a relatively large short circuit reactance. This effectively provides arc stability (BSE is able to simulate arc stability of setpoints). Thus the goal was to reduce the serial reactor to a proper value. In this case it is an air core reactor with fix taps. To change the tap requires some work in a planned downtime. The customer was reluctant to a change because larger flicker was expected based on past experience with 40% tap operation and the power supply company being sensitive to „excessive" flicker. But the customer finally agreed, seeing the (surprising) result of a flicker measurement carried out by the author during operation with the BSE-Elarc at 70% reactor tap and having the expected substantial power input increase resp. power-on time decrease in mind. The installation has the following parameters:

- 120 (+20%) MVA, 33,000 / 1,250 V, 60 Hz
- 2 Ohm (100%) air core serial reactor with fix taps
- 165 MVAr SVC compensation
- short circuit reactance of high current system X_{sc} = 3.76 mOhm, conductive electrode arms
- 3 basket operation due to scrap conditions

Table 1 depicts the average results per heat (from 387 heats measured) of the optimization campaign carried out following the commissioning of the BSE-Elarc system and using the following main setpoints:

- scrap melting 1250 V, 60 kA, reactor 70%, $L_{arc} \approx$ 458 mm
- scrap melting 1,250 V, 60 kA, reactor 55%, $L_{arc} \approx$ 478 mm
- refining 1,223 V, 64 kA, reactor 70%, primary power factor > 0.7
- refining 1,223 V, 65 kA, reactor 55%, primary power factor > 0.7

The full overload range of the transformer was purposedly not utilized.

The P_{st95} flicker of 2013 and 2020 was not measured by BSE. The average primary voltage at the transformer increased from 29.5 kV with 70% reactor to 30.5 kV with 55% reactor. Note that the large transformer secondary voltage is required to overcome the voltage drop over the large short circuit reactance of this furnace. An arc length of less than 500 mm for melting is not a very large length.

Table 1, row „BSE-Elarc 70% Reactor" shows the results of power profile tuning and better performance of the BSE-Elarc regulator. It was possible to use the full range of the proportional valves (± 100% opening) with more dynamic electrode movements, even though the mechanical mast-arm system is not very stiff, resulting in shaking electrodes. The backup regulator could only handle up to ± 50% valve opening before, combined with low dynamic, producing also unbalanced electrode currents. A tuning of it was too difficult due to its obscure functionality and reporting. In other words: this regulator can not handle long arc operation with a low reactor tap. With BSE-Elarc the electrode currents and thus the arcs are much more steady and well balanced during the melting process, keeping best active power input per heat also under unfavourable scrap conditions (**figure 1**). (This as well applies to ladle furnaces where we achieved an increase in heating rate by + 30% in a recent project.) The average current of the heat with BSE-Elarc is larger than with the backup regulator because the power profile was optimized, especially by a larger refining current setpoint. Before the lower current arcs were inefficient for energy (heat) transfer.

The power input was then further improved by reducing the serial reactor value to 55%, **table 1**, row „BSE-Elarc 55% Reactor". This resulted in almost 90 MW average primary active power input. Power-on time reduced by almost 3 minutes, energy remained almost constant as expected. Though expected, this is a very interesting result, showing that $P_1 \cdot POT_1 = P_2 \cdot POT_2$ in very good approximation for $P_2 = P_1 + 6.5$ MW and we assume that the identiy holds up to $\Delta P \leq 10$ MW at least (P: active power, POT: power-on time). The flicker slightly decreased or in other words it did not increase at all. The flicker measuring time with BSE-Elarc operation was 4 days for 70% reactor and 3 days for 55% reactor. More time was not available at site. However, the measuring time is sufficient for a proper P_{st95} result. It is also important to mention that the scrap conditions during the measuring period with the 55% reactor were really unfavourable. Though the flicker is lower. This clearly indicates the advantage of long arc operation made possible by a well performing regulation system and proper serial reactor tap.

In 2020 the customer used 40% reactor tap for a while but was forced by the power supply company to change to the 70% tap. The P_{st95} with 40% reactor setting was too large as indicated in **table 1**.

This clearly shows the influence of an insufficient low dynamic regulation performance. Now the customer can consider again to reduce the reactor value to 40% in the future, expecting no flicker increase due to well regulator performance in terms of dynamic electrode movements. The best solution for optimal power input would be of course to convert to a serial reactor with onload tap changer to utilize the full potential of refining active power input, like at BSW.

Low impedance EAF up to the 1990's used short arc operation with lower transformer voltages and larger electrode currents in combination with today outdated, low dynamic, black box analogue regulation systems. Under these conditions comparably narrow holes are bored into the scrap, supporting large current variations that promote flicker. Long arcs create large holes in the scrap by their intense radiation that is proportional to the arc voltage [1]. Variation of the arcs or the currents is different and less flicker sensitive. This assumtion is now supported by the results presented in **table 1**.

An important result also for German steel industry because flicker limits are very restrictive in Germany (the P_{st95} limit is below 0.45 at 400 kV and below 0.7 at 110 kV). Obviously much more restrictive than for the customer of **table 1** where a P_{st95} of 1 at 161 kV is already a good message, making improved productivity feasible. A further assumption of the author is that very large power long arcs from operation of 200 MVA to 300 MVA furnace transformers are even less flicker sensitive due to the enormous force and radiation of the arcs.

Influence of foaming slag on active power input

Another very interesting effect became obvious for this EAF. This is the well known influence of foaming slag (arc coverage) on the active power input into the liquid steel. **Figure 2** depicts the primary side active power trend and the foaming slag index trend measured by BSE-Elarc. It is very obvious that active power in refining (third basket) very much depends on the foaming slag quality. This customer has the problem that an early deslagging is required due to constructive problems of the EBT area of the furnace.

The active power loss and thus the increase in power-on time is substantial, the difference in active power between very good foaming slag and insufficient slag shown in **figure 2** being up to 10 MW. A very clear indicator for the influence of high harmonic level of uncovered arcs. The potential for improvement of productivity for this customer is great and this example is also interesting for DRI steelmaking of the future in Germany.

Conclusion

The assumption that a larger serial reactor value always damps flicker is too „narrow". The presented results show that under proper conditions (including a well performing electrode regulation system that enables dynamic electrode movements) a lower reactor value does not increase flicker, even with unfavourable scrap conditions. This supports the assumption that a proper long arc operation for scrap melting can limit flicker of high power EAF.

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OXYGEN ENRICHMENT ON THE BURNERS OF A BILLET REHEATING FURNACE

SN Maia Siderurgia Nacional in Maia, Portugal, has successfully completed a new oxygen enrichment project on an existing billet reheating furnace. This marks a significant milestone to optimize furnace performance and improve energy efficiency.

SN Maia Siderurgia Nacional, the largest rebar production plant of the MEGASA Group – a leading European steelmaker, was looking to install a new oxygen system to reduce natural gas consumption, having the possibility to produce oxygen on site at a lower cost. The project was entrusted to Fives Steel Spain, a subsidiary of Fives Group which had previously modified the combustion system of the same furnace. The company developed a new technology called PREMIX™, which injects additional oxygen into the combustion air duct upstream of the burners. Oxygen levels were increased to 25% with around 6% fuel savings, exceeding initial energy efficiency expectations.

Enhanced combustion efficiency

"By introducing additional oxygen, we are improving combustion, which allows for higher temperatures without increasing fuel usage, contributing to both cost savings and reduced CO_2 emissions. This requires minimal investment if oxygen is available at marginal cost in the steel plant, so it can be convenient for many other steelmakers who own their O_2 production," says Oiane Gerrikagoitia, R&D Manager & Thermal Process Technical Expert at Fives Steel Spain.

The partnership between SN Maia Siderurgia Nacional and Fives was positive and collaborative throughout the project, with strong communication and mutual support from both sides. A key factor was the implementation of pre-assembled technology, which minimized operational downtime. The solution was designed to be easily integrated and have a minimal impact on the plant's production. Experts from Fives Steel Spain were able to perform most of the installation while the furnace was still running, ensuring that production continued smoothly and without significant delays.

Fives Group – Steel & Glass

STEELMAKING

The correct measurement of total non-active and apparent powers at the EAF

It is well known in EAF steel industry what the total active power input of an EAF is. It is the power that physically melts the charge material. But what is the total apparent and total non-active (reactive) power that occurs and that needs to be compensated to not load the supply network? Often there is only a superficial knowledge about what those powers are and how they are determined or measured.

Let's start with the simple electrical system, the so called two-pole as depicted in figure 1. The two-pole has one supply voltage and one current going through it. Voltage and current can have arbitrary curve form but shall have equal frequency, e.g. 50 or 60 Hz. These quantities are called „periodical". They are designated by u(t) for the periodical voltage and i(t) for the periodical current. Probably everybody knows that power is voltage times current:

$$p(t) = u(t) \cdot i(t)$$

To be more precise, p(t) is the „instantaneous" power of each single moment in time. Is that the melting power that is needed in the arc furnace? No. The melting power is the temporal average of the instantaneous power, it is the „active" power P and only that is transformed into e.g. heat and radiation and can do work. More precise:

$$P = 1/T \int u(t) \cdot i(t)\, dt$$

where T is the time period of the oscillation which is 20 ms for 50 Hz and 16.7 ms for 60 Hz systems. T can be chosen arbitrarily large, depending on the measuring time (but shall be greater than one period of the oscillation). The melting energy then is

$$W = P \cdot T$$

usually measured in kWh. Because energy is a so called extensive physical quantity, active powers of more than one two-pole are summed algebraically, for example the total active power of the arcs of all electrodes is:

$$P_{\Sigma} = P_{EI.1} + P_{EI.2} + P_{EI.3}$$

This is common knowledge and nobody thinks about this any more. However, how to correctly sum non-active or apparent powers is not at all obvious.

The active power P is just one part of the total power of an arbitrary two-pole. Experience shows that generally there is not only active power involved in electrical circuits. What does that mean? It is well known that the so called root mean squares (RMS) of voltage U and current I are important values of electrical circuits. Concretely, the effect of a RMS value of a periodical current is equal to that of a DC current with equal value, i.e. in an ohmic resistor both generate an equal amount of heat. The product of a RMS voltage and a RMS current is also a power, namely the „apparent" power

$$S = U \cdot I$$

If we compare S and P we find that $S \geq P$ always. That is the reason why S is called the apparent power: apparently there is more power than the active power. This important phenomenon is related to the properties of the periodical oscillations of voltage and current. The reason why $S \geq P$ is non-proportionality caused by:

- time shifted zero crossings of voltage u(t) and current i(t) and/or
- non-sinusoidality (harmonics) and/or
- discontinuity.

Only if the oscillations of voltage and current have equal form and equal zero crossing (zero phase shift), so only if they are proportional, then S = P. Proportionality means that e.g.

$$i(t) = k \cdot u(t)$$

where k is a linear proportionality factor (a real number) over a full period T. How are P and S related mathematically? By the geometric relation

$$S^2 = P^2 + Q^2 \text{ (Pythagoras triangle)}$$

where Q is the orthogonal (non-active, reactive) power and $Q \geq 0$. The root of this geometric relation is orthogonality. Two functions (oscillations) x(t) and y(t) are orthogonal if $\int x(t) \cdot y(t)\, dt = 0$. There is a standardised method how to compute the

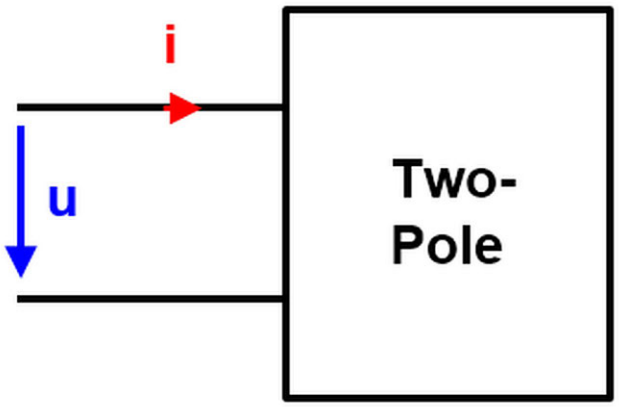


Figure 1. Electric Two-Pole (single-phase system)
(Picture: BSE)

Dirk Riedinger, Badische Stahl-Engineering GmbH, Kehl, Germany – Contact: dirk.riedinger@bse-kehl.de

so called proportional current component $i_{prop}(t)$ and its complement, the orthogonal current component $i_{orth}(t)$ from the total two-pole current i(t) [1]. This is useful because the proportional current i_{prop} generates all the active power with the two-pole voltage:

$$\int u \cdot i_{prop}\, dt = P$$

The orthogonal current i_{orth} generates all the useless orthogonal (non-active) power Q with the two-pole voltage. The important difference is that always

$$\int u \cdot i_{orth}\, dt = 0$$

so the orthogonal power oscillation p_{orth} has no average. In other words: it is not an extensive physical quantity that can be summed algebraically. Both current components are related by

$$\int i_{prop} \cdot i_{orth}\, dt = 0$$

Thus P and Q are orthogonal quantities that are always related by the Pythagorean triangle. Concluding, we can now state the equations that constitute the two-pole powers:

- instantaneous power:
  $p(t) = u(t) \cdot i(t)$, [p] = W
- active (proportional) power:
  $P = 1/T \int u(t) \cdot i(t)\, dt$, [P] = W
- RMS voltage:
  $U_{RMS} = \sqrt{(1/T \int u^2\, dt)}$, [U] = V
- RMS current: $I_{RMS} = \sqrt{(1/T \int i^2\, dt)}$, [I] = A
- apparent power:
  $S = U_{RMS} \cdot I_{RMS}$, [S] = VA
- orthogonal (non-active) power:
  $Q^2 = S^2 - P^2$, [Q] = VAr

At the two-pole it is simple to determine Q from the Pythagorean orthogonality relation.

As already mentioned, it is essential to know that it is physically wrong to sum values of S_μ and Q_μ algebraically:

$S_{total} \le S_1 + S_2 + \ldots + S_n$ and

$Q_{total} \le Q_1 + Q_2 + \ldots + Q_n$

in general. A geometric summation law is required (like that for mechanical forces). It is the aim of this article to make this comprehensible.

The two-pole as a single-phase system is a special case of poly-phase systems. Only at the two-pole the orthogonal (non-active) power is determined using the apparent power and apparent power is a measure for the system load. What about the power relations at poly-phase systems (multi-poles)?

Electric powers at the three-phase system

At the two-pole the terms „orthogonal" and „non-active" (reactive) can be used synonymously. For the poly-phase system we will distinguish between „total non-active" as the term for a technical definition serving a special means to an end and the term „total orthogonal" for the fundamental quantity.

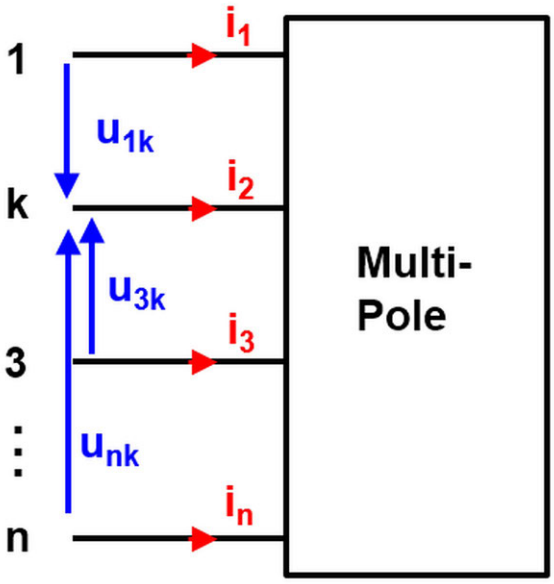


Figure 2. Poly-phase system with 1..n conductors (terminals) (Picture: BSE)

The electric poly-phase system with μ = 1..n conductors, μ = 1..n-1 linearly independent circuit loops (with $u_{\mu k}$ and i_μ) and the reference conductor k is depicted in **figure 2**.

For the sake of simplicity but without loss of generality we focus on the three-phase system with three conductors (lines, poles, terminals) which is the EAF supply and a special case of the poly-phase system. We can imagine the three-pole (= three-phase system) as a combination of two two-poles. Thus the three-pole has only two linearly independent circuit loops that can be chosen arbitrarily: either {loop 12 and loop 32} or {loop 13 and loop 23} or {loop 21 and loop 31}. Loop 12 means: go from terminal 1 through the circuit to terminal 2. „Linearly independent" means that the system is completely determined by only two out of three possible loops. Note that the second index denotes the reference conductor k against which the loop voltages are measured, e.g. for loop 12 from 1 to 2. The three-phase system has some special properties. Always $i_1 + i_2 + i_3 = 0$ and $u_{12} + u_{23} + u_{31} = 0$ instantaneously. How are the total powers determined? This is simple for the total (index ∑) instantaneous and active powers. We take conductor 2 as the reference. Then

$$p_\Sigma(t) = u_{12} \cdot i_1 + u_{32} \cdot i_3$$

$$P_\Sigma = 1/T \int u_{12} \cdot i_1\, dt + 1/T \int u_{32} \cdot i_3\, dt$$

Here the conductor current i_1 equals the independent loop current i_{12} and conductor current i_3 equals the independent loop current i_{32}. The linearly dependent conductor current i_2 equals $-(i_{12} + i_{32})$.

But how can we determine total orthogonal / non-active and apparent powers of the three-phase system? This is not obvious because algebraic summation is not allowed because orthogonal power oscillations $p_{orth}(t)$ have no average. Typically the following simple equation is used for the total apparent power, that states the furnace transformer's rated power for example:

$$S_\Sigma = \sqrt{3} \cdot U_{LL} \cdot I_L$$

where U_{LL} is one line-line voltage and I_L is the related line current. As there are two independent loops, how can we calculate the total apparent power with only one line-line voltage and one line current? This is because symmetry is assumed: both loops have equal voltage and current, that is where the factor √3 comes from. And there is another hidden assumption: namely that the loop voltages and currents of the three-pole are sinusoidal. So it is obvious that this power equation can not be general (not be a measurand but only a limit case), especially not at an EAF that is usually in a more or less non-sinusoidal and asymmetric condition. What to do? The German standard DIN 40110-2 defines a total (aggregate) apparent power $S_{\Sigma agg}$ via defined aggregate RMS voltage U_Σ and current I_Σ as follows [2]:

$S_{\Sigma agg} = \sqrt{(1/3 \ (U_{12}^2+U_{23}^2+U_{31}^2))} \cdot \sqrt{(I_1^2+I_2^2+I_3^2)} = U_\Sigma \cdot I_\Sigma$

From this the defined aggregate non-active power results:

$Q_{\Sigma agg}^2 = S_{\Sigma agg}^2 - P_\Sigma^2$.

This definition is really peculiar [3]. Remember first, that the three-pole has only two independent loops. But the aggregate apparent power uses all three RMS voltages and currents though these are linearly dependent. Then there is a factor 1/3. This can again only be valid for a symmetric system. There is another prerequisite: namely that again the system is sinusoidal. But this is not all: the equation is in fact only valid in the one limit case of a sinusoidal and symmetric and proportional system. In other words: it is the result of the application of the rules of DIN 40110-2 (that are essentially compensation rules) at the terminals of the system. It is also the limiting case of the (geometric) total orthogonal power. The problem is that nobody is aware of this and then wrongly uses the aggregate apparent power as a measurand, so as the actually measured total apparent power (the standard does not explain the meaning of $S_{\Sigma agg}$). But especially for an asymmetric three-pole where $U_{12} \neq U_{32}$ or $I_1 \neq I_3$ the aggregate apparent power measured is meaningless. The electric arc furnace is a good example. Imagine an operation with two electrodes (= single-phase condition). Then just one electrical circuit (loop) is active (loaded), e.g. loop 12, so one voltage U_{12} and one current $I_1 = I_2$ generate power. This is a two-pole and the two-pole power $S_{12} = U_{12} \cdot I_1$ should result from a three-phase power measurement. But the aggregate apparent power does not reduce into this two-pole apparent power as one can easily calculate ($S_{\Sigma agg} > S_{two\text{-}pole}$).

Is there another way to determine the total apparent and orthogonal / non-active power? There is one way typically applied. However this is also not generally valid but can be a sufficient approximation for EAF [3]. For this method a fictitious (virtual) starpoint „0" of the voltage measurement needs to be defined to be able to measure powers „per phase". This is called fictitious because it is not necessary to physically build it with ohmic resistors [2]. Thus each line current gets one phase-starpoint voltage: I_1 and U_{10}, I_2 and U_{20}, I_3 and U_{30}. $u_{10} + u_{20} + u_{30} = 0$. In a symmetrical system $U_{10} = U_{12} / \sqrt{3}$ holds for example. Then the definition of total powers takes a kind of detour to be meaningful. First the (fictitious) phase apparent power per line (or pole or terminal) is determined:

$S_{10} = U_{10} \cdot I_1$ etc.

Then the (fictitious) phase non-active power per line is computed:

$Q_{10}^2 = S_{10}^2 - P_{10}^2$ etc.

Then these are summed algebraically and make the (fictitious) total non-active power:

$Q_{\Sigma 0} = Q_{10} + Q_{20} + Q_{30}$.

Only then the (fictitious) total apparent power is

$S_{\Sigma 0}^2 = P_\Sigma^2 + Q_{\Sigma 0}^2$

What method of determination (measurement) of total orthogonal and total apparent power is correct under all circuit conditions? The solution is to take the geometric nature of orthogonal power seriously. The correct summation law was found by W. Quade (1933 to 1937). How this works is explained in detail in [3, 4]. Here we just state the important relation

$|\vec{U}|^2 \cdot |\vec{I}|^2 = (\vec{U} \cdot \vec{I})^2 + |\vec{U} \times \vec{I}|^2$

so $\vec{Q} = \vec{U} \times \vec{I}$ is a vector, and focus on the main conclusions.

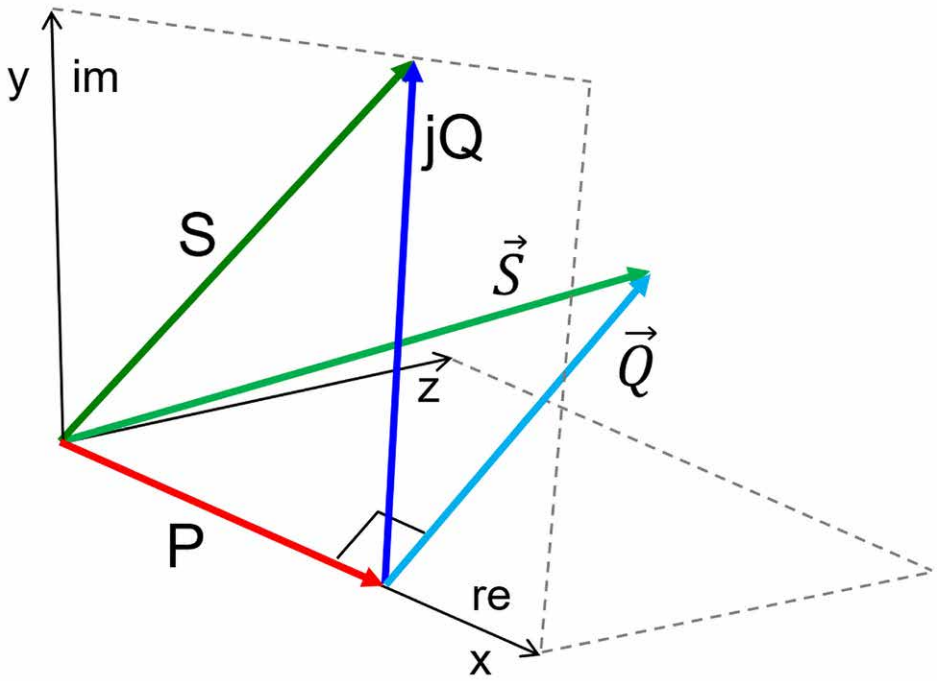


Figure 3. Visualization of the vector character of orthogonal power $\vec{Q}$ (Picture: BSE)

Figure 3 depicts the vector $\vec{Q}$ that turns into the usual imaginary component ±jQ of the complex apparent power S = P ± jQ in a purely sinusoidal condition (P is the real part „re", jQ is the imaginary part „im"). The key for the solution of the geometric summation problem is the following calculation. We explain it with two vectors $\vec{Q}_\mu$ to make it simple but there can be arbitrarily many vectors (and scalar products):

$Q_{\Sigma q}^2 = (\vec{Q}_1+\vec{Q}_2)^2 = Q_1^2 + Q_2^2 + 2 \cdot \vec{Q}_1 \cdot \vec{Q}_2$

Q_1^2 and Q_2^2 are known. The orthogonal powers $\vec{Q}_1$ and $\vec{Q}_2$ are vectors in three-dimensional space. Their product is the scalar product which contains the angle between the vectors (the phase information) δ by $\vec{Q}_1 \cdot \vec{Q}_2 = Q_1 \cdot Q_2 \cdot \cos\delta$, which is required to correctly sum orthogonal power oscillations with average zero. This is very abstract but it is very remarkable that the scalar product can be solved immediately with only measurable voltages and currents [3, 4]. The result for the three-phase system with two loop orthogonal powers $\vec{Q}_{12}$ and $\vec{Q}_{32}$ with phase 2 as the reference conductor is depicted in **figure 4**. The sum of the two summands with the integrals is identic with the scalar product $\vec{Q}_{12} \cdot \vec{Q}_{32}$. The two summands are the so called interference terms that contain the phase information and that consider the superposition of orthogonal power oscillations $p_{orth}(t)$ that result from the connection of the individual circuit loops. The interference / superposition is neglected when just summing orthogonal power magnitudes. The geometric summation law has all the properties of generality. It is characterised by ("<->" means continuous transition):

- only linearly independent quantities involved
- periodical (non-sinusoidal) <-> sinusoidal

$$Q_{\Sigma q}^2 = U_{12}^2 \cdot I_1^2 - P_{12}^2 + U_{32}^2 \cdot I_3^2 - P_{32}^2$$
$$+2 \cdot \frac{1}{T}\int_0^T u_{12} \cdot u_{32} dt \cdot \frac{1}{T}\int_0^T i_1 \cdot i_3 dt$$
$$-2 \cdot \frac{1}{T}\int_0^T u_{12} \cdot i_3 dt \cdot \frac{1}{T}\int_0^T u_{32} \cdot i_1 dt$$

Figure 4. Result for the 3-phase system with two loop orthogonal powers (e.g. EAF) with phase 2 as the reference conductor

- poly-phase <-> single-phase
- vector space $\vec{Q}_\mu$ <-> complex plane $\pm jQ_\mu$
- The aggregate and total fictitious powers are limit cases of the geometric total orthogonal power.

Note that the total orthogonal power $Q_{\Sigma q}$ has been determined in general, not the total apparent power which is only a consequence of the total orthogonal power, determined subsequently by the power orthogonality relation

$$S_{\Sigma q}^2 = P_\Sigma^2 + Q_{\Sigma q}^2$$

The total orthogonal power is really fundamental, not the total apparent power. The consequences of this result are analysed in [3]. One that is important for EAF is that the total apparent power $S_{\Sigma q}$ is not generally a measure for the system (transformer) load. The load (compared to the rated values of voltage and current or apparent power) is correctly determined by the two-pole apparent powers $S_{\mu\nu}$ of each loop, i.e. loop 12, loop 23 and loop 31. Another one is that an asymmetric poly-phase system can have zero total orthogonal power. The goal of compensation is to let a poly-phase system appear sinusoidal, symmetric and proportional to the sinusoidal supply at the terminals, so that $S_{\Sigma q} = S_{\Sigma 0} = S_{\Sigma agg} = P_\Sigma$.

As an innovative company, BSE is the first to have implemented the general summation law for the measurement of the total powers in its BSE-Elarc electrode regulation system for AC-EAF (measured on the primary side of the furnace transformer). It would be desirable that manufacturers of digital power and power quality instruments as well implement this general method into their recorders. It is just a matter of programming today. The interested and curious reader my ask why this seemingly complicated method found by W. Quade should be applied. First, the method is not complicated, quite basic mathematics are sufficient for understanding and the method is certainly correct and easy to implement. Second, each poly-phase system with similar dynamic (non-sinusoidal, asymmetric) proporties like EAF should be assessed with the most general method and not only with limit cases or approximatively.

Why is Quade's method obviously unknown today, even to experts? Simply because the field of electric power theory is very special and general poly-phase systems are not part of university teaching and also not of textbooks (there is only one from 1947) and though known, the method was ignored by the makers of DIN 40110-2 because it does not fit the purpose of the standard which is current decomposition and compensation. This is the same reason why specialised power theory textbooks do not even mention Quade.

Conclusion

The shortcomings of the usually applied measurement of total apparent and total non-active (reactive) powers of three-phase systems like the EAF are described and the correct general and fundamental method is explained. The author hopes that more electrical experts in the field of electric arc furnaces but not limited to it take note of this fundamental rule of electric power summation and are willing to apply the correct general method as well.

References

[1] DIN 40110-1: 1994-03: "Wechselstromgrößen, Zweileiter-Stromkreise (Quantities used in alternating current theory; two-line circuits)"

[2] DIN 40110-2: 2002-11: "Wechselstromgrößen, Teil 2: Mehrleiter-Stromkreise (Quantities used in alternating current theory – Part 2: Multi-conductor circuits)"

[3] Riedinger D.: „A review and analysis of Quade's fundamental geometrical time domain concept for the summation of non-active powers of poly-phase systems", Przeglad Elektrotechniczny 9'2022, p. 1 – 8, doi:10.15199/48.2022.09.01 (open access)

[4] https://de.wikipedia.org/wiki/Blindleistung, section „Blindleistung von Netzwerken im periodischen Fall"

SSAB STEEL SERVICE CENTRE TO UPGRADE CUT-TO-LENGTH LINE

The SSAB Steel Service Centre in Ghedi, Italy, is going to upgrade its cut-to-length line to be able to cut ultra-high strength steel coils of up to 1,350 MPa to virtually any length. The upgrade will be executed by FIMI Machinery.

While the Ghedi service centre operated by SSAB Swedish Steel is currently limited to cutting steel coils with maximum yield strengths of 700 MPa, the upgrade will enable the processing of up to 1,350 MPa, 6.5 mm thick strip, including most hot-rolled Hardox abrasion-resistant steels and Strenx structural steels. Once the upgrade has been completed, SSAB will ship a greater range of steels to Italy as coils, which is faster and more efficient than shipping cut lengths in packaged bundles from Sweden. As part of the upgrade FIMI Machinery's will provide three new brushing machines connected to a filtration system. The scale produced by the straightener and levellers will be extracted. Consequently, there will be less imprints on the surface, improving the overall quality. Due to better stress relieving, the sheets will be flatter, an important aspect when processing SSAB laser grades.

SSAB / FIMI

Baku Steel Company achieves substantial process improvements after an EAF upgrade (Picture: Primetals Technologies)

STEELMAKING

EAF upgrade completed with significant improvements at Baku Steel Company

The upgrade project from Primetals Technologies generates outstanding electrical energy and electrode consumption savings and a remarkable 4-minute reduction in power-on times

Primetals Technologies has recently received the final acceptance certificate for an upgrade of the 60-ton electric arc furnace (EAF) at the steelmaking plant of Baku Steel Company CJSC group located in Baku – capital city of Azerbaijan. For the steel company this project marks a major step forward in optimizing production processes and enhancing operational efficiency.

The Primetals Technologies scope of supply included a burner system with carbon injection technology, the Melt Expert electrode control system, SlagMon tapping equipment for optimized slag detection, as well as advisory services for installation and commissioning.

Remarkable decrease in consumption

In 2023, an initial study conducted by experts from Primetals Technologies identified substantial potential improvements through the addition of a fourth refining combined burner and a modern electrode control system in the steel producer's EAF. Building on this feedback, Baku Steel Company and Primetals Technologies have successfully implemented the upgrade.

Following the successful installation and integration of the new plant equipment and automation systems, Baku Steel Company reported impressive results within just a few days of operation. Key improvements include a significant reduction in electrode consumption by more than 20 percent, a substantial decrease in energy consumption, as well as a notable 4-minute reduction in power-on times. These outcomes demonstrate the immediate impact of the upgrade on the efficiency and performance of the steelmaking process.

Increased process stability

Melt Expert from Primetals Technologies enables dynamic control over the melting process and increases process stability. The system improves furnace productivity by addressing reduced throughput and efficiency, common issues in steelmaking operations. It also lowers energy consumption, helping to mitigate the high energy costs associated with the melting process.

With an annual production capacity of 800,000 tons, Baku Steel Company is the largest steel production enterprise in the Caucasus region. The company manufactures billets, pipes, and construction rebars from carbon and alloy steel, as well as standard and shaped rolled products including channels, angles, I-beams, wire rod, and shaped casts. Baku Steel Company exports its products to more than 20 countries across Europe, the US, Africa, and Asia.

Primetals Technologies, Limited

CONTINUOUS CASTING

Izmir Demir Çelik Sanayi increase billet and bloom production capacities

After commissioning of a new continuous casting plant the Turkish steel company doubles its annual production to approximately 3.1 million tons, addressing growing market demands. The new facility can produce billets and blooms in six different section sizes, allowing the steel manufacturer to quickly adapt to changing market needs.

İzmir Demir Çelik Sanayi A.Ş (IDC), a manufacturer of reinforcing steel and profiles, has expanded its steelworks with a Concast seven-strand continuous caster at its plant in Aliağa, İzmir, Türkiye. This new machine provides IDC with the flexibility to efficiently meet diverse market demands, while also increasing production capacity and enhancing the quality of billets and blooms.

The installation of the new continuous casting plant significantly expands IDC's annual steel production output from 1,550,000 tons to approximately 3,100,000 tons. This increase enables IDC to meet growing market demands more effectively while reducing its dependence on imported semi-finished products. The new caster's ability to produce billets and small blooms in six distinct section sizes, ranging from 150 mm x 150 mm to 220 mm x 280 mm, gives IDC the flexibility to adapt quickly to changing market needs. The continuous casting plant is designed with a casting radius of 10.25 meters and offers casting speeds ranging from 0.6 meters per minute to 4.0 meters per minute. These features ensure optimal performance across a variety of production scenarios, allowing IDC to maintain high quality standards while reducing operational costs.

The new 7-strand continuous caster at IDC's steel works in Aliağa, İzmir, Türkiye is designed to produce billets and small blooms in six distinct section sizes (Photo: SMS group)

Product quality is enhanced thanks to advanced technologies

Tundish flow control. The new continuous casting plant integrates advanced technologies to increase product quality and optimize process control. To ensure superior cleanliness and keep inclusions to a minimum, the plant features advanced tundish flow control, an optimized refractory design, and monobloc submerged entry nozzles (SEN). The large casting radius supports inclusion flotation, while state-of-the-art mold level control ensures a precise and stable production process.

Optimized cooling systems. Surface quality is significantly improved through the use of a convex mold design, optimized secondary cooling systems, and a mold oscillator with remote control capability. Insulation tunnels maintain high surface temperatures before unbending, while the automated CONFEED powder feeding system ensures a stable mold powder layer for consistent quality results.

Innovative stirring technologies. Internal quality is enhanced through electromagnetic stirring (M-EMS) and modular wave stirring (MWS) technologies, which guarantee a homogeneous internal structure. Additionally, precise strand guidance, accurate cooling spray alignment, and a three-zone secondary cooling system further improve billet and bloom quality. This innovative setup enables IDC to produce high-quality steel products efficiently while reducing operational costs and meeting diverse market demands.

This project highlights the partnership between SMS and IDC and serves as a key reference for SMS in Türkiye. The new continuous casting plant optimizes production processes, reduces operational costs, minimizes downtimes, and enhances efficiency. For IDC, this investment strengthens its position in the steel industry, enabling the company to meet diverse market demands with greater flexibility. The new continuous casting plant successfully went into operation in April 2024. The final acceptance was signed shortly thereafter in October.

SMS group

PROCESS CONTROL

Measuring system for long products with small diameters

KOCKS and LAP expand the 4D EAGLE S portfolio: The new 4D EAGLE S 50 model adds a high-precision laser measuring system for long products with small diameters to the series. This new product was officially launched for global sales at AISTech 2025, held from May 5 to 8 in Nashville, USA.

One year after the successful market launch of the 4D EAGLE S measuring systems, jointly developed by LAP Measurement Technology GmbH and KOCKS Measure + Inspect GmbH & Co. KG, the product portfolio for the steel industry has been expanded.

The primary model 4D EAGLE S 120 is designed to measure diameters from 10 to 140 mm. In contrast, the new 4D EAGLE S 50 model measures smaller diameters, ranging from 4.5 to 50 mm. Producers of long steel products now have access to this advanced laser measurement technology for an even wider range of hot measurement applications. By expanding their product lineup, the collaborating partners are reinforcing their commitment to offering pioneering products that ensure comprehensive quality assurance in the rolling process over the long term.

Duo for quality assurance in rolling mills: 4D EAGLE S in sizes 50 (left) and 120 (Picture: KOCKS)

Integrated profile measurement and surface inspection

The 4D EAGLE S systems integrate advanced laser measurement technology for profile assessment with intelligent software for surface classification, creating a powerful solution. Utilizing the laser light section method, these systems accurately capture the complete profiles of rolled products while identifying and classifying various rolling defects. Incorporating high-resolution surface inspection technology allows for the real-time detection of even the smallest surface defects. The SMART CORE X analysis software offers rolling mills extensive evaluation and visualization tools, facilitating seamless quality assurance and targeted process optimization.

Every new 4D EAGLE S 120 and 4D EAGLE S 50 system comes standard with surface inspection and classification functions. The 4D EAGLE S offers various expansion stages, thus providing a future-proof solution for comprehensive quality assurance in the rolling process. Thanks to these systems' scalability, both hardware and software can be customized to meet individual requirements, ranging from precise profile measurement to fully integrated surface inspection. This adaptability enhances the system's potential throughout its life cycle, ensuring long-term investment security for rolling mills.

Friedrich Kocks GmbH & Co KG

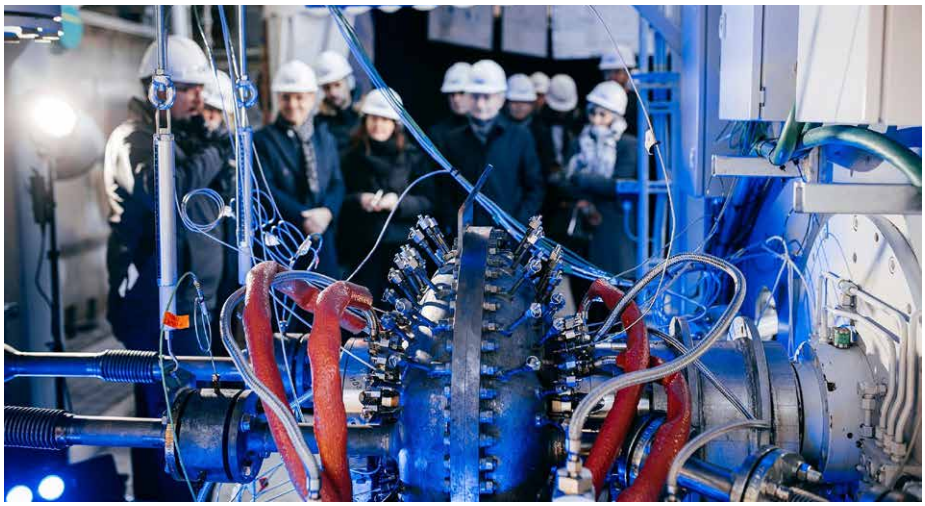
PLANT TECHNOLOGY

Electrification of high-temperature heating processes

Two companies – Coolbrook and Tenova – partner to deploy RotoDynamic Heater™ technology for electrifying high-temperature metal processes. This will replace the burning of fossil fuels with clean electricity to cut CO_2 emissions.

Coolbrook, a transformational engineering and technology company focusing on industrial electrification, and Tenova, a leading provider of innovative and sustainable solutions for the metals and mining industries, have announced a strategic partnership on the development and deployment of Coolbrook's proprietary RotoDynamic Heater™ (RDH™) technology. This will replace the burning of fossil fuels with clean electricity in high-temperature heating processes in the iron, steel, and broader metals industries.

Coolbrook's expertise in electrifying high-temperature industrial processes aligns with Tenova's portfolio of innovative and sustainable solutions. Coolbrook's RDH™ Technology and Tenova's expertise are particularly complementary to provide fully electrified and decarbonized processes across numerous applications in iron, steel, and other metals production that significantly reduce CO_2 emissions.



Large-scale pilot tests have proven the RotoDynamic Heater™ technology's heat-generating capabilities at temperatures above 1000°C (Picture: Coolbrook)

Start with acid regeneration plants

The aim of the strategic partnership is to develop joint solutions that integrates Coolbrook and Tenova's technologies, providing distinctive, seamless, and comprehensive offerings for industrial customers. The initial focus of the partnership will be the integration of Coolbrook's RDH™ technology into Tenova's proprietary technology for acid regeneration plants. Once completed, Tenova and Coolbrook are planning to expand the collaboration to other applications across the metals industry.

Antonio Catalano, EVP for the Downstream BU at Tenova, said: "At Tenova, we are committed to driving the metals industries towards a more sustainable future. Our collaboration with Coolbrook marks a key milestone in decarbonizing high-temperature industrial processes by combining Coolbrook's innovative RDH™ technology with our advanced solutions. By replacing fossil fuels with renewable electricity, we can dramatically reduce CO_2 emissions but also achieve a significant step in process efficiency – making production cleaner, faster, and more cost-effective. This is a powerful example of how technological innovation can accelerate both sustainability and operational excellence in our industry."

Joonas Rauramo, CEO of Coolbrook, said, "Our partnership with Tenova is a significant step in advancing industrial electrification and accelerating the transition to clean energy. By integrating our RDH technology with Tenova's innovative solutions, we can develop joint offerings to decarbonize highly challenging applications that have previously been impossible to electrify. Through this partnership, we are positioned to deliver broader, more sophisticated solutions to our customers than either company could achieve independently. Our partnership with Tenova is a key milestone in our strategy to establish a strong and collaborative ecosystem around Coolbrook's RotoDynamic technology, ensuring its rapid industrial-scale adoption."

Electrification of high-temperature industrial processes

Coolbrook's RotoDynamic Heater™ Technology is a groundbreaking innovation that enables high-temperature industrial process heating using CO_2-free electricity. As a key step toward carbon-free manufacturing, RDH™ Technology has the potential to revolutionize heavy industries by significantly reducing reliance on fossil fuels. When deployed at scale, it could cut over 2.4 billion tons of CO_2 emissions annually, making a transformative impact on industrial decarbonization. Large-scale pilot tests have proven its heat-generating capabilities beyond 1000°C, with the technology reaching up to 1700°C, a crucial breakthrough for decarbonizing high-temperature industrial processes. Coolbrook aims to establish the RDH™ technology as an industry standard by 2030.

Tenova / Coolbrook

INNOVATIVE FORGING TECHNOLOGY FOR THE AVIATION INDUSTRY

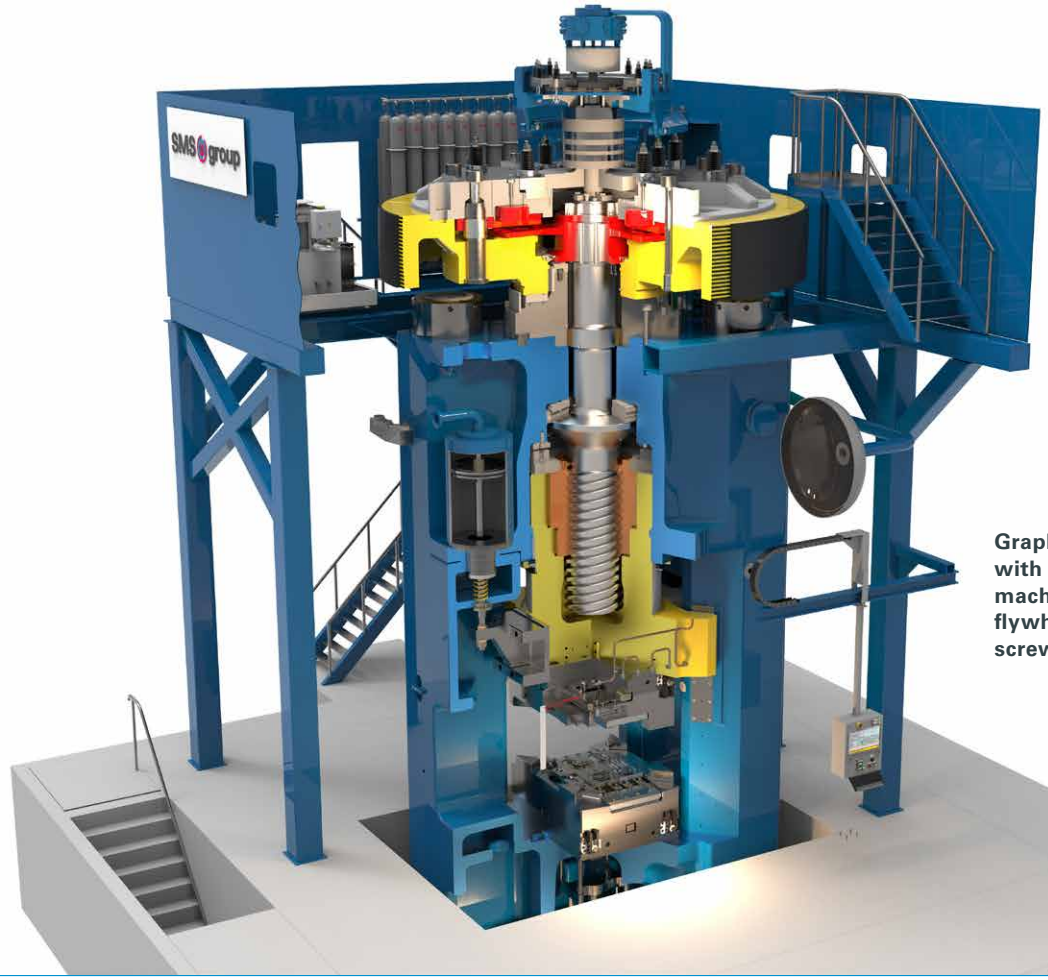
Clutch-operated screw presses produce components for turbine applications

The energy efficiency and performance of aircraft engines are crucial criteria when it comes to making purchasing decisions in the aviation industry. To increase both parameters, the combustion pressure and temperature are particularly relevant. This requires turbine components to be forged using increasingly sophisticated alloys with complex shapes.

SMS group is the only company worldwide to offer clutch-operated screw presses for closed-die forging. Thanks to their unique operating principle and backed up by effective service partnerships, customers with this type of press can manufacture aircraft components of the highest quality, reliably and cost-effectively. In this way, SMS group empowers forging technology customers to shape workpieces with highly complex geometries and challenging materials that bring the performance of advanced engines to a completely new level.

The SPKA type clutch-operated screw press

While direct-driven screw presses are widespread, their large and technically advanced sisters – the clutch-operated screw presses – are comparatively



Graphic representation of the SPKA with a sectional view of the machine showing clutch (red) and flywheel (yellow) at the top of the screw (Picture: SMS group)

Lukas Heyer, Product Management & Product Development; Lars Ziegenhagen, Product Expert Screw Presses – Automation, Digital and Service Solutions, SMS group; Möchengladbach, Germany – Contact: lukas.heyer@sms-group.com

unknown. These forging giants, weighing up to 2,900 tons, are known for their extremely high useful forming energies and forming process control precision. With a hard-on-hard blow force of up to 365 meganewtons, they provide very high forging forces with simultaneously low forming speeds. This enables the forging of difficult-to-form materials, as these require high forming forces on the one hand but also time for plastic flow for mold filling on the other. Moreover, this prevents the formation of undesired microstructures and material overheating. Clutch-operated screw presses are primarily used to forge structural parts and landing gear components for aircraft, as well as turbine blades, rings, and disks for the aviation and energy sectors. With references in the USA, Europe, and China, this type of press from the range of traditional SMS Hasenclever presses makes an important contribution to today's high-tech industries.

The unique operating principle of the clutch-operated screw press

The main difference and the basis of the range of benefits of the clutch-operated screw press lies in its continuously horizontally-rotating flywheel, which stores the forging energy in the form of kinetic energy. A hydraulic clutch connects this flywheel to the spindle, which, as it rotates, accelerates the ram toward the workpiece. In this way, these two forging parameters, forming energy and forming force, are uncoupled from each other and can be controlled independently. Furthermore, this means that the screw mass to be accelerated can be relatively small, while the size of the flywheel and thus the energy supply is almost exclusively limited by the cost-effective production capability, thereby enabling tremendously high forming energies to be provided.

The first step of a stroke is when the flywheel of the SPKA rotates with the clutch open and is driven by a frequency-controlled asynchronous motor via a flat belt. At the same time, it stores many more times the maximum energy required

Mounting screw and nut of a SPKA press at the SMS group's workshop in Mönchengladbach, Germany
(Picture: SMS group)

Forging of turbine blades at a clutch-operated screw press PPKA 22400 (Picture: SMS group)

for the forming process in the form of kinetic energy. When a stroke is initiated, the stationary spindle is synchronized instantaneously with the flywheel speed via the hydraulic clutch. The ram is thus accelerated to the preselected linear downward speed via the screw and screw nut. This takes only few fractions of a second.

Once the workpiece has been impacted, the clutch is opened and the flywheel is thus released from the screw. The main drive recharges the energy taken from the flywheel by accelerating the unit to the output speed. The system, which comprises the screw and clutch disk and now rotates freely downwards, performs the forging process until it comes to a standstill. Then, the spring energy built up in the press housing is released and reverses the screw movement by means of the upward-moving ram. The latter, assisted by a hydraulic return stroke drive, if necessary, moves into its selected starting position. A shut-off system controls the hydraulic clutch opening procedure by relieving the pressure, which ensures that the clutch is force-free within fractions of a second.

The clutch opening process can be controlled either as a function of the desired force or the desired stroke length. With force-dependent strokes, the ram hits the workpiece at a force and impact speed preselected by the operator. A clutch torque, defined before the stroke, is thus obtained from the force and impact speed. The clutch remains frictionally closed until the shut-off system undergoes a defined relative movement as a result of the clutch torque being exceeded between the flywheel and the clutch disk. As an alternative to this, the possibility of having position-dependent strokes is one of the major advantages of the SPKA compared to conventional screw presses. This means that the operator can set a specific ram position, which, when reached, causes the press control system to start opening the clutch. This application is ideal for rough-forging blanks to the desired height before finish-forging in a second step. This option allows the number of heating cycles to be reduced.

Clutch-operated screw press applications and products

With the SPKA clutch-operated screw press, SMS group has provided the market with a closed-die forging press that is both unique and specifically suited to the requirements of the aviation industry. This press was designed and built to complement other features compared to conventional screw presses. As the aviation industry sets its sights on greater sustainability, reliability, and fuel efficiency, it is increasingly turning to higher-strength, more heat-resistant materials. These high-performance materials, including high-alloy steels, titanium alloys, and nickel-based alloys, pose a challenge when it comes to forging technology. To be able to shape such materials, a combination of high deformation energy and a low deformation rate is required, which controls the material flow during forging. In addition, both parameters must be set and checked very precisely. For example, if the deformation speed is too low, this results in excessive cooling of the workpiece sur-

face and inhomogeneous microstructure over the component cross-section, while an excessively high deformation speed results in severe heating of the component as well as in an unfavorable microstructure. In the worst-case scenario, cracks may even appear in the component. At the same time, high forming energies are required to ensure that the die engraving is completely filled, as the alloys, depending on their intended use, exhibit a high strength and, in many cases, lower ductility, which means high forces are necessary for die filling. Furthermore, they often demonstrate comparatively low thermal conductivity and thus inhomogeneous heat distribution, which also results in larger forming forces that are consistently required over the entire stroke. Clutch-operated screw presses are particularly suitable for such high-energy forming tasks. Turbine blades, disks, and rings for aviation and power generation applications are part of the product portfolio of companies operating SPKA screw presses. In addition to these forged parts, which with their rotationally symmetrical shape are typical of screw presses, structural components and aircraft landing gear parts can also be forged due to the high resistance to tilting of the ram guide under off-center loads and the large surface area available under the screw. Thanks to the high rigidity and accuracy of the press, it is particularly suitable for precision forging.

Process advantages thanks to clutch control and low accelerated masses

Standout features of the forging process are the precise controllability of the forming force and the low screw and clutch disk masses to be accelerated by the flywheel. The hydraulic pressure in the clutch allows the force applied during forming to be set very precisely and made available almost constantly until the end of the process. In this way, forging can always be performed at maximum force, irrespective of the forming speed, and a wide range of combinations of forming force and speed is possible.

Due to the masses of the flywheel system that need to be accelerated, which are small in relation to the continuously rotating flywheel, a very short synchronization time is possible, such that the maximum forming speed and force are already available after approximately 15-20 percent of the nominal stroke. This allows for a short stroke time and fast stroke sequences and offers the option of varying the upper and lower reversal points during the stroke. As a result, the cycle time can be shortened to enable fast cooling materials to be forged and individual stroke sequences to be set.

In the case of alloys requiring slow forging, it is thus possible to vary the ram's speed of impact on the workpiece to achieve a perfect forging result without any loss of force or energy. This is also crucial for forging complex geometries, such as turbine blades, for example. This is where the transition from the relatively thick root to the thin, curved blade plays a particularly vital role.

If the material is not given sufficient time here for flowing, defects such as folds may appear that lead to the material being rejected. The extremely short clutch opening times and the high rebound speeds also allow very short workpiece contact times to be achieved. On the one hand, this is gentle on the dies and, on the other, it reduces cooling-down of any sensitive workpieces.

Aviation – a challenging industry

The demands to be met by components in the aviation industry are among the most challenging in any sector today. For example, they must be capable of withstanding very high mechanical loads and high temperature differences. This applies especially to structural parts as well as engine and landing gear components. The latter are subjected to particularly high thermal and dynamic loads.

As well as eliminating component failures, high dimensional stability and the maximum component longevity are crucial to enabling cost-efficient aircraft operation. Alongside the cost-effectiveness of production, the reliability of the supply chains is also playing an increasingly important role. In view of these demands on the components, the forging process boasts an array of crucial advantages and is considered indispensable in the construction of modern aircraft.

Forging provides the components with a dense, homogeneous microstructure and their grain flow adapts to the outer contour during the forming process. As a result, overall strength is increased, and the ability to permanently withstand high static and dynamic loads is enhanced in particular.

Furthermore, forged components are less sensitive to notches, which has a positive effect especially on components with significant changes in cross-sectional areas. Consequently, forging provides the components with good mechanical properties on the one hand, while on the other hand it gives manufacturers the possibility of producing cost-effectively compared to alternative processes, particularly in the case of larger quantities. In addition, forgings have a favourable weight-strength ratio, which has a positive effect especially in the aviation industry with its focus on weight saving solutions.

To enable the manufacture of these high-tech products reliably and efficiently, the forging press must be kept in good condition. This is where SMS group's technical service, with its many years of experience with screw presses and the SPKA clutch screw press in particular, excels. In the words of both Devrim Caliskanoğlu (Managing Director) and Stefan Galler (Head of Process Technic) at voestalpine Böhler Aerospace GmbH & Co. KG, say: "With its unique mode of operation, the SPKA 22400 clutch screw press has been the centrepiece of our forge for over 17 years, especially for complex die forging tasks in the aerospace industry. It is a key component of our success in this demanding field. Thanks to the close cooperation and excellent service provided by SMS group, including the use of predictive maintenance and the implementation of FMEA, we have been able to minimise unforeseen downtimes and continuously optimise our production processes. SMS group plays a key role in ensuring the reliability of our plants and strengthening our supply chains."

SMS group

ADDITIVE MANUFACTURING

3D-printed stainless steel components for use in the aerospace and aviation sectors

Outokumpu pioneers stainless steel metal powder in additive manufacturing for aerospace and aviation industry applications

Industry-first batch of a new stainless steel powder grade for a unique 3D printing application (Picture: Outokumpu)

Outokumpu, a leading manufacturer of sustainable stainless steel, entered the metal powder market for additive manufacturing in 2023. Since May 2025, the commercial production phase has expanded into the aerospace and aviation industry, as Outokumpu delivered the industry-first batch of a new stainless steel powder grade for a unique 3D printing application. A jointly engineered heat exchange component for the aerospace sector, subject to prototype validation, supports the company's primary focus on producing metal powders that are not yet on the market and are suitable for companies that use technologies to produce parts for demanding specialty applications.

"Outokumpu is committed to accelerating circular business models for high tech stainless steel applications. Our go-to-market strategy is to innovate product designs for complex, high performance geometries for niche applications. While we focus on our expertise in creating new recipes for metal powders, we rely on our ecosystem of 3D printing engineering partners to create end-products according to customer specifications. We are excited to enter the aerospace and aviation industry with our powder solutions," says Marten Franz, Head of Metal Powder Business at Outokumpu.

The spherical stainless steel powder for the aerospace and aviation industry is refined with specific alloy additives to make it a high performance austenitic stainless steel powder. The solution is an alternative to nickel-based alloys in highly demanding 3D printed applications and has been developed to meet the customer requests for components in small quantities and with shorter development cycles.

Sourcing stainless steel powders to multiple industries

Besides pioneering stainless steel in additive manufacturing for aerospace and aviation applications, Outokumpu has the potential to play a decisive role in shaping new powder grades to serve a variety of sectors.

"We have been ideating medical-grade powder specifications for the health-tech applications, dedicated to the development of nickel-free materials. Such material grade can also be used in jewelry, such as nickel-free stainless steel earrings or watches. In addition, Outokumpu is working on developing heat-resistant alloys for additively manufactured components such as turbines or for use in power plants", says Marten Franz.

Additive manufacturing is one of the key technological innovations of the 21st century and will play a significant role in the green transition of global economies. Outokumpu's ambition is to create a wider advanced manufacturing ecosystem where cross-industry collaboration networks and joint development can accelerate circularity in additive manufacturing.

Outokumpu Corporation

> Outokumpu is working on developing heat-resistant alloys for additively manufactured components
>
> *Marten Franz, Head of Metal Powder Business at Outokumpu*

ADVANCED AUTOMOTIVE BODY IN WHITE COMPONENTS

Volkswagen wins Swedish Steel Prize 2025

The winner of the 2025 International Swedish Steel Prize is the Volkswagen Group from Germany. The prize has been awarded for SIBORA®, a revolutionary manufacturing process that enables new possibilities for optimising safety components for improved crash performance.

For the Swedish Steel Prize jury, it is an entirely new way of thinking steel. "With their holistic approach the Volkswagen Group and their partners have developed a press hardening process to obtain different high strength and high ductility properties out of one single steel alloy. Their patented method will provide unique advantages when optimizing future car body structures, in terms of weight and performance and with an unshakable focus on safety," says Eva Petursson, chair of the Swedish Steel Prize jury and head of SSAB's research and innovation.

Volkswagen Group, the largest car manufacturer in Europe, aims to become carbon neutral by 2050. Using less material for construction and putting a lighter car on the road is central to reaching this goal.

In order to combine different properties in one car component, such as zones of optimised strength and crash energy absorption, multiple materials must usually be welded together. But with the new method developed by the team of Dr Ansgar Hatscher, Research Specialist and SIBORA Project Manager at Volkswagen Group Innovation, these specific properties can be achieved using one single sheet of press hardening steel. The SIBORA® alloy concept simultaneously results in high strength and improved ductility and the 3-step process can be adjusted to achieve different properties in different areas of the component.

The winning VW team at the awards ceremony in Stockholm on 8 May 2025 (Picture: SSAB)

SIBORA® will allow stronger, lighter and better car components to be developed faster and in a more targeted manner – with a leaner production process, easier assembly, reduced costs and improved sustainability. And the automotive industry is only the beginning…

The runners-up – The Greenbrier Companies from the U.S., InfiniSpring from Finland, and Loglogic from the UK – were also celebrated at the award ceremony in Stockholm, Sweden on 8 May 2025.

The Swedish Steel Prize celebrates engineering, cooperation and steel innovations that lead to a better and more sustainable world. The winner receives a diploma, a statuette by the sculptor Jörg Jeschke and intense media exposure. In conjunction with the Swedish Steel Prize 2025, SSAB will make a SEK 100,000 donation to UNICEF in support of their efforts to provide quality education and learning opportunities to children and adolescents worldwide.

SSAB

In a nutshell: SIBORA® alloy and process

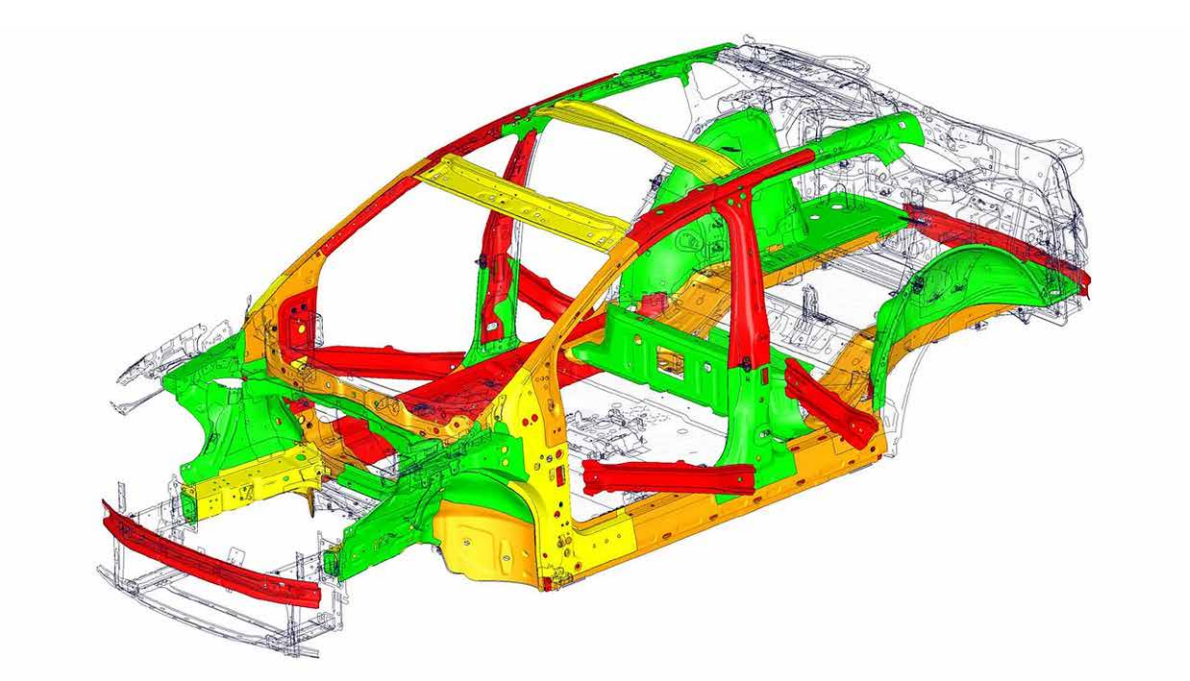
Hot press forming (press hardening) of sheet metal is an effective, forward-looking technology that can significantly reduce the CO_2 footprint of automotive body in white components. The use of materials plays a crucial role here. Volkswagen Group and Kirchhoff Automotive have therefore jointly worked on the material and process development of a silicon-boron steel grade called 'SIBORA' for a modified hot press forming process, the so-called BQP process. 'SIBORA' is a new steel grade that exhibits high strength in the press-hardened state and, due to the content of bainite and metastable residual austenite, also higher residual formability. By using the steel grade 'SIBORA', an improvement in crash safety can be achieved because of higher energy absorption with a simultaneous reduction in body mass.

Kirchhoff Automotive

BEHIND-THE-SCENES INFORMATION

The SIBORA® story

Materials form the basis of the value chain, from iron ore to vehicle components. In order to increase sustainability in production all materials must be used more efficiently. This is where the story of SIBORA® steel – Silicon-Boron Steel with Retained Austenite – begins.



The SIBORA® alloy concept allows for the adjustment of the 3-step process to achieve different properties for different areas
(Picture: SSAB / Volkswagen)

Volkswagen Group, headquartered in Wolfsburg, Germany, is the largest car manufacturer in Europe. Over 600 000 employees produce vehicles and vehicle-related services in 114 production plants in 17 European countries and a further 10 countries in the Americas, Asia and Africa.

By 2050 the entire company aims to become carbon neutral. With over 44 000 vehicles produced every working day and a total of nine million new vehicles on the road in 2024, the Volkswagen Group are, in effect, shaping the future of mobility.

One steel to rule them all

"It all started in 2017, when I picked up a pencil and some paper. I thought that today we are playing the part of a steel producer," says Dr Ansgar Hatscher, Research Specialist and SIBORA Project Manager at Volkswagen Group Innovation.

Ansgar and his colleagues started out with an innovative idea of how to optimize the properties of high strength steel by introducing multiphase design in press-hardened components. After only one year of research and trials they had a breakthrough in the laboratory. It was a singular moment. "Those early results took the topic of steel to a completely new level in our research department."

SIBORA® went on to become a patented alloy concept in combination with a new production route – the bainitic hot forming process – that simultaneously results in high strength and improved ductility. The 3-step process can be adjusted in different ways to achieve different properties in the high strength steel component.

If you want to combine different properties in one car component, specifically zones of optimised strength and crash energy absorption, you currently have to weld various materials together. With SIBORA® these specific properties can be achieved using one single sheet of high strength steel. "It's a totally different way of thinking steel," says Ansgar.

Ideas and collaboration are key

Group innovation is rare in the automotive industry, but the Volkswagen Group encourages it. The SIBORA® project brought together scientific expertise in the fields of automotive engineering, materials science, production processes, materials testing, and simulation. "You need innovative partners, you cannot do it alone", says Ansgar.

The cooperation with Matplus GmbH and Comtes FH a.s. was a game-changer. It allowed Ansgar and his team to simulate the effects of different alloy compositions and processing steps. Together with Metakus Automotive GmbH they devel-

> I picked up a pencil and some paper. I thought that today we are playing the part of a steel producer.
>
> *Dr Ansgar Hatscher, Research Specialist and SIBORA Project Manager at Volkswagen Group Innovation*

oped a unique research prototype line for pre-serial validation of the new process route.

Kirchhoff Automotive GmbH was the first partner to prove the SIBORA-method suitable for serial component production. With SSAB, the feasibility of a large-scale industrial melt could be demonstrated. Finally, the simulation study on crash properties and lightweight potential conducted together with GNS mbH is a prerequisite for use in future vehicle developments.

What you want, where you want

One single alloy cast in one sequence – but with the potential to give you a variety of different properties you want, where you want. In the near future SIBORA® will allow new, better car components to be developed faster and in a more targeted manner. With a leaner production process, with easier assembly, with reduced costs, and improved sustainability.

How far you can take the concept is an ongoing discussion with SSAB and the other collaborators. "We don't use the full potential of steel today. It is a very exciting material," says Ansgar.

The secret is out

Using less material for construction and putting a lighter car on the road both result in a smaller CO_2 footprint. In a SIBORA® research study based on the Volkswagen model ID.4 car the weight reduction was estimated at up to 30 kg. If this reduction were to be adopted by every brand in the Volkswagen Group it would mean multiplying the result by approximately nine million every year.

It gets even better. The SIBORA® research results have been published and Ansgar and his team hope that others will follow. Their ground-breaking process has the potential to affect not only the automotive industry, but the global steel industry.

Nominated as a finalist, then winner of the Swedish Steel Prize 2025

When the Swedish Steel Prize jury selected the Volkswagen Group as a finalist for the 2025 prize, they had the following motivation in mind: "A manufacturing method providing unique advantages in design of car body structures for crash energy absorption and light weight. By processing one steel grade to a range of high strength and high ductility properties new levels of optimization of components can be achieved. This demonstrates a high level of material knowledge, importance of partnership and innovation as well as dedication to sustainability targets." Volkswagen Group was finally declared the winner of the 2025 Swedish Steel Prize during the awards ceremony held in Stockholm, Sweden, on 8 May.

SSAB

SALZGITTER TO DELIVER PIPES TO ANGOLA FOR WATER SUPPLY

CNT Bau, a subsidiary of Portuguese construction company Casais, has signed an agreement with Salzgitter Mannesmann International and Mannesmann Grossrohr for the delivery of spiral-welded large-diameter pipes and pipe fittings for a water supply system in Angola.

The pipes will play a decisive role in the drinking water supply redesign urgently required for the capital city of Luanda, which has around 10 million inhabitants. With its three outdated water supply systems, the city is currently suffering, day in day out, from a water deficit of around 1.2 million m³. In many cases, drinking water still has to be transported via tank trucks. The Quilonga Grande project will therefore pave the way for a sustainable and future-oriented drinking water supply in the growing capital city.

The project secures capacity utilization for Mannesmann Grossrohr through to mid-2026, while creating new jobs in Angola. Mannesmann Grossrohr GmbH and Mannesmann Line Pipe GmbH are responsible for manufacturing the pipes in Salzgitter and Hamm, which will demand a wide range of manufacturing capabilities from both companies. Pipes in diameters of 508 mm right up to 1,626 mm are required for the various sections of the around 105 km long system. As the pipes in question are needed for a drinking water system, the tubes will be coated with a special thick-layer epoxy coating on the inside and a three-layer polyethylene coating on the outside for protection.

Along with financing and coordination, Salzgitter Mannesmann International GmbH will handle all the logistics, right through to the harbor in Luanda and will procure any additional pipe bends and other accessories that are needed.

Salzgitter AG

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1160 Direct reduction plants

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47059 Duisburg, Germany
☎ +49 203 80398-900
🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

04.09 Components

2182 Burning lances (oxygen) for tundish and ladle gate valves

BEDA-Oxygentechnik GmbH
An der Pönt 59
40885 Ratingen, Germany
☎ +49 2102 9109-0
E-Mail: info@BEDA-com
Internet: www.BEDA.com

2270 Injection plants for argon

BEDA-Oxygentechnik GmbH
An der Pönt 59
40885 Ratingen, Germany
☎ +49 2102 9109-0
E-Mail: info@BEDA-com
Internet: www.BEDA.com

04.09 Components

2440 Handling equipment for oxygen/carbon lances

BEDA-Oxygentechnik GmbH
An der Pönt 59
40885 Ratingen, Germany
☎ +49 2102 9109-0
E-Mail: info@BEDA-com
Internet: www.BEDA.com

04.09 Components

2490 Coal dust injection lances

BEDA-Oxygentechnik GmbH
An der Pönt 59
40885 Ratingen, Germany
☎ +49 2102 9109-0
E-Mail: info@BEDA-com
Internet: www.BEDA.com

2530 Lance robots/-manipulators

BEDA-Oxygentechnik GmbH
An der Pönt 59
40885 Ratingen, Germany
☎ +49 2102 9109-0
E-Mail: info@BEDA-com
Internet: www.BEDA.com

2580 Oxygen nozzles

LOI Thermprocess GmbH
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E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

04.09 Components

2600 Oxygen lance equipment

BEDA-Oxygentechnik GmbH
An der Pönt 59
40885 Ratingen, Germany
☎ +49 2102 9109-0
E-Mail: info@BEDA-com
Internet: www.BEDA.com

2655 Fuses (multifunction) for burners

BEDA-Oxygentechnik GmbH
An der Pönt 59
40885 Ratingen, Germany
☎ +49 2102 9109-0
E-Mail: info@BEDA-com
Internet: www.BEDA.com

2660 Special safety oxygen hose reels

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An der Pönt 59
40885 Ratingen, Germany
☎ +49 2102 9109-0
E-Mail: info@BEDA-com
Internet: www.BEDA.com

07 Hot rolling

07.10 Components

4430 Decoilers and rewinders

GUILD International
7273 Division Street
Bedford, OH 44146, USA
☎ +1 440-232-5887
E-Mail: sales@guildint.com

08 Forging, extrusion

08.03 Components

5150 Forging manipulators

Glama Maschinenbau GmbH
Hornstr. 19
45964 Gladbeck, Germany
☎ +49 2043 9738-0
🖷 +49 2043 47268
Internet: www.glama.de

5155 Forging manipulators, rail-mounted

Glama Maschinenbau GmbH
Hornstr. 19
45964 Gladbeck, Germany
☎ +49 2043 9738-0
🖷 +49 2043 47268
Internet: www.glama.de

5160 Forging robots

Glama Maschinenbau GmbH
Hornstr. 19
45964 Gladbeck, Germany
☎ +49 2043 9738-0
🖷 +49 2043 47268
Internet: www.glama.de

10 Cold rolling

10.01 Cold rolling mills

5490 Strip, sheet, cold and metal rolling mills

hpl-Neugnadenfelder Maschinenfabrik GmbH
Spangenbergstr. 20
49824 Ringe/Neugnadenfeld, Germany
☎ +49 5944 9301-0
E-Mail: info@hpl-group.de
Internet: www.hpl-group.de

10.04 Annealing lines

5670 Annealing lines

LOI Thermprocess GmbH
Schifferstraße 80
47059 Duisburg, Germany
☎ +49 203 80398-900
🖷 +49 203 80398-901
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Internet: www.loi.tenova.com

11 Surface treatment

11.04 Surface treatment plants

6270 Strip edge trimming

hpl-Neugnadenfelder Maschinenfabrik GmbH
Spangenbergstr. 20
49824 Ringe/Neugnadenfeld, Germany
☎ +49 5944 9301-0
E-Mail: info@hpl-group.de
Internet: www.hpl-group.de

11.04 Surface treatment plants

6280 Strip processing and finishing lines

hpl-Neugnadenfelder Maschinenfabrik GmbH
Spangenbergstr. 20
49824 Ringe/Neugnadenfeld, Germany
☎ +49 5944 9301-0
E-Mail: info@hpl-group.de
Internet: www.hpl-group.de

11.05 Aluminizing, tin plating, galvanizing

6630 Hot dip galvanizing lines

LOI Thermprocess GmbH
Schifferstraße 80
47059 Duisburg, Germany
☎ +49 203 80398-900
🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

14 Sheet metal processing

14.03 Welding technology

8120 Strip welding machines

GUILD International
7273 Division Street
Bedford, OH 44146, USA
☎ +1 440-232-5887
E-Mail: sales@guildint.com

14.03 Welding technology

8205 Laser welding machines

GUILD International
7273 Division Street
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☎ +1 440-232-5887
E-Mail: sales@guildint.com

8210 Laser beam welding machines

GUILD International
7273 Division Street
Bedford, OH 44146, USA
☎ +1 440-232-5887
E-Mail: sales@guildint.com

8220 MIG, MAG and TIG\057TIG welding torches

GUILD International
7273 Division Street
Bedford, OH 44146, USA
☎ +1 440-232-5887
E-Mail: sales@guildint.com

8257 Rolling seam resistance welding equipment

GUILD International
7273 Division Street
Bedford, OH 44146, USA
☎ +1 440-232-5887
E-Mail: sales@guildint.com

14.03 Welding technology

8330 Welding machines, general

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7273 Division Street
Bedford, OH 44146, USA
☎ +1 440-232-5887
E-Mail: sales@guildint.com

8360 Welding accessories, general

GUILD International
7273 Division Street
Bedford, OH 44146, USA
☎ +1 440-232-5887
E-Mail: sales@guildint.com

8380 Butt welding machines, electric

GUILD International
7273 Division Street
Bedford, OH 44146, USA
☎ +1 440-232-5887
E-Mail: sales@guildint.com

8400 Resistance welding equipment

GUILD International
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☎ +1 440-232-5887
E-Mail: sales@guildint.com

16 Furnace and energy technology

10170 Furnace optimization (conversion to low NOx combustion)

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WS Wärmeprozesstechnik GmbH
Dornierstr. 14
71272 Renningen, Germany
☎ +49 7159 1632-0
🖷 +49 7159 2738
E-Mail: ws@flox.com
Internet: www.flox.com

10190 Rational use of energy

WS Wärmeprozesstechnik GmbH
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71272 Renningen, Germany
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Internet: www.flox.com

16.02 Forging furnaces

10230 Forging furnaces

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Internet: www.loi.tenova.com

16.03 Roller Hearth Continuous Furnaces

10260 Roller Hearth Continuous Furnaces

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47059 Duisburg, Germany
☎ +49 203 80398-900
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Internet: www.loi.tenova.com

10270 Roller hearth and walking beam furnaces

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☎ +49 203 80398-900
🖷 +49 203 80398-901
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Internet: www.loi.tenova.com

16.05 Top-hat furnaces

10310 Top-hat furnaces

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Internet: www.loi.tenova.com

16.08 Heating furnaces and heat treatment plants

10408 Continuous furnaces

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10410 Co-step furnaces

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47059 Duisburg, Germany
☎ +49 203 80398-900
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10430 Bogie hearth furnaces

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Internet: www.loi.tenova.com

10460 Chamber furnaces

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16.08 Heating furnaces and heat treatment plants

10510 Roller hearth and walking beam furnaces

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☎ +49 203 80398-900
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E-Mail: loi@tenova.com
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10540 Pusher-type, roller and rotary hearth furnaces

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47059 Duisburg, Germany
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10560 Heat treatment plants

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47059 Duisburg, Germany
☎ +49 203 80398-900
🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

10562 Heat treatment furnaces (continuous and discontinuous)

LOI Thermprocess GmbH
Schifferstraße 80
47059 Duisburg, Germany
☎ +49 203 80398-900
🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

10570 Heat treatment furnaces for batch operation, open heated

LOI Thermprocess GmbH
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47059 Duisburg, Germany
☎ +49 203 80398-900
🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

16.09 Bath furnaces

10580 Aluminum melting furnaces

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☎ +49 203 80398-900
🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

16.13 Components

10890 Natural gas burners

WS Wärmeprozesstechnik GmbH
Dornierstr. 14
71272 Renningen, Germany
☎ +49 7159 1632-0
🖷 +49 7159 2738
E-Mail: ws@flox.com
Internet: www.flox.com

11010 Regenerative burners

WS Wärmeprozesstechnik GmbH
Dornierstr. 14
71272 Renningen, Germany
☎ +49 7159 1632-0
🖷 +49 7159 2738
E-Mail: ws@flox.com
Internet: www.flox.com

11020 Recuperative burners

WS Wärmeprozesstechnik GmbH
Dornierstr. 14
71272 Renningen, Germany
☎ +49 7159 1632-0
🖷 +49 7159 2738
E-Mail: ws@flox.com
Internet: www.flox.com

16.13 Components

11070 Radiant tube burners

WS Wärmeprozesstechnik GmbH
Dornierstr. 14
71272 Renningen, Germany
☎ +49 7159 1632-0
🖷 +49 7159 2738
E-Mail: ws@flox.com
Internet: www.flox.com

18 Machinery and plant engineering

12210 Plant engineering, general

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🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

18.06 Ventilation plants and equipment

12660 Air conditioners for heat plants

FrigorTec GmbH
Hummelau 1
88279 Amtzell, Germany
☎ +49 7520 914820
E-Mail: info@frigortec.com
Internet: www.frigortec.com

12670 Air conditioners for crane lances, crane bridges, etc.

FrigorTec GmbH
Hummelau 1
88279 Amtzell, Germany
☎ +49 7520 914820
E-Mail: info@frigortec.com
Internet: www.frigortec.com

18.10 Power and work machines

13070 Piston pumps

HYDROWATT AG
Freistrasse 2
8200 Schaffhausen, Switzerland
☎ +41 52 624 53 22
E-Mail: info@hydrowatt.com
Internet: www.hydrowatt.com

18.10 Power and work machines

13160 Vacuum pumps

LOI Thermprocess GmbH
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☎ +49 203 80398-900
🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

21 Measuring and testing technique

21.02 Measurement of physical properties

16608 Strip thickness control (AGC)

POLYTEC GmbH
Polytec-Platz 1-7
76337 Waldbronn, Germany
☎ +49 7243 604-0
🖷 +49 7243 69944
E-Mail: info@polytec.de
Internet: www.polytec.de

21.02 Measurement of physical properties

16652 Dressing degree and mass flow measuring systems

POLYTEC GmbH
Polytec-Platz 1-7
76337 Waldbronn, Germany
☎ +49 7243 604-0
🖷 +49 7243 69944
E-Mail: info@polytec.de
Internet: www.polytec.de

21.02 Measurement of physical properties

16830 Speed measuring devices

POLYTEC GmbH
Polytec-Platz 1-7
76337 Waldbronn, Germany
☎ +49 7243 604-0
🖷 +49 7243 69944
E-Mail: info@polytec.de
Internet: www.polytec.de

21.02 Measurement of physical properties

16910 Length measuring devices for tubes

POLYTEC GmbH
Polytec-Platz 1-7
76337 Waldbronn, Germany
☎ +49 7243 604-0
🖷 +49 7243 69944
E-Mail: info@polytec.de
Internet: www.polytec.de

16950 Length and speed measuring systems (optical)

POLYTEC GmbH
Polytec-Platz 1-7
76337 Waldbronn, Germany
☎ +49 7243 604-0
🖷 +49 7243 69944
E-Mail: info@polytec.de
Internet: www.polytec.de

16960 Laser speed and length measuring systems

POLYTEC GmbH
Polytec-Platz 1-7
76337 Waldbronn, Germany
☎ +49 7243 604-0
🖷 +49 7243 69944
E-Mail: info@polytec.de
Internet: www.polytec.de

24 Environmental protection and disposal

24.01 Dedusting and gas cleaning

18360 Exhaust gas cooling systems

LOI Thermprocess GmbH
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47059 Duisburg, Germany
☎ +49 203 80398-900
🖷 +49 203 80398-901
E-Mail: loi@tenova.com
Internet: www.loi.tenova.com

18400 Treatment of dusts from steel mills and foundries

Maschinenfabrik
Gustav Eirich GmbH & Co KG
Walldürner Str. 50
74736 Hardheim, Germany
☎ +49 6283 51-0
🖷 +49 6283 51-325
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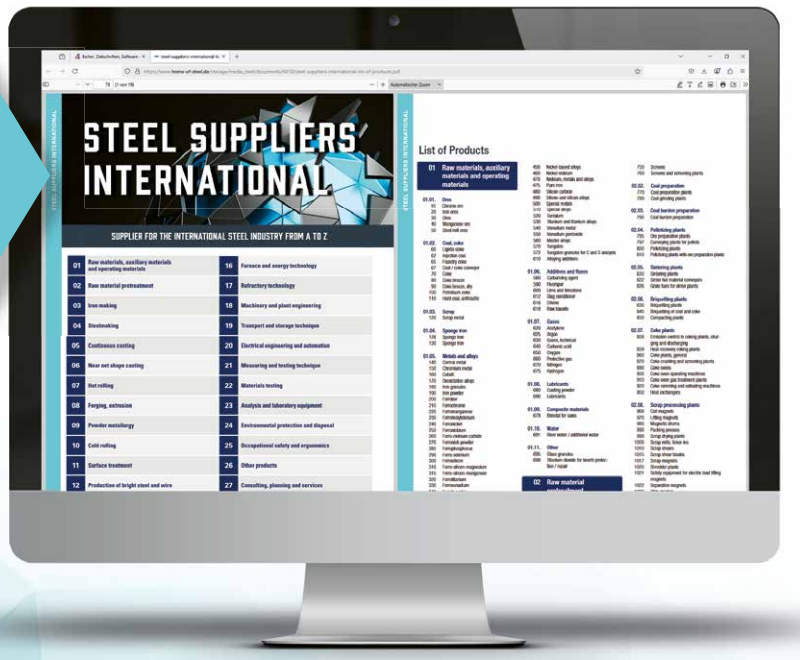

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