Metals Magazine

Innovation and technology for the metallurgical industry

SIEMENS
VAI

Issue 1 | 2012

Reuse of waste energy | **Top-gas cleaning for blast furnaces** | **Recovery of waste heat from hot EAF offgas**

Innovation and the environment

Green steelmaking of tomorrow

Dear Readers,

The ability to manage change has always counted among Siemens' entrepreneurial strengths. This applies to technological innovations that help our customers to successfully shape the future, as well as to changes in our company's structure intended to strengthen our competitive position. What you have before you is the first issue of our new "Metals Magazine," the successor to the "metals&mining" magazine.

But not only the title of our magazine is new. By concentrating on topics like green steel production of tomorrow, as in this issue, going forward we intend on taking an even closer look at the underlying developments impacting our customers and the markets – developments that we shape as a provider of technology and solutions, and that we can promote for the good of our customers. For us, this change involves the transition from an engineering company and facility builder with European roots to a global lifecycle partner for the metallurgical industry.

Our evolution from facility builder to lifecycle partner is linked more than anything to the introduction of new technologies and customer-oriented services, supported by developments in mechatronics as well as in software and IT. Among the topics that we will be turning our attention to are data connections between facilities and continuous modernization to realize all potential for optimizing production. For us this goes hand in hand with getting young people interested in our business, and attracting the industry's best up-and-coming talent, whether for metallurgical tasks or for jobs in facility building and software development.

"Metals" will always be part of our DNA, and "Metals Magazine" will continue to focus on technical topics. In this context, customers and sector experts will also have their say – as in this issue with the article "A roadmap to carbon-lean steelmaking" from the technology experts at ArcelorMittal. Together with our readers and authors, we want to look at the big picture and sharpen our view for new developments, which more than ever are the product of the global network with customers, experts and technicians. As such, dialogue will play an even more important role in "Metals Magazine" with the goal to sooner recognize trends of the future.

Yours sincerely,

Werner Auer
CEO of Siemens Metals Technologies

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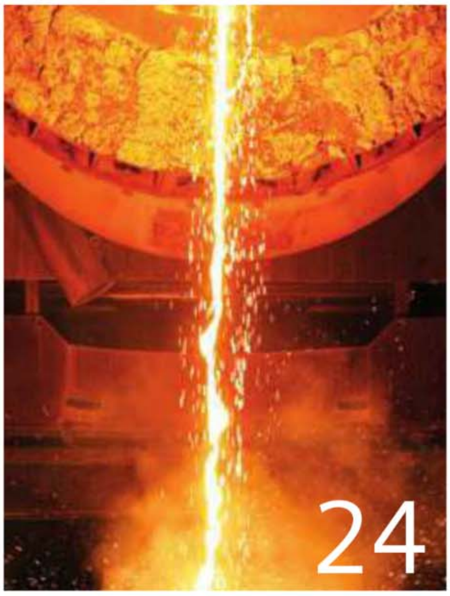

Technology

Columns

Focus: Green steelmaking of tomorrow

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Turmstrasse 44
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Editor in chief
Wieland Simon

Editorial board
Tim Dawidowsky (Casting & Rolling), Andreas Flick (CTO), Heiko Hünsch (Communications), Michael Irnstorfer (Electrics/Automation), Norbert Petermaier (Steel Plants, Minimills, Environmental Technology), Dieter Siuka (Ironmaking), Dr. Anton Stallinger (Metallurgical Services)

Editorial staff
Julia Broucek, Dr. Lawrence Gould, Dr. Rainer Schulze

Editorial assistance and contact:
Bettina Wimmer
Phone: +43 732 6592-4848
E-mail: wimmer.bettina@siemens.com

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Corporate Publishing
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Final acceptance certificate

Xingtai Steel starts production of stainless and special steels

Siemens ladle furnace at Xingtai Steel, China

Xingtai Iron & Steel Corp., Ltd. (Xingtai Steel), a Chinese steelmaker, issued Siemens the final acceptance certificate (FAC) for secondary steelmaking facilities and a four-strand continuous billet caster. The facilities are part of a new steelworks in Xingtai, in the Hebei province, for producing stainless and special steels. The secondary steelmaking facilities for the Xingtai Steel comprise a 50-ton AOD converter and a 50-ton ladle furnace. Siemens was responsible for the engineering and the supply of key components, and for the basic (Level 1) and process automation (Level 2), including metallurgical process models for both plants. Siemens China handled the locally manufactured items, and supplied some key components for the AOD converter and the ladle furnace, as well as electrical equipment and the basic automation for the steelworks. Xingtai Steel has an annual production capacity of around 3 million tons of low alloy and high-carbon steels. The company is China's leading producer of high-quality special wire and bar steel.

Korea

Novelis extends aluminum mill

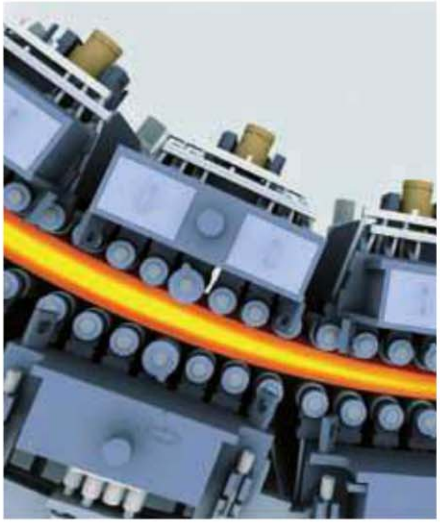
Siemens has received an order from Novelis Korea Ltd. to extend its aluminum rolling mill in Ulsan. To this end, a three-stand finishing line will be added to the plant. The project is aimed at boosting capacity and enabling future production of high-grade aluminum strip. The first strip will be rolled in July 2013. Up to now, the aluminum hot-rolling mill operated by Novelis in the Korean city of Ulsan consisted of a single reversing stand with two coilers and the necessary secondary systems. Siemens is supplying the mechanical and electrical equipment for the new, three-stand tandem rolling mill including a coiler and a coil-handling system. In the future, the existing reversing stand will function as a roughing mill. Lightweight cropping shears will also be installed in the entry to the finishing line.

ZISCO

Upgrade increases production

Chinese steel producer Shanxi Zhongyang Iron and Steel Company Ltd. (ZISCO) contracted Siemens to add a high-speed mini finishing mill to each of its three rod mills in a suburb of Zhongyang County, Shanxi province, China. The new mills are expected to be commissioned by late 2012, at which point their production speed will jump from 500,000 tons per year to 700,000 tons. ZISCO, a private enterprise, is an integrated mining, steelmaking and power-generation company that produces carbon-grade rod and rebar for the Chinese construction market. In 2009 ZISCO produced 3.6 million tons of steel wire.

JSW Steel



DynaGap Soft Reduction enables the taper and thickness to be controlled automatically at every point of the strand-guiding system to create the basic conditions for high internal slab quality

Order for a new slab caster

Leading Indian steel producer Jindal South West Steel Ltd. (JSW Steel) has ordered a new continuous slab caster for its steelworks in Toranagallu, Karnataka. As with Caster No. 3, also supplied by Siemens, the casting plant will be equipped with DynaGap Soft Reduction. This solution enables the taper and thickness to be controlled automatically at every point of the strand guiding system, thus creating the basic conditions for high internal slab quality. The continuous slab caster, to be commissioned in mid-2013, will have an annual production capacity of 1.4 million tons. It will be able to cast slabs with thicknesses between 220 mm and 260 mm, and widths between 800 mm and 1,600 mm. It will produce carbon, micro and low-alloy steels, as well as HSLA (high-strength low-alloy) steels, which will be further processed into sheets, strips and pipes.

Automation

Upgrade for ThyssenKrupp Steel Europe casting-rolling mill

ThyssenKrupp Steel Europe AG is upgrading the casting-rolling mill at its Duisburg-Bruckhausen, Germany, location with new basic automation and technology packages. The order will be completed by spring 2013. Siemens is equipping the casting-rolling mill with a series of state-of-the-art technological controls, such as Mold Expert breakout prevention and LevCon mold level control. The scope of delivery also covers DynaFlex oscillator control for flexible adjustment of the oscillation parameters, optimized DynaWidth control of the adjustable mold for online modification of slab width, ASTC (Automatic Strand Taper Control) segment adjusting, and bender and straightener adjustment. Moreover, the casting-rolling mill will be equipped with a new Simatic PCS7 basic automation system including a visualization system. The automation packages and the technological controls will be installed and commissioned without additional downtimes.

The Mold Expert visualization system for early breakout detection

Southwire

Aluminum rod mill for Beauty Sun

Siemens has received an order from the Southwire Company of Carrollton, Georgia, to supply an aluminum rod rolling mill for Beauty Sun Holdings Ltd. The new mill will be located in Yixing, Jiangsu province, China, with commissioning expected during the first quarter of 2012. Siemens is responsible for the engineering, manufacturing and commissioning of the rolling mill and coiler equipment for the Southwire SCR AL 7000 rolling mill. The new mill will produce aluminum rod for the power conductor market and will complement the company's existing Southwire copper rod system, which was also equipped by Siemens.

Southwire and Siemens have worked together for more than 40 years. During that time, Siemens has built more than 80 non-ferrous mills for Southwire customers and completed nearly 30 upgrades.

Aluminum rod mill from Siemens

Revamp

Gerdau Mogi das Cruzes invests in flat-bar production

The Gerdau plant specializes in long-rolling products

The Brazilian steel producer Gerdau S.A. has issued an order to Siemens for the revamp of its bar mill at the Mogi das Cruzes location for the production of flat bar. For this purpose, the intermediate train, the finishing train and the cooling bed will be revamped. The supply includes the mechanical equipment, the mechatronical packages and the complete electrical and automation systems. The upgraded plant is scheduled to commence production in early 2013. The Gerdau plant in Mogi das Cruzes, state of São Paulo, specializes in producing long-rolled products for the construction industry. The bar mill has a capacity of around 260,000 tons per year. After completion of the revamp, the mill will be capable of rolling flat bar with widths between 50 mm and 106.6 mm and thicknesses from 5.4 mm to 51 mm. As part of the project, Siemens will modernize the combined intermediate and finishing train and the cooling bed. The company will also supply the basic automation and Siroll mechatronics packages for control of the rolling stands and the shears. The scope of supply will also include electrical systems such as medium-voltage switchgear, low-voltage distribution, transformers, motors for the drives of the rolling line, a motor control center and an uninterruptible power supply.

China

Shougang Tonghua modernizes bar and bar-in-coil mill

Siemens will supply equipment to modernize the bar mill of the Chinese Shougang Tonghua Iron & Steel Co. The project will also optimize the entry of the cooling bed of the bar production and the Garrett reel in the bar-in-coil production. The equipment will reduce wear on the work pieces considerably and improve the quality of the final products. Completion of the modernization is scheduled for mid-2012. As part of the project the original bar and bar-in-coil mill, installed in 2006 by Siemens in the Beijing area, will be relocated to Tonghua in the Jilin province. With an annual capacity of 600,000 tons of straight and coiled quality steel bars, the mill can produce bar stock with diameters from 14 mm to 80 mm and coiled bar with diameters from 14 mm to 50 mm. Shougang Tonghua is part of the Shougang Group, one of China's leading steel producers.

E&A

Bhushan Steel to expand hot-strip mill

Bhushan Steel Ltd., an Indian steel producer, has engaged Siemens to supply the electrical and automation equipment for the expansion of its existing hot-strip mill in Meramandali, in the Indian state of Orissa. The objectives of the project are to increase the production capacity and widen the range of products. A second roughing stand, an additional finishing stand and a third coiler will be installed during the course of the extensive modernization. This will enable Bhushan Steel to not only add thinner strips to its range of products but also increase its output.

Shaoguan Iron and Steel Group

New bar mill for a new plant in Songshan

Precision sizing stand from Siemens

Siemens received an order from Baosteel Engineering & Technology Co. Ltd. to supply a new bar mill to the Shaoguan Iron and Steel Group (Shaoguan). The plant for producing alloyed round bars with diameters up to 80 mm with sizing technology will be installed in Songshan in the Guangdong province, southern China, and is scheduled to commence operation in early 2013. For the new bar mill in Shaoguan, Siemens will supply a four-stand prefinishing mill, a four-stand finishing mill, a crop shear, a precision sizing mill, and three cooling sections for thermomechanical processing. The two rolling mills are equipped with Red Ring stands in HVHV configuration. The scope of supply from Siemens will also include the basic automation and Siroll mechatronics packages for the sizing mill, cooling sections, shears, cut optimization and cold cutting saws. Around 460,000 tons of alloyed round bar stock with diameters between 20 mm and 80 mm can be produced per year in the bar mill. The Shaoguan Iron and Steel Group, the majority of which is owned by the Baosteel Group, is China's biggest steel producer with an annual output of around 40 million tons.

Byelorussian Steelworks

New equipment for Zhlobin to boost production

Siemens has received an order from Byelorussian Steelworks (BMZ) to equip its Zhlobin factory with secondary metallurgical plants and a new six-strand continuous billet casting plant. The addition will help BMZ boost its production capacity to around 1.2 million annual tons and expand its product spectrum and quality. The order volume is in the mid-double-digit million euro range. The project is to be completed in early 2013. The order includes two 100-ton ladle furnaces, a 100-ton RH plant, the complete alloy material management including the weighing and transport systems, a dust extraction system and water management. Integrated basic automation (Level 1) will ensure an optimum interplay of all plant components. The ladle furnaces and the RH plant will also have a Level 2 process optimization system. The new equipment will enable BMZ to manufacture a broader range of steel grades, including high-strength, alloyed and standard carbon steels. Around 1.5 million tons of liquid steel can be treated on an annual basis in the new secondary metallurgical plant.

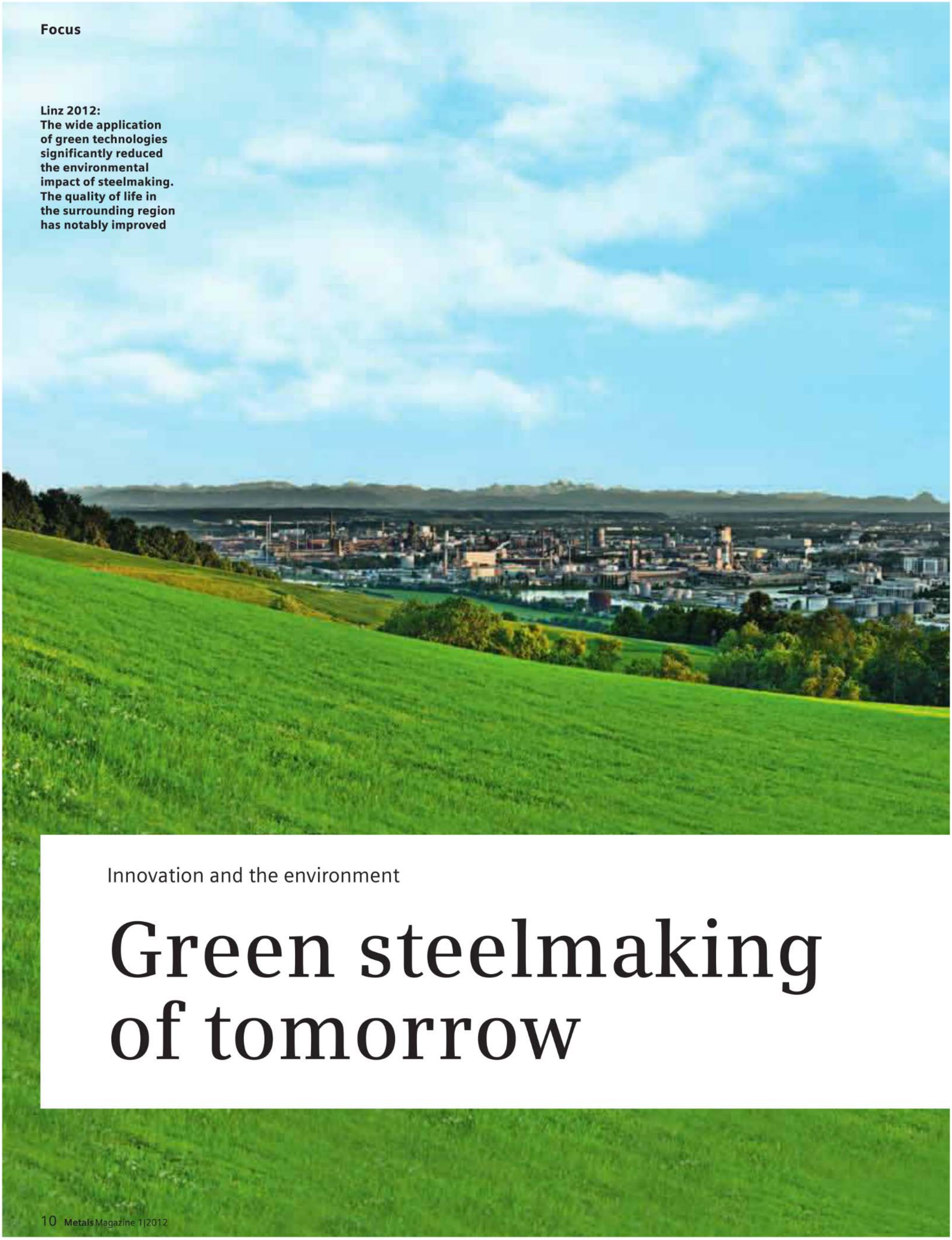
State-owned BMZ was founded in 1984. The current project with Siemens is part of a modernization program that will be running until 2015

Italy

Riva modernizes medium-section mill in Sellero

Section rolled on a Siemens rolling mill for medium-sized products

Siemens has received an order from Riva Acciaio to modernize the roughing train of the medium-section mill in Sellero, Italy. The scope includes the complete process and mechatronics packages for the blooming stand, the electric and automation systems, and construction. The objectives of the project are to boost productivity and expand flexibility in regard to operation modes and product changes. The modernization is to be completed in the second half of 2012.



Linz 2012: The wide application of green technologies significantly reduced the environmental impact of steelmaking. The quality of life in the surrounding region has notably improved

Innovation and the environment

Green steelmaking of tomorrow

A ton of steel can be produced using far less input materials and energy than had been possible at any time in the past. Nevertheless, the combination of current technologies with tomorrow’s solutions will one day allow the vision of a zero-emission steelworks to become reality.

In the future, steel will become increasingly sophisticated and demands to produce competitively will drive both steel companies and solution supplier to achieve maximum performance. At the same time, innovative companies will redefine basic conditions for sustainable production. "We are making substantial investments in research and development," says Werner Auer, CEO of Siemens Metals Technologies. "Ultimately, our vision is the green mill of the future where waste becomes a resource, where a plant not only consumes energy but also produces it, and where recycling is a profitable activity within a plant."

These ideas are not entirely new. For decades, the European steel industry has safeguarded its locations with innovations and new processes, and it has continued to expand its technological leadership in terms of processes and production methods. A number of new developments in plant and process engineering have clearly reduced the amounts of raw materials and energy needed to produce a ton of steel. At the same time, these innovations have further boosted output. And with the higher production figures comes the need to do even more to protect the environment. In this area, Europe holds a pioneering role. For example, specific consumption of coal, as conclusively proven by the German Steel Federation (Wirtschaftsvereinigung Stahl), dropped by 149 kg per ton between 1980 and 2008. In absolute figures, this equates to 6.4 million tons yearly, and corresponds to a reduction of around 18 million tons of CO_2 every year. In those 28 years, freshwater consumption was also reduced – by about 70%. Since 1960, German companies have increased their iron output during steel production from 65% to 89%. During the same period, specific energy consumption of 30 GJ per ton of crude steel was cut to 18 GJ per ton. This corresponds to a drop of around 40%.

In the green mill of the future waste becomes a resource for raw material and energy.

These figures are impressive proof of how plant process engineering can enhance steel production, boost raw material and energy efficiency, and help protect the environment. These technology developments have also led to an increase in the number of steel grades that can be produced. Finally, European companies have set new technological standards and greatly improved product quality. And there is still potential to improve steel production.

Aside from pressure to constantly improve, European steel producers currently face challenges to stay profitable. One of these challenges is costs: energy, coal and ferrous raw materials account for the lion's share of expenditures to produce steel. Furthermore, indirect charges for consuming fossil fuels – in the form of CO_2 taxes – are looming. In Europe, for example, within the third trading period costs are expected to rise to €30/ton of CO_2. To put this figure into perspective, integrated steelmakers emit about two tons of CO_2 for each ton of steel produced. This development imposes additional pressure to cut the specific energy demand. Furthermore, the trend toward even tighter environmental legislation will continue. Altogether, these developments will make it increasingly difficult for steel producers to ensure profitable operations.

"Together with our customers we face further challenges such as how to combine the extremely volatile raw material prices with foresighted as well as economic production," says Auer. Therefore, in Europe solutions are being created to reduce energy use and lower CO_2 emissions with other processes. To date, substantial investments have been made for environmental protection equipment to reduce dust, SO_2 and NO_x. As a result, most plants in Europe have become

Selective Waste-Gas Recirculation System installed in Sinter Plant No. 1 at Dragon Steel Corporation, Taiwan

Developed in Europe, exported to Asia: Meros plant in operation at Maanshan Iron & Steel Co.

models for the worldwide steelmaking community. As a lifecycle solution provider, Siemens contributes not only technology but also automation solutions, all in an effort to make steel manufacturing more cost effective and environmentally friendlier, and above all to make production more economical and thus safeguard a company's competitiveness. Progress made in Europe also benefit operators in other countries.

One example is the new Thyssen Krupp plant in Brazil, which fulfills the highest environmental standards. As the European steel industry expands to other countries, it builds plants that adhere to the European level in regard to environmental protection. And even the most recent plants being constructed for Indian and Chinese customers increasingly conform to high environmental-protection standards. However, many older installations have yet to be retrofitted so that they comply with modern requirements. Here again, European steel producers have demonstrated that it is possible to modernize plants so that they comply with the highest environmental standards.

But what technologies are now available and what is still needed to substantially lower emissions? In the following, various solutions, ideas and visions of Siemens are discussed, each of which can help steel producers to attain their current and future sustainability goals.

Sintering

In the unique Selective Waste-Gas Recirculation system from Siemens, 30% to 40% of the total sinter offgas is extracted from selected wind boxes, dedusted, mixed with ambient air and/or off-air from the sinter cooler, and then recirculated to the sinter strand. The heat and CO content of the recirculated waste gas helps reduce the solid-fuel consumption during sintering. In addition to the positive impact on the sintering process, the offgas volume directed ►

to the stack is lowered, which reduces the related investment and operational costs for emission treatment.

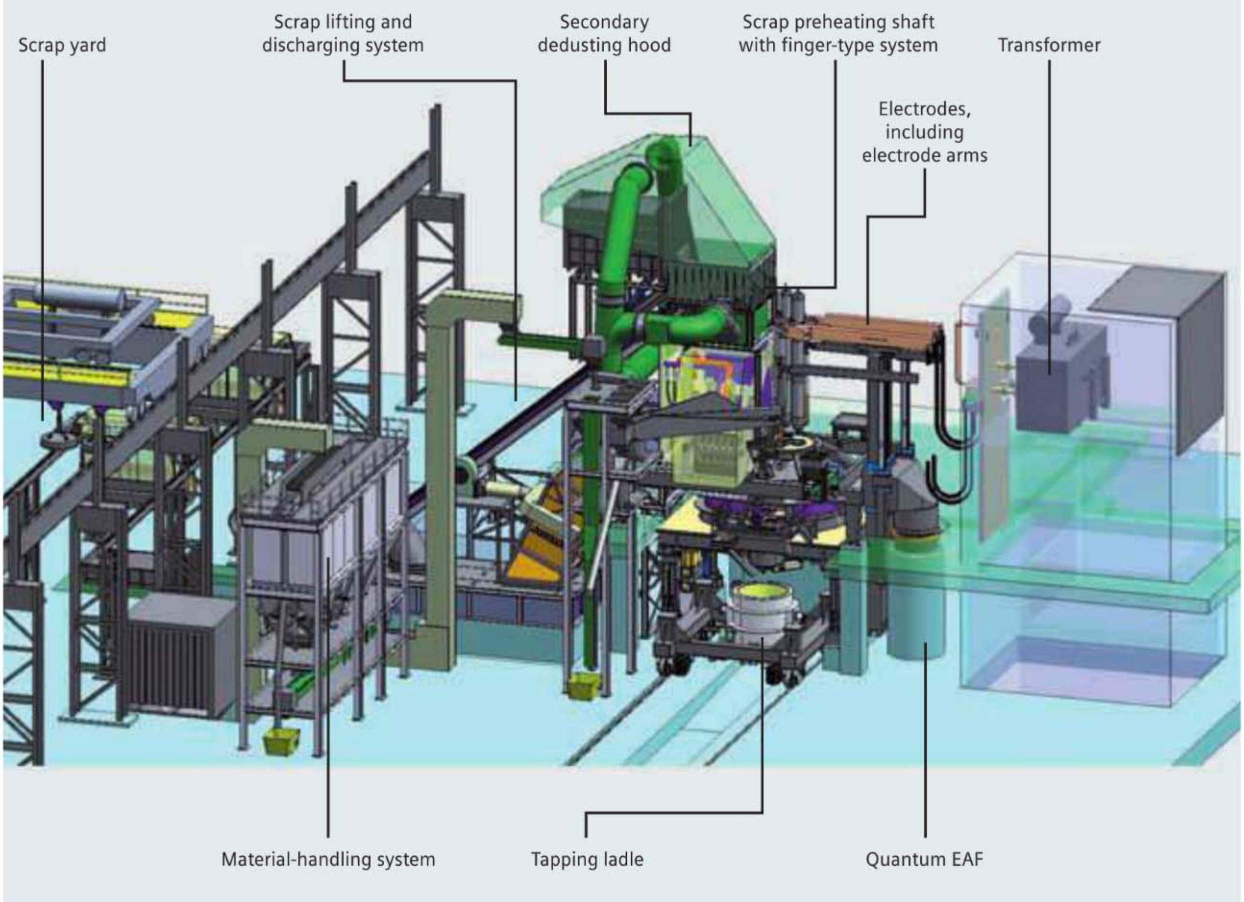
The Meros (Maximized Emission Reduction Of Sintering) process is a major environmental milestone for the treatment of offgas from the sinter plant and reduction of specific emissions. Dusts, acidic gases, and metallic and organic components present in the sinter offgas are reduced in a series of process steps to levels previously unattained with conventional offgas treatment systems. For example, in the Meros plant installed at voestalpine Stahl in Linz, Austria, dust emissions could be lowered by more than 99% to less than 5 mg/Nm^3; mercury and lead emissions were reduced by 97% and 99%, respectively; organic compounds such as dioxins and furans (PCDD/F) were eliminated by about 97%; and total condensable VOCs could be destroyed by more than 99%. SO_2 emissions were also considerably reduced.

At Siemens investigations are currently being carried out on how to ideally utilize the remnant heat from the sintering process for heating applications or for steam production to generate electrical energy. Even more exciting is the possibility to charge hot sinter exiting the sinter strand directly into the blast furnace by means of an insulated conveyor system. Doing so would lead to enormous energy savings in the form of lower specific coke consumption to produce hot metal. An added benefit would be the simultaneous reduction in CO_2 emissions. Hot sinter charging to the blast furnace represents perhaps the greatest untapped potential for energy savings in the iron and steel industry. Further investigation and the introduction of new technical solutions are required before such a process can be applied on a broad industrial scale.

Ironmaking

Blast furnace slag with its well-known hydraulic properties is already widely used as a substitute for cement clinker. Depending on the particular cement application, the ratio

Schematic view of a Quantum EAF plant



Pilot dry-slag granulator in operation

between ground granulated blast furnace slag and clinker that could be used to produce a good-quality Portland cement can lie between 30% and 95%. Each ton of slag that substitutes clinker not only reduces the energy consumption in the cement-production process but also eliminates approximately 0.7 tons of CO_2 emissions (less limestone needs to be decarbonated in a rotary kiln). Other slags, such as LD (BOF) converter slag and those from secondary metallurgical processes, can be chemically modified in such a way that they can also be used as a cement clinker substitute. Presently, less than 25% of total blast furnace slag is further processed to cement. The rest is used for landfill, road construction or simply dumped in a waste heap.

Converter steelmaking

The recovery of CO gas from LD (BOF) converter offgas is becoming increasingly important for steel producers to reduce energy costs and CO_2 emissions. Offgas exiting the converter at temperatures up to 1,700°C is first cooled and then dedusted. The inherent thermal energy in the offgas is used to generate steam for various applications within the steelworks. If the CO content of the converter offgas is above a certain concentration, it is routed in the gas switchover station to a cooler followed by storage in a gas holder. Roughly 70–100 Nm^3 of highly energetic CO gas can be recovered per ton of liquid steel and subsequently used for heating applications or for electricity generation. This decreases fossil-fuel costs and the related CO_2 taxes.

EAF-based minimills

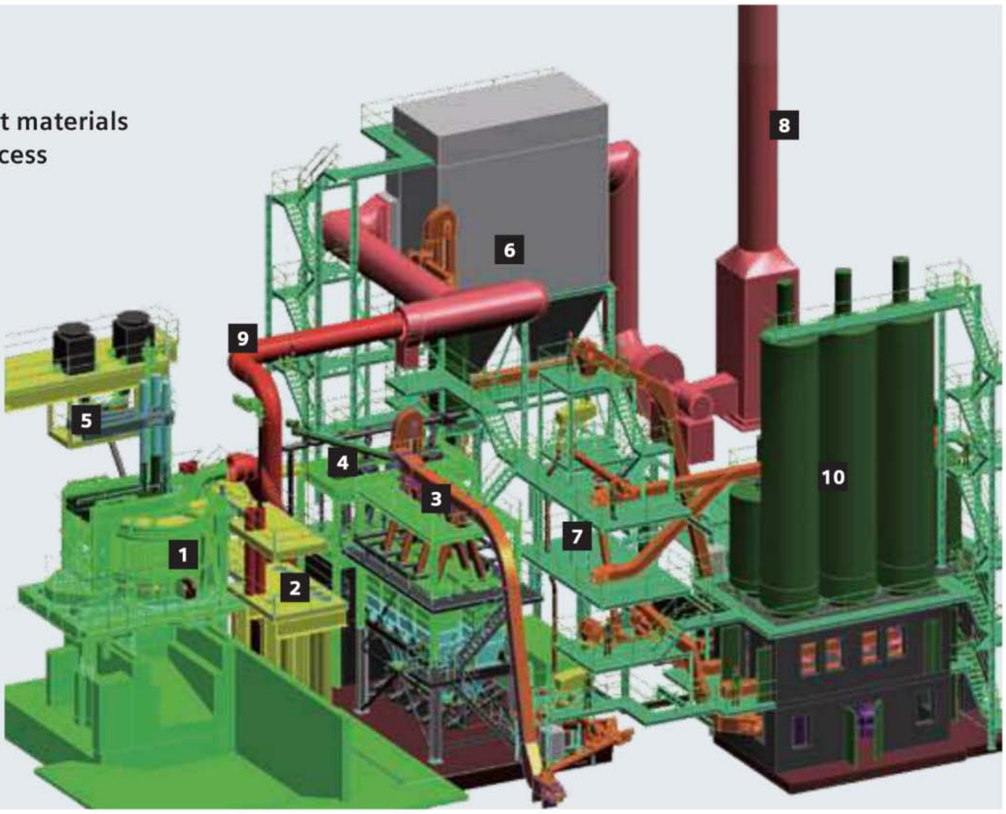
Compared to the integrated iron and steel production route, a minimill offers a number of important advantages including lower investment and operational costs; flexibility with respect to the charge materials such as scrap, direct-reduced iron (DRI), hot-briquetted iron (HBI) and hot metal; fewer by-products; and lower emissions and greenhouse gases per ton of tapped steel. The minimill route offers even greater potential to become more energy efficient and for implementing a zero-waste strategy. In the following, four trendsetting innovations from Siemens are outlined that offer the most energy-efficient solution on the market today for a scrap-based minimill.

Currently, scrap-based electric arc furnaces (EAF) release more than 25% of the primary energy input with the furnace hot offgas. In conventional installations, this energy is transferred to the cooling water and thus lost to the atmosphere in the form of waste steam. An alternative approach is to use the energy from the offgas to preheat scrap, which is applied in the Siemens Quantum EAF. This solution, which is based on well-proven finger-shaft technology, features a revolutionary furnace design with an impressive combination of highly innovative solutions for optimized scrap charging to the shaft, preheating, melting, tapping and offgas treatment. Furthermore, the Quantum EAF also allows a continuous melting process to be applied in combination with a different scrap-charging procedure. The specific electrical energy consumption can be reduced from 390 kWh/t of tapped steel in a conventional EAF to 280 kWh/t of steel in a Quantum EAF. CO_2 emissions are lowered by 20%, taking into account the average European CO_2 emission factor for power generation.

> To reduce 80% of emissions from steelworks you need 20% of the environmental investment costs. Tackling the remaining 20% of emissions will claim 80% of the total costs.
>
> **Dieter Bettinger**

In a new generation of ultra-energy-efficient minimills, liquid steel from a Quantum EAF equipped with Heat 2 Power is then processed to long products in continuous casting-rolling facility. In the WinLink solution from Siemens, a high-speed billet caster equipped with the latest technological packages to allow casting speeds in excess of 7 m/min is directly linked with a multi-flexible rolling mill. The uninterrupted production of long products directly from liquid steel is the basis for ▶

Input and output materials of the ZeWa process



1. Reduction furnace
2. Injection-lance storage
3. Injection system
4. Injection dispenser
5. Addition material-charging system
6. Gas-cleaning facility
7. Preparation facilities
8. Exhaust stack
9. Water-cooled hot-gas line
10. Waste storage bins

Trial investigations of the ZeWa (zero-waste) process in Vítkovice Steelworks, Czech Republic

relatively low investment expenditures, major energy savings due to the direct rolling of hot billets, a smaller environmental impact as a consequence of reduced electrical energy required for rolling, and highly profitable production of long products.

ZeWa process

Until recently, it was not possible to efficiently recover many of the by-products generated by the steel industry (e.g., slags, dusts, sludges and scales) and other important sectors (e.g., fly ash from power plants, residues from car dismantling, ash from urban incinerators). In the course of a European Union project conducted from 2001 to 2005, a cooperation between Siemens, Arcelor, CRM and Lafarge led to the development of a new industrial waste-treatment process in which suitable blends of by-products could be converted into valuable metallic and mineral products. Referred to as ZeWa, a name that reflects the “zero-waste” approach, this process involves high-temperature smelting-reduction operations carried out in a specially designed, electrically heated reactor.

A demonstration plant with a by-product production capacity of 2 t/h, including all of the related auxiliary facilities (e.g., injection plant, bunkers, slag granulator), was erected at the Vítkovice Steelworks in the Czech Republic. In a series of test campaigns, the technical and economical feasibility of generating useful metallic and mineral products from the residues of carbon and stainless steel production were investigated in the ZeWa process. Through the injection of by-products and additives into a ZeWa reactor, the slag chemistry and thus the composition of the mineral product is adjusted according to the foreseen purpose. Reclaimed metals or alloys can be directly recycled in the metal-production process. Mineral products from ZeWa can be used in a wide range of applications such as a clinker substitute in the cement industry. The quality of the mineral product for this purpose can even exceed that of good blast furnace slags. The composition of the mineral aggregates can also be adjusted to produce desulfurization powders for use in secondary metallurgy. The process dust, which is highly enriched in zinc, is a valuable raw material for the zinc industry.

China is a front runner in reducing SO_2 emissions and the United States in NO_x reduction; Europe focuses on CO_2 and fine-dust reductions.

Dr. Alexander Fleischanderl

Cold briquetting

Cold briquetting of various dusts and sludges allows integrated recycling within existing primary production units. After pretreatment of the residues, including drying, screening and mixing, binders are added and the mixture, which can then be briquetted using roller-type presses. The binder system used depends on the input materials and the foreseen downstream application. Briquettes with a high iron content and high basicity can be charged to LD (BOF) converters, replacing cooling scrap or ore. Briquettes rich in carbon but with limited alkali and zinc contents can be charged to the blast furnace.

Greenhouse gases – the final challenge?

Even if all metallurgical slags could be used in the cement industry, if all dust could be filtered from the waste gas, if all by-products could be recycled and if all heat-recovery solutions were implemented, the production of steel would still generate huge quantities of CO_2. There are several approaches to deal with the problem, including carbon capture and storage (CCS); the use of algae to produce biomass or jet fuel; bacteria to convert CO/CO_2 into ethanol and basic chemicals; and the use of hydrogen instead of carbon for the reduction of ores. Each of these technologies is still in its infancy, so at best they must be placed in the category of "vision." A brief outline of two of these solutions follows:

Hydrogen-reduction metallurgy

For the long term, a decisive step to slash CO_2 emissions in a green steel mill would be to partly or completely replace carbon-based reductants with hydrogen produced using renewable energy sources. For example, excess energy generated from wind power or photovoltaic plants that temporarily cannot be fed to the power grid could be used to produce hydrogen by means of electrolysis. The hydrogen can be easily stored and piped to industrial consumers. Siemens is currently involved in a future-oriented R&D program to define the technological and economical parameters of this technology.

A longer service life

In the future, steel plants will be operated for longer periods than before, and they may well run for over 50 years. In the process they will have to meet not only current standards but also new requirements regarding energy efficiency, safety and environmental protection. "Extending operating periods in this way is technically possible and it makes economic sense, but such an approach requires continuous plant modernization," explains Auer. According to him it will become increasingly important to modernize and upgrade existing plants in order to enable production of new steel grades and material properties. This is especially the case for countries with a rising demand for consumer goods such as India and China. "Besides the construction and commissioning of new plants equipped with state-of-the-art environmental-protection technology, we're now expecting stronger demand for modernization, upgrade and service to further optimize operating procedures and individual processes," says Auer. This protects investments of steel companies for the long term, improves their cost-effectiveness in the short term, and reduces the environment impact from production.

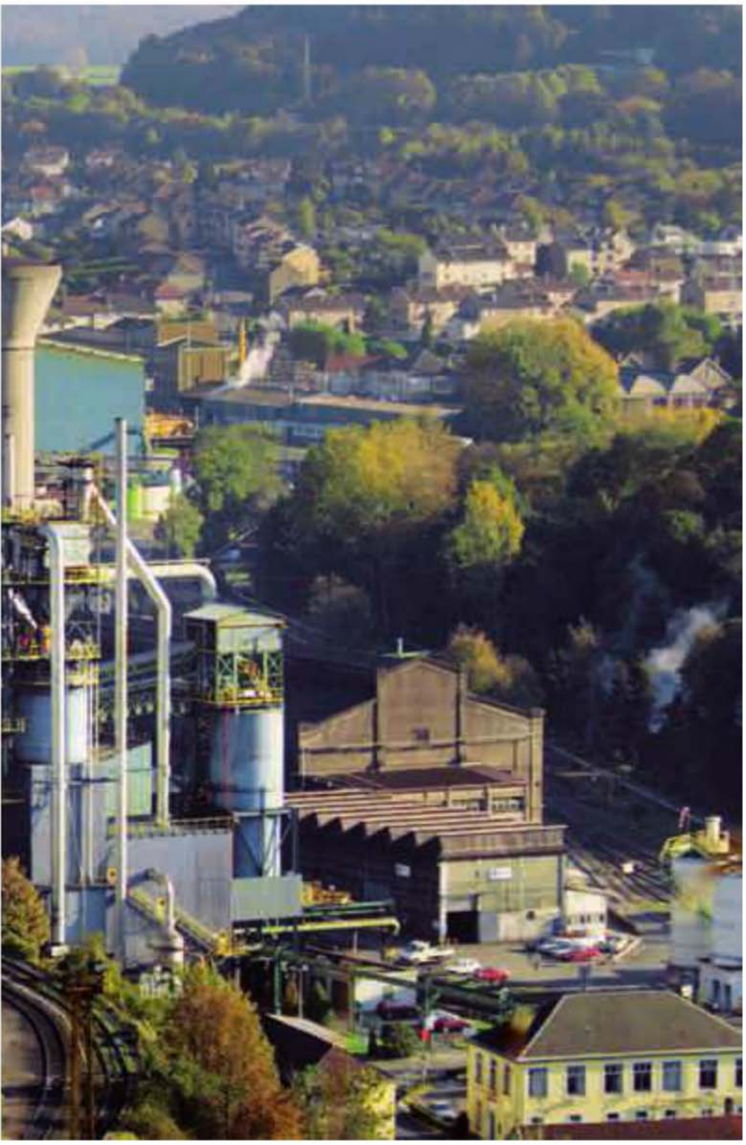
Since the recovery of the world market in 2010, steel demand has been growing, and operators are receiving more orders for high-quality steel grades. At the same time, rising raw material and energy prices as well as tighter environmental requirements are posing new challenges for steel producers. "Business for modernizing and optimizing existing plants is growing faster than business with new plants," observes Auer. Siemens has therefore systematically expanded its portfolio for this modernization and service market with technical innovations and modular system packages that increase the productivity of steel plants. ■

Authors
Dieter Bettinger, vice president of energy and environmental care
Wieland Simon, Dr. Alexander Fleischanderl, vice president and head of technology for steelmaking, minimills and the environment

ArcelorMittal takes major steps to reduce CO_2 emissions

A roadmap to carbon-lean steelmaking

During the past several decades tremendous progress has been made to reduce energy consumption – and hence CO_2 emissions – along the iron and steel production chain. Additional improvements applying conventional solutions are made continuously; however, at the time these are only incremental at best. Going forward, it will therefore be imperative to develop and apply breakthrough technologies to ensure continued major advances in energy efficiency. This article outlines current and planned efforts at ArcelorMittal to minimize steelmaking's carbon footprint.



Angelika Kostall inspects steel strip fresh from the galvanizing shop at EKO Stahl, an Arcelor company

Blast furnace panorama at ArcelorMittal Lorrain in Florange, France. The P6 blast furnace (first blast furnace from the left) will be converted into an ULCOS blast furnace

During the past 40 years, the energy consumed by the steel sector worldwide has declined dramatically, as confirmed by several steel organizations. For example, the American Institute for the Steel Industry (AISI) reported a 75% decrease in the specific energy demand since 1950 for steel shipped in the United States, and Eurofer recorded a 55% decrease since 1975 (Figures 1 and 2). Although these figures are impressive, a closer look is needed to identify the various contributing factors and to estimate the remaining potential.

An important reason for the reduced specific energy consumption is the greater availability of scrap and the development of the electric arc furnace (EAF) route that followed suit, mainly since the beginning of the 1970s. Although there are no precise statistics on worldwide scrap quantities, estimates show that the availability of scrap today rises by more than 1% per year in the European Union and North America, whereas total steel production has hardly increased in these regions at all. This trend is expected to continue for the long term.

Another reason for the lower specific energy demand is linked to an enormous increase in the material efficiency of steel plants. Thanks to the adoption of continuous casting and the progress made in quality and process management in rolling mills, the output of steel plants today is about 25% higher than 40 years ago for the same amount of liquid steel produced. Given the high material efficiencies that are achieved today (about 95%), the possibility for further improvements in this field has become very limited.

The last important factor is related to the continuous advances that have been made in iron and steel production processes. Progress in this area is mainly attributed to two key factors: First of all, hot-metal production has become more efficient. Since the 1950s there has been a notable improvement in the iron burden quality. The widespread introduction of ore sintering, ore beneficiation and the decreased use of low-grade iron ores have had a significant impact. Blast furnaces have become pressurized and, due to the use of better refractory materials, higher blast temperatures (>1,200°C) ►

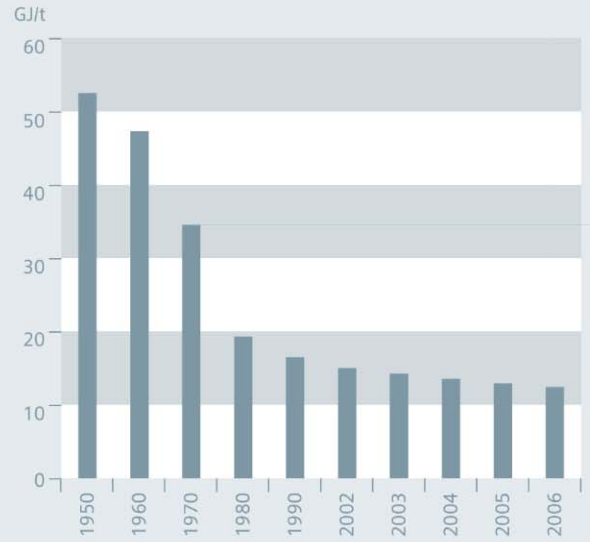


Fig. 1: Energy consumption per ton of steel shipped in the United States

Fig. 2: CO_2 emissions per ton of finished steel in the EU-15

have become possible. More recently, a number of blast furnace developments have brought performance close to the limits of what is thermodynamically possible. Examples include the introduction of bell-less top-charging equipment for better control of burden charging; instrumentation of blast furnaces together with the application of mathematical process models; and online computerized management of the process. Hence, important future progress with classical process technology is not to be expected here. Secondly, noticeable improvements have also been achieved by phasing out obsolete technologies such as open-hearth furnaces, and by introducing continuous casting, which eliminates the slabbing mill and the associated reheating step. A further energy-saving measure, which for many reasons is often difficult to implement, is the hot charging of slabs directly to hot-rolling mills. Improvements in the specific energy-consumption rate are fewer despite the increased pressure and demand for continued progress. Today, there are no clear breakthrough technologies on the process level that can be industrially applied to substantially decrease the energy required to produce steel.

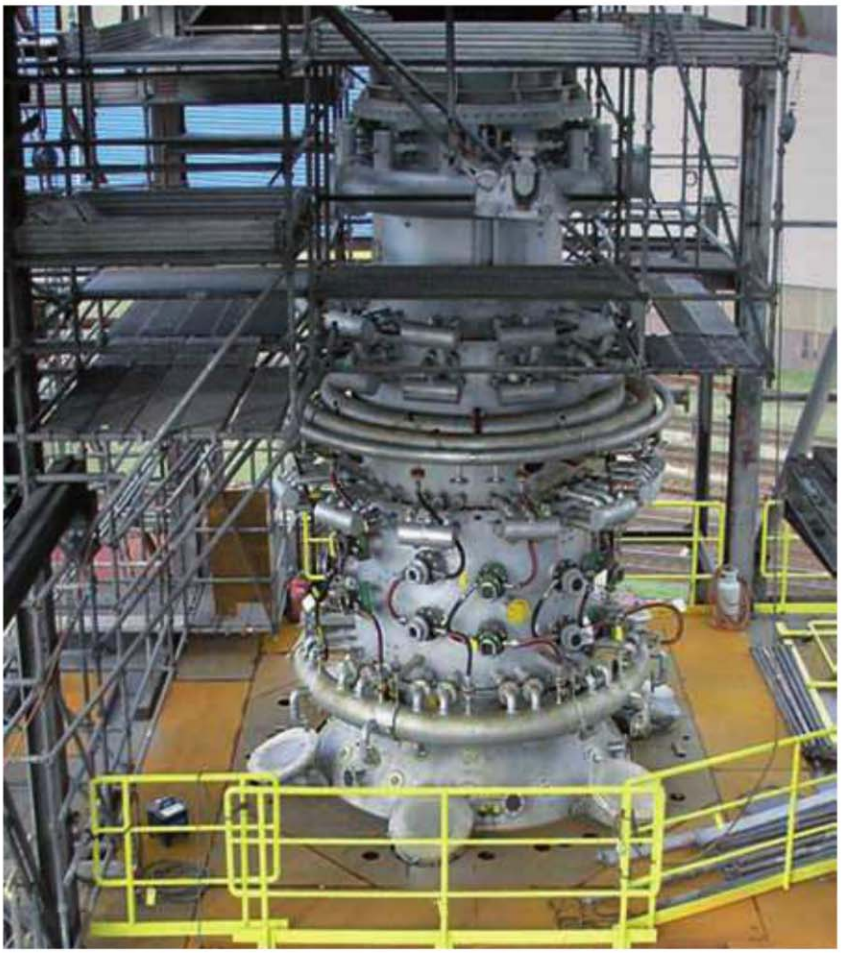
Mid-term action plan of ArcelorMittal

On the basis of a detailed analysis of each of its steel-mill facilities, ArcelorMittal has outlined its overall improvement potential. Plant management was invited to devise a plan to bridge the gap between present performance and achievable levels. In total, about 400 actions were proposed for 40 different plant sites. The various measures can be classified and ranked according to their importance as follows:

- Phase-out of obsolete technologies, including the shutdown of open-hearth furnaces and the elimination of ingot casting and soaking pits
- Process improvements such as enhancing the efficiency of poorly performing blast furnaces and sinter plants and maximizing material yield to reduce direct emissions
- Higher energy efficiency through the reduction of flare losses, installation of energy-recovery equipment and boosting the efficiency of combustion processes

A last category concerns the use of alternative raw materials such as lump ore, scrap, direct-reduced iron (DRI) and biomass, etc.

The resulting plan, which was adopted by the management board of ArcelorMittal, will yield a reduction of 8% in specific terms (about 17 kg CO_2 per ton of steel) by 2020 compared to the emission levels of its installed steelmaking facilities as of 2007. Also taken into account are all non-steelmaking activities at the steelmaking sites such as power generation and lime production. The emissions considered are all direct emissions and include exported waste gases; indirect emissions related to the purchase of electricity beyond what can be produced with plant-process gases; and emissions linked to other upstream emissions for purchased intermediate products such as coke,



HIsarna smelting-reduction pilot plant, Ijmuiden, the Netherlands

Laboratory investigations of electrolytic iron ore reduction in the Ulcowin process

pellets, DRI and lime. Emission credits for by-products such as granulated blast furnace slag were also evaluated.

Breakthrough strategies for steelmaking

After the adoption of the Kyoto Protocol in 1997, the industry realized that options to reduce the CO_2 footprint of steelmaking were too limited to address the challenges ahead. In 2001 ArcelorMittal, together with other leading steel producers, launched an initiative to develop breakthrough technologies for primary steel production. The initiative led to collaboration within the World Steel Association for screening possible ideas for new alternatives to produce steel with lower CO_2 emissions. After two years of study, a European initiative under the name ULCOS (Ultra Low CO_2 Steelmaking) emerged in 2004, backed by a consortium involving most major European steel producers. In total, 48 E.U. partners took part in this program. Initially more than 80 process concepts were studied. After 18 months of investigation and benchmarking, four major candidates for a new steelmaking breakthrough technology were selected. Essential for the selection was that the new technology would be at least 50% less CO_2 intensive than the benchmark blast furnace. The four candidate technologies are outlined as follows:

1) ULCOS-BF or Top-Gas Recycling Blast furnace (TGR-BF): Figure 3 gives a schematic overview of the process, which is based on a classical blast furnace. However, instead of exporting the blast furnace gas to a power plant for final energy recovery, the gas is sent to a gas-separation unit to isolate CO from CO_2. CO is preheated and recycled to the blast furnace, which decreases the specific coke consumption rate by about 25%. Furthermore, the hot blast is replaced by oxygen, which not only avoids an accumulation of nitrogen in the recycling loop but also dramatically increases the smelting performance of the blast furnace. Direct emissions from primary steelmaking will decrease by about 18%. Since the flue gas is almost pure CO_2, it is very well suited after an additional purification step for underground carbon capture and storage (CCS), a step that will additionally lower carbon emissions by another 50%.

Out of 80 concepts, four candidates were selected for a new technology.

This technology was developed and tested with positive results at the pilot-scale blast furnace of LKAB in Luleå, Sweden. The technology was mature enough to move on to a large-scale demonstration plant. The ULCOS consortium therefore launched a demonstration project ▶

with complete CO_2 storage at an ArcelorMittal plant in northern France. This project was presented to the NER-300 program of the European Union in February 2010. If all goes well in terms of process selection and financing, the demonstration plant should be ready to start up as a full CCS facility by the end of 2015.

2) HIsarna smelting reduction pilot plant: The single reactor vessel integrates two operations comprising a melting cyclone for ore melting and a smelter vessel for final ore reduction and iron production. The setup has the advantage that there is no need for burden preparation, hence avoiding coke, sinter or pellet plant emissions. It also uses pure oxygen, and hot gas from the bath smelter is postcombusted in the cyclone to recover latent heat. As such, the end product is a CO_2-rich gas, which in principle is ready for direct storage. If the technology operates as expected, direct emissions per ton of hot-rolled coil can be reduced by about 80%. A pilot plant has been operating in Ijmuiden, the Netherlands, since May 2011.
3) ULCORED – a new direct-reduction process: The production of DRI generates a solid product that is melted in an EAF. In the ULCOS natural-gas-based version of the process, reforming is carried out by partial oxidation. CO is shifted to H_2, and gases are recycled and purged of CO_2, which is then sent to storage. Large gains in emissions are obtained if electricity from a carbon-lean grid is used.
4) Ironmaking by means of the Ulcolysis or Ulcowin electrolysis processes: Electrolysis of iron ore offers the opportunity to produce almost-zero direct emissions, while indirect emissions are only those of the electricity grid. The concept has not yet been developed because of the relatively “high” price of electricity and the “low” price of steel. Low-temperature and high-temperature processes are currently being investigated on a laboratory scale. Ulcowin operates at 100°C and Ulcolysis at 1,550°C.

Great strides have been made in the efficiency of steel production over the last 40 years. The remaining potential to improve process or material efficiency is limited and insufficient to face the requirements for reduced carbon emissions. Nonetheless, ArcelorMittal has identified and is addressing this potential. An action plan was developed and a commitment has been made to improve carbon efficiency by 8% in the short and medium term. In the long run, ArcelorMittal is engaged in the development of breakthrough technologies that have the potential to further reduce carbon emissions by at least 50%. The first candidate technology should be ready for demonstration by 2020.

More details on the progress of projects for ultra-low CO_2 steelmaking can be found at *http://www.ulcos.org*. ■

Authors
Armelle Jouet, ArcelorMittal CTO Energy; Jean-Pierre Birat, ArcelorMittal Global R&D Maizières-lès-Metz; Karl Buttiens, ArcelorMittal CTO Environment

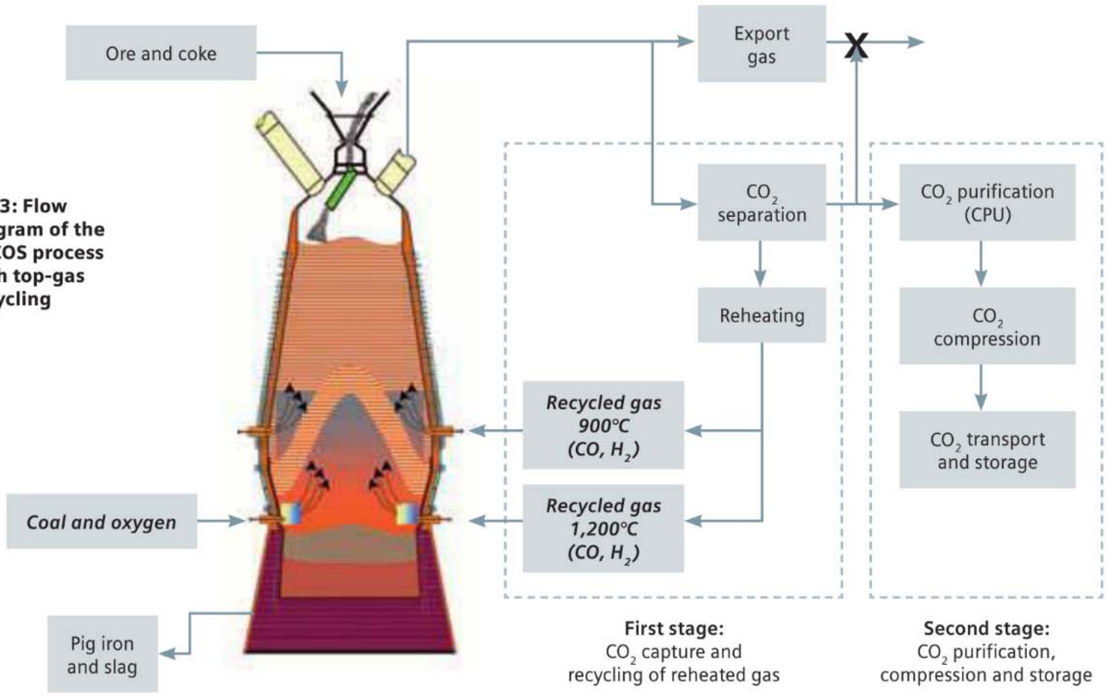
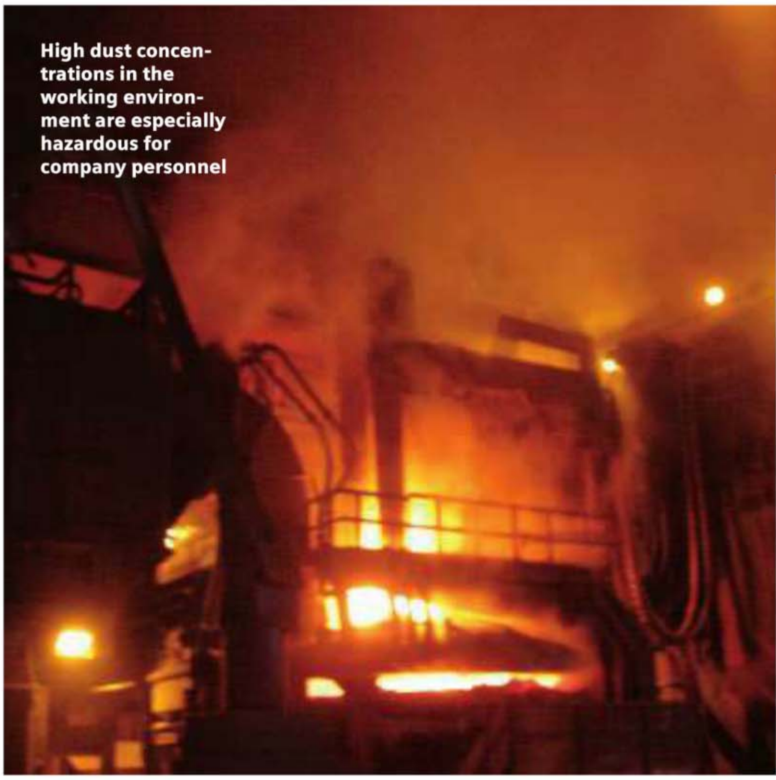


Fig 3: Flow diagram of the ULCOS process with top-gas recycling



High dust concentrations in the working environment are especially hazardous for company personnel

Finding the best dedusting solution for older steel plants

Dust free at last

Siemens offers detailed environmental studies to help producers ideally meet environmental targets with efficient and cost-effective solutions.

Siemens is a leading supplier of primary and secondary dedusting facilities for all types of steelmaking plants, including the associated ladle furnaces and material-handling and alloy-addition systems. Since 2000, the company has installed a total of 15 wet-type primary dedusting plants, more than 50 dry-type primary dedusting plants, and 14 secondary dedusting plants in electric and oxygen steelmaking plants of renowned steel producers worldwide. With this wealth of experience, Siemens now offers comprehensive environmental studies that identify the necessary solution steps to be implemented to ensure that the target emission limits are met both within the steel bay (typically <5 mg/Nm³) and at the stack exit (typically <10 mg/Nm³).
The studies include the following activities:

1. Description of the existing ambient conditions
2. Root-cause analysis of deficiencies
3. Preparation of a detailed engineering report with proposals for the adaptation of existing equipment or the installation of new equipment
4. Forecast of expected performance figures following plant modifications
5. Preparation of drawings and documents as the basis for subsequent engineering and design work
6. Estimation of project costs and implementation schedule

These studies also specify the number and length of the proposed implementation phases that are coordinated with regularly scheduled plant shutdowns.

Following a customer invitation, a team of Siemens specialists is dispatched to the plant site. Once the measuring points have been defined, a series of dust-concentration measurements are carried out over a period of time. Steel-production events such as charging, oxygen blowing, power-on time and tapping are recorded and correlated with the dust-level measurements during each heat. Temperature, gas flow and pressure are also taken into account.

With the use of a unique computational fluid dynamics (CFD) tool jointly developed with the University of Linz, Austria, the dedusting efficiency of various secondary dedusting solutions is simulated and visually displayed on a computer. This allows the optimum solution to be identified to meet the specific requirements. The actual implementation may be, for example, a stepwise revamping program that is carried out during scheduled maintenance periods. Solution steps in an electric steel mill could include redimensioning of the canopy hood and offgas ducts, capacity expansion of the exhaust fans, or the installation of a larger stack to cope with increased gas volumes. A key challenge in the redesign of dedusting facilities is that new equipment and systems must be post-installed within the typically tight confines of a steel mill.

Simulation shows the optimum solution of secondary dedusting solutions.

This is where the experience and expertise of an knowledgeable partner is decisive. Contact Siemens to find out more about the services offered for proposing and implementing the best environmental solution with minimum impact to ongoing production operations.

Author
Willibald Kloibhofer, senior expert for steelmaking plants

A successful outcome of this project and the subsequent industrial implementation will mean a notable reduction of CO_2 from a steelworks.

The current praxis of blast furnance slag quenching or dumping is a wasteful misuse of valuable energy

Recovering the heat of blast furnace slag in a dry-type granulation process for heating and power-generation applications

Reuse of waste energy

A consortium comprised of steel producers, a research institute and Siemens is currently investing the possibility of using only air as the slag-cooling media. The process parameters for the recovery of the inherent slag heat for other applications will also be defined. Finally, the suitability of dry-granulated slag for use in, for example, the cement industry will be tested.

Key driving forces in the steelmaking industry today include major efforts to reduce energy costs and emissions, and to ensure a maximum reuse of waste energy. The blast furnace ironmaking process, which consumes huge amounts of energy, has therefore become a major focus of investigations to improve energy efficiency and reduce the CO_2 footprint in the steel production chain. Each year approximately 400 million tons of blast furnace slag are produced worldwide. The slag, which has a tapping temperature of around 1,500°C, is generally processed into a suitable by-product. But until now no attempt has been made to utilize the associated heat energy, which amounts to approximately 1.5 GJ of energy per ton of slag. The current state-of-the-art practice to solidify molten blast furnace slag is to rapidly cool it in granulation plants using large volumes of water. Alternatively, it is simply dumped into open slag pits. In either case, all of the heat energy is subsequently lost to the atmosphere.

Joint research project and targets

Siemens in conjunction with ThyssenKrupp Steel Europe AG (Germany), voestalpine Stahl GmbH (Austria) and the FEhS Building Materials Institute (Germany) has embarked on a new research project to develop a reliable dry-quenching technology for molten blast furnace slag. The goal is to recover the high-temperature waste heat for other applications – such as the preheating of combustion air or the generation of steam to drive a power turbine – and to simultaneously produce a cement-grade granulated slag. The first granulation trials will be carried out at the University of Leoben in Austria. The laboratory phase of the project will form part of a master's thesis for students at the university. The research team intends to identify the optimum operating conditions of a dry granulating process with heat recovery, and to determine the process boundary conditions that would apply at a full-sized industrial plant. The research will be carried out on a laboratory-scale rig using remelted slag under reproducible conditions. A flash reactor housed in the university research center will provide the required quantity of molten slag at a predetermined temperature for a single batch. The optimum mixture of slag and airflow can then be determined. Repeatable trials would not be possible if the rig were placed in an actual furnace slag stream, as the slag from a furnace is variable in quality, flow rate, chemical composition and temperature.

The findings from the trials will be used to calibrate a 3-D CFD (computational fluid dynamics) model of the granulator at the Siemens Corporate Technology center in Erlangen, Germany. The model will then be scaled up to replicate a full-sized industrial plant. This procedure will allow researchers to demonstrate not only that the process will work but that it will also function in an industrial plant.

Another important aspect that will be considered is whether the granulate produced by the process is suitable for use in the cement industry. The partner for this step of the process is FEhS Building Materials Institute, a world-renowned slag specialist.

A successful outcome of this project and the subsequent industrial implementation of a dry-type slag-granulation process will mean a notable reduction of CO_2 from a steelworks. ►

Slag from a convertor is being poured to a slag pot in a workshop of the RMK's Karabashmed industrial complex located in Karabash city, Chelyabinsk region.

Dry granulation concept

Dry slag granulation is based on molten slag atomization using a variable-speed rotating cup or dish. The slag is delivered onto the center of the cup from a slag runner via a vertical refractory-lined pipe. The rotation of the cup forces the slag outward to the cup lip, where it is atomized. The resulting slag droplets cool in their flight toward the water-jacketed chamber wall. On impact with the wall, the droplets are sufficiently solid to ensure that they do not stick to the wall. The solidifying granules fall into an aerated bed of granules that is designed to ensure there is no agglomeration. The cooling particles then fall into a discharge trough that forms an inner annulus.

Challenges

There are two methods in which slag can be fed to a slag-granulation plant: In the first, the granulator is located close to the blast furnace, which enables the slag to be delivered to the granulator directly from the slag runner. In the second method, the granulator is more remote from the furnace. This requires the transfer of slag in pots that are emptied into the granulator via a ladle tilter. Initial on-site investigations will be conducted remotely from the blast furnace to ensure that the granulation system will be stable under conditions of constant slag flow. The process challenges to be faced in a direct-feed plant will be revisited in subsequent trials to solve the issues involving irregular slag flow, limited space availability, varying slag temperatures and chemical composition.

Benefits

The calculated temperature of the air that will exit from the granulator is estimated to be 400°C. By tuning the distribution of the cooling air, the outlet temperature could be increased significantly, perhaps to 650°C. If this hot air is passed through a heat exchanger, it can be used – depending on a plant's requirements – to preheat combustion air for space heating or to produce process steam and electricity. Other benefits of this dry slag-granulation process can be summarized as follows:

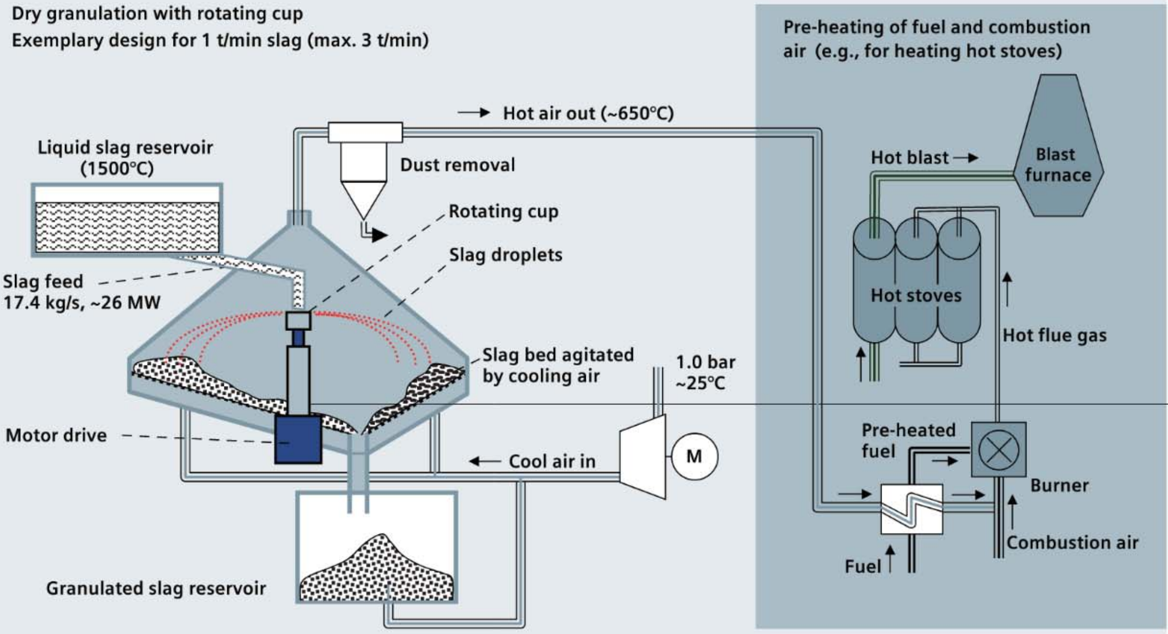
- Potentially lower capital, operating and maintenance costs compared with an equivalent wet-type granulation system
- No steam emissions and the associated environmental and corrosion problems
- Significantly lower sulfur compound emissions compared with wet-type slag-granulation processes
- Elimination of water runoff and therefore no groundwater contamination
- No downstream drying costs
- Highly efficient utilization of the remnant heat of molten slag for other applications and therefore a significant reduction of the CO_2 footprint in a steelworks
- Generation of a fine-grained, easy-to-handle slag product, potentially with fluid properties that allow pneumatic transport
- Production of a high-grade granulate suitable for use in the cement industry

Concluding remarks

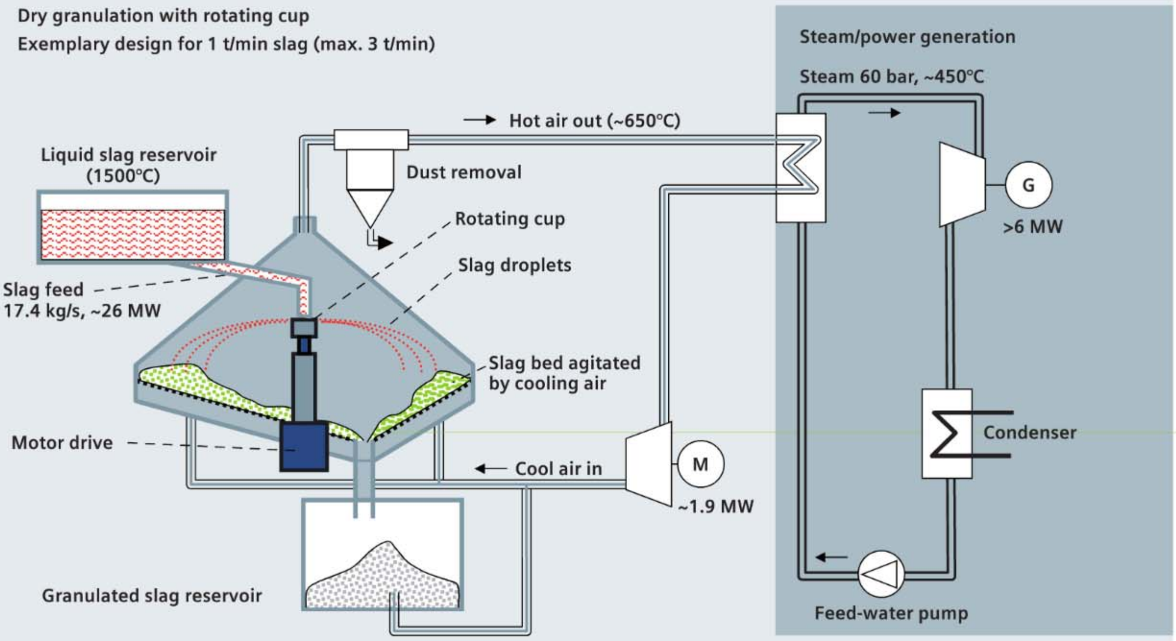
Slag is increasingly being seen in the industry not as an inevitable waste product of the blast furnace ironmaking process but as a valuable by-product. An intensive research project will be initiated by a consortium to focus on the development of a new industrial process to recover and utilize the remnant heat of molten slag. If the outcome of this project is successful, slag as a value-added by-product will represent an important source of energy that will additionally reduce the environmental footprint of ironmaking. ■

Author
Ian McDonald, blast furnace innovation manager

Dry slag granulation coupled with fuel preheating



Dry slag granulation coupled with steam and power generation



Advanced top-gas cleaning for blast furnaces

Cleaner and cheaper dust capture

Siemens has developed a new top-gas cleaning system using a cyclone for coarse dust separation and a fabric filter for fine dedusting. With this solution the costs for energy and waste disposal can be reduced to levels that were unachievable until now. What's more, the gas emissions meet current and upcoming environmental regulations, and the CO_2 footprint of blast furnace gas cleaning is reduced.

Siemens dry top-gas cleaning for blast furnaces sets new benchmarks for environmental protection at the lowest costs possible

New bag-filter system for fine dust capture

The common solution for top-gas cleaning of blast furnaces is normally carried out in a two-stage dedusting process comprised of a dust catcher or cyclone in the first stage, and a wet scrubber in the second stage. Whereas the dust that is trapped in the first stage of cleaning is usually recycled in the ironmaking process, the dust from the wet scrubber, which emerges as sludge, is normally discharged. This incurs additional costs for disposal.

The Merim dry dedusting system

Merim, the new dry-type top-gas cleaning system from Siemens, consists of a specially designed cyclone for the coarse-dust separation stage followed by a fabric filter to collect fine dust. With this technology several benefits compared to the wet system can be achieved. First, wastewater and sludge management are avoided completely. Second, the pressure drop and temperature loss are much lower than in wet-type systems. Consequently, the energy output of the top-gas recovery turbine (TRT) can be increased by approximately 20–30%. The elimination of the need for sludge processing and the higher energy output of the top-gas recovery turbine are important factors for reducing the CO_2 footprint in blast furnace gas cleaning. Finally, the new cyclone design ensures optimized separation in recyclable dust and fine dust with a high zinc concentration.

Feasibility studies have shown that a greenfield installation would cost roughly 30% less than a scrubber system that includes wastewater management. The costs of operation would also be significantly reduced. The space needed for a complete installation amounts to only about 40% of the space required for the installation of a comparable wet-type facility. The highly efficient coarse dedusting takes place in a Siemens cyclone where approximately 85% of the dust is removed to maximize iron recovery. The generated dust can be easily reused in the sinter plant. However, not all top-gas dusts are suited for recycling in the ironmaking process. High concentrations of heavy metals in the burden, especially zinc, can potentially affect blast furnace operation. An optimized dust-separation device in the first stage of top-gas treatment is important from an operational and cost perspective.

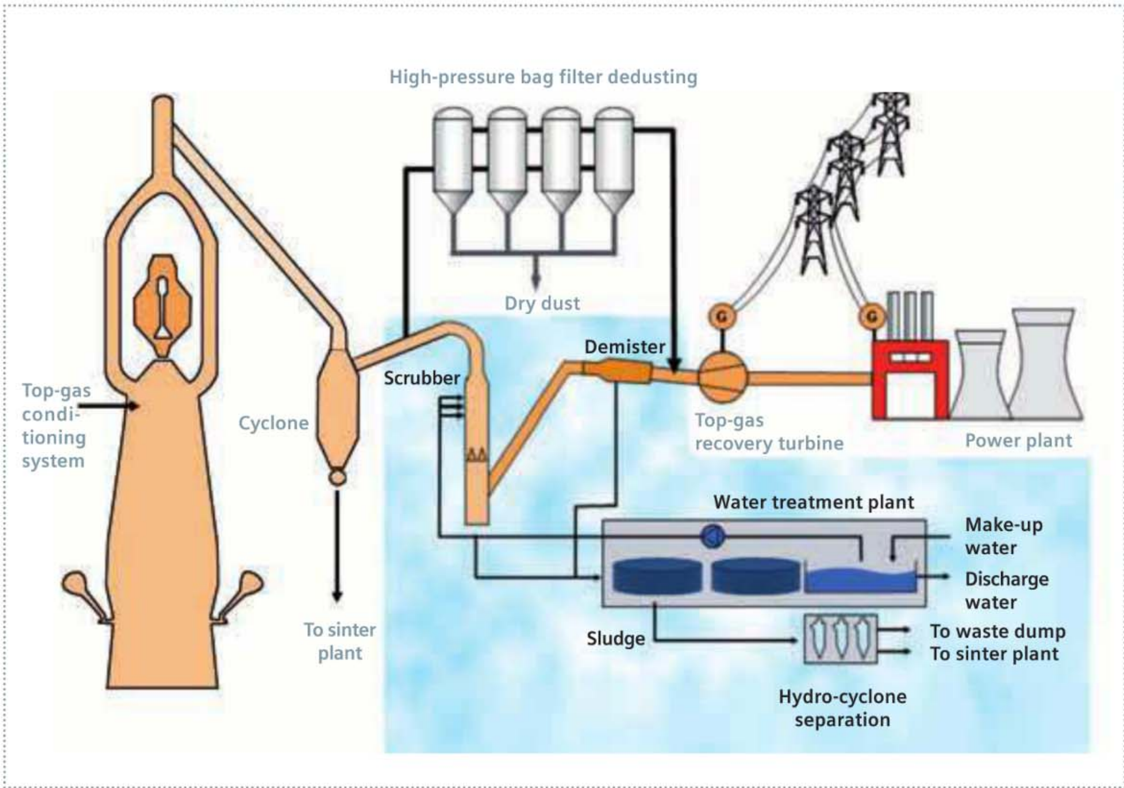
New three-inlet cyclone design

For the cyclone contract received for Tata's Steel Port Talbot No. 4 Blast Furnace, the original as-sold design was based on the Siemens traditional single tangential inlet arrangement. However, during the engineering phase for this project, an alternative design was proposed using three tangential inlets.

This new three-inlet cyclone design exhibits advantages over the previous single-inlet design. The main benefit of using three inlets is that the downcomer can be supported centrally through the cyclone vessel. In contrast, with the single-inlet design the cyclone inlet branch supports the weight of the downcomer. Three inlets greatly improve the support system and lead to a second advantage: it is much simpler to carry out maintenance on the cyclone inlet branches, as they do not support any additional weight. Individual branches and cyclone isolation valves can easily be removed and repaired or replaced, whereas repairing the inlet with the single-inlet design is a much more significant task, and installation or repair of an isolation valve is a major undertaking. Computational fluid dynamics (CFD) modeling was carried out to analyze and compare this new design with the traditional single-inlet one. The results showed that the three-inlet design should not suffer from any notable reduction in performance or any additional wear in the inlet branches. With the design of the three-inlet branches, the cyclone inlet retains its classifying effect, meaning that larger dust particles enter the cyclone at the bottom of the duct while smaller particles ►

The benefit of using three inlets is that the downcomer can be supported centrally through the cyclone vessel.

New three-inlet cyclone



Blast furnace top-gas cleaning: conventional wet method (within the cloud) and the new Merim dry dedusting system

enter slightly higher. These smaller particles are then able to bypass the cyclone via the bypass lines in the top of the vessel. This reduces the collection efficiency of the cyclone in the smaller particle size range, which carries the highest zinc content, and so minimizes zinc recycling to the furnace via the dust collected by the cyclone. Instead, the finer dust with the higher zinc content is collected in the bag filters, and it can be sold for zinc recovery or disposed of.

Fabric filter for blast furnace gas cleaning

Fine dedusting is carried out in the newly developed bag-filter system. Here, the gas laden with the remaining fine dust first enters a number of pressure-resistant filter vessels. Inside these, the dust is collected on high-performing filter media that ensure the dust content in the clean gas is less than 5 mg/Nm³. In fact, even levels below 1 mg/Nm³ are achievable. The removed dust is collected on the bottom of the filter and transported via a pneumatic conveyor into a storage silo. The cleaned top gas from the filter vessels is collected in a main duct that guides the gas stream directly into a top-gas recovery turbine (TRT) where the high energy content of the gas is converted into electricity. Handling the varying top-gas temperatures is a major challenge because filter bags only work properly in a temperature window of 80–250°C. Therefore, Siemens investigated a top-gas conditioning concept that allows the reduction of high and low temperature peaks. This concept consists of a burner and an advanced burden spray.

Gas emissions meet current and upcoming environmental regulations.

Recently, a pilot installation designed to treat 6,000 Nm³/h of offgas was installed at an ironmaking plant to further investigate the dry dedusting filter system. The temperature of the gas reaches 220°C, and dust in the load ranges between 20 g/Nm³ and 40 g/Nm³. Normally, very fine particles with a volumetric distribution of particle sizes between D(v,0.90) 20 µm (90% of the particles have a diameter below 20 µm) and D(v,0.5) 8 µm (50% are below 8 µm in diameter) prove to be particularly challenging for the bag-filter system. Not so here: during the tests a clean gas-dust concentration of <2 mg/Nm³ was achieved, which shows that the fabric filter system can meet the requirements for top-gas cleaning.

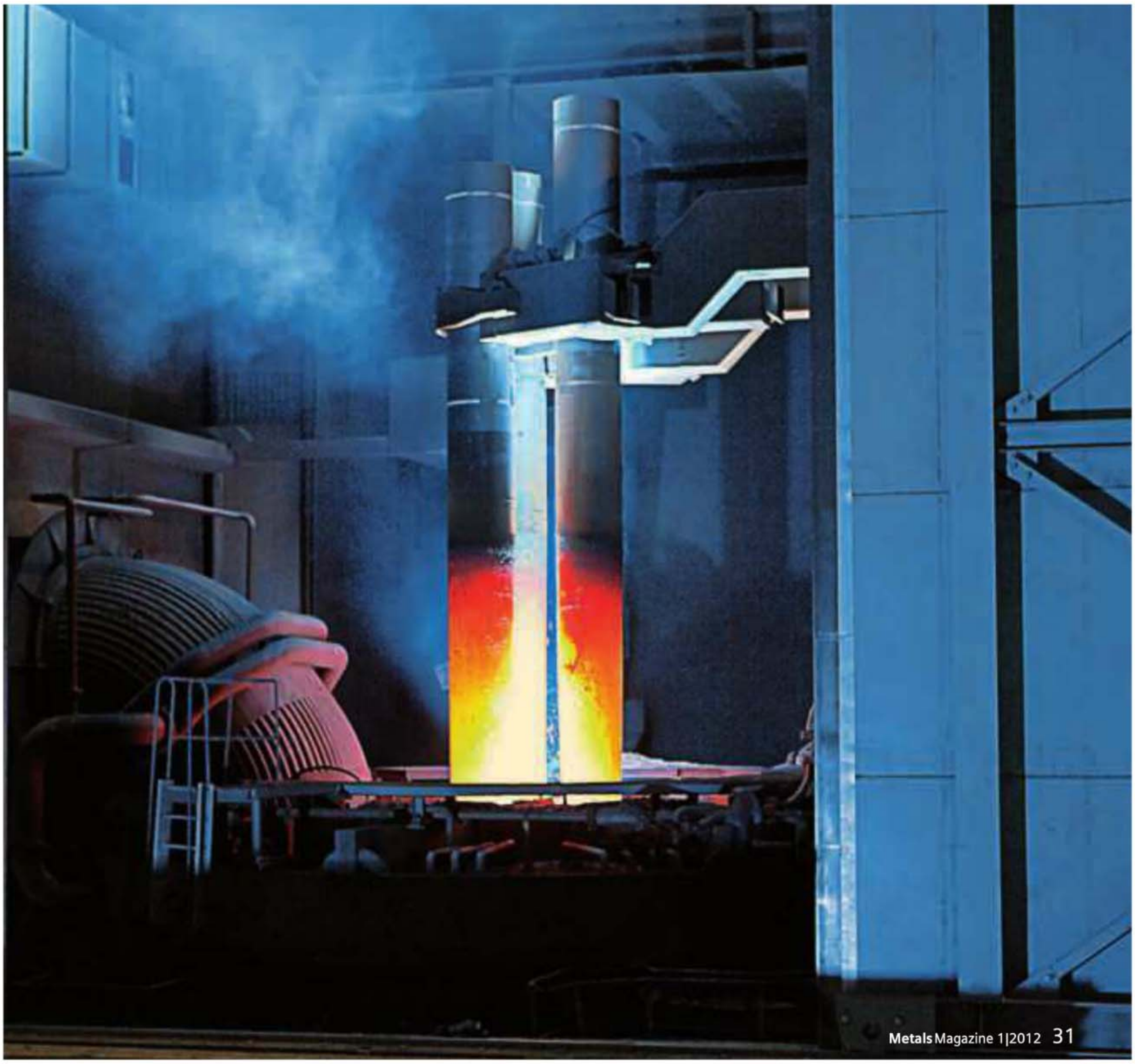
Siemens has developed the Merim dry dedusting system to expand its environmental portfolio with a technology that sets new benchmarks for high-performance top-gas cleaning at the lowest costs possible. ■

Author
Andreas Klugsberger, product lifecycle manager for Merim

Recovery of waste heat from hot EAF offgas

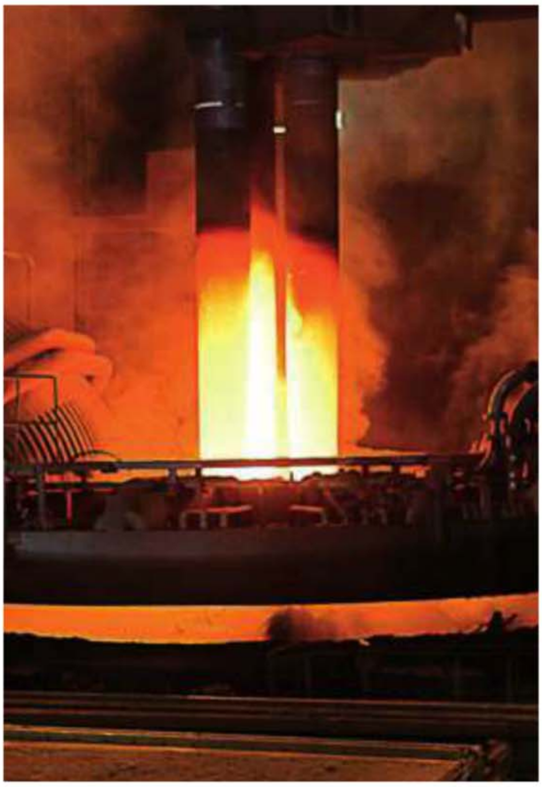
Innovation power

In times of steadily growing energy prices and global warming, steelmakers are keen to reduce their consumption figures and greenhouse-gas emissions. To help them reach these targets, Siemens has developed different concepts for comprehensive energy recovery from hot electric arc furnace (EAF) offgas. Well-proven concepts from steelmaking as well as other industries and state-of-the-art developments have been joined together to establish a new benchmark in energy-efficient and green electric steelmaking.



Energy recovery from hot electric arc furnance offgases reduces power consumption and environmental impact

Due to increasing costs in both electricity and CO_2 certificates Siemens is responding with reliable energy-recovery systems



For decades operators of electric steelmaking plants have been well aware of the vast amount of thermal energy contained in the hot offgases from EAFs. Various attempts have been made to capture this source of energy, but the widely varying quantities of offgas emitted from the EAF caused them to abandon their efforts.

Now, due to steadily increasing costs in both electricity and CO_2 certificates, future-oriented meltshop owners are revisiting the topic, and Siemens is responding with an efficient and reliable energy-recovery system. This solution combines the latest developments for intermediate energy storage with proven technologies from oxygen-based steelmaking. The result: maximized heat-energy recovery from EAF offgases.

No compromises

Siemens engineers identified two ways of recovering energy in the EAF offgas and evaluated them in terms of feasibility. The first is the production of steam only. The drawback to this solution is that minimills do not have their own steam network, and that they do not need steam for other processes. Therefore, the second method of energy recovery – electric power generation from waste heat – was developed. To come up with an optimal solution, Siemens established the Heat 2 Power (H2P) development team. The team's task: create a system that is just as efficient as a common power plant. More specifically, the ambitious goal was to create a system able to recover the highest-possible portion of thermal energy from the offgas combined with an attractively short payback period. Depending on the intended extent of energy recovery, an H2P system can substitute the ordinary water-cooled offgas system starting with the fixed elbow on the dropout box all the way down to the uncooled duct in front of the filter.

Research and development for H2P was done in a top-down approach. Starting with the most complex application – electric power generation – the team transferred single components and lessons learned from easier-to-realize energy-recovery systems. One example was for the genera-

tion of steam. Whether saturated or superheated, steam is the predecessor for electric-power generation. So for the whole steam-generation unit of this challenging application, the team relied on its considerable experience in recovering energy to produce steam.

Electric-power generation from a more or less stochastic offgas energy source proved to be a somewhat tricky task. Steam turbines are sensible to temperature and load changes, and it is crucial to provide them with a constant flow of the appropriate steam. As mentioned above, however, the thermal emissions of an EAF are very unstable. Therefore, a downstream buffer storage was incorporated to ensure that the turbine is continuously fed. At the heart of the solution is the well-known Ruths steam storage system from LD (BOF) steelmaking, adapted to an electric steelmaking environment. If the turbine requires superheated steam, additional thermal energy storage has to be considered. Another alternative for superheating – albeit less economic – is natural-gas burners.

Proven technology

Keeping in line with its reputation as a technology leader, Siemens transferred a well-proven energy storage concept to steelmaking: molten salts. Molten salts are used to store surplus energy when energy emissions from the furnace are low.

Aside from widespread use in the solar industry, molten salts have proven their applicability as heat transfer/storage fluids over decades in the chemical industry. In the targeted temperature range above 400°C, their thermophysical properties (e.g., energy storage capacity) are outstanding. Because this method of storing heat requires no pressure, the performance of molten salts for this application is second to none. An added advantage is that the salts are nontoxic and noncorrosive. With ongoing development on low melting points of about 50°C for these eutectic salt mixtures, even direct salt cooling of the offgas system is viable (Siemens patent pending).

Getting the setup right

Due to the missing turbine and its auxiliaries, energy recovery in terms of steam production only is easier to realize. Nevertheless, the steam storage concepts to bridge the idle times of the furnace or to provide downstream consumers (e.g., VD/VOD plants, CO_2 strippers) have to be investigated in depth. Experts at Siemens – covering areas from furnace technology to energy recovery – are able to predict the steam production of future installations even in very early project phases. Using the charging diagram, the offgas emissions of the furnace are calculated on a dynamic basis. The subsequent boiler design for the maximum load case represents the last major piece in the puzzle for the comprehensive simulation of the whole heat recovery system, including the steam boiler, thermal energy storage, the turbine, if applicable, and all other auxiliaries. Customers have security of planning in terms of payback period and related aspects. Furthermore, the effects of changing operational conditions or unexpected failures can be observed in advance for additional security.

Bottom-line savings

For a typical scrap-operated furnace with a tapping weight of 120 tons and a tap-to-tap-time of 55 minutes, energy recovery systems within the range of 60–80 kWh/t were developed. These systems do not require any external energy sources. With the German energy mix for the national power grid as the basis, a recovery system of this scale reduces the respective carbon footprint by 34–45 kg CO_2/t of tapped steel. Annual savings for electricity and carbon dioxide certificates amount to well over €5 million. If the recovered energy is converted into steam alone, operators can count on a constant provision of 50 t/h at 50 bars. The restrictions in CO_2 certificate trading that will come into effect in 2013, and the expected increase in the price for the certificates, is another strong argument for the installation of an energy-recovery system for EAFs. Despite all necessary and useful optimizations in the furnace process, major energy losses will always be associated with hot offgas. For this reason, H2P solutions from Siemens for EAFs will concentrate on offgas to help achieve the vision of the green minimill. ■

Annual savings for electricity and carbon dioxide certificates amount to well over €5 million.

Author
Florian Zauner, R&D project leader

Energy consumption and roll lubrication in a PLTCM

Significant optimization potential

The last issue of the Siemens Metals Magazine (2/2011) provided an overview of the potential for saving energy and protecting the environment in a linked pickling line and tandem cold mill (PLTCM). In this issue, the focus turns to Siemens' solutions for cold-rolling mills to lower energy and material consumption, and to reduce emissions.

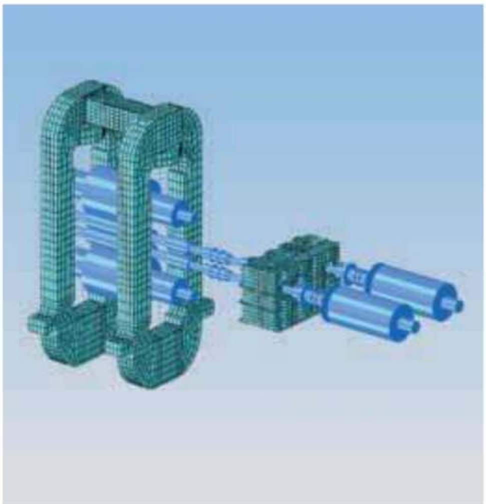
In addition to measures already put in place by Siemens and outlined earlier, roll lubrication systems in tandem cold mills offer considerable potential to reduce even further primary energy input and oil consumption. Mill main drives are the main energy consumers, and they are the biggest motors installed in a PLTCM. Keeping lubricants flowing also requires significant amounts of energy. In this article the huge optimization potential in energy consumption related to motors and emulsion flow is examined.

Precise and powerful models

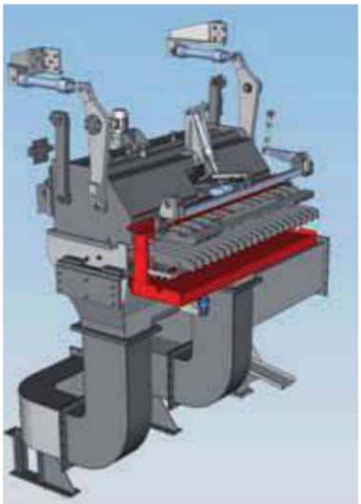
In order to tap into this optimization potential, Siemens uses precise and powerful models to calculate PLTCM process parameters. The pass schedule calculation, for example, is performed to define the thickness and tension distribution across the different passes in a tandem mill. Mill productivity is primarily defined by minimized rolling times and maximized yield. To obtain the highest product quality, the forces adequate for correct flatness and required surface quality are calculated, with consideration to constraints such as maximum motor load.

For this purpose, Siemens has developed a powerful multi-variable optimization algorithm, where one of the variables to be optimized is the required energy. Using the results of the pass schedule calculation, the flatness actuators are calculated to achieve the mill's optimal flatness performance. The flatness pre-adjustment defines the initial setpoints for the flatness automation system.

It is well known that more accurate setpoints enhance product quality and production yield, which leads to a more energy-efficient PLTCM. Because the pass schedule calculation and the flatness pre-adjustment have a strong impact on the quality of the process model, Siemens has emphasized its process model development. This includes the (non-circular arc) rolling model, which is very flexible in order to handle new steel grades; the roll temperature ►



Dynamic model of mill stand with drive train



Roll-gap lubrication and strip blow-off system

crown and wear model to provide a description of wear and the effects of asymmetric temperature fields; and the roll-gap model for online calculation of roll-pressure distribution within the roll gap.

Minimizing rolling oil use and emulsion flow or loss

A roll temperature crown and wear model tool from Siemens helps to predict precisely the heat behavior of rolling-mill components, for example work rolls. This knowledge is essential for the optimal design and arrangement of lubrication headers. In a recent installation, the emulsion flow rate of an existing line was reduced by more than 50% (valid for a special reference example) without having to change the temperature level of the work rolls. Exact knowledge of the tribological behavior in the roll gap – which involves the friction, lubrication and wear of interacting surfaces that are in relative motion – creates the foundation for the optimized design of the lubrication system in tandem cold mills. To turn this design into an actual lubrication product, Quaker Chemical Corporation, voestalpine Stahl GmbH, Johannes Kepler University Linz and Siemens combined their experience and expertise in 2009 to develop better lubricant and cooling solutions for industrial applications. Advantages of using the new oils and emulsions include higher mill productivity, an extended rolling-product range, improved strip-surface quality and lower energy costs during rolling.

> Highly efficient Sinamics drive systems reduce operating losses.

A strip blow-off system located at the exit of the last mill stand removes all remaining emulsion from the strip to ensure a dry strip surface during coiling. The liquid removed through the air blast from the strip is captured in the surrounding exhaust system and collection pans, and then drained back into the emulsion return line. This Siroll design ensures efficient blow-off at all mill speeds, contributing to highest strip-surface quality after rolling and a minimum of emissions. Tight control of strip surface quality and strip thickness requires drives with excellent dynamic response and precise speed characteristics. With Sinamics drive technology, Siemens offers a wide range of solutions for nearly all market requirements. The medium-voltage source-converter system Sinamics SM150 covers all the requirements of mill drives; the low-voltage converter system Sinamics S120 is mainly used for auxiliary drives.

Energy efficiency and environmental protection

Using energy-saving motors that conform to European Union efficiency classes EEF 2 as well as the American EPAct norm is just one contribution being made by Siemens to optimize PLTCM operations. Equally important is tapping into the significant optimization potential in oil and emulsion systems, which saves up to 40% of energy needs using speed-controlled pumps, improves lubrication effectiveness, and minimizes the overall impact of PLTCM operations on the environment. ■

Authors
Jürgen Hofer, product lifecycle manager for cold mills
Andreas Maierhofer, product lifecycle manager for cold mills
Anna Stabauer, product manager for cold mills

Power cooling process helps ThyssenKrupp increase the product range

Keeping cool

With a new intensive-cooling unit installed in Hot-Strip Mill 2, ThyssenKrupp Steel AG produces additional steel grades with a high degree of precision.

ThyssenKrupp Steel Europe is the leading company for the European carbon-steel activities of the ThyssenKrupp Group, one of the world's largest producers of quality flat steel. The 2,030 mm hot-strip mill in Duisburg-Beeckerwerth rolls up to 6 million tons of steel per annum, which is one of the highest mill outputs in the world.

In recent years the trend to develop and produce new steel grades with higher strength can be observed. High cooling rates and the capability of very early cooling lead to a fine-grained structure, which is the key for the production of most of these products. In addition, a fine-grained structure helps to improve the toughness of the material – a prerequisite when it comes to the production of high-strength American Petroleum Institute (API) pipe grades. Specifically, the production of high- and highest-strength steels in the upper thickness range of up to 2.5 cm requires high cooling rates. A further mechanism to improve strength involves reducing transformation into ferrite, which increases the bainite or martensite content in the microstructure.

Intensive-cooling equipment

ThyssenKrupp Steel AG in Duisburg-Beeckerwerth commissioned Siemens to install the intensive-cooling unit in its Hot-Strip Mill 2 to increase the maximum cooling rate for high-strength material and to adjust the flow rate depending on steel grade and strip gauge. Furthermore, the unit ensures the uniform cooling conditions from the top and bottom sides, and adjusts the top-header position.

The intensive-cooling unit at ThyssenKrupp Steel consists of numerous top and bottom cooling headers. For each header a separate on/off valve, a flow control valve, a flowmeter and a pressure transducer were installed to allow for maximum operating flexibility. Each header is equipped with numerous solid-jet nozzles. The total flow rate of all headers is about 6,200 m^3/h. The overall length of the cooling section is only about 7 m. The valve control is implemented in the process automation from Siemens; it operates in a 200 ms cycle with the microstructure target-cooling model, and it can give direct actuator commands via Simatic S7 basic auto-

Shanghai, China

New competence center for metallurgical plants

With an investment of $80 million Siemens is to further expand and localize manufacturing capabilities in China.

"Backed by solid collaboration within the global Siemens network, our business in China has developed its own solutions for local and export markets," said Werner Auer, CEO of Siemens Metals Technologies, at the inauguration of its new engineering and production center in the Minhang District, Shanghai, China. Here, more than 450 Chinese engineers will provide lifecycle and modernization services, and develop plant components for local and export markets.

In-house manufacturing

Welded structures for ThyssenKrupp

In-house manufacturing is now in place for the modernization of Hot-strip Rolling Mill 1 at ThyssenKrupp in Bruckhausen, Germany. The Siemens Legelshurst in Germany workshop will be delivering a total of 94,000 kg of welded structures for upsetting-device gears. Previously these structures were purchased from a third-party producer.

The Siemens workshop in Legelshurst

Service

China as a growth engine

Jan Lueder, Siemens China

"Service offerings and local product development have opened a new chapter in the lifecycle of Chinese steel plants," says Jan Lueder, who is responsible for Siemens' metals business in China. With its service portfolio, and in particular its modernization solutions packages, Siemens supports Chinese steelmakers to upgrade their production plants. Today the lifecycle of a steel plant is 40 years. Modernization has become a decisive factor for sustainable steel production. "With holistic upgrades, Chinese steel plants can remain competitive and meet future steelmaking requirements," adds Lueder. "We differentiate ourselves through our strong capabilities in metallurgic equipment as well as in electrotechnology and automation." The R&D center is also aimed at technology transfer and sharing expertise to develop simple, maintenance-friendly, affordable and reliable products for the local market.

Continued from page 37

mation to the valves and the pumps. Some of the existing cooling headers had to be removed to allow installation of the new equipment immediately behind the gauge house in mill stand F7. In order to take the lower efficiency of the bottom cooling headers into account, the design flow rate on the bottom side was somewhat higher than on the top side. When producing standard products, the headers are normally operated at a lower flow rate according to the actual cooling rate requirements. Since the new cooling unit replaced the first headers of the existing cooling line, the new headers are used for all strips that require early cooling. To avoid collisions, especially when producing thin strips exiting the finishing mill at high speeds, the top headers are moved to the uppermost position. Water is supplied from an overhead tank at 25 m, which yields a static pressure of about 2.5 bar. When maximum flow rates are required, the water can be pressurized by pumps to a level of about 4 bar. To cool thicker high-strength strips like API pipe-grade material, the top headers are lowered to further increase cooling capacity. The first thick-gauge strips manufactured with the full potential of the new cooling unit rolled off the line in February 2011.

Electric and automation system upgrade

The automation and process model of the cooling line at Hot-Strip Mill 2 had originally been supplied by Siemens in 2007. In the framework of that project the new microstructure target-cooling model was implemented for a significant improvement in the quality of the cooling results. The existing microstructure monitor from Siemens was integrated in the cooling model at that time. In the most recent project, microstructure target

Minimill Symposium

Customer consultation in Moscow

During the Siemens Technology Symposium in Moscow, experts from several Siemens locations introduced minimill technologies from Siemens and provided individual technical consultations. The center of competence for minimills in Legelshurst, Germany, organized the symposium in collaboration with colleagues from Russia. More than 50 participants were greeted in Moscow by Mario Sucker, responsible for the Siemens business in Russia. The symposium was held at the Moscow University of Steel and Alloys (MISIS). First, the main systems – including EAFs, ladle furnaces, secondary metallurgy, continuous casting, rolling mills, dedusting units, water systems, energy supply, E&A, BOP and mill services – were discussed in general. After that, the systems were presented and discussed in greater detail during special workshops. The joint efforts of the Siemens specialists from the different areas of expertise made it possible to present an integrated minimill solution at the symposium.

The Middle East Service Center is a competent partner for deliveries and services in the Middle East

Middle East Service Center

Upper shell for EAF delivered

With its expanded manufacturing expertise and extended service presence, the Middle East Service Center (MESC) in Bahrain is also processing orders from Europe: MESC is delivering to a renowned customer in Europe a complete upper shell, roof and related panels for an electric arc furnace (EAF). The EAF will start operation during the first half of 2012 and will be used to smelt scrap into new steel. The execution of this order included the upper shell for an EAF with a diameter of roughly 9 m, 25 water-cooled EAF panels, the roof, and the supporting arm with a total weight of 138 tons. Thanks to continuous quality assurance and close cooperation between all Siemens experts in Linz, Austria, Legelshurst, Germany, and Bahrain, the work was completed quickly in the newly expanded service workshop in the Persian Gulf. A new manufacturing order for replacement panels for the EAF has already been placed. Further orders for spare parts and repairs will soon be placed in the areas of EAF-panel manufacturing and long-rolling-guide manufacturing.

cooling and the microstructure monitor were upgraded. One part of the upgrade was to accommodate the new features of power cooling for new capabilities in terms of cooling range and possible cooling rates. The model upgrade included the implementation of a state-of-the-art comprehensive temperature model, which integrates the model calculation of the finishing temperature and the cooling-temperature course. This ensures optimum results for the whole product in respect to microstructure and mechanical properties.

A newly developed cross-plant temperature model is also being used for plant operation. The model applies a uniform calculation method for the entire finishing mill, through the cooling section and into the coiler. This enables highly accurate prediction for the start of the phase transition, even if it takes place in the finishing mill. Furthermore, the calculation of the bainitic portions of the structure is also integrated within the model.

More flexibility

The cross-plant temperature model helps the phase transitions to be controlled even more precisely during the cooling of hot-rolled steel strip, thereby increasing the flexibility of the rolling mill. With these powerful and flexible cooling actuators and the advanced cooling models, different types of steel can be produced in any sequence, and new types of steel can be produced without having to change the software or model parameters. ■

Authors
Günther Grasser, product manager for hot-strip mills
Alois Seilinger, senior expert for rolling-mill technology

Regular EAF modernizations ensure high plant efficiency and profitability

Performance gets a boost

In a highly competitive and globalized market, steelmakers constantly need to find new ways to optimize their cost structures and decrease their conversion costs. Consumption figures and thereby costs can be reduced with continuous improvements in technology, equipment and system maintenance. Enhancements in plant availability and utilization boost productivity and improve quality and consistency. To attain high plant performance and production efficiency, steelmakers strive to achieve maximum improvements with minimum investments. All of these requirements are met by adopting a strategy of continuous modernization over the entire lifecycle of a steel plant. The following article reviews what this means for electric arc furnace (EAF) installations.

During the commissioning phase, an EAF is equipped with an initial inventory of spares for start-up and operation. After that period, the necessary spare parts are defined and managed to account for equipment wear and to ensure high plant uptime. Additionally, an EAF needs to be fine-tuned with additional technical assistance and training to ensure high and consistent plant performance. This assistance is best provided by the EAF supplier during operation as well as during scheduled plant shutdowns. The subsequent inspections and on-site investigations serve as a basis for recommendations for ongoing process improvement. As problems are identified during the plant's lifecycle, the plant supplier continuously improves and redesigns the corresponding components. If significant modifications are required, parts of the plant are upgraded and revamped. Within a long-term cooperation, the EAF manufacturer offers comprehensive onsite technical as well as technological support with engineering and process expertise.

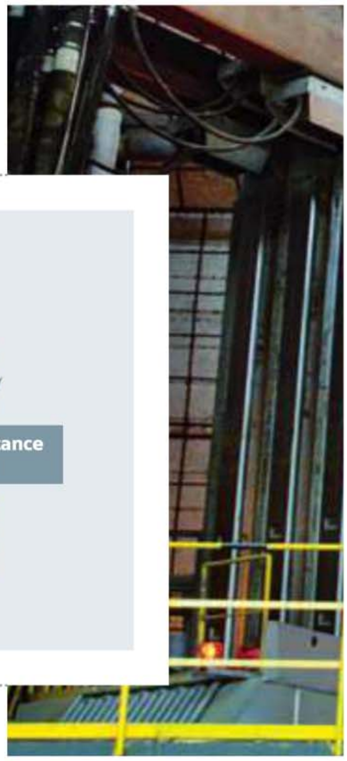
EAF modernization at Çolakoğlu Metalurji A.S., Turkey

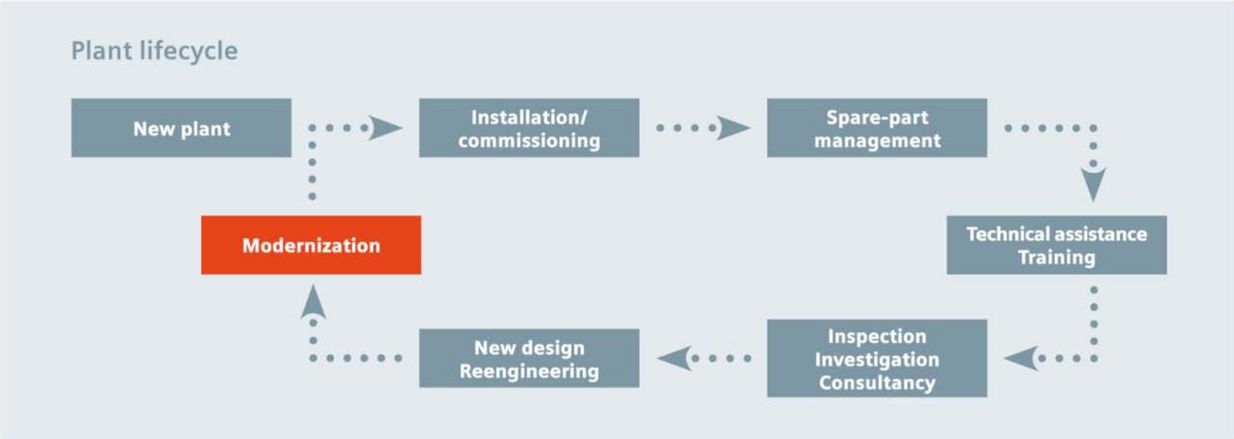
The steps described above constitute the typical lifecylce loop of a plant, which is repeated several times. The benefit of such a procedure is a constant or increasing asset value that enables the plant operator to deliver consistent product quality and to even improve profitability. Typical measures to enhance EAF performance and efficiency are described below.

EAF improvements for lower conversion costs

The primary factors determining conversion costs are plant availability and reliability. Optimally, the steel plant's staff and the supplier's service department cooperate on establishing an ongoing feedback process of plant problems and jointly develop customer-specific solutions. Initial activities focus on optimized spare-parts management and subsequently on identifying specific components that need to be re-engineered to suit the operator's specific requirements. These solutions are then implemented on site and the results are monitored. In general, the solutions discussed in this context are small modifications and revamps that produce a maximum short-term effect. The next factor in reducing conversion costs is boosting productivity. To do so, the existing productivity of an EAF must first be determined during an on-site fact-finding mission. The productivity of an EAF is defined as the number of tons that can be produced per hour. Productivity can be influenced by increasing tapping weight while keeping the same cycle time. Other factors influencing productivity are the electrical power input, the power-on time during every cycle, and improvements of the EAF's mode of operation. Energy consumption is another parameter that has an impact on conversion costs.

A further possibility to boost productivity is to use higher electrical power levels during the power-on phase. This requires the full utilization of the existing transformer capacity combined with a revision of the entire electrical transmission path to the arc or the installation of more powerful transformers. Productivity also means reducing power-off time, upgrading EAF movements and reducing delays. For example, a revamp of the hydraulic system with a gantry modification as well as EAF equipment tuning and process optimization can yield further increases in productivity. To ►





reduce power-off time and increase productivity, the steel producer needs to involve technical assistance for fine-tuning and process optimization. For all operation modes, the target is to achieve a steelmaking operation with fewer delays and less maintenance, quick diagnosis and short reaction time, fast spare replacements, and efficient material handling with minimum waiting time. A further promising modification is to better utilize the input energy by charging the EAF using larger scrap buckets and a correspondingly optimized EAF geometry. The tapping weight can be increased by using higher and larger furnace shells, and a bottom shell with higher capacity. Additional improvements can be implemented by including new design features with additional technologies such as injection tools and cooling blocks in the shell. The deployment of an additional injection system using a chemical energy medium is another way to increase the total energy input, and to improve the efficiency of the thermal and metallurgical processes.

Tailored solutions from a lifecycle service provider

It takes close and continuous cooperation between a plant operator and a service provider to identify which of the above measures will yield the maximum gains for a given process and production situation. It is also helpful if the cooperation extends over the entire service life of the EAF so that the service partner has a detailed understanding of all of the customer's specific operational and maintenance aspects.

The service provider needs to hold a wide range of skills that span from equipment design, service and maintenance management up to technological competence and all the way to process control. This expertise is necessary to offer the multidimensional solutions required to preserve asset value over the entire EAF service life. Problems with the plant have to be resolved with tailor-made technological upgrading solutions that are implemented in short installation times and that fit into scheduled plant shutdowns. The supplied components and systems need to be designed for reliability, low maintenance, safety and environmentally friendly operation. In case of emergencies, fast response and short delivery times for the service provider are of vital importance. Besides having a long track record as an equipment manufacturer, Siemens provides a comprehensive range of services and is capable of covering all aspects of system operation across the entire lifecycle of a plant. Siemens service support goes far beyond spare parts and emergency service – the company's specialists provide operator training and help analyze equipment performance, and they develop customized upgrade and revamp packages that can be easily installed in normal, scheduled service breaks. In recent years, Siemens has made a name for itself for competent process support and highly efficient upgrading and revamping projects for all aspects of a plant, from electrical and mechanical services up to plant erection and all project execution steps.

> Service covers all aspects of system operations across the lifecycle of a plant.

Ancillary process solutions

Apart from offering EAF upgrades and modernizations to cover the aspects described above, Siemens has also developed a number of innovative solutions for specific aspects of EAF operation. Precise, reliable and predictable acquisition of temperature data is important to ensure consistently high product quality as well as safe working conditions.

Steelmaking is all about knowing the exact liquid steel temperature at any given time. Until now, this was accomplished

1 Improvement of EAF and scrap-bucket geometries

2 Utilization of maximum available electrical power and upgrade of EAF movements

3 On-site technical and technological support

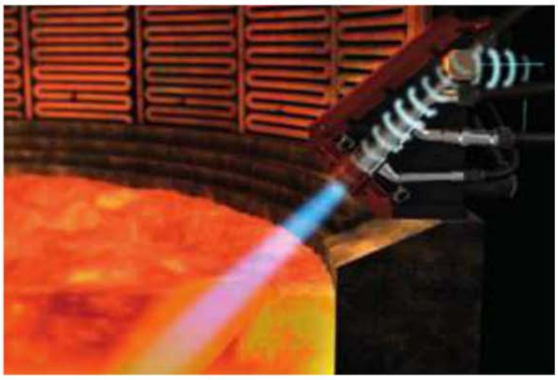
through time-consuming and dangerous manual cartridge handling. The supersonic oxygen-injection technology based on the Refining Combined Burner solution (Simetal RCB Temp) offers an innovative new approach. The burner preheats the scrap during power-on time, accelerates the melting process, and injects a supersonic oxygen stream into the furnace during the refining phase. As soon as the defined homogenization level is reached, the system switches to temperature mode and measures the temperature at short intervals in a contact-free procedure. Compared with manual sampling, this simplifies and expedites the decision as to when to tap the EAF. The result is shorter tap-to-tap times, higher productivity and greater safety for operators. Additionally, this system reduces operating costs by eliminating expensive cartridges.

Another solution is Simetal LiquiRob for the EAF, a highly flexible robot-aided automatic measuring and sampling system that is optimized for the rough environment of EAFs, converters, secondary metallurgical plants and casters. The system gives the operator the flexibility and reliability needed to ensure uninterrupted, fail-safe and controlled EAF steel production. Simetal LiquiRob replaces mechanical manipulators and performs fully automatic temperature and sample-measurement cycles, and it also performs automatic cartridge replacement. Thanks to Simetal LiquiRob, manual work in hazardous areas is largely eliminated.

Other EAF-specific modernization solutions target process optimization and help boost productivity while decreasing energy consumption: A DC EAF revamp that includes a Simetal fin-type anode modernization contributes to longer plant service life by offering a faster exchange time and improved safety, since no cooling water is required underneath the EAF. In steel plants in which hot metal is available, greater flexibility in the selection of charge materials adds to the economic advantages. The implementation of the Simetal EAF hot-metal charging turret with tilting ladle and launder offers increased flexibility for material input.

Estimating lifecycle costs

With regard to both technological development and market conditions, the world is in constant change. Consequently, ▶



Simetal RCB Temp performs contact-free temperature measurements

Simetal EAF hot-metal charging

a plant's EAF asset value can only be maintained if typical service expenses are factored in the economical calculation over the entire lifecycle. The overall service expenses of an average EAF are about 1.5 times the original investment costs, which are typically €15 million for an initial EAF purchase price of €10 million.

The following expenses are generally incurred over the entire EAF lifetime: The largest share within the spare-parts budget is allocated to water-cooled panels. These represent about half of the overall spare and wear expenses of approximately €8 million in an EAF lifetime of ten years. Personnel costs for service, technical assistance, training and studies are roughly €100,000 per year, which amounts to €1 million for a decade. Within the ten years, there is usually one major revamp package costing €2–3 million, and three smaller revamp cycles costing €500,000 to €1 million each. In all, this amounts to approximately €5 million within a decade. Furthermore, approximately €1 million, or around 20% of the price of these modernization packages, is earmarked for expenditures associated with erection, commissioning and fine-tuning. This calculation shows the importance of service and modernization expenses within the EAF's lifetime and highlights the need to invest in continuous improvement to consistently decrease conversion costs and boost productivity.

Conclusion

When investing in an EAF, expenses for service, maintenance and modernization need to be included in the overall lifecycle cost calculation. A wide scope of EAF modernization and revamping solutions is available to help maintain or even increase the EAF asset value. The corresponding activities extend over a long period of time and require that a service partner has a deep understanding of the customer's operation and processes. Cooperation with a lifecycle partner such as Siemens ensures optimum EAF performance, flexibility and efficiency.

Author
Michel Huck, head of sales/metallurgical services and head of service/electric steelmaking and secondary metallurgy

Modernization example:

Siemens boosts EAF productivity by 12%

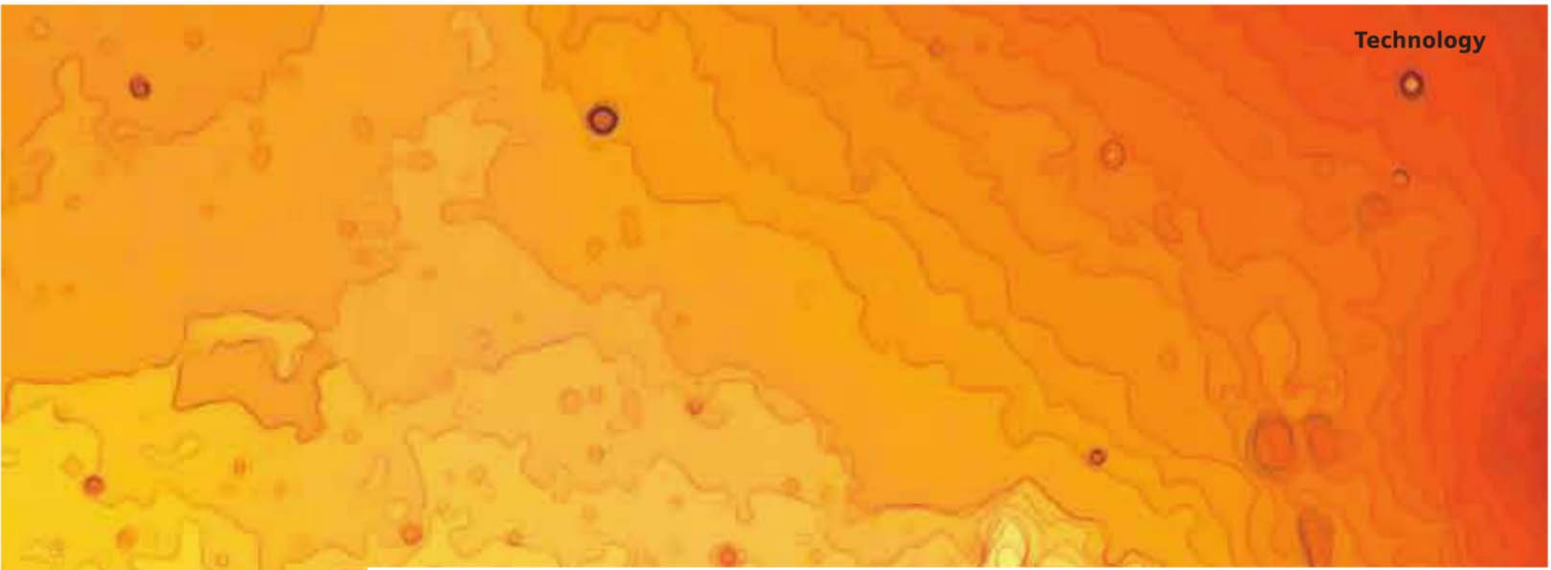
In early August 2011, Siemens received the final acceptance certificate from the Turkish steel producer Çolakoğlu Metalurji A.S. for the modernization of the No. 1 EAF at the company's Gebze plant in western Turkey. As one of the most productive EAFs in the world even before the plant upgrade, performance could be improved still further. Electrical active power input was increased by 8% along with a 6% reduction in the amount of electrical energy use – without increasing fossil-energy consumption. In fact, a furnace output of 350 t/h with 350 KWh/t was achieved as an average performance figure only one week after the first heat.

The net result is a boost in overall EAF productivity of 12% without any change in tapping weight.

The furnace was originally designed for a charge volume of 250 tons with a two-bucket charge operation. Over time a tapping weight of 315 tons was achieved. The higher steel output in addition to increased charging of lower-density scrap meant that more than two scrap buckets had to be charged per heat. This led to longer heat-cycle times.

The modernization project comprised the renewal of a large part of the EAF mechanical equipment, including lower and upper shells, the gantry, lifting columns and the furnace cover. These measures increased the shell volume by approximately 20% while keeping the tapping weight unchanged. Once again, the furnace could be charged with just two buckets. New current-conducting electrode arms for electrodes with a diameter of up to 800 mm were also installed to feed the maximum electrical power available. Production levels are now at more than 2.5 million tons of steel per year.

A special highlight of this project was the short implementation time; the new equipment was installed in just 20 days in July 2011.



Flexibility for scrap types and steel grades

Getting the max out of minimills

The new Simetal EAF Quantum powers up minimills with tap-to-tap times of 33 minutes and less. Added benefits include a 30% drop in electrode consumption and an energy requirement of only 280 kWh per ton of scrap.

Steelmakers need to be flexible. They face weak power grids, high energy prices and flicker problems. An electric arc furnace (EAF) therefore needs to be capable of processing a wide variety of charging materials, and conversion costs must remain within reasonable bounds. Utilization rates must remain high and extended standstills must be kept to a minimum.

Maximum energy efficiency in preheating, steady energy intake and short power-off times are important factors to ensure a fast and attractive return on investment. Better safety at work helps prevent accidents, thus further improving production sustainability. And to meet increasingly stringent regulations, environmental compliance and offgas processing need to be optimized.

A new EAF solution based on decades of experience

Siemens designed Simetal EAF Quantum to meet these requirements. The development is rooted in more than 20 years of experience in preheating and melting, and in more than 40 years of experience in electric steelmaking technologies. ►

The new EAF employs a number of new solutions that change EAF operation and performance, and that influence its ongoing costs and other economic factors.

A consequent concept in process design

All of the scrap is preheated using furnace offgas before the final melting process in the vessel. This results in substantial energy recovery so that a smaller transformer can be used. Since charging, tapping and tap-hole refilling can be performed during power-on, there are fewer switching cycles and less network disturbance. This leads to further significant energy and cost savings, and to a substantial reduction in tap-to-tap times (down to less than 33 minutes).

Combined with a large hot heel, the melting phase is reduced to a pure flat-bath operation with minimum flicker. Continuous furnace operation also results in an electrode consumption that is reduced by up to 30% compared with conventional EAFs. All of these measures can work together to achieve a substantially reduced energy consumption of 280 kWh per ton as well as less oxygen intake. The Simetal EAF Quantum does not use any burner power: There are no gas burners or jet burners such as refining combined burners (RCB) installed in the upper shell's sidewall. Oxygen and carbon for slag foaming are injected through top lances. The scrap batch melts in the large liquid heel, resulting in extremely short melting times.

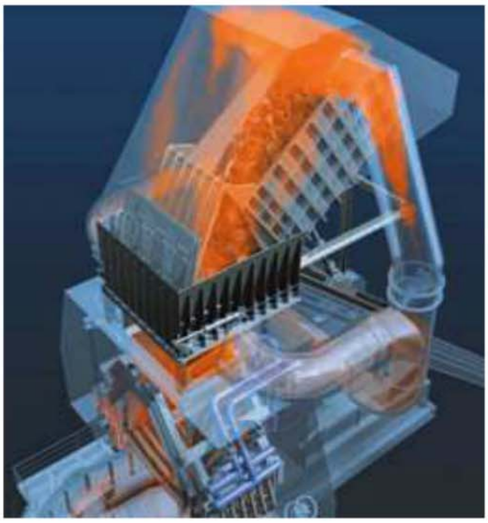
The FAST tapping system ensures efficient operation and lower maintenance.

The furnace uses the optimized and patented FAST (Furnace Advanced Slag-free Tapping) system for normal operation, and a second conventional tapping hole to empty the furnace. The FAST system uses a siphon design for slag-free tapping into the ladle. Since the furnace only uses tilting angles of 3–7° for tapping and slag removal, tapping can be performed during active power operation. This reduces power-off times as well as mechanical wear, ensuring fewer load-switching steps and lower maintenance requirements.

To avoid steel from freezing in the FAST chamber, a 1 MW burner is installed in the tapping system. The FAST bottom mechanism can be repaired or exchanged on a maintenance stand. Combined with the shell-exchange approach, the FAST system is an excellent alternative to conventional solutions.

Environmental regulations

Efficient energy recovery is achieved by a scrap preheating system that uses the thermal energy contained in the furnace offgas. This new offgas-treatment system employs a special hood design that ensures that all dust and offgas emissions from processing as well as from charging are



The scrap skip discharges into the shaft; offgas is exhausted from the hood

transferred to the primary offgas suction line. Reduced furnace movements (see above) and improved leak tightness of the entire system ensure comprehensive offgas monitoring. This allows a considerable reduction in the secondary suction line and canopy installation.

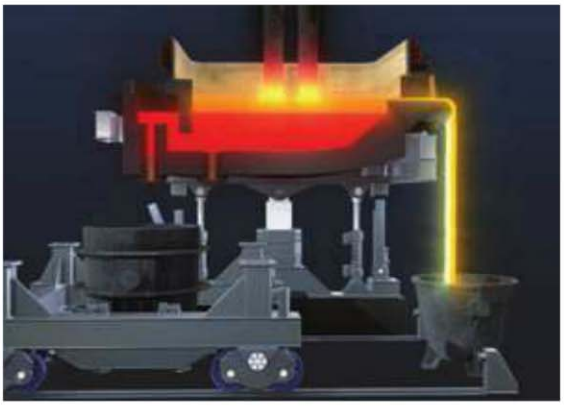
In addition, the preheating system was optimized in terms of leak tightness and efficiency. The system uses a trapezoidal-shaped shaft design in combination with a redesigned retaining system. This mechanism ensures better scrap distribution and improved offgas routing for optimized heat transfer, and prevents any scrap from sticking and blocking the inside of the shaft. The preheating temperature in the shaft is at least 600°C, and in normal cases around 1,000°C.

Directly after the primary and secondary suction lines, a post-combustion chamber with an integrated burner regulates the offgas temperature and incinerates harmful substances. A successive water quench ensures that the gas is cooled down through the temperature bands of 650°C and 450°C within a time of 1.5 seconds. This is important because a back-formation of furans and dioxins is possible in these temperature ranges.

A measurement system in the offgas duct of the quench monitors the gas output. In the improbable case that harmful substances are detected, activated carbon is injected into the gas stream. In conventional EAFs, NO_x peaks can be generated by a free electric arc directly after scrap charging. Since the Quantum features flat bath operation, no NO_x peaks will occur after charging.

Scrap lying in the furnance next to the electrodes is being melted

Yellow: slag
Red: molten steel
Excess slag continuously flows out of the furnance to the right



Reduced maintenance

Simetal EAF Quantum encompasses a number of design features that ensure reduced maintenance requirements. The design of the furnace itself has also been optimized for low maintenance: flat-bath operation ensures that there is no arcing on the roof and sidewalls.

Scrap preheating

Efficient energy recovery, thanks to 100% scrap preheating, is responsible for energy consumption of less than 280 kWh/t. This is realized by means of a trapezoid-shaped shaft design in combination with a redesigned retaining system, which results in an optimized allocation of scrap and improved offgas routing for optimized heat transfer.

Furthermore, the Quantum retaining-system concept offers enough volume in the vessel to open the fingers and load the scrap at any moment, even for the first batch of the next heat.

The finger-exchange procedure for maintenance has also been optimized: First, the backside of the finger housing is opened, and then the finger system is swung out and hooked to the supporting crane. The finger is then disconnected and pulled out of the assembly. The latest generation of water-cooled fingers and their associated spring packages have a lifetime of 10,000 to 12,000 heats.

Quantum is capable of preheating scrap with densities from 0.5 to 0.85 t/m³ in three to four batches per heat (as per the European specification for scrap with a maximum length of 1.5 m). Up to 20% of the scrap payload can consist of shredded scrap. Hot metal and DRI can be charged conventionally – hot metal through the slag door, DRI via roof feeding.

A suitable solution for minimills

The economical Simetal EAF Quantum features described above indicate that this furnace is suitable for deployment in a dedicated and well-coordinated minimill concept for the production of billets and blooms and all kinds of rolled products. Short furnace tap-to-tap times in connection with high-speed casting can set new performance levels. The term "mini" for the Quantum furnace only applies to production costs. In terms of productivity, capacity, flexibility and future orientation, these long-product minimills deserve to be called "maximills." ■

Authors
Dr. Markus Dorndorf, head of R&D
Dr. Martin Fleischer, head of sales

Steelmaking

New electric arc furnace for direct reduced iron melting

A new electric arc furnace (EAF) boosts the productivity of electric steel operations by up to 15 %. Simetal EAF FAST DRI features a continuous melting process during which the electrical energy input and (direct-reduced iron) DRI are supplied during tapping. This shortens tap-to-tap times and reduces the specific energy consumption. The arc furnace has a modular structure, which also makes it possible to retrofit existing, conventional furnaces. The EAF has a tiltable lower vessel with an extensive liquid heel. The resulting continuous flat-bath operation allows electrical energy input and DRI feeding during tapping. Thanks to the patented Furnace Advanced Slag-free Tapping system (FAST), charging, tapping and taphole refilling are possible under power-on conditions. Compared with conventional arc furnaces, tap-to-tap times can be reduced by up to 15 %. Energy consumption is cut by 20 kWh per ton and electrode consumption falls by 10 %. The continuous supply of electrical energy during flat-bath operation not only improves productivity but also avoids line harmonic distortions such as flicker. The continuous operation of the furnace offers a number of other benefits. Coal and oxygen injection as well as foaming slag control can be implemented even more precisely. Slag-free tapping leads to an enhanced alloy yield and better steel desulfurization. The installation of additional burners thus becomes superfluous. Thermal stress on the refractory and structure materials also remains constant, which helps prolong their useful lives.

Simetal EAF FAST DRI from Siemens: the new electric arc furnace was specially designed for the use of direct reduced iron

Steelmaking

After upgrade, Turkish steel plant increases productivity

After modernizing its electric arc furnace in the western Turkish city of Gebze, steel manufacturer Çolakoğlu Metalurji A.S. improved productivity and even achieved a new record of 8,577 tons per day. At the same time power consumption was reduced by 6%. To put this record into perspective, the average Simetal EAF Ultimate has a daily output of approximately 7,833 tons. The dedicated team under the leadership of Siemens project manager Günter Braun is behind the record. The overall productivity of the electric arc furnace was boosted by 12% without any change in the tapping weight. This showpiece project is notable also because of its extremely short implementation period. The modernization was completed within only 20 days, and only four days after the first melting Çolakoğlu issued the final acceptance certificate. The project involved renewing a large part of the mechanical equipment of the electric arc furnace, including the lower and upper shells, gantry, lifting columns and furnace cover. Thanks to the upgrade, Çolakoğlu Metalurji A.S. is one of the most productive steelworks in the world.

Hot-strip mill

New quick-exchange pinch-roll cassette for downcoilers

Roll-change time can now be reduced significantly thanks to a new method for changing the pinch rolls in downcoilers. The pinch-roll unit, designed as a quick-exchange cassette, can be replaced within just ten minutes without an additional interruption of production – instead of the up to eight hours typically required with conventional solutions. The ability to quickly exchange rolls reduces maintenance time, increases yield, and makes it easier to switch from one steel grade to another. The change is carried out automatically, and cleaning no longer has to be done during ongoing operations. This eliminates a potentially dangerous task for rolling-mill personnel. The short time required to replace rolls now allows an exchange to be synchronized with specific operational requirements, such as a change in the grade of steel to be rolled or the specific strip-quality requirements. The technology allows operators to flexibly respond to changing market requirements. The output of the rolling mill can be increased and the surface quality of the strip improves.

Ironmaking

Russia's largest pellet plant to be built for an NLMK subsidiary

The Russian steel producer Novolipetsk Steel (NLMK) placed an order with a consortium comprised of Siemens and Outotec Oyj, headquartered in Espoo, Finland, for the supply of a new pellet plant with an annual production capacity of 6 million tons of magnetite pellets. The plant will be built at NLMK's Stoilensky Mining and Beneficiation Plant (SGOK) in Stary Oskol. The total order value for Siemens is approximately €125 million. The pellet plant is scheduled to be started up in 2014. With the project Siemens is further strengthening its competence in iron ore agglomeration technology. A major technical upgrade and expansion program is underway within the NLMK group. The new pellet plant to be built in Stary Oskol in the Belgorod region, 600 km south of Moscow, will be based on traveling grate induration technology and will produce high-grade magnetite pellets that will have an iron content in excess of 65%. Siemens will supply engineering and equipment for the preparation of the iron ore concentrate, material handling and storage, utilities, and the related electrical and automation systems. Outotec will supply the process technology and plant equipment for the iron ore pelletizing plant.

SGOK, a wholly-owned subsidiary of NLMK, is Russia's third-largest iron ore producer and accounted for approximately 14% of the total iron ore output in Russia in 2010

Steelmaking

Robots automate casting platform and increase safety

CC7 caster equipped by Siemens at voestalpine Stahl in Linz, Austria. The casting platform is automated by the LiquiRob robot systems

For the first time in a European steelworks, two LiquiRob industrial robot systems have been installed to utilize an automated casting platform, a step that significantly improves the level of work safety for operating personnel. The Siemens delivered casting line at voestalpine Stahl in Linz, Austria, is designed to produce slabs with thicknesses up to 355 mm at widths of up to 2,200 mm. The robots have been installed in front of and behind the ladle turret – one near the ladle support and the other in vicinity of the tundish car. Tasks assigned to the robots include automatically connecting electrical and utility supply to the ladle, connecting the shroud and sliding cylinder, and unlocking the ladle tilt hinge bolt. Procedures at the tundish such as temperature measurements, the determination of oxygen and hydrogen content, sample taking, the addition of casting powder and ladle oxygen lancing are now completely automated and carried out by the robots. The operating personnel must no longer enter potentially dangerous zones and can safely monitor and control the casting process from the control room. For the purpose of producing high-quality steel grades and in order to achieve quicker response times to changing market requirements, the continuous casting line was equipped with a wide variety of technological packages. The strand guide system is equipped with the remotely adjustable Smart Bender and Smart Segments that work together with the DynaGap Soft Reduction 3D system to allow rapid and automatic slab thickness changes. EcoStar strand guide rollers are used for strand support. The newly developed Dynacs 3D process model for secondary cooling dynamically calculates a three-dimensional temperature profile along the entire strand. This calculation model can be used to determine the operating points of secondary cooling, thus precisely defining final strand solidification as dependent on the casting speed, slab format and steel grade.

Inside view of the intensive mixer (inner diameter ≈ 4 m, inner height ≈ 1.5 m)

The Intensive Mixing and Granulation System allows an excellent sinter raw mix to be produced even with high portions of pellet feed

Improving quality and plant performance

The wish of sinter producers to use higher portions of low-cost fine and ultra-fine iron carriers in the sinter raw mix has led to a new development by Siemens in the field of agglomeration technology. Referred to as the Intensive Mixing and Granulation System (IMGS), this highly innovative solution allows far-higher portions of fine iron ores to be used in the sintering process than is possible with conventional solutions.

In the future, iron ore mines will generate increasingly larger portions of fine ores. Raw material treatment in blending yards, followed by the preparation of the sinter raw mix in conventional mixing and granulation drums, is not capable of achieving the degree of homogeneity required to produce good-quality sinter when high portions of fine iron ores are used. These fines are normally pelletized prior to charging into a blast furnace, which incurs higher costs for producers compared with ore agglomeration by means of sintering. Siemens has therefore developed a special raw-mix preparation process, known as the Intensive Mixing and Granulation System, in which the entire raw mix is treated in such a way that, depending on the raw materials, even up to 60% pellet feed (grain size: <0.1 mm or <0.045 mm) can be used to produce a high-quality sinter at high productivity levels. This can be achieved while assuring excellent product and process parameters related to productivity, the physical characteristics and chemical quality of sinter, low fuel consumption and stable sintering operations.

IMGS is comprised of proportioning bins, an intensive mixing unit, and an intensive granulator or a standard granulation drum. Different raw materials stored in separate bins are precisely dosed onto a conveyor belt in sandwiched layers. Modifications to the chemical composition of the sinter product are easily carried out by automatic adjustments of the raw material dosing rates according to the sinter chemistry. This is remotely performed in the control room applying a sophisticated Level 2 process-optimization system. The raw materials extracted from the dosing bins are transferred to the intensive mixer where they are thoroughly homogenized. After the material exits the intensive mixer, it is transported to the granulator where it is granulated to attain the required permeability prior to charging onto the sinter strand (see flow sheet).

The entire raw material mix is treated so that up to 60 % pellet feed can be used to produce high-quality sinter.

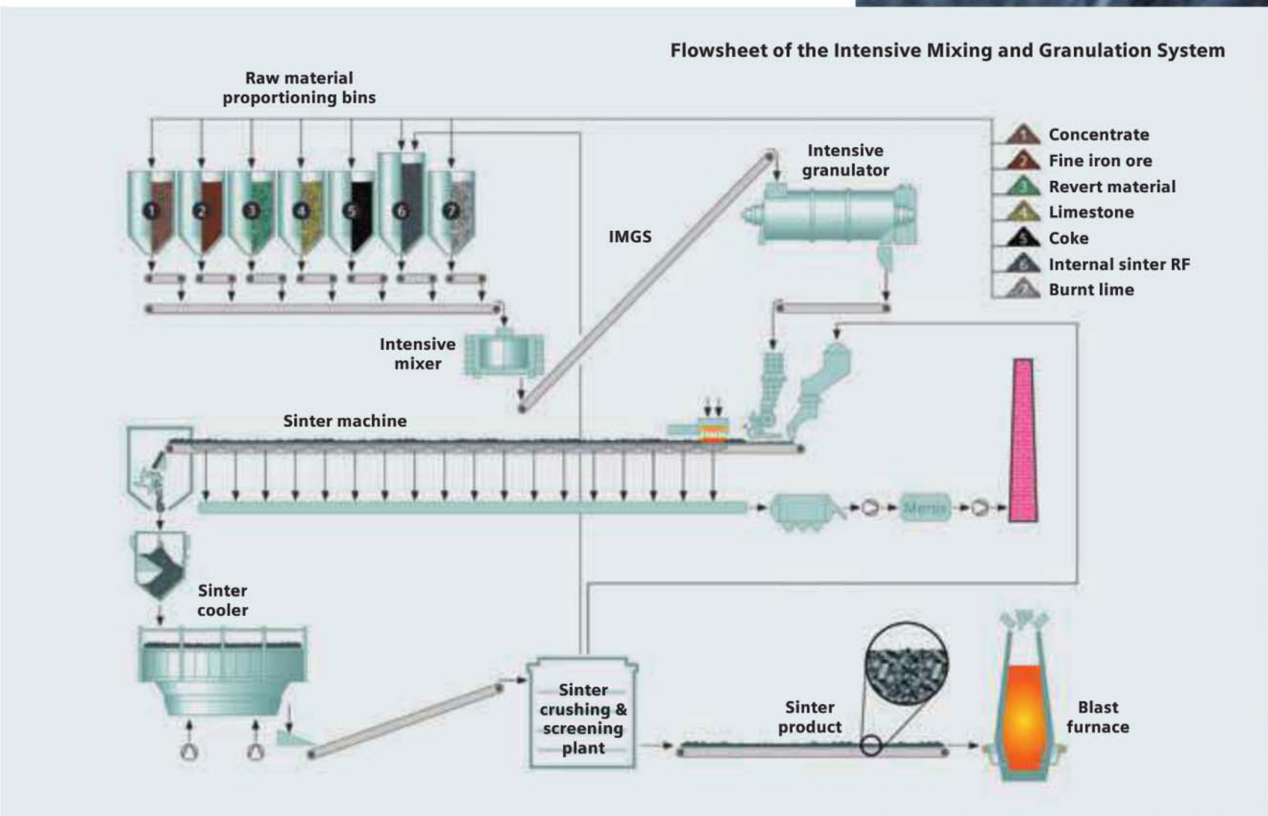
Process investigations and development

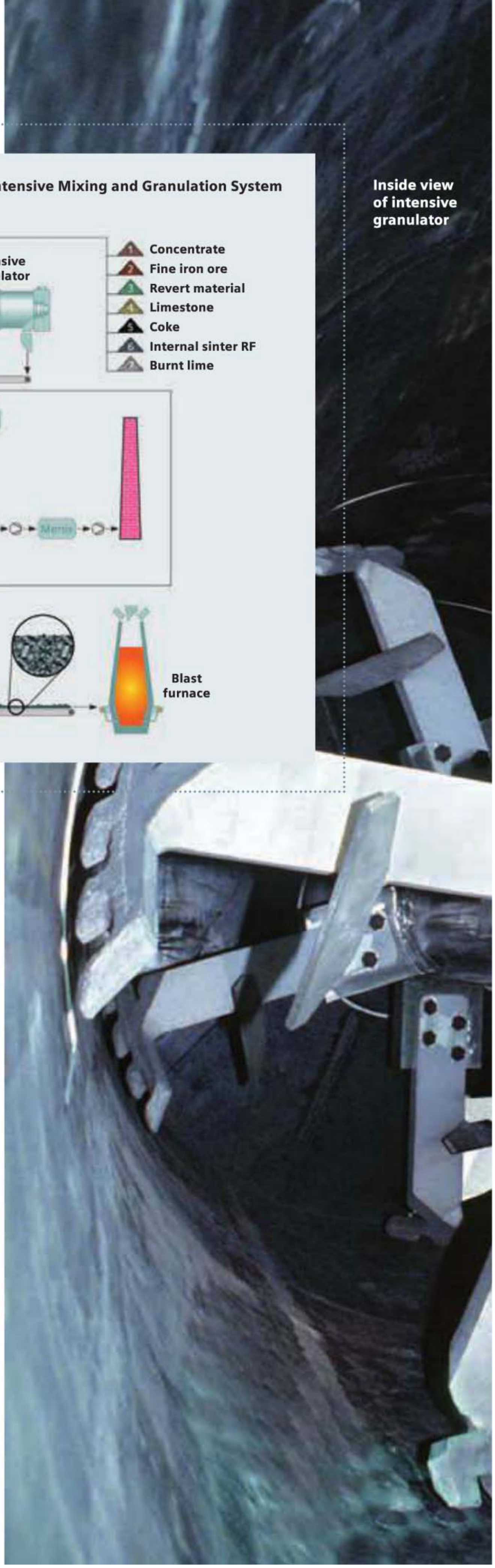
Exhaustive investigations were carried out using different mixing and granulation machine types and designs. A wide range of iron ores with varying grain-size distributions, even up to 100% pellet feed, were also systematically tested. After the mixing and granulation steps, the material was sintered in sinter pot test equipment to evaluate its performance in the sintering process. The focus of investigations in the mixing step was to obtain a high homogeneity of the sinter raw mix, while the main issue in the granulation step was to maximize the permeability of the material mix. Coarse and very fine sinter raw mixes were compared.

The investigations demonstrated that a higher homogeneity of the material mix could be achieved in an intensive mixer compared with a conventional mixing drum. Furthermore, superior homogeneity results were reached sooner using the intensive mixer.

Different material mixes were then investigated in the granulation step. It was determined that carefully controlled additions of water to the material mix and, in particular, the ratio of water injected into the mixer and granulator units, are decisive for proper granulation and for ensuring a high degree of permeability. A key target in the granulation tests was to achieve good permeability with the lowest possible amount of water. When high portions of fine ore were used in the sinter mix, the quantity of burnt lime added to the mix was increased accordingly.

The intensive granulation unit offers a number of advantages compared with conventional granulation in a drum. For example, high amounts of ultra-fine materials can be processed without adverse effects on the granulation process. Self-cleaning of the inside walls of the intensive granulator is conveniently performed by rotating arms. (Very fine material often sticks to the inside wall of the granulation equipment.) ►




Inside view of intensive granulator

Installation of the system at Dragon Steel Corporation in 2009 meant no more blending yards.

▸ Furthermore, the rotation speed of the granulation tools can be adjusted in the intensive granulator, whereas a conventional granulation drum has only one rotational speed.

Cold permeability tests were carried out using a special apparatus in which defined quantities of sinter raw-mix granules were subjected to differential pressure for a certain material height. The results were measured, compared and analyzed. A direct relationship could be observed between granulation behavior, permeability and the productivity of the sinter strand. It was shown that excellent permeability is achieved for both coarse and very fine material using the intensive granulator.

Sinter pot tests were then performed to produce sinter using different mixtures of sinter raw mix. Coarse and very fine materials were used. The sinter product and the respective productivity rates were compared. It was even possible to produce a good-quality sinter using 100% pellet feed, however, at a much lower productivity rate (<30 t/m²/day). The results depend to a major extent on the raw materials used and the selection and combination of equipment to produce

Main benefits*

- Lower investment costs
- Elimination of the need for blending yards
- Increased flexibility in the selection of raw materials
- Improved sinter raw mix homogeneity, including recyclable reverts
- Reduced solid-fuel consumption
- Excellent sintering results even using high portions of ultra-fine iron ores

*Compared with conventional sinter raw mix preparation systems

the sinter raw mix. To make precise statements, each raw material combination has to be carefully investigated applying mixing, granulation permeability and sinter-pot tests.

Industrial application

The first IMGS system was first put into operation at the sinter plant of voestalpine Stahl Donawitz, Austria, in the late 1990s. Installation of the system at Dragon Steel Corporation in 2009 meant that blending yards could be dispensed with altogether. The latest plant start-ups were at the Ipatinga and Cubatao steelworks of the Brazilian steel producer Usiminas S.A. in late 2011 and early 2012, respectively. At both of these sites an intensive mixer was built upstream of the existing combined mixing and granulation unit – which was modified to a granulation unit only – to significantly increase the portion of iron ore fines that could be added to the sinter raw mix. IMGS commissionings will follow in Taiwan and India.

Concluding remarks

The ideal combination of mixing and granulator machine types and dimensions is made on the basis of the available raw materials. The industrially proven Intensive Mixing and Granulation System from Siemens therefore offers producers customized and cost-optimized solutions for achieving maximum sinter plant performance and achieving highest product quality.

The author wishes to express his gratitude to voestalpine Stahl GmbH for their support in the development of the Intensive Mixing and Granulation System. ■

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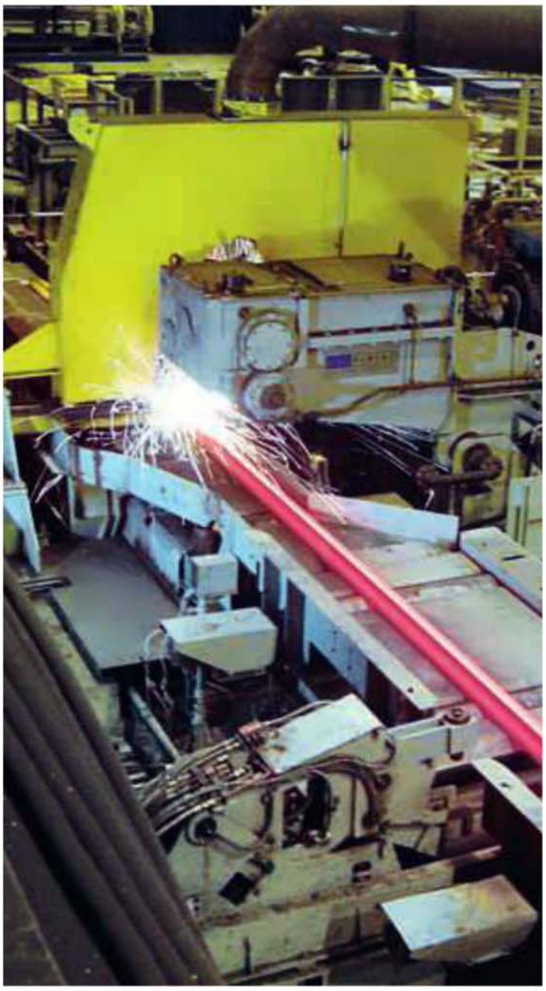
Author
Prof. Dr. Johann Reidetschläger, process engineer responsible for agglomeration technologies

High-precision equipment for longer rails

Right on track

In recent years, high-speed rail transportation has proven its convenience and cost-effectiveness for short and mid-range distances. At the same time, heavier payloads are being transported on freight trains. Both market trends are forcing the steel industry toward modern production concepts.

Production of ultra-long rails at the Bhilai plant of Steel Authority of India


Abrasive disc saw for rails

Today, railway cruising speeds exceeding 350 km/h are not uncommon. And when a train is traveling at this speed, strict quality requirements have to be met. Wear resistance, rolling contact fatigue, vibration and dynamic loads, and rail linear tolerances are just some of the issues that have to be addressed. Superior-grade rails are also required for freight trains that transport heavier payloads.

Operators want high-quality rail solutions that are flexible and that help increase operational profitability.

Operators therefore want high-quality rail solutions that are flexible and that help increase operational profitability. Furthermore, to reduce costs, the market is calling for longer rails – up to and over 100 m. The answer lies in modern production facilities that offer rolling flexibility, high efficiency and quick change of production with minimum downtime.

For mills that produce rails only, the best layout is composed of two reversing breakdown stands, a continuous universal mill, an in-line heat-treatment process, a cooling bed with a pre-cambering system, a straightening system, and ancillary systems such as sawing units, hot marking, stacking and binding, and control systems (Figure 1). With this type of configuration, rails up to 120 m in length may be rolled continuously. The following is a review of the most important components.

Continuous universal mill

The universal mill reduces the leader pass to the final rail shape through a sequence of continuous passes typically using five to seven universal/horizontal Red Ring stands. This allows for a fast and easy conversion between universal and horizontal configuration. The same configuration may be adopted for sections up to 300 mm. Advantages of rolling rails with a continuous universal mill:

- High production rates
- High reliability of rolling process (off-line stands are preset)
- Smooth rolling process with less equipment maintenance
- Perfect rail shape control (one edging pass after each universal pass)
- Better control of roll wear, longer roll life and fewer roll changes
- Reduced rail-heat loss with lower power consumption and better tolerance
- No need to change stand as the line is set up after each pass
- Reduced downtimes for stand changes with a quick-change device.

Universal mill for rails and large sections

When sections exceed 300 mm, the solution is a 3+1 universal mill, with a Red Ring reversible intermediate-finishing train with U-H-U configuration, followed by a single pass universal finishing stand. The finishing stand is used only for the final pass and thus experiences reduced wear and fewer roll changes. In addition, a single-stand, remote-control change system minimizes downtime, and its lower weight allows for a more compact roll-shop design and more efficient crane usage. Furthermore, this solution requires less ancillary equipment and fewer spare components.

In-line heat-treatment process (head hardening)

Standard rails are rolled with alloy constituents in order to reach the desired pearlite microstructure. By deploying cooling zones along the rolling train, the rolling temperature may be lowered to approximately 800–850°C, which produces the same effect while reducing alloy costs.

As standard rail grades show a limited resistance to wear, there is a trend toward achieving bainitic structures, which offer improvements of strength and fatigue resistance over pearlite. To obtain these structures, the rail temperature is controlled during rolling, and rails are processed through the in-line head-hardening system before the rail is delivered to the cooling bed. Modeling allows precise control of the cooling process around the rail outer profile to obtain the desired microstructure and hardness distribution across the rail section.

Rolled rails enter the cooling bed on their sides with a non-uniform mass distribution across the vertical plane. Consequently, the rails will tend to bend inwards on their head side during cooling on the cooling bed, making post-cooling straightening very difficult. Pre-cambering using carriages with hydraulic grippers is therefore applied to the rails at the entry side of the cooling bed to compensate for subsequent bending. Individually programmable travel distances of the grippers allow different pre-cambering patterns to be applied, which are calculated in accordance with the respective rail parameters and appropriate cooling models. Pre-cambering allows the rails to be sufficiently straight when entering the straighteners to minimize the applied straightening force and residual stresses.

High-speed trains call for extremely tight tolerances of linearity and rail shape, and low levels of internal residual stress. Before entering the straightening area, a hydraulically operated manipulator positions the rail onto its foot and ensures entry to the straightening machines.

The straightening line is composed of horizontal and vertical straightening machines within a rigid frame containing two staggered rows of rollers. The roller position and centerline is adjustable according to the rail size and its section modulus, and hydraulic counterbalance eliminates backlash. The rollers are mounted in a removable cassette for quick changing so that the cassette can be automatically removed and replaced with a standby cassette. A suction system removes the scale.

Sawing units

Sawing is preferred to shearing to achieve the desired length for hot-cut rails. Sawing eliminates the deformation of rail ends and obtains better cut quality and precision. Depending on the application, either metallic or abrasive hot saws can be used. The rail is clamped at both sides of the wheel. Wheel movements can be either pendulum or linear, and an automatic system compensates for the wheel wear and minimizes the process cycle time. Saws are used for nose and tail cropping and sampling. Automatic crop and sample discharge systems are deployed. Swarf is collected in a bin at the saw, and a separate dust removal and filtering system is provided.

Hot marking

To ensure that each individual rail may be tracked and identified from the initial production steps to final installation and usage, the rails are embossed in-line at periodic intervals by hot-stamping machines with rotating heads.

Rail monitoring and testing

The continuous monitoring of rail profile, temperature, rolling speed and rail identification is done on each rail before it enters the cooling bed. This data allows for the automatic adjustment of rolling parameters and can automatically spot surface defects.

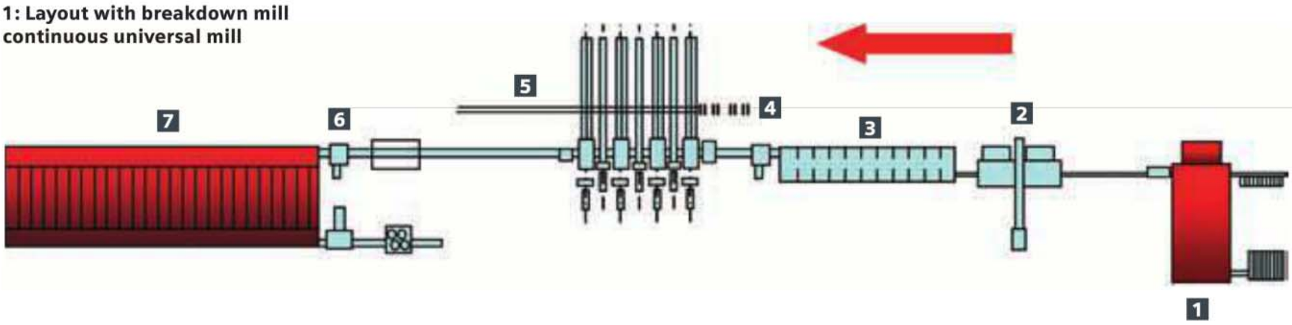
The non-destructive testing area is located after the straightening units. To ensure that each rail complies with international and country-specific quality standards, it includes an eddy current testing unit and an ultrasonic device, which check the rail outer surface and internal structure, respectively.

Conclusion

Global trends are forcing the steel industry to focus on flexibility, quality and operational profitability for rails. The issue of final product quality cannot be limited to the rolling process, but must be addressed in a holistic way to include the steelmaking, secondary metallurgy and bloom-casting methodology as well as rail rolling and finishing. ■

Authors
James Hogg, senior proposals manager
Luigi Giacomini, marketing communications

Fig. 1: Layout with breakdown mill and continuous universal mill



1 Reheat furnace
2 Roughing train
3 Cross transfer
4 Saw
5 Finishing train
6 Hot saw
7 Cooling bed

Simple and efficient approaches to ingot descaling

Quality production of ultra-thick plates

Ingots as feedstock for plate rolling are making a comeback for die steel, construction, yellow goods, shipbuilding and offshore platforms, pressure vessels and tanks, the nuclear industry, armor plating, wind-turbine foundations, penstocks and others applications involving plate thicknesses up to 400 mm or higher. These thicknesses are achieved with an ultra-thick caster, such as at Shougang in China, Posco's Pohang steelworks in Korea, and the new 5-meter-wide plate mill at Xiangtan, China, which uses ingots up to a thickness of 1,000 mm. The author explains more about how Siemens' innovative technology can descale ingots and help to ensure quality production of ultra-thick plates.

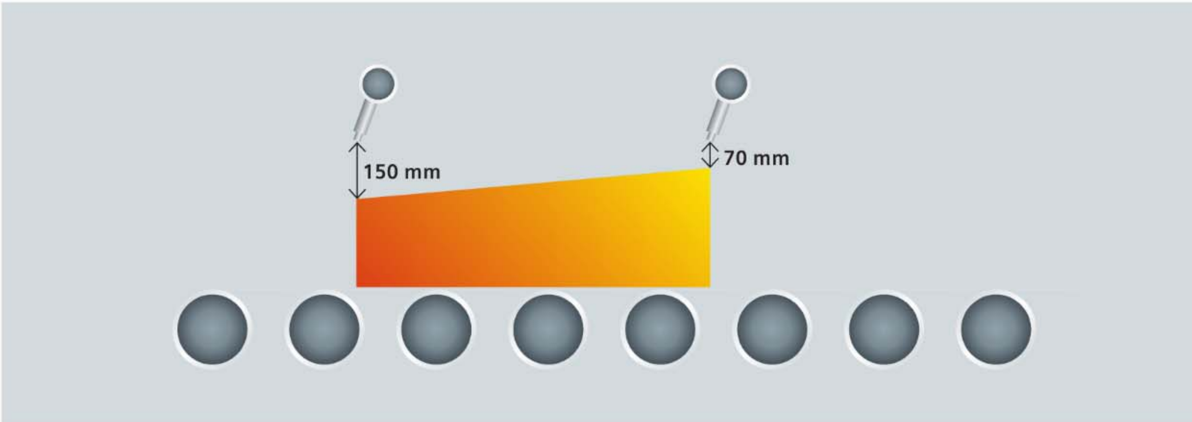


Fig. 1: Ingot laid on its side for descaling

High water pressure upon impact is essential for the proper descaling of the ingot or slab surface. To achieve this pressure, most descaling systems use flat fan-type nozzles as depicted in Figure 2. These produce a fan-shaped jet, which is very narrow in one plane and has a fan shape in the other. Parameters include supply pressure; the size of the nozzle, nozzle angle α and flow rate, which is proportional to the square root of the supply pressure; and the standoff distance h2. The shorter the standoff distance, the higher the impact pressure and the more nozzles that are required to cover the full width of the slab.

Other important parameters are the angle of inclination of the nozzle measured from the vertical plane and the offset angle. The angle of inclination ensures that the high-pressure water and scale bouncing back from the surface of the slab do not interfere with the direct jet; the offset angle ensures that adjacent jets do not interfere with each other.

Generally speaking, for a given standoff distance h2, the spacing between the nozzles E is chosen to give a small overlap D between adjacent nozzles. This small overlap ensures that the full surface of the slab is descaled properly; the impact pressure drops off at the very edges of each fan shape, so a small overlap is necessary to avoid stripes that are not descaled properly.

If the actual standoff distance is greater than the design figure, then the impact pressure of the jets will be reduced, and descaling will not be as effective. If the actual standoff distance is less than the design figure, then the jets will no longer overlap, and the slab will have stripes of scale left along it.

For these reasons, most plate mills use a variety of slab thicknesses, and the top headers can usually be adjusted for height using screw jacks, hydraulic cylinders or other actuators. The control system sets the correct header height for a particular slab before the slab enters the descaler so that the standoff h2 is approximately the same regardless of the slab thickness.

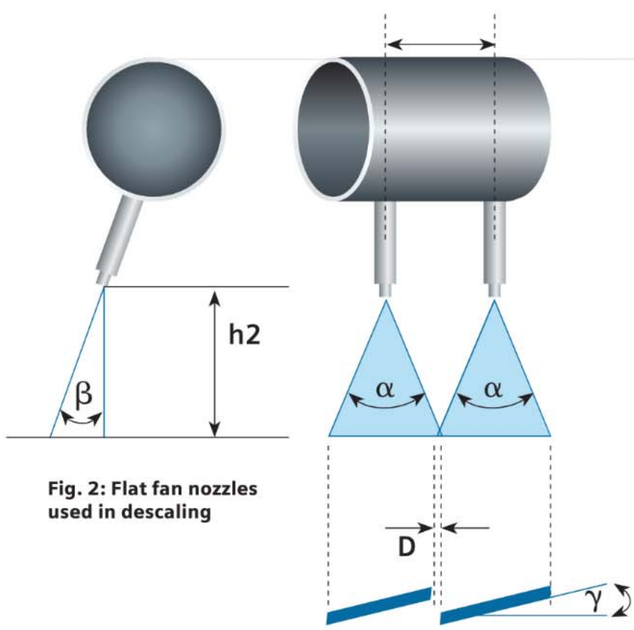


Fig. 2: Flat fan nozzles used in descaling

Descaling challenge: tapered ingots

The fundamental problem with descaling ingots is that they must be tapered to allow them be removed from the mold (Figure 1). A large ingot can have a taper of 80 mm or more in thickness along its length. Although in reality the ingot is cast vertically, for the sake of this descaling discussion the ingot is assumed to be laid on its side, so that length refers to the dimension in the rolling direction. An ingot, for example, might be 1,000 mm thick at the thickest end and 920 mm thick at the thinnest end.

Since the standoff distance on a descaler is typically about 150 mm, it is not possible to descale an ingot satisfactorily with the header of a conventional descaler set at a fixed height. If the header height is set correctly for the thick end of the ingot, then the impact pressure at the thin end will be too low for good descaling. If the header height is set for the thin end of the ingot, then the jets will not overlap properly at the thick end, and stripes of scale will remain.

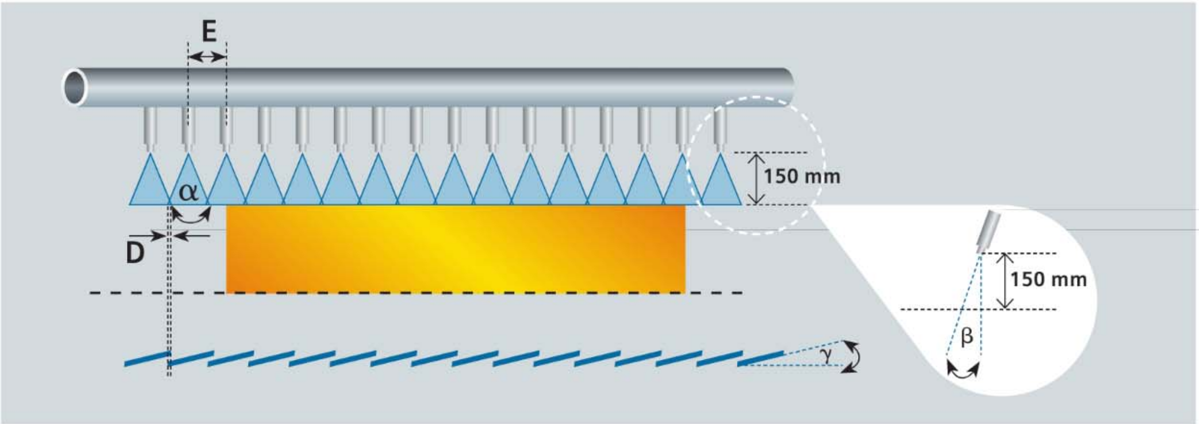


Fig. 3: Spray pattern of one header at the correct standoff distance

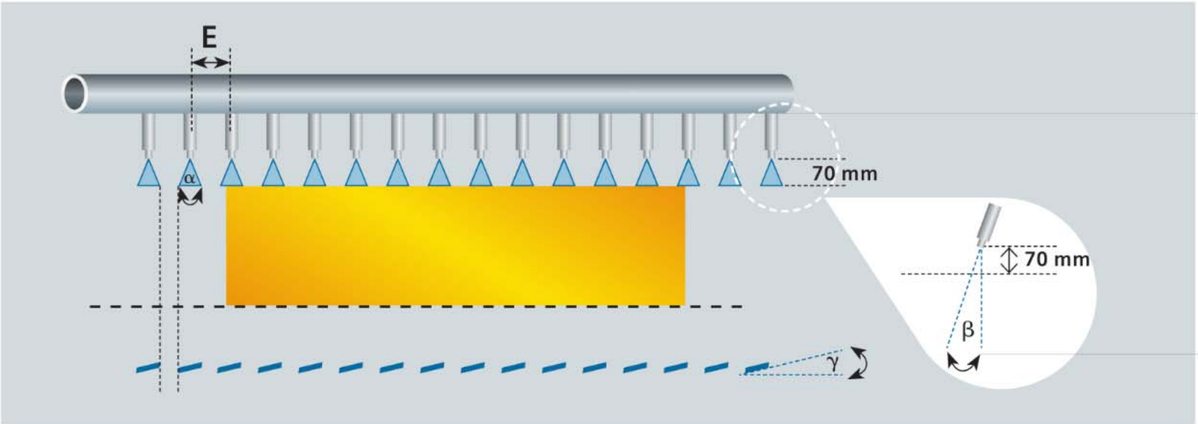


Fig. 4: Spray pattern with standoff reduced from 150 mm to 70 mm for ingot tapered by 80 mm

In order to roll ingots into quality plates, Siemens has developed a number of new technologies including de-tapering using multipoint setups for both the thickness reduction and the edger reduction; a high-force, high-torque edger with an increased roll-barrel length specifically engineered for ingots; and a simple and elegant ingot descaling approach.

Figure 3 shows the spray pattern for one header when it is set at the correct standoff distance from the slab or ingot. There is a small overlap D between the sprays. Figure 4 depicts the spray pattern produced if the standoff is reduced from 150 mm to 70 mm due to the 80 mm taper of the ingot; there are large gaps between the sprays, creating a scenario that makes it impossible to reach stripes that are not descaled.

For the ingot descaler with two headers, the second header is offset in the width direction. When the descaler reaches the thick end of the ingot, where the standoff distance is at a minimum, the gaps between the sprays from the first header are covered by the sprays from the second header.

At the thick end of the ingot, the impact pressure is higher than it is at the normal standoff distance, so descaling is even more effective. At the thin end of the ingot, both headers are at the normal standoff distance, and both headers achieve full coverage so the thin end effectively gets descaled twice. Under this approach, only one of the headers is needed to descale normal slabs; the other header can be switched off.

Edge descaling – another Siemens option

Ingots and thick slabs can also be subjected to edge descaling, which uses a combination of position and force-controlled skids. The hydraulic cylinder is used to set the initial position of the edge descaling for the ingot dimension, but then the ingot itself pushes against the skid plates to maintain the correct standoff, irrespective of any skew or off-center tracking of the ingot. This configuration also eliminates the need for a second edge descaling header. For slabs, the edge descaling can be set to the correct width and the skid plates only contact the slab if it tracks off-center.

The increasing use of ultra-thick plates has fueled demand for ultra-thick feedstock, including ingots. Having developed a number of new technologies for quality rolling plates from ingots – including de-tapering using multipoint setups for both width and thickness and a high-force, high-torque ingot edger – Siemens applied for a simple solution for descaling that uses two headers with an offset between them to achieve good descaling of tapered ingots. An additional edge-descaling solution ensures that the tapered edges can be descaled properly. ■

Author
Mike Clark, head of R&D in Sheffield, UK, and expert for plate mills

New state-of-the-art galvanizing lines in Europe

A galvanizing effect

Siemens supplies galvanizing technology and all related electrical and automation solutions covering the full range of applications. To deliver state-of-the-art technology to customers, Siemens has made significant investments in mechatronic packages – in addition to the full range of technologies covering all kinds of heating, cooling and annealing concepts. Two typical galvanizing line designs are outlined in the following article.

The first example of a facility for which Siemens took full process turnkey responsibility – a vVv (vertical entry accumulator, Vertical furnace, vertical exit accumulator) high-capacity, wide-coated strip production line – has been on stream since 2009. The line features an annual capacity of 550,000 tons and processes a wide product mix that includes cold-rolled strips of low-carbon soft steels; high-strength steel (HSS), dual-phase (DP) steels, and transformation-induced plasticity (TRIP) steels with strip thicknesses of 0.6 mm to 2.5 mm and strip widths up to 2,050 mm. The line's output is used in the automotive sector and in this article it is referred to as the A (Automotive) line.

Production of the second new facility with a capacity of 350,000 t/a is destined for appliance, non-exposed automotive and building applications. Therefore, for this article it carries the designation of the B (Building) line. The hHh (horizontal entry accumulator, Horizontal furnace, horizontal exit accumulator) line was designed to handle cold-rolled carbon steels with thicknesses of between 0.25 mm and 2.0 mm and widths between 750 mm and 1,530 mm.

Strip entry and welding

The entry section of each galvanizing line includes a dual pay-off reel to provide sufficient coil loading and joining time to reduce the impact of any unscheduled delay on the front end. The double pay-off reel arrangement enables new coils to be brought into the line and prepared while the previous coil is processed through the line. A welder joins the tail of the previous coil to the head of the new one at the entry of the line to create an endless strip for the continuous galvanizing process. A mashed lap welder that fulfills all technical requirements is typically used in the B line. This older-generation welder is still valued for its rapid return on investment and well-proven technology. For the A line, Siemens generally employs laser technology, which produces a weld joint without over thicknesses. The laser welding process not only makes it possible to attain coil build-up operation, but also produces the highest-quality resistance-seam welded joint, which is suitable for passage through the skin-pass mill and tension-leveling section of the line without having to open the work rolls. This method ensures maximum yield of prime-quality product by minimizing the unprocessed material at the weld joint. In addition, the laser system also allows the strips to be cut with the laser beam, which means no wear of cutting tools, perfect cutting quality, and no limitation in terms of mechanical properties of the steel grade to be cut.

Siemens offers both horizontal and vertical accumulators. The decision to select one design over the other is not as simple as it may seem, and several aspects have to be taken into consideration. To determine which solution is best, the strip-storage capacity is first calculated considering the transient period of entry and exit coil change. Independent from an A or B application, it is then necessary to think not only about the available space for the plant but also about the desired end material and the appropriate technology. Though on average horizontal accumulators are half as heavy as vertical models, their technical design involving dolly cars or separator arms can cause some marks on the strip surface. For this reason, an A line is almost always equipped with entry and exit vertical accumulators. This design is recognized as the best solution to prevent any possible strip surface marks. For a B line, an economical horizontal setup is usually best.

The extensive know-how and expertise of Siemens in galvanizing lines goes into the design of state-of-the-art strip-processing facilities.

Zinc pot, wiping system and temper mill

To minimize the building height, the horizontal entry accumulator is traditionally situated underneath the furnace section, as with conventional applications. Depending on the actual targeted throughput quality, either a vertical or horizontal accumulator is placed at the exit.

Cleaning before heating

To clean the strip surface upstream of the annealing furnace, the strip-cleaning section generally comprises a hot alkali spray tank, followed by a brush scrubber, rinse tank/wringer rolls, dryer, fluids circulating system, and a fume exhaust system. Siemens recommends each of these steps for an A line, as they provide an enhanced strip surface condition for the zinc-coating process. For a B line the steps are optional. In a nutshell, a cleaning section ensures good zinc adherence and minimizes production of zinc dross formed in the zinc pot by iron fines. The furnace design is usually tailor-made according to the product mix, product quality and targeted final throughput. For an A line the furnace section is more sophisticated, and the radiant tube technology installed in a vertical furnace is probably the most suitable. A more economic solution is the installation of a horizontal furnace.

Wiping zinc residue

The heart of the process is dedicated to ensuring strip coating according to a defined coating type. In the case of galvannealed (GA) products for automotive applications, the after-cooling tower is fitted with an induction-heating furnace with a soaking zone after the wiping area. The coating pot uses electric induction technology to heat the molten charge, ensuring the most efficient and clean heating environment while minimizing zinc contamination. Bath management is ensured by reliable temperature control of the molten zinc and frequent composition measurements. To improve the ►

bath cleanliness of an A line, it is possible to install an automatic dross removal system in front of the snout, instead of manual removal by operators. Wiping techniques are of highest importance for coating qualities in the manufacture of continuous galvanized steel sheets. High-quality wiping nozzles are essential for a uniform coating weight and excellent product surface smoothness. As a consequence, whether for an A or B line, Siemens recommends the installation of its own wiping system. This solution enables the nozzle lip gap and shape to be adjusted across the strip width. The operator is thus able to adjust the system to closely match the required zinc-coating thickness across the width and along the strip length, leading to a reduction in zinc consumption. This component now includes transverse coating control, a non-contact baffle system for thin products, and an automatic cleaning device to remove zinc particles from the lips.

Skin-pass mill and tension leveler

Once coated and cooled, the strip passes through the skin-pass mill and tension leveler. The aim of the skin-pass mill is to modify the mechanical characteristics of the strip by eliminating the yield-point elongation. The action of the skin-pass mill is performed by elongation or roll force. The skin-pass mill is also used to print the requested surface texture on the strip by transferring the work-roll roughness to the strip surface. The tension leveler is used to correct the flatness defects by elongation or flexion. Elongation is controlled with a high accuracy in order to not affect the roughness given by the skin-pass mill. The tension leveler is equipped with a wet system, which sprays water in the leveling stand to clean the roll.

From post-treatment to side trimming

To ensure uniform and controllable chemical coating for an A line, Siemens recommends the use of a roller coater that eliminates all the drawbacks of conventional coating technology using spray or dip tanks. While its frame stiffness and guiding precision prevent extraneous vibrations likely to cause surface defects on the strip, its fast hydraulic system and automation control allow compensating eccentricity of the applicator and pick-up rolls. Combined, these systems guarantee perfect coating quality, homogeneous thickness and optimized consumption. In order to eliminate the rolling or process defects of the strip edges and to calibrate width, the strip then goes through the so-called side trimmer, which aims to cut the lateral edges of the strip by means of two pairs of rotary knives. In the early design phase it is worth considering whether a side trimmer is really needed. Only end materials intended for stamping require tight geometrical tolerances. For an A line, when tight geometrical tolerances are needed, a side trimmer offering high cutting quality and fast and easy maintenance must be chosen to meet customer demand for high availability and cutting quality.

Inspection and exit

Automated surface-inspection systems have become standard tools for the manufacturing of steel products. Their benefits are twofold, as they allow monitoring of both the product quality and the process. Siroll SIAS (Automated Surface Inspection System) meets these two goals and exceeds the quality control requirements of the automotive industry. Using technology from the aerospace and defense industries, both pioneers in image processing, the system has been adapted to the steel industry for more than 15 years, and today there are approximately 100 references all over the world. Siroll SIAS combines sophisticated detection based on multidimensional convolution filters and advanced classification algorithms to enable the system to detect and classify the most critical defect after just two weeks of operation. The exit section of the line comprises an electrostatic oiler, a shear and a tension reel. The electrostatic oiler applies a precisely controlled protective coating of oil onto the strip surface. Its sturdy construction and simple mechanical design and control system are specifically designed to withstand the environment of a galvanizing line. The strip then goes through a shear, which removes the weld, cuts samples and divides the coils for further processing. The cut sheets are guided into a sample tray or into a scrap bin. The shear design (up-cut or

The mirror picture in a strip production line shows the right galvanizing configuration

rotary-drum shear) is fully dependent on the exit accumulator capacity and the maximum process speed. Finally, a tension reel ensures continuous winding of the finished strip. For an A line handling large coils of about 30 tons, a single tension reel is usually sufficient.

The entire galvanizing line is equipped with an in-house electric and automation concept that includes matched basic automation, process automation, drives and a human-machine interface (HMI) for very accurate tension control, highly responsive drives, optimized sequences and intuitive diagnostics. Automation is handled throughout the plant by Simatic S7 programmable controllers using standardized application modules as part of the integrated Siroll solution. This setup ensures easier commissioning, maintenance and service work. The Level 1 basic automation uses Simatic S7 400 programmable controllers for the different functions such as sequential controls and the function module FM 458 for high-speed technological controls. Sinamics, the advanced technology frequency converters for AC drives, achieves the excellent dynamic performance required in processing-line drive applications. The AC drive solution ensures high reliability and significant savings in maintenance costs combined with an increase in efficiency. The modular voltage-source DC-link converter system has an innovative digital control system and uses common DC-bus operation for sections of the drive systems in the plant. Finally, for both A and B lines, TCOptimizer software from Siemens can be installed to assist plant managers in the daily handling of the line. This software collects data and signals not only from all the sections of the line itself but also from upstream sections (hot-strip mill, tandem cold mill) and even from the laboratory. A multi-source data correlation model filters all these signals and the software transforms all related gigabytes of data stored everywhere within the plant into relevant manufacturing events and just-in-time alarms that pop up on a blank screen. These alarms are related not only to predictive maintenance (sensor drift, consumable tracking) but also to coil quality (mechanical properties estimation, coarse grain risk) and process conditions (out-of-range temperature, bad coating grip risk). The just-in-time feature allows almost immediate corrections that result in operational cost savings. ■

Authors
Stéphane Georges, Alain Challaye, Philippe Podda, Andreas Maierhofer

Green solutions in Maanshan, China

Meros plant captures media attention

In cooperation with Maanshan Iron & Steel Co. Ltd (Masteel), Siemens introduced its environmental strategy and green solutions to Chinese media representatives in Maanshan, in the Anhui province. The first Siemens Meros plant to go into operation outside Europe was a focal point of the press event. The first day started with an overview of the environmental portfolio of Siemens, including Corex, DDS and Meros, a technology that dramatically reduces emissions including dust, sulfur dioxide, dioxin and organic matter. The assembled journalists were then invited to tour the first Meros plant outside Europe. The second day of the conference focused on discussions on the topics of holistic environmental protection and sustainable development in China's metallurgical industry. The event was a response to the current five-year plan of the Chinese government, which calls for a substantial reduction in emissions.

Siemens Environmental Awards

Green Award for Siemens Steelmaking Team

Until now, the steelmaking segment is the only unit at Siemens to have received the Environmental Award twice. In the 2011 round, an Austrian-German team under the direction of Alexander Fleischanderl and Alexander Müller won in the environmentally compatible products and solutions category with EAF Quantum and a heat recovery solution. Generally, the waste heat from electric arc furnaces (EAF) is lost. Thanks to a revolutionary Siemens process for EAFs in combination with waste-heat recovery, energy requirements can be greatly reduced and CO_2 emissions cut by 20 % compared with conventional methods. Wolfgang Bloch, head of the environmental protection unit and host of the Environmental Awards at Siemens, says, "The Environmental Awards are our way of saying thank you to our employees for their commitment to environmental protection." From the 70 applications submitted, the jury selected 15 finalists.

United Kingdom

Siemens employees take home IoM3 awards

Ian Craig (right) with Jan Lewis, President of IOM3

Ian Craig and Joe Lee, two Siemens employees, were honored in the U.K. for their services to the iron and steel industry. The Institute of Materials, Minerals and Mining (IoM3) represents metallurgists and materials scientists in the U.K. IoM3 awards the prestigious Hadfield Medal in recognition of distinguished achievement in engineering within the iron and steel industry. This year's winner was Ian Craig, Technical Director of the blast furnace ironmaking segment in Stockton. Craig was the first senior manager in the business to advocate a design approach based on unit equipment solutions for blast furnaces, complemented with process engineering methodologies adapted from the chemical and petrochemical industries. Joe Lee was awarded with the Frank Fitzgerald Medal. This IoM3 award for outstanding young professionals is annually conferred to a member under 35 who has demonstrated excellence in the field of iron and steel technology.

Third award for resident engineer

Bernhard Scholz receives the Chime Bell Award

For the third time, Bernhard Scholz has been recognized by the Chinese city of Wuhan for his successful work at Wuhan Iron and Steel Corp (Wisco). Representatives of the provincial government presented the Chime Bell Award to the 62-year-old in a festive ceremony on October 1, 2011, the Chinese National Holiday. During his 35-year career, Bernhard Scholz has worked on more than 20 projects all over the world. Since 2000 he has been the resident engineer and commissioning manager at Wisco. In this position he has been responsible for the construction and optimization of two cold-rolling mills, numerous renovations and the new construction of a heavy-plate mill.

ALFRED PIESINGER, Chief Executive Officer of Siemens Metals Technologies Ltd. in Sheffield, U.K, took over the role as Commercial Head of the Business Segment Steel Plants, Minimills & Environmental Technology.

NIGEL HAYES, Head of the Business Subsegment Rolling Mill & Alu, is now the Managing Director of Siemens Metals Technologies Ltd. in the U.K.

Siemens

Stars for the best suppliers

From left: Martin Krauss, the winners Pietro Galbiati, Galbiati Group Srl; Heinrich Obernhuber, Maschinenfabrik Liezen und Gießerei; Christian Dorninger, Dorninger Hytronics, with Werner Auer and Ewald Feidner

In a glamorous gala celebration in the Viennese Planetarium, Siemens awarded the Supplier Star for the first time to the best of its 150 worldwide suppliers. Two Austrian companies and an Italian supplier were awarded the main prizes in the categories of product quality, innovation and global competitiveness. “We want the prize to be something that strengthens our strategic partnerships and long-term customer relationships built on trust, while at the same time documenting the best and most successful customer solutions,” Siemens Metals Technologies CEO Werner Auer explained at the celebration. The company plans to sponsor the Supplier Star every two years as part of a quality initiative at Siemens. “We improve our global competitiveness with top-quality and innovation in plant building, and increase our opportunity for joint market success,” Auer said. The Supplier Star in the Quality category was presented to MFL Maschinenfabrik Liezen und Gießerei Ges.m.b.H. of Styria, Austria. The company supplies components such as screw feeders that Siemens installs for material transport in steelmaking plants. Other companies nominated in the Quality category were GeGa Lotz GmbH, Alpine Metal Tech Numtec Magnemag, Sheffield Forgemasters International Ltd. and SKF Österreich AG. Dorninger Hytronics GmbH, a company headquartered in Upper Austria, was awarded for its outstanding supplier merits in the area of Innovation. The company supplies hydraulic-mechatronic solutions for production lines such as continuous casters, making them safer and quicker, and extending maintenance intervals. Hainzl Industriesysteme GmbH, RHI AG and Timken Europe were honored as finalists in this category. The Supplier Star in the Global Competitiveness category was awarded to the Italian Galbiati Group. Srl. Galbiati delivers gears and mechanical components for rolling mills and continuous casters. Auer spoke of how the company has now begun to “work together with other manufacturers worldwide in order to ensure rapid, flexible and high-quality components to metallurgical plants delivered by Siemens.” Other nominees in this category included Burimec S.p.A., Doosan Heavy Industries and Construction Co. Ltd, Sinsosteel Xingtai Machinery & Mill Roll Co., Ltd and China First Heavy Industries Co., Ltd.


The new No. 6 blast furnace at AHMSA

Simetal BF VAiron process optimization at AHMSA

A blast of expert technology

The Simetal BF VAiron process-optimization system from Siemens is now in operation in all three blast furnaces of AHMSA, an integrated 3.8 million t/a steel producer.

Modularly scalable process models and a closed-loop expert system are the core elements of Simetal VAiron. The system, which operates on the basis of advanced process models, artificial intelligence, well-proven software applications, graphical user interfaces and operational expertise, is comprised of three layers.

The Process Information Management layer is responsible for handling the blast furnace-related process data such as online measurements, charging data and raw materials, as well as hot-metal and slag samples and other tapping data. The layer also includes user interfaces for displaying and modifying the data, and the reporting system. All process data are kept in a relational database for long-term storage.

The second layer is the Simetal BF VAiron process models package, which includes mathematical blast furnace models for online and offline calculations. Operational experience has shown that the most useful models for the furnace operation at AHMSA are the burden distribution model, which visualizes the coke and burden layer structure in the upper part of the shaft, and the shaft calculation model, which gives an immediate overview of the accuracy of the charging and the smoothness of the burden descend.

The closed-loop expert system represents the top layer of the Simetal BF VAiron system. Relying on a large metallurgical rule base, it diagnoses the status of the blast furnace with the help of fuzzy logic, suggests corrective action as needed, and explains in detail the reasoning behind the diagnosis and suggested action. The main difference between a closed-loop and an advisory expert system is the automatic and simultaneous execution of corrective actions when necessary.

Application at AHMSA

The Simetal BF VAiron systems have been in use in AHMSA's blast furnaces No. 4 and No. 5 since 2007, and the system for the new No. 6 furnace was commissioned in April and May 2011. Since 2007, 90–99% of the recommended actions of these closed-loop functions were accepted at blast furnaces No. 4 and No. 5, and similar results were achieved during the first months of operation of the No. 6 blast furnace.

Flexible operation and fast commissioning

For added flexibility and convenience of operation, the Simetal BF VAiron expert system provides a metallurgical model toolbox and its own scripting language, enabling the modification of existing rules and the creation of new rules based on the specific requirements of operations at AHMSA. Since 2007, system maintenance, tuning and further development at AHMSA have been performed in close cooperation with Siemens and Mexico's Consultancy Reduction Metallurgy SC (CRM), which provides technical services.

More than four years of experience with blast furnace operation at AHMSA, efficient cold commissioning and testing of the system through the remote data connection, and well-executed hot-commissioning work split between Siemens and CRM reduced the time between furnace start-up and Simetal BF VAiron system acceptance to just five weeks on the No. 6 blast furnace. Following on the heels of the No. 4 and No. 5 furnaces, AHMSA's blast furnace No. 6 has become the latest success story for the Simetal BF VAiron optimization system, which is already applied in connection with more than 10% of hot-metal production worldwide. ■

Author
Dr. Martin Schaler, project manager for engineering & product lines for E&A, ironmaking, steelmaking, casting and process automation

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