10th European Oxygen Steelmaking Conference - EOSC CTSI 2025

Tuesday 20 May 2025 - Thursday 22 May 2025

Book of Abstracts

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Converter Revamping: There's Life in the Old Dog Yet…

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Even in our future, green industry, many steel producers will continue to rely on the BOF process for the liquid side of their production route. The steel plant of the future is a hybrid plant and with its small carbon footprint, large scale and capability for producing the most challenging steel qualities, the BOF converter shop will remain a major capacity hub in many future plant configurations.

Traditionally, converter vessels have been designed and built as part of the larger scale BOF shop. This still holds true in the case of greenfield plants. Mature steel producers, through their decades of experience, have come to develop requirements specific to their individual process and plant conditions, maintenance practices and lifetime targets. Today, plant transition scenarios may add additional—individual—requirements. Each of these requirements translate into design features such as vessel material selection, cooling system design, improved trunnion ring arrangements, condition monitoring tools, etc. The present article elaborates the latest developments in this respect.

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Highly Efficiency and Long Life Steelmaking Technology

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Through summarizing and analysis of problemes and contradiction in the steelmaking process, reasonable highly efficiency and long life combined blowing mechanism and choice was proposed. Laboratory experiments and research of slagging and element oxidation mechanism were carried out with the aim of adapting the highly efficiency refining control technique, in which the salgging characteristics and elements selective oxidation during blowing was estimated. The result showed that when oxygen blowing intensity increased to 3.5~3.72Nm3/(t.min), the refining dynamics demand of defferent period can be satisfied eventually. When bottom blowing intensity increased to 0.2 Nm3/(t.min), the dead zone will be reduced 57.30%.To resonable combined blowing metallurgical results,the bottom blowing intensity and the flow pattern were vital, in which bottom blowing intensity, bottom tuyere type, bottom tuyere number, bottom blowing pattern and maintaince technique were the key influencing factors. Finally, a highly efficiency and long life combined blowing technology was constructed by combining the refining mechanism,dynamics requirement and oxidizability control. After 10 years practice, the effect was confirmed with commercial 300 ton converter. The reasonable results showed that the final w [C]·w [O] product reduced to 0.0013, average slag T.Fe content decreased to 15%, the campaign with good result increaded to 7450, and the efficency has been increased obviously.

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Enhancing Molten Steel Temperature Prediction Using a Hybrid Approach: Machine Learning and Finite Volume Method

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Molten steel temperature control is an important aspect of the steelmaking process, which influences product quality, energy efficiency, and the performance of continuous casting (CC). To include a safety margin, operators often set the endpoint temperature of steelmaking routes such as Basic Oxygen Furnace (BOF) or Electric Arc Furnace (EAF) higher than necessary. This ensures the appropriate molten steel temperature when it reaches the CC despite temperature losses during ladle transportation and waiting times. However, higher steel temperatures in the BOF or EAF not only increase energy consumption but also complicate phosphorus removal, highlighting the need to balance refining efficiency with proper casting temperatures.
In this study, an existing finite volume method was applied to simulate the temperature of molten steel throughout the complete cycle of production. This model offers valuable predictions, though it shows deviations in comparison to actual temperature measurements for steels, limiting the effectiveness of thermal management.
To overcome this challenge, a data-driven approach is proposed to predict the error between the simulated and measured molten steel temperatures. We aim to leverage a machine learning model to enhance the temperature prediction accuracy by correcting the physical model's prediction. Additionally, Optimization techniques are also applied to estimate the thermal model's parameters, further improving its performance. The optimized physical model is then combined with plant data to train the machine learning algorithm. This hybrid framework has the potential to enhance the efficiency of thermal management, reduce energy consumption, and improve the quality of produced steel.

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Effect of the Jet from Top Lance on Slag Foaming Behavior in Basic Oxygen Furnace Process

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In the basic oxygen furnace (BOF) process, excessive foaming beyond the converter capacity is called "slopping". Slopping reduces iron yield and equipment lifespan. Therefore, it is important to control slag foaming properly. In previous studies, the jet from top lance in BOF process effectively suppressed slag foaming. However, the mechanism that the jet from top lance suppresses slag foaming is unclear, and its quantitative effect has not been reported. To clarify the effect of the jet from top lance on slag foaming, the effects of the number of nozzle holes and lance height on slag foaming were investigated by water model experiments. Experimental results confirmed the foaming suppression effect of the jet. Furthermore, this effect increased with the increase in number of nozzle holes. Slag foaming model was developed considering the foaming suppression effect caused by the entrainment of foaming slag into the jet, and the measured values were generally reproduced. The foaming suppression mechanism of the jet can be explained by the amount of foaming slag entrained into the jet.

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The potential of selective adjustments to the suction gas in iron ore sintering to reduce greenhouse gas emissions

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European steel companies are endeavoring to switch to direct reduction plants and will do so in the coming years, although primary steel production in Europe is currently still conducted exclusively in integrated steelworks. The ferriferous feed material is mainly produced in sinter plants for the blast furnace, with waste gas recirculation representing the current state of the art. For infrastructural reasons, the transition from the blast furnace route to direct reduction plants can only take place gradually, so that these two production routes will coexist and potential synergies can be exploited. For example, an increased use of oxygen as a by-product of electrolysis is possible. In addition, new types of metallurgical waste gases, exemplified by those derived from direct reduction plants, can be used. For these reasons, the sinter process is facing a transformation to meet future challenges and therefore a more profound understanding of the potential influence of the individual constituents, in particular O2, CO, and H2O, in the suction gas is essential. Within this paper miniaturized lab scale sinter experiments are presented using an industry like raw mixture to study the effects of individual O2 , CO and H2O variation on the sinter process and sinter quality. As the O2 content (up to 30 vol.%) in the suction gas increases, both the sintering yield and the strength increase resulting in lower return rates, with more or less constant amounts of CO in the off gas. Productivity and sintering strength increase with increasing CO concentration, while NO concentrations in the exhaust gas tend to be lower. With increasing moisture, productivity and sintering strength increase with significantly lower CO concentrations in the off gas, due to the water-gas shift reaction taking place in the flame front. The results show potential for adjusting the recipe of the raw mixture by selectively adjusting the suction gas, in particular towards a lower coke breeze content, which would enable a reduction in the specific emissions of CO and CO2 per ton of product sinter.

Transformation towards electric steelmaking (EAF, SMELTER) / 15

Selection of carbon bio-sources based on inherent properties and reactivity for electric smelting furnace applications

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In electric smelting furnaces, a carbon source functions as both a reducing agent and a carburizer. Carbon bio-sources, namely biochar, offer an alternative to fossil carbon sources but differ in properties and reactivity. Reactivity is a complex characteristic and requires considering properties such as volatile matters (VM), ash and mineral matters, fixed carbon (FC), specific surface area (SSA), thermochemical properties, etc. The biochar selected is derived from wood chips (VM: 5.41 wt.%-daf; FC: 92.02 wt.%-db). For comparison, anthracite (VM: 2.27 wt.%-daf; FC: 92.88 wt.%-db) and coke (VM: 1.59 wt.%-daf; FC: 87.70 wt.%-db) were included. Determined SSA revealed the following increasing order: coke (2.54 m²g⁻¹) < anthracite (9.07 m²g⁻¹) < wood chips biochar (273.71 m²g⁻¹), indirectly indicating that the biochar reactivity can be significantly higher. Thermogravimetric combustion analysis under non-isothermal conditions showed increasing average reactivity and comprehensive combustion characteristic index in the order of coke < anthracite < wood chips biochar. To obtain key kinetic parameters, the Coats-Redfern integral method, combined with main reaction mechanism models

for solid-state, was used. Anthracite and coke show higher activation energies than biochar, with anthracite ranging from 66.7 to 150.1 kJ mol⁻¹ and coke from 84.2 to 185.7 kJ mol⁻¹, indicating more difficult ignition and lower reactivity. In contrast, wood chips biochar has lower activation energies, ranging from 53.9 to 121.1 kJ mol⁻¹, suggesting easier ignition and combustion. Additionally, the pre-exponential Arrhenius factor values for wood chips biochar are lower than those for the coke. Ultimately, wood chips biochar can offer a more reactive and easier-to-ignite alternative to fossil carbon sources such as coke and anthracite, with the added benefit of significantly reduced nitrogen and sulphur inputs.

Impact of changed raw material mix on BOF process and secondary metallurgy / 16

NITROGEN REMOVAL DURING SECONDAR Y METALLURGY AS PART OF STEELMAKING TRANSITION: IMPACT ON TYPE OF DEGASSING UNIT

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During the past few years remarkable changes have occurred in the field of steelmaking, especially in ladle metallurgy. As a result, steelmakers are able to meet customers'demands for higher quality with new process steps, mainly based on the electric arc furnace process. Nitrogen control, including different nitrogen removal techniques during degassing, is explained in detail in the article, with the target to support a proper, Best Available Technique approach during new project evaluation.

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Utilizing an AI counting system for shipping deformed steel bars

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The number of deformed steel bars is checked visually by human at the end of each product in each bundle. For this reason, in the case of thin-diameter product bundles in which the number of products in one bundle is large, not only is the burden on workers high, but the time required for the work also leads to a decline in shipping efficiency.
This time, by utilizing this technology and constructing a number management system that uses image recognition of end surfaces, we have reduced work time by 76% compared to the conventional method.

Keyword: AI, deformed steel bar, shipment, reduce workload

Energy savings and energy efficiency optimization / 18

Reduction of Electrode Unit Consumption in Ladle Furnace

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In recent years, electrode costs have been increasing along with the rising unit price of needle coke. Furthermore, from the perspective of carbon neutrality, efforts to reduce electrode unit consumption have been becoming more active.
In order to suppress the side loss due to oxidation and the tip loss due to sublimation in Ladle Furnace (: LF) electrodes, we improved the LF operation (reviewing the power input pattern, optimizing the argon gas flow rate for stirring molten steel) and introduced LF electrode water cooling equipment. We achieved the reduction of the LF electrode unit consumption by about 30%. This paper introduces these results.

Keyword: Ladle Furnace, electrode, Operational Improvements, spray cooling

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Cavity Formation under Top Blowing on Liquid Bath at Various Gas and Bath Composition

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For the purpose of obtaining further information on decarbulization blowing with oxygen jet in BOF, a course of study on cavity formation with water model was carried out using CO2 gas as a dissolving gas. Ar gas, CO2 gas, or a mixture of them was blown from a lance onto aqueous bath of various composition. The cavity formed under CO2 blowing was larger compared to that under Ar blowing of the same flow rate, beyond the difference of gas density. Such behaviour would reflect that dissolving reaction proceeds the cavity formation. The cavity depth formed under Ar and CO2 blowing onto aqueous surfactant solution was slightly larger compared to those on ion-exchanged water. In the case that CO2 was blown onto aqueous surfactant+NaOH solution, the cavity became much deeper. Such results suggest that decrease in surface tension would help cavity formation, and what is more, dissolving reaction of gas would exceedingly promote the cavity formation. Those consideration corresponds to the classical findings that interfacial tension may lower under transfer of component between two phases, such as the increase in interfacial area between molten slag and metal droplet during desulfurization reaction.

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New BOF references, equipment features and relining solutions

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Achieving the highest productivity and cost-optimized production is essential for the long-term competitiveness and profitability of integrated BOF steelmaking. To meet these demands, steel plants, particularly in the Americas and Europe, are increasingly focusing on revamps, upgrades, and modernization to ensure maximum productivity, stable output quality, availability, minimized maintenance efforts, and enhanced safety. Meanwhile, in Asia—especially India—a significant number of new BOF plants are being constructed with similar objectives in mind.
This presentation summarizes the latest technological advancements realized in recent BOF revamps and greenfield projects , such as the maintenance-free Vaicon Link suspension system, the robust tilting solution Vaicon Drive, Vaicon Sublance 2.0 and advanced air and water cooling systems designed to extend vessel and trunnion ring lifetime. Additionally, vessel temperature monitoring solutions allow improving both availability and durability of BOF installations.
Converter relining remains a crucial factor in maximizing converter availability and ensuring personnel safety. To enhance the safety, speed, and ergonomics of this process, innovative, customized relining solutions have been developed and implemented. One concept, implemented for two customers in Brazil, involves a rope-suspended top relining platform combined with personnel and brick pallet elevators. Another advanced solution for a European customer, a semi-automatic bottom relining machine with automatic brick depalletizing and transport, showcases how relining ergonomics can be significantly improved, eliminating the need for manual heavy lifting of bricks.

By-product management in iron and steel production / 22

Green Steel Initiatives Supported by CERO Waste Refractory Concept, Enhanced Slag Engineering and Using Circular Metallurgical Additives.

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In the pursuit of a sustainable refractory and steel industry, the circular economy offers the most resilient answer. RHI Magnesita and MIRECO close the loop by engaging producer, user and recycler of refractories. In addition to the CERO Waste Concept, this approach also involves a slag engineering solution and circular metallurgical additives. The CERO (Continuous Economic Recycling Optimization) Waste Concept encompasses the collection, sorting, reuse assessment and disposal, as well as legal management of refractory material. This concept generates circular minerals serving as alternatives to primary raw materials for circular refractory products and green metallurgical additives, thereby maximizing refractory recycling rates, reducing CO2 emissions, and minimizing landfill use. A metallurgical consultancy service for slag engineering provides deep insights into process optimizations, the application of green metallurgical additives and slag compatibility with refractory linings. Three studies on electric arc furnaces, basic oxygen furnaces, and secondary metallurgy ladle treatments illustrate opportunities with circular metallurgical additives and address challenges such as MgO saturation, slag foaming, desulfurization and alloys saving. These studies, using e-tech slag modelling tools, highlight the added value in metallurgical, refractory, and circular economy knowledge for a steel plant's green steel strategy.

Transformation towards electric steelmaking (EAF, SMELTER) / 23

Effects of liquid-phase viscosity, gas phase fraction, and sedimen-

tation particle density on foam bubble structure and particle sedimentation behavior

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In a converter process, foaming slag has advantages in that it facilitates intermediate deslagging and protects refractory materials in the furnace. On the other hand, in an electric arc furnace process, foaming slag improves the arc heat transfer efficiency by acting as an insulator. In both steelmaking processes, slag foaming is important. In the slag, there are suspended particles of iron that are caused when gases blown into the molten iron lift the liquid iron phase into the slag phase, and the maximum size of the particles is about 2 mm. After the refining and smelting process is completed, the slag is discharged from the furnace after the steel is tapped. If the particle iron is not sufficiently settled at this time, the particle iron present in the slag will become iron loss as it is. Therefore, the sedimentation behavior of particles in forming slag, which is a gas-liquid multiphase fluid, is an important issue, however, the sedimentation behavior in this fluid is obviously different from that of particles in the homogeneous liquid phase. In this study, falling-ball experiments were conducted at room temperature to investigate the sedimentation behavior of particles in a gas-liquid multiphase fluid by varying the single liquid phase viscosity, gas phase fraction, and sedimentation particle density. From the results, apparent viscosity was determined using the Stokes' law. While, viscosity of the single liquid phase affected a bubble-filling structure of the gas-liquid multiphase fluid, and each sedimentation particle with different density exhibited dissimilar sedimentation behavior.

Transformation towards electric steelmaking (EAF, SMELTER) / 24

Monolithic. Steel Ladles - Advanced and Sustainable Refractory Solution as part of the Green Steel Transformation

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Monolithic linings for steel ladles have emerged as a economically and ecologically sustainable alternative to traditional bricked based linings.
This lining method offer several advantages, including enhanced durability, reduced material waste, improved thermal insulation, and reduced maintenance costs as well as an essential impact on heat management and CO2 greenhouse emission in the respective scopes.
Additionally, casting a ladle brings significant improvements regarding health and safety on the shopfloor, as transport of pallets in confined spaces, lifting and laying bricks as well as cutting them can be avoided.
The absence of joints in monolithic linings minimizes the risk of cracks and weak points, leading to a longer service life and better performance under high thermal and mechanical stresses. Additionally, monolithic linings contribute to higher steel cleanliness by reducing contamination risks. Innovative installation techniques, such as the use of pre-formed spinel castables, further enhance the efficiency and effectiveness of these linings. This paper reviews the sustainable benefits of monolithic linings, compares them with conventional brick linings, and discusses recent developments in installation methods.

Transformation towards electric steelmaking (EAF, SMELTER) / 25

Observation of fluid flow characteristics by bottom blowing in the EAF-shaped vessel using physical modelling

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Electric arc furnace steelmaking is an important way to bring carbon neutrality to the steel industry by 2050 because the blast furnace and basic oxygen furnace processes release the higher CO2 emissions than the EAF process. However, as the heat generated by the arc affects the upper part of the molten steel locally, the stirring energy of the EAF molten steel is insufficient to achieve the high efficiency operation. To improve the stirring energy in EAF, bottom blowing technology has been developed and widely adopted. It is well known that the bottom blowing technology can promote fluid flow in the molten bath, accelerate the melting rate and decarburization rate and enhance the quality of molten steel. In fact, when technology was applied in the 55- ton of EAF, the tap-to-tap time was reduced, and the yield of iron was improved. Therefore, in this study, to identify the characteristics of fluid flow under the bottom blowing conditions, the water vessel with shape of EAF was designed by 1/8 scale of 120-ton EAF. The dynamic similarity between the real EAF process and the water vessel was obtained using a modified Froude number and hydraulic diameter which is assumed the eccentric shape of the EAF as a cylinder. By using electrical conductivity, the perfect mixing time was measured to investigate the influence of gas flow rate on the mixing time in the EBT zone and determine the optimal stirring conditions. When the electrical conductivity was achieved about 95 pct, the time was assumed to be the perfect mixing time. Furthermore, using particle image velocimetry methods, the effect of gas flow rate on the fluid flow was observed. The movement of water flow was filmed at 15 frames per second for 10 seconds to obtain 150 frames of data per area.

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Investigation of the reoxidation and material behaviour of directly reduced pellets

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European steel companies are endeavouring to switch to the use of directly reduced ores for steel production. Therefore, in future the transport of iron pellets directly reduced with hydrogen by rail to various melting works will play an increasingly important role. Along with this change, the quality parameter of the metallization of the material is essential for further processing. In the present study, pellets were therefore reduced with H2 and tested for their reoxidation behaviour under realistic conditions on a laboratory scale.
Pellets reduced under conditions similar to the Midrex-process were used for comparison as well as the accompanying fines of these pellets, to illustrate the influence of the largest possible specific surface area. Furthermore, the storage tests were carried out in defined container geometries –simulated with various boxes –in order to be able to assess the influence on the material to be transported. To represent all possible conditions that can occur during transport by rail, parameters with different temperature and humidity were defined. The procedure for analysing is based on an optical assessment as well as a recording of the change in mass over a defined period of time in order to be able to precisely record the increase in weight due to the different reoxidation behaviour

caused by the simulated environmental conditions. Furthermore, computer tomography images of specific H2-reduced pellets were taken at defined process stages to quantify the change in the material structure both externally and internally. This allows conclusions to be drawn about the cracking potential, which can be linked to the reoxidation behaviour. The findings obtained on a laboratory scale indicate a significant influence of the particle size and the oxidation conditions of the pellets as well as of the environmental conditions and the container geometry during the storage period on the reoxidation behaviour.

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Reducing CO2 Emissions and Increasing Scrap Recycling in the Integrated Blast Furnace - Basic Oxygen Steelmaking

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The iron and steel industry is accountable for 7.2% of the total GHG emissions with a dominant BF-BOF route still covering today 70% of the total pig iron world production. Therefore, any quick solution to reduce the carbon footprint of this steelmaking route avoiding high investment costs is welcome.
The increase of the scrap ratio fed into the BOF vessel is one of such solution because the hot metal ratio decreases and thus the CO2 emissions (scope 1 & 2) per ton of crude steel are reduced as well. Before charging into the BOF converter, the hot metal temperature coming from the BF at around 1480℃ can be heated up to 1550℃ with a combined process of electrical heating and desulfurization. The combination of these 2 processes implies additional benefits like higher desulphurization yield, minimal disruption of steel ladles logistic and optimized space requirements due to commonly used auxiliary equipment's like dedusting system, steering lances and overhead cranes.

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High-speed liquid steel analysis for improved control of primary steelmaking

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Abstract

The proposed study aims to reduce the analysis time for on-site liquid steel characterization, facilitating quicker adjustments in scrap use to enhance steel production efficiency. Reducing the overall analysis time enables steelmakers to better control the primary steelmaking process.

The direct analysis (DA) approach focuses on developing an optimized sampler geometry that provides high-quality, low-temperature steel samples suitable for immediate analysis. Initially, a computational fluid dynamic (CFD) model was developed in MAGMASOFT to analyse the filling and solidification behaviour of the sampler. A parametric study of the simulation model identified optimal geometric and process parameters, which were subsequently validated through experimental back to back testing at industrial applications.

Additionally, an improved optical emission spectroscopy (OES) procedure has been designed to deliver accurate results without prior sample preparation, ensuring compatibility with shop-floor conditions. The DA sampler, however, eliminates the need for surface preparation, significantly reducing sample analysis time compared to conventional devices. Reduced waiting times offer numerous advantages, including faster processing, increased yield, lower energy consumption and efficient production control

Keywords: Optical emission spectroscopy, Direct analysis, Steelmaking, Computational fluid dynamics

Transformation towards electric steelmaking (EAF, SMELTER) / 29

Refractory solutions for the transformation to Green Steel production –solving challenges due to new furnace designs and complex raw material demands for minimum conversion costs and high productivity.

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The ongoing transformation of steel production to Green Steel making is a demanding and collaborative effort involving various stakeholders, including steel producers, Original Equipment Manufacturers (OEMs) and technology providers to overcome technical and economic challenges. For example, the upscaling of Electric Arc Furnaces (EAF) with tapping weights exceeding 250 tonnes and more complex raw material supply from steel scrap to DRI and HM necessitate additional systems to enhance process efficiency, as automatic maintenance systems or inert gas stirring. New DRI smelter furnaces require entirely new lining designs. The application of H2 gases provides new challenges to furnace linings. Refractory materials and solutions are pivotal in ensuring the efficiency, sustainability, and economic viability of EAF and continuous electrical smelting aggregate operations, playing an essential role in the green steel transformation. This paper outlines the roadmap, opportunities, case studies and benchmarks for the respective EAF and continuous electrical smelting aggregates.

Transformation towards electric steelmaking (EAF, SMELTER) / 30

PREVENT BOTTLENECKS AND OPTIMIZE LADLE AND CRANE LOGISTICS FOR AN EAF-BOF MELT SHOP

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In the transition to green steelmaking, hybrid steel plants incorporating both EAF and BOF technologies face several critical logistical challenges. Different tap-to-tap times, variations in steel chemistries and temperatures, the positioning of new equipment, and integration with existing plant infrastructure significantly impact ladle logistics. Inefficient ladle flow and overutilized cranes can cause delays at both the BOF/EAF and casters, but these issues can be mitigated. In this paper, we present the main challenges and solutions based on simulation work with six European integrated steel plants undergoing this transformation.

Impact of changed raw material mix on BOF process and secondary metallurgy / 31

A Holistic Approach to Sustainable Steelmaking: Innovative Methods for Achieving Ultra-Low Carbon, Low Nitrogen, and Low Sulfur with Modern Secondary Metallurgy

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The transition to green steel production presents significant challenges, particularly in the context of low nitrogen, low sulfur and ultra-low carbon (ULC) steelmaking. This paper explores the role of RH degassers in addressing these challenges, with a focus on reducing nitrogen and sulfur levels. The use of raw materials already present in the Electric Arc Furnace (EAF) and alternative approaches in secondary metallurgy are examined to achieve the goals of low nitrogen, sulfur, and carbon content in steel.

Recent experiences from the startup of a modern 200 t RH degasser are highlighted, showcasing the benefits of full process automation and advanced metallurgical models. These innovations have demonstrated high performance in achieving low nitrogen and carbon levels, essential for producing high-quality ULC steel. The findings underscore the importance of integrating advanced technologies and process optimizations in the pursuit of sustainable steel production.

Energy savings and energy efficiency optimization / 32

Continuous optimization through adaptive boiler cleaning using Shock Pulse Generators

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In thermal power plants, heat recovery boilers, smelting plants, coking plants and metallurgical plants, efficient boiler cleaning is required to achieve long operating times with high efficiency levels despite the comparatively difficult fuels. Regular cleaning of the boiler surfaces prevents excessive deposits of flue dust from impairing heat transfer.

Various traditional technologies are used for boiler cleaning. These differ in their operating principle, the cleaning media used (water, air, steam, mechanical energy input) and the type of installation.

Using Shock Pulse Generators, the boiler is cleaned by an impulse of pressure waves triggered by the sudden combustion of small quantities of a mixture of a combustible gas (natural gas or methane) and an oxidation medium. In contrast to manual methods applying the same principle of action (e.g. blast cleaning with inflatable balloons, detonating cords or cartridges), the Shock Pulse of SPGs is triggered automatically whereby an instant incineration of the mixture takes place in a stable, pressure-resistant device outside of the boiler. The generated pressure wave is directed via a valve and a discharge nozzle into the boiler, where it vibrates the flue gas, the boiler tubes and walls in such a way that the deposits are cleaned off. Due to the spherical spread of the shock pulse, the cleaning is effective in all directions and reaches even the shaded areas of tube bundles. This enables gentle

cleaning of boiler heating surfaces in all temperature ranges from the furnace to the economizer, without increased mechanical stress on the heating surfaces.

Furthermore, Explosion Power has developed a procedure in which the first step is to create a digital boiler model based on the P&I diagrams and plant data. This model is used to form the process engineering correlations between the measured values involved, derive the required parameters (e.g. load and/or temperature-adjusted flue gas pressure losses) and assess the significance of the measurements (incorrect or mismatched measurements, balance differences, etc.).

Links:

https://www.explosionpower.ch/shock-pulse-generatoren-spg-erweisen-sich-als-hervorragendes-hilfsmittel-zur-reinigung-grosser-ueberkritischer-kraftwerkskessel/

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Industry 4.0: Automation, modelling and on-line process analyses / 33

Data-driven predictions of castability in low-alloyed steels with the aid of ab-initio datasets

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Continuous casting is often hindered by the clogging of submerged entry nozzles (SEN), caused due to the agglomeration of non-metallic inclusions (NMIs). SEN clogging is challenging to monitor and requires probabilistic models for online predictions of 'castability'. In this context, data-driven models emerged as a promising tool to be used in the existing industrial settings. Despite the occurrence of SEN clogging, collecting large datasets under both 'good'and 'bad'SEN conditions remains challenging due to the stochastic nature of clogging. This results in a natural imbalance in the input data, where instances of 'good'castability vastly outnumber those of 'bad'castability. The scarcity and imbalance in this data hampers the ability to develop and train traditional data-driven models effectively. To overcome these challenges, a physics-informed data-driven model was proposed in this work. A physics-informed approach integrates explicit physical principles into data-driven frameworks, increasing model's capability to utilize limited data while adhering to known physical laws. The steel chemistry from low alloyed aluminum killed steel grade was considered for the formulation of data-driven model, employed with a hybrid approach of Adaptive Neuro Fuzzy Inference System (ANFIS) and Long-Short Term Memory (LSTM) networks. The actual ground truth of 'castability'was approximated by a 'Castability Index'parameter. The integration of outputs generated from physics-informed calculations provided sufficient to compensate for the lack of process data. To further enhance accuracy, an advanced methodology involving use of ab-initio data repository was developed. This repository contained material-specific data including high-temperature non-retarded Hamaker constants of NMIs comprising Al_2O_3, CaO, MgO, and CaS in specific particle size range of 1-10 μm. A novel parameter 'Clogging Factor' was proposed to monitor the output generated from physics-informed models. This offered significant advantages for steelmaking process control for more realistic and reliable predictions than traditional data-only approaches. While the model's effectiveness in reducing SEN clogging demonstrated its practical value, the proposed physics-informed data-driven strategy still awaits validation in online industrial settings.

Keywords: Ab-initio, Castability, Clogging, Data-driven, Online, Steelmaking

By-product management in iron and steel production / 34

Evaluation of the Usage of Secondary Iron Ore Pellets in the DRI-EAF-Process

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The metal industries face huge challenges in terms of sustainability, diminishing resources and the need for higher recycling rates. As an example, the alumina production creates red mud as the by-product of the Bayer-Process for the conversion of bauxite to alumina. Due to its environmental impact, it is stored in residue storage areas like dammed ponds or landfills. On the other hand, it is a huge source of raw material, since it contains a high amount of iron oxides of up to 60 wt-%. With a new process the haematite content can be increased to more than 80 wt-%, which makes it attractive as a secondary raw material for the steel production. It would be a promising step towards a resource-saving economy and a strong link between the aluminium and steel industry.
These secondary iron ore pellets (SIOP) can be used as a feed for the DRI-EAF process which should be the medium and long-term process for Europe's steel industry due to the ambitious climate goals. Due to the higher rates of gangue (especially Al_2O_3 and TiO_2) it cannot be a direct substitute for normal iron ore pellets. Based on the analysis of the slag composition in the EAF, it is shown that a usage of up to 10 % of SIOP with 90 % of DR-pellets should be possible to keep the Al_2O_3 content in the range of 12 %. As an additional effect, the amount of slag will increase by 13 %, which lowers the yield and the energy efficiency of the EAF. Despite the challenging effects on the performance of the DRI-EAF process, the usage of SIOP might be an economically advantageous option and will avoid the deposition of huge amounts of red mud.

CO2 mitigation in iron and steelmaking / 35

Application of hydrochar composite briquettes for sustainable slag foaming process in the electric arc furnace

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An urgent challenge for the iron and steel industry is to reduce its CO2 emissions, which can be achieved through enhancing the energy efficiency and by reducing the consumption of fossil fuels. Slag foaming is an important operation in the electric arc furnace (EAF) process which enhances energy efficiency and promotes more effective refining of the liquid steel. Conventional slag foaming is achieved by simultaneous injection of oxygen into the liquid steel and the injection of fossil coal or coke into the liquid slag. The reduction of iron oxide by carbon generates CO and CO2 which subsequently foams the slag.
One alternative method to realize sustainable slag foaming is by charging self-reducing briquettes into the liquid slag. Such briquette typically contains a metal oxide and a carbon material, which reacts and produces CO gas (and also other gas such as H2, CxHy if the carbon material releases volatiles) at elevated temperatures which promotes slag foaming. By using this method, the amount of oxygen injection required in the EAF process can be reduced by replacing it partially with oxygen present in the metal oxide, which can be a waste or a by-product generated during the steelmaking process (e.g. mill scale, pellet fine). The fossil coal added in the self-reducing briquette can also be replaced by biocarbon for the reduction of fossil CO2 emissions.

This study presents the prospects of utilizing hydrochar (a type of biocarbon)-mill scale composite briquettes to achieving slag foaming in the EAF process. Results from the thermogravimetric analysis of the composite briquettes with different recipes—which reflects the amount of gas formed in the different temperature ranges and the duration of gas formation, would be presented. These results would be used to interpret the findings from laboratory slag foaming experiments, where the composite briquettes were charged into a MgO crucible filled with molten EAF carbon steel slags (~600 g) to determine their slag foaming performance (e.g. total change in slag height, foaming duration). Lastly, the influence of briquette addition on the EAF process, such as energy consumptions, and the compositions of slag and steel would also be discussed.

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Designing the secondary metallurgy for future steel plant based on Ultimate Electric Arc Furnace

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With the ongoing efforts to reduce the CO2 emissions of the iron and steel industry the importance of the electric arc furnace (EAF) significantly increased. While in 2020 only 36% of the announced steelmaking capacity used an EAF based route in 2023 it was already 92%. With the shift towards an EAF based steel industry, the question remains, how the typical product mixes from the blast furnace and basic oxygen furnace route can be produced via an EAF based route. The aim of this study was to evaluate how an EAF steel plant must be designed, to be able to produce those product mixes. For the study a product mix including interstitial free grades, non-grain-oriented silicon steel grades, API grades and commodity grades, like S235JR, was chosen. The heart of this steel plant is an EAF Ultimate, as this technology was proven to be very well suited for the transition and chosen by many important players in the steel industry for their transition projects. This study shows the necessary charge mix and how a secondary metallurgy plant needs to be designed, to meet the requirements for a modern steel plant, and the produced steel grades.

Impact of changed raw material mix on BOF process and secondary metallurgy / 37

Prospects of utilizing alternative fluxing agents for replacing fluorspar in steelmaking processes

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Fluorspar (CaF2) is an industrial mineral which has been categorized as a critical raw material by the European Union. Fluorspar is commonly added in steelmaking processes (e.g. EAF, AOD, ladle..etc.) to lower the melting point of slags to promote the development of a liquid, fluid slag. This promotes more thorough reaction between the liquid slag and the steel, which enables lower impurity (e.g. O, S, P) concentrations in the steel to be achieved.

Substitution of fluorspar by alternative fluxing agents is one way to reduce risks stemming from the disruption of fluorspar's supply chain and to secure long-term, resilient supply of slag fluxing agents—a key to ensuring the competitiveness of the European steel industry and to maintaining the high quality of the steel produced. A decrease in fluorspar's use may also contribute to wider recycling options of steelmaking slags—by eliminating the risks of fluorine leaching which can potentially contaminate ground water.
This study presents some aspects of replacing fluorspar used in the argon-oxygen-decarburization (AOD) process with alternative fluxing agents during stainless steel production—which is the largest area of use of fluorspar in Sweden. Thermodynamic calculations which concern the changes in slag properties (liquid fraction, viscosity, MgO saturation) and steel chemistries (Al, S concentrations) when alternative flux agents are used would be presented. The findings would be compared with experimental results obtained from hot finger tests, where the degrees of refractory erosion are determined under different slag compositions containing various flux additions. The amount of fluorine leaching from the synthesized AOD slags which contain different types of fluxing agents would also be presented. Lastly, this study discusses the challenges and opportunities of replacing fluorspar with alternative fluxing agents in AOD process, which may be extended to other steelmaking processes.

CO2 mitigation in iron and steelmaking / 38

REDUCING USE OF FOSSIL CARBON AND FUELS TO DECARBONIZE THE ELECTRIC STEELMAKING ROUTE: EVALUATION OF THE EFFECTS OF ALTERNATIVE C-BEARING MATERIALS AND HYDROGEN IN THE ELECTRIC ARC FURNACE

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Electric steelmaking route is considered pivotal for the transition towards C-lean processes: it is expected that the share towards scrap-based electric route will increase in future and that the Electric Arc Furnace will be at the basis of novel routes exploiting direct reduction processes. Scrap-based steelmaking is already well integrated in a circular economy concept, as it exploits a secondary raw material (i.e. scrap) as main feedstock. Nevertheless, the sustainability of this route can be increased and further contributions to lowering its impact can be obtained by replacing fossil carbon and fuels with alternative non fossil materials. Currently, fossil carbon is used for foaming slag formation and for providing part of the chemical energy used in the EAF. Furthermore, also natural gas contributes to provide part of the required heat. However, urgent actions are needed to counteract climate change and to achieve the target of decarbonization expected, for instance, by the Europe in accordance to the European Green Deal. In addition, even more unstable geopolitical situations of main fossil carbon/fuels supplying countries make actions for reducing related dependence fundamental. In this context, several solutions are under investigations within the project entitled "Gradual integration of Renewable non-fossil Energy sources and modular HEATing technologies in EAF for progressive CO2 decrease (GreenHeatEAF)"(GA: 101092328), that has received funding from the European Union in the Clean Steel Partnership framework of Horizon Europe programme.
Among the different investigations that are being carried out, the use of alternative carbon sources (e.g. biochar) in EAF or the use of hydrogen in EAF burners are considered. Related effects are investigated by using both industrial trials and complementary simulations through a flowsheet model of the entire EAF-based route that has been ad-hoc adapted for the previously mentioned trials. In the present work, after the presentation of the used model, main results of both simulations and industrial trials concerning the exploitation of alternative carbon-sources in EAF will be discussed. The pursued investigations highlight that, although alternative C-materials can generally lead to

significant fossil CO_2 reduction and did not negatively affect the product or most process aspects, a high ratio of some of them can compromise safety of operations while leading to poor slag foaming. Finally, some first simulation results of hydrogen use in EAF burners will be presented, mainly focusing on the reduction of CO_2 emissions, on the increase of moisture content in off-gases and on hydrogen content in molten steel.

Energy savings and energy efficiency optimization / 39

Smart management of process off-gases paving the way to the decarbonization of the steel production route

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An optimal exploitation of energetic streams is of utmost importance for the sustainability of steel production not only in their current configuration but also in the perspective of the transition to new C-lean steel production routes. Process off-gases are among these energetic streams that are normally used for electrical and thermal energy production. The possibility of maximizing their usage by avoiding flaring shows a direct impact on the reduction of CO_2 emissions, but this is not an easy task, as their production is often discontinuous in terms e.g. of calorific value and volume flows.
This issue will remain important even in future, when some processes are foreseen to gradually disappear being replaced by new ones, but possible fluctuations in the provision/production of relevant energy-carriers will need to be faced. Moreover, the transition toward fully C-lean steel production will not be sharp. During the transition, the problem of optimal handling, managing and exploiting gaseous energy carriers and their distribution networks will play a key role in ensuring economic and environmental sustainability of the transition itself. Furthermore, future steelworks will most probably be increasingly integrated within larger industrial parks by implementing industrial symbiosis solutions involving exchange and/or sharing of energy carriers to maximize energy efficiency. Optimal exploitation of valuable energy streams can only be achieved by synchronizing their production and consumption and considering the boundary conditions related to availability and costs of external energy sources that will be needed by the new production processes. Therefore, the present work analyses different scenarios to assess the environmental, energetic, and economic impacts of transition from the traditional Blast Furnace-based route to a route based on Direct Reduction and Electric Arc Furnace from the perspective of the management of process off-gases. In particular, the present investigation explores how various system configurations and operational strategies affect the overall energetic performance of the steelworks. Among the developed models, Machine Learning-based solutions are adopted to accurately forecast off-gases generation and demand patterns, to enable the implementation of strategies to optimize their usage while minimizing energy waste and costs. Mixed-integer linear optimization techniques are incorporated to solve the energy distribution problem, considering constraints such as gas storage limits, calorific values, and process synchronization. Among the considered dynamic scenarios, this study considers the possibility to produce methane and methanol through novel synthesis processes that exploit process off-gases and hydrogen, an interesting industrial symbiosis solution, as these by-products could be sold or reintegrated into the steelmaking process, by contributing to increase revenues and reduce the company's dependence on external energy sources.

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Numerical Modeling of Hydrogen Electric Arcs for Optimizing Green Steel Production in EAF

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The Electric Arc Furnace (EAF) significantly reduces carbon emissions in steel production by utilizing electricity instead of traditional fuels, especially when powered by renewable energy sources. This reduction is further enhanced through the adoption of green hydrogen technology, which replaces carbon-based reduction processes with hydrogen, resulting in an almost carbon emission-free operation. In this context, hydrogen, combined with inert gases, acts as a reducing agent for iron oxides within the EAF. Understanding the behavior of electric arcs in hydrogen-rich atmospheres is therefore critical for scaling hydrogen-based technologies to industrial levels.
In this study, we present a three-dimensional numerical model designed to simulate hydrogen electric arcs. The model integrates electromagnetic field dynamics with the behavior of hydrogen plasma arcs, focusing on flow characteristics and heat transfer under atmospheric pressure and a direct current (DC) power supply. The simulations reveal the transient and unstable characteristics of hydrogen arcs compared to traditional arcs operating in air or argon. This model enhances the understanding of arc behavior and provides insights to predict and mitigate potential failures during operation, contributing to the optimization of hydrogen-integrated EAF processes.

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CFD-Driven Analysis of EAF Dynamics: Insights into Thermal and Flow Optimization

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The Electric Arc Furnace (EAF) has become a cornerstone of modern steel production, accounting for over 43% of Europe's output. Despite its widespread adoptionseveral aspects of the furnace are operated and optimized empirically due to the extreme conditions within the furnace. Numerical modelling provides a valuable approach to bridge this gap by simulating arc behaviour and its interactions, enabling industrial advancements and greener technologies.
We present a comprehensive numerical model that is able to simulate industrial scale furnace. The model couples the high-speed arc jet with magnetohydrodynamic (MHD) flow of the liquid slag and molten metal and the interaction including arc impingement. The model effectively captures key interactions within the furnace, including those between the plasma, liquid pool, and refractories. Thermal and flow patterns predicted by the simulation align closely with experimental measurements, demonstrating its accuracy. It successfully simulates the arc jet flow, magnetohydrodynamic flows, and thermal flow interactions inside the furnace. Additionally, the model examines the impact of external magnetic fields on furnace performance and their implications for energy transfer. The insights gained contribute to improved furnace design, enhanced energy utilization, and optimized EAF operations.

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Highly efficient technologies for increased yields in steelmaking processes and reduced environmental impact - HIYIELD

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HIYIELD project addresses the need for sustainable and competitive steel production, essential to achieving a climate-neutral, circular, and digitized industrial framework. While steelmaking enables green technologies for providing relevant material for climate neutrality, the industry however contributes to 7% of global CO_2 emissions [1]. HIYIELD targets this challenge by promoting circular economy practices through increased scrap utilization, thereby reducing reliance on coal-fired blast furnaces and associated emissions from pig iron production. The project aims to enhance the efficient use of scrap material in steel production and targets to improve steel quality and performance through smart data generation, digitalization, and advanced control systems that increase scrap uptake across various processes. The project applies advanced technologies such as deep learning-based computer vision for scrap identification, digital scrap information cards for scrap tracking, and high-speed liquid steel analysis for efficient on-site characterization of liquid steel. The project focuses to promote circular economy by increasing scrap uptake within the European steel production processes, by improving the scrap quality and classification techniques, HIYIELD supports the European steel industry's competitiveness while promoting a circular economy.
[1] J. Kim, "Decarbonizing the iron and steel industry: A systematic review of sociotechnical systems, technological innovations, and policy options,"Energy Research & Social Science , Volume 89, 2022.

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Decreasing the environmental impact of the electrical steel route through advanced modelling techniques

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Although EAF-based steelworks produce steel from recycled ferrous scrap and inherently implement the concept of circularity, they are challenged to reduce their overall environmental impact and take actions to reduce CO2 emissions and maximize energy and resource efficiency. Advanced digital technologies, including artificial intelligence-based techniques, can significantly contribute to making the necessary transition of the steel industry sustainable from an environmental, economic and social point of view.
In this context, the European project "Data and decentralized Artificial intelligence for a competitive and green European metallurgy industry" (ALCHIMIA–G.A.101070046) targets the optimization of the Electric Arc Furnace (EAF) charge mix and the entire production processes. The global idea of the project is to build a platform based on Federated Learning as a methodology for training Machine Learning models, with the main advantage of using data from different industrial plants with similar processes without sharing process data among different stakeholders. This platform will act as a Decision Support System to help the industrial staff in decision-making procedures by means

of the prediction of energy consumption and other parameters affecting the environmental impact according to the input material mix.
The core of the ALCHIMIA platform is modelling: several modelling techniques have been applied to reproduce all the different stages of the production process (from the purchasing of input materials to the exit of secondary metallurgy processes). In the present paper, Machine Learning models are presented, which estimate the sterile content of the different types of scrap that arrive to the scrap yard and the chemical composition and temperature of the steel at the exit of the Ladle Furnace.

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A novel approach to energy management in electric steelworks

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The electric steelmaking route since its birth appeared to be a paradigmatic representation of the raising concept of circular economy, as it recycles steel components at the end-of-life products. Moreover, its importance is foreseen to increase according to the increasing demand of decarbonizing steel production to meet the ambitious goals of the European Green Deal.
However, being the EAF-based route still characterized by a limited diversification of energy supply sources, it results into the necessity of optimizing its use considering several aspects at the same time such as efficiency, cost reduction and as a consequence, the optimization of the production planning to be related to the on-time availability of energy. Such optimization Task needs the key factor of appropriate energy management to reduce production costs while ensuring satisfaction of the energy demands coming from all different processes, not limited to EAF. It implies a strict relationship between the behaviour of the Power Grid and the production plan.
Consequently, the optimization of energy consumption in the steel production chain can only be achieved by simultaneously looking at the individual processes as a network of users in which each individual process is already close to their optimal operating point. This results in a huge number of energy consumers to be managed.
In this context, the European project entitled "Energy Management in the Era of Industry 4.0" (EnerMIND), co-funded by the European Union through the Research Fund for Coal and Steel, aimed at the effective and efficient steel production which needs to run component processes of the manufacturing chain thus realizing a high utilization rate of production facilities.
To achieve this aim, the development and implementation of a novel energy management system based on innovative components and a flexible infrastructure and a software demonstrator. Such demonstrator considers the most energy intensive areas of the steelworks and exploits artificial intelligence and optimization methodologies to minimize electricity consumption and level trends through matching intelligent production planning and Power Grid offer and related energy costs.
The paper will provide an overview of the developed solution, and the set of models based on neural networks that allow forecasting with good accuracy the electricity consumption in EAF and LF as a function of the main production information. The models were trained and validated through production and process data from a real steelwork with encouraging results.

New developments in converter technology / 46

Nitrogen Refining Kinetics in Current and Future Oxygen Steelmaking Process: Modelling and industrial validation

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Nitrogen is a critical element with regards to steel quality. Depending on the application, the maximum allowable N-concentration varies between 20 to 120 ppm. Over the years, the BOF (Basic Oxygen Furnace) route of steelmaking is known to be superior in N control, largely due to the stripping effect of CO gas bubbles generated during decarburisation reactions. However, in the future low-CO2 routes of steelmaking, using low-carbon liquid metal is expected to pose an unfavourable scenario for N control in the BOF process.
In this study, a multi-zone kinetic model for nitrogen prediction in liquid steel was developed by incorporating the fundamental understanding on [N] mass transfer across three reaction zones :(1) Jet impact (2) slag-metal droplet and gas emulsion and (3) bottom stirring through bulk metal. Industrial trials using special sub-lance probes were conducted and additional steel samples at 40% and 60% of the total oxygen blow were taken. The concentration of nitrogen and carbon in steel samples were measured by combustion analyser and the data are used to validate the model predictions.
The variation of measured nitrogen during the oxygen blowing period was analysed in relation to the process parameters such as bottom stirring gas (N2 and Ar), initial hot metal composition, scrap, oxygen and N2 injection via top lance. From the results of nitrogen and carbon analyses, four major stages with distinct nitrogen removal and pick up have been identified, primarily based on the sampling points. The dominant factor for de-N rate control in these stages are also identified. The insights on the de-N rate control factors can aid in designing better process parameters such as bottom stirring schemes, top lancing (O2/N2), hot metal composition, scrap type & nitrogen level, allowable nitrogen impurity (in O2 gas, coal, etc.).
The dynamic nitrogen model suggests that the emulsion zone is a primary zone for [N] removal with residence time of the N2 gas in the emulsion phase being critical for the accurate prediction of [N] in liquid steel. Additionally, the model was used to investigate the effect of variation of carbon in hot metal and bottom gas purging methods on control of final [N] in liquid steel in future REF (Reducing Electric Furnace)-BOF route.

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Simulation of Logistics for Sustainable Steelmaking: Enhancing Efficiency in Green Steel Transitions

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The transition to carbon-free steel production presents significant challenges for steel manufacturers, particularly in adapting to new process timelines, routes, and transport logistics. The shift from the conventional integrated plant based on Blast Furnace (BF) operation and Basic Oxygen Furnace (BOF) process to electric steel production entails substantial changes in secondary metallurgy and primary aggregates, disrupting established operational workflows. Additionally, evolving material flows - including scrap, hot metal, Direct Reduced Iron (DRI), and Hot Briquetted Iron (HBI) - necessitate a reconfiguration of production facilities.

Leading steel manufacturers worldwide use logistics simulations to optimize processes in melt shops and adjacent areas such as scrap yards, securing investments, and facilitating the transition to electric steel production.

This paper explores the role of simulation in addressing these operational complexities and supporting the industry's decarbonization efforts. It examines the critical importance of transport logistics simulation in integrating an Electric Arc Furnace into an existing BOF-based steel plant, with a particular focus on the case study of voestalpine Linz.

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Forging the Future: Advanced Automation in Converter Steelmaking for a Sustainable Twin Transition

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The steel industry is undergoing a transformative phase driven by digital and green transitions, known as the Twin Transition. Automation solutions are a core of the Twin Transition, seamlessly integrating digital innovations to enhance efficiency and precision while enabling sustainable practices that reduce emissions, optimize resource use, and drive decarbonization in industrial operations. This paper gives an insight in how Twin Transition in converter steelmaking is enabled by integrating condition monitoring, process optimization and expert systems to achieve the vision of an autonomous plant, improved efficiency, sustainability and reliability.

The concept of Autonomous Plant, meaning the acceleration of plant operation by minimizing human intervention, enabled by remote monitoring, merged control and one-person-operation with the Central Operation Cockpit, is introduced as an important step toward leaner and more agile operational frameworks. This approach combines intuitive human-machine interfaces and autonomous systems, with the future goal to empower a single operator to oversee multiple converters safely and efficiently.
Several automation solutions are applied to pave the way to an Autonomous Plant.
Expert Systems, like the BOF Tapping Expert, equipped with AI-based optical imaging and smart decision-making capabilities enabling automated functions, enhances operational safety through minimized human intervention and in parallel increases productivity.
Process Optimization combines dynamic simulation and data analytics to improve process accuracy and product quality, reduce consumption figures, fine-tune parameters, and lower emissions.
Condition Monitoring leverages data acquisition and predictive analytics to detect anomalies and prevent equipment failures, ensuring plant availability and product quality. The digital assistant ALEX provides intelligent support for setting fast actions to properly handle alarms and warnings. This is done with 24/7 available digitalized know-how of experienced operators and experts from Primetals Technologies, which can be continuously extended.

This paper highlights the potential of the Twin Transition supporting future steelmaking. Through the introduction of use cases and industrial applications, this paper offers insights into how automation in converter steelmaking can achieve a balance between economic profitability and environmental responsibility, positioning the industry at the forefront of innovation.

New developments in converter technology / 49

Online Temperature and Deformation Measurement for Vessel Shell of Oxygen Steelmaking Converters

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To know the temperature and deformation of the vessel shell of steelmaking converters, is already years a wish for the maintenance team of steelmaking plants in order to predict remaining lifetime

of top cone, detect damages in refractory, compare operation conditions, etc. However, the most interesting areas for this information are barrel section and top cone. But these areas are not visible from outside, because trunnion ring and slag shields are hindering a direct view e.g. by thermo cameras. Hence, sensors have to be arranged directly on the vessel shell in a high temperature surrounding. But this fact makes it impossible to use electronics, which has a maximum working temperature of 80° C.

In 2019 Danieli Corus developed an online temperature measurement system and the first field tests have been applied within a co-operation with voestalpine Stahl GmbH in Linz. In the first approach 3 temperature measuring elements, the so called Q-Temp 2.0 element, have installed on LD-converter #9 inside the trunnion ring. After some optimization, these 3 elements are giving online temperatures of the vessel shell since April 2021.

Based on this design, such Q-Temp elements have been installed on both 180 t LD-converters for a steel plant in Brasil, which are running since 2021 and 2023. There, 32 Q-Temp elements and two infrared cameras are arranged for temperature image of the complete vessel shell. In 2024 all 3 LD-converters at voestalpine Stahl Linz have been equipped with such elements monitoring the temperature of the top cone close to the tap hole.

In a next step, Danieli Corus upgraded the Q-Temp 2.0 sensor, which can additionally measure the deformation of the vessel shell. This, so called Q-Temp 2.1 element, was developed and tested in the laboratory of Danieli Corus. The first prototype was then installed on LD-converter #7 of voestalpine Stahl Linz in November 2024. The measured deformation are very promising and now the long term experience is under the focus. By end of 2024 a revamped 240 t LD-converter in Latin America will come in operation, equipped with 12 Q-Temp 2.0 elements, two infrared cameras as well as 4 Q-Temp 2.1 elements.

By-product management in iron and steel production / 50

Coarse dust briquetting for reuse in the converter

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In the steel mill, additionally to the room dedusting after the converter there is also coarse and fine dust generated. These dusts have different chemical compositions. There are significant differences, particularly in the zinc-, quicklime- and metallic iron-content. Therefore, some of the dust is passed on to external recyclers and some is recycled internally. Internal recycling means that the dust is briquetted, and the briquettes are reused as iron- and lime-carriers and as coolants in the converter. However, the coarse dust alone cannot be moulded into briquettes in the hot briquetting process at voestalpine Stahl GmbH.
One method of forming briquettes in hot briquetting is to mix the coarse dust with fine dust to make it suitable for briquetting. Due to the higher content of Femet and CaO in pure coarse dust briquettes (or also in a mixture with little fine dust (up to 20%)), a savings potential can be achieved by returning the briquettes to the converter as feedstock (reduced use of scrap and quicklime as well as savings in disposal costs).
As an alternative to the addition of fine dust, voestalpine Stahl GmbH is pushing ahead with the moulding of pure coarse dust briquettes. A research project was carried out for this purpose and, after a series of tests, a spraying system was installed which sprays a graphite suspension (Berulit) onto the roller presses, thus enabling the moulding of pure coarse dust briquettes. In addition to the good moulding of the briquettes, the surface is sealed by the graphite suspension and the briquettes are more dimensionally stable than those not sprayed.

New developments in converter technology / 52

Impact of elevated phosphorus content in hot metal on crude steel quality and the phase formation of slag

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In steelmaking, the phosphorus content of the hot metal is an important input parameter which can have a direct impact on the quality of the produced steel. Due to the diminishing quality of iron ore deposits, it can be assumed that the input of phosphorus into the blast furnace will increase in the future. For this reason, there is a need to develop effective phosphorus slagging strategies for the LD converter which acts as the main dephosphorization unit.

Operational trials were carried out at the voestalpine Stahl GmbH production site in Linz, in order to simulate these expected future conditions. In the course of these trials, the phosphorus content of the hot metal was deliberately increased step by step. The effects on the BOF process were recorded and evaluated.

The present paper describes the operational results of these trials. In addition to determining the achieved phosphorus content in the crude steel after special BOF treatment, the mineralogical composition of the formed slags has also been determined using analytical methods, such as LOM, SEM-BSE/EDX and XRD. In a further step, the results of the metallographic analyses are compared with calculations using the FactSage 8.1 software.

Impact of changed raw material mix on BOF process and secondary metallurgy / 53

RH High-efficiency Combined Blowing Denitrification Technology Based on Microbubble Metallurgy

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Reducing carbon emissions in the steel production process poses a significant challenge to the steel industry. Increasing the scrap ratio in converters and adopting the electric arc furnace (EAF) short-route steelmaking are recognized as viable solutions and emerging trends to address this issue. However, effective control of nitrogen content in molten steel resulting from these practices remains unresolved. Vacuum denitrification stands as the primary method for nitrogen removal, but deep nitrogen removal under vacuum has always been difficult to achieve due to the combined effects of the surface-active properties of oxygen and sulfur in molten steel, along with the slow mass transfer and diffusion of nitrogen. One potential solution to this problem lies in blowing hydrogen into the molten steel, using the precipitation of dissolved hydrogen in the form of dispersed micro-hydrogen bubbles during vacuum treatment. This paper delved into the mechanism of RH efficient hydrogen blowing technology for generating micro-hydrogen bubbles to remove nitrogen, examining aspects such as the reactions of hydrogen, oxygen, and sulfur in molten steel, the kinetics of hydrogen dissolution and precipitation, and microbubble metallurgy. This technology addresses challenges, including rapid hydrogen enrichment in molten steel, enhanced nitrogen mass transfer, overcoming the hindrance posed by the enrichment of oxygen and sulfur on bubble surfaces and the vacuum chamber steel surface, and increasing the gas-liquid reaction interface. Consequently, it significantly enhanced the potential for deep denitrification in the RH process.

Plenary Talk / 55

Green Transition and the Future of Oxygen Steelmaking

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The iron and steel industry is one of the largest industrial CO2 emitters and a transition to greener and more sustainable production routes is inevitable. The green transition will bring a number of new processes to our industry requiring optimization to ensure that the best production process is used for the targeted steel and product quality. Oxygen steelmaking will play a crucial role in this optimization leading to a more focused use of oxygen steelmaking for applications were it is strictly necessary while leaving the more easy grades to alternative production routes.

Plenary Talk / 56

voestalpine's Strategy for the CO2-reduced steel production in Austria

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voestalpine as the quality steel producer in Europe has developed a stepwise transition to a CO2-reduced steel production. Already now voestalpine is able to produce steel with lower CO2 emissions. In 2027 two EAF's will start operation. With it's stepwise transition and hybrid-steel production, voestalpine will keep the quality on the same level as now.

Plenary Talk / 57

Kinetic Insights and Modeling for Oxygen Steelmaking Processes Future Perspectives

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coming soon….

CO2 mitigation in iron and steelmaking / 58

Techno-Economic and Environmental Assessment of By-product Coke-Making Using non-recyclable Waste Plastics: A European Perspective

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Amid growing economic and ecological challenges within the ironmaking industry, there is a clear need to transition towards cleaner production methods. One approach is the partial replacement of costly coking coal—a critical raw material in coke production—with non-recyclable waste plastics recovered from solid waste sources—materials that would otherwise be landfilled or incinerated. In this work, a techno-economic-environmental assessment of a standard European by-products coke-making plant is presented, based on prices from 2019, 2022, and 2023. Two scenarios were evaluated: the Benchmark Scenario, which involves conventional coke production using exclusively coking coal, and the AlterCoal Scenario, where 2 wt% of the coal is replaced with pellets derived from non-recyclable waste, referred to as solid recovered fuel (SRF). The study compares direct and indirect emissions, and gross profit between both scenarios, and examines the influence of coke plant design and SRF pellets density on gross profit and direct emissions. The results show that direct and indirect emissions are reduced by 11.2% and 5.7%, respectively, in the AlterCoal Scenario compared to the Benchmark Scenario. Over the three years analysed, the gross profit of the AlterCoal Scenario was higher than that of the Benchmark Scenario, primarily due to the decreased reliance on coking coal, the use of relatively cheap SRF pellets, and an increased production of coke oven gas. Moreover, increasing pellet density boosted the gross profit of the AlterCoal Scenario, albeit with a slight rise in carbon emissions. A linear correlation was identified between gross profit and oven pushes, demonstrating that fewer coke oven discharges per day lead to higher profitability. Finally, plant designs with fewer discharges per day generated higher gross profit per ton of CO_2 directly emitted.

Impact of changed raw material mix on BOF process and secondary metallurgy / 59

Innovations and Optimizations in Tracing Non-Metallic Inclusions in Steel

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The steel industry is at a critical turning point, driven by the urgent need to lower CO_2 emissions. The transformation includes the development and implementation of novel processes as well as a higher recycling rate to produce iron and steel efficiently and sustainably. However, the high demand for steel quality cannot be disregarded. One major point within this topic is steel cleanness, which relates to the significance of non-metallic inclusions (NMIs). These mainly microscopic particles appear during steel making and cannot be completely avoided. Hence, it is necessary to identify the sources of NMIs and track their modification over the process, especially for novel production procedures and higher scrap recycling rates.

A common technique to trace NMIs during steelmaking is active tracing by directly adding specific metals, primarily rare earth elements (REEs), to the melt or oxides, such as BaO or SrO, to the slag. Active tracing has the advantage of marking and tracking deoxidation products over different production steps. However, the determination of REE-traced NMIs requires an optimization of the state-of-the-art- characterization method, the automated scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDS), as these NMIs appear brighter than conventional deoxidation products. Since this method influences the behavior of NMIs, and it is therefore necessary to search for novel tracing techniques.

One promising approach is the use of REE fingerprinting, a passive method already applied in food

chemistry to identify the origin of raw products. This technique is based on the natural concentration of REEs in potential sources and NMIs. By analyzing similarities in the REE concentration patterns, connections between sources and NMIs can be identified. These patterns make it possible to determine which auxiliary materials contributed to the formation of specific NMIs.

Transformation towards electric steelmaking (EAF, SMELTER) / 60

Evaluation of the changes in oxidic steel cleanness linked to tramp elements introduced by increased scrap recycling

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The transformation towards climate neutrality is one of the most urgent topics for steel producers and research facilities. One of the pillars to drastically reduce greenhouse gas emissions is increased recycling of steel scrap in EAFs. Unfortunately, various tramp elements are not removable from melts and accumulate over recycling cycles which often leads to scrap exports and downcycling to lower steel qualities.
Different influences of tramp elements on material properties and processes such as hot-shortness or shifting of transformation points are already well known. However, the interplay of tramp elements and non-metallic inclusions (NMIs) remains mostly unresearched. The chemistry modification due to introduction of these elements leads to altered surface tension and wetting behavior, which alters nucleation and separation of NMIs. Furthermore, possible agglomerations of tramp elements around NMIs can affect the deformation behavior of the particles.
In this study, medium-carbon steels were modified by alloying with the tramp elements copper, molybdenum, tin, and nickel. The alloys were investigated using drop shape analysis, quenching and deformation dilatometry as well as scanning electron microscopy to investigate possible effects of tramp elements on the steel matrix and NMIs and to contribute to a more thorough understanding of the interaction between them.

Transformation towards electric steelmaking (EAF, SMELTER) / 61

Smelter for Green Iron Production and Consequences for the BOF

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Hydrogen-based direct reduction combined with a two-step process employing a Smelter and a BOF is the most promising green steel production route using low-grade iron ores. As the BOF is still operated in this new route, todays and future crude steel quality requirements can be fully met. The hot metal from the Smelter is similar to the blast furnace one, with slightly lower carbon and silicon levels, reducing the available chemical energy in the BOF for scrap melting. Several tools and practices have been developed to compensate for this and push for higher scrap rates.
In the paper, the BOF operations using melts from BF or Smelter are compared with a focus on C, Si, N, and S. In addition, options to increase the scrap rate are presented such as post-combustion and scrap preheating lances. Furthermore, a roadmap for first realization, validation and upscaling of this new process is shown.

Impact of changed raw material mix on BOF process and secondary metallurgy / 62

BOF Steelmaking - dead or alive? How to survive in the 21st century?

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The transformation toward sustainable green production is focusing on hydrogen technologies and recycling of scrap.
The constraints of resources availability are known (green H2/electricity, high grade DRI, scrap volume and quality).
Therefore, the BOF process solution will remain for the next 25 years the prominent technology:
• Economic aspects on increasing P levels will define applied process solutions with optimized slag control.
• Synthetic hot metal will require adapted process control.
• Maximised scrap rates are in contradiction to tramp element control.
Solutions and perspectives will be presented to keep
the BOF technology fit for the future.

Energy savings and energy efficiency optimization / 63

The new Performance level - Catching up productivity gaps in BOF meltshops

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Catching up productivity gaps in BOF meltshops

The paper is covering the important topic how to identify and eliminate productivity and performance gaps in meltshops.

Comprehensive methodologies are applied taking benchmarking practises including data driven appoaches of operation and metallurgical results into consideration. Furthermore, assessments of installed equipment and applied process technology is evaluated.

Adjusted operational strategies are elaborated and proofed with push - pull principles to check bootleneck eliminations.

The apporach has been utulized and had been applied in practise, specific examples will be presented.

Impact of changed raw material mix on BOF process and secondary metallurgy / 64

Automatic Scrap ClassificationOpportunities for Improvements of the Scrap ecosystem in Meltshops

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Situation:
Today, established mini mill concepts applying scrap based EAF technologies are not viable, in serving the market for advanced high end grades like automotive sheets for exposed surface applications, tin plate or electrical grades. In BOF shops, with scrap rates of around 25%, scrap quality control is also if highest importance, especially when economics of steelmaking is improved by scrap management. The paper explains the opportunities for the utilisation of an AI/ML software development for automatic scrap grade classification.

Future areas to be covered are for safety application in identifying hazardous and improper scrap pieces also in regard to environmental aspects in emission control.

CO2 mitigation in iron and steelmaking / 65

Microstructural effect of Al2O3 on the H2-based direct reduction of iron ore

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The supply of green H2 as a reducing agent, as well as electricity from renewable energy sources, is essential for transforming the steel industry towards greener production, making the efficient use of H2 and electricity crucial. The impact of gangue on the H2-based direct reduction (DR) process of iron ore remains less well-understood, yet it is important for optimizing the efficiency of the process. To understand the effect of gangue on the H2-based DR of iron ore pellets, powder compacts with defined concentrations of gangue were produced, serving as model systems for DR pellets. The effects of concentration, particle size, and pore distribution on the H2-based DR of hematite at 700℃ were systematically studied by microstructural investigations in combination with thermogravimetric analysis. Using Al2O3 as an example of a common iron ore gangue, it was shown that a concentration of 5 wt.% Al2O3 decreased the final reduction degree by ~4% compared to pure Fe2O3. Additionally, by decreasing the particle size from 90 to 1 µm of the added Al2O3 powder, the reduction kinetics were significantly decelerated, and the final reduction degree was further decreased, specifically by ~9% compared to pure Fe2O3. This shows that not only the gangue concentration is relevant for the H2-based DR, but also its microstructural distribution. EDX spot analysis reveals the presence of an interface region between Al2O3 particles and the iron matrix after reduction, consisting of Fe, Al, and O, which indicates the formation of the hercynite phase (FeAl2O4), leading to a lower final reduction degree. This study allows for a better understanding of the mechanisms behind the H2-based DR using gangue-containing iron ore pellets as well as providing recommendations for the iron and steel industry regarding the optimal design of DR pellets.

Transformation towards electric steelmaking (EAF, SMELTER) / 67

The way from BOF to EAF? Investigations and decisions to be done

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A fully comprehensive process transformation from a conventional integrated steel mill with blast furnace and converter to a modern electric steel mill with the aim of drastically reducing CO2 emissions involves many dangers and requires a precise weighing of all possible solution variants, including their effects on both productivity and the steel grades to be produced.

This article describes examples and solutions of one of several possible transformation variants for integrated steel mills: the implementation of an electric arc furnace.
Various considerations and challenges are shown, such as: Maintaining the tapping weight, is the necessary electrical connected load available or is the given grid stability sufficient and what solutions are there if not, are the space conditions in a plant that has grown over decades sufficient or suitable for the integration of new reduction and melting units, what will the raw material situation look like in 10 or 20 years? years?
What is possible with an electric arc furnace? Is it possible to produce the steel grades to be produced with an electric arc furnace as a melting unit and does this change productivity? Can existing equipment be reused in secondary metallurgy or do investments also have to be made here?

All these questions and challenges are also explained and described in this article using existing reference examples.

CO2 mitigation in iron and steelmaking / 68

The Revival of the KOBM Process

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The green transition of the iron and steel industry is well underway, with new production routes—such as the use of Electric Arc Furnaces (EAF)—being implemented in numerous plants. This transition is also bringing new requirements for the existing oxygen steelmaking route –this route needs to focus in future even more on high quality steel and a further push to increase the scrap rate will happen. Both challenges can be handled well by the KOBM converter –thanks to the intensive mixing the metallurgical process in this converter is close to the equilibrium and lowest concentration of Carbon, Oxygen and Phosphorus at the end of the blow are easier to reach. The combined blowing also supports the melting of scrap that can be further pushed by dual-flow post combustion lance or coal injection.
Primetals Technologies has recently implemented two new KOBM converter projects: one at HBIS Handan, where an existing 260t BOF converter was revamped to KOBM, and a new 120t KOBM converter at a greenfield project in Longfengshan. Both converters feature a combined blowing process with a top lance and a detachable converter bottom, along with bottom blowing and lime injection systems. Additionally, Primetals Technologies' advanced converter process model and LOMAS off-gas analysis system were implemented.
After the start up and the optimization the full advantages of the KOBM with higher yield, highest phosphor removal and lowest CxO product could be realized in both projects! Reference figures from HBIS Handan show that total iron content in slag was reduced to around 11%, enabling the highest yield. Consistent [C] x [O] product values as low as 12 at tapping have allowed for the elimination of RH treatment for certain grades, resulting in significant cost savings.
This paper will present selected references, the results achieved, and improvements compared to BOF operation.

CO2 mitigation in iron and steelmaking / 69

Decreasing Hot Metal Ratio with dual-flow post-combustion lance at ArcelorMittal Dunkerque

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ArcelorMittal Dunkerque is experimenting a new BOF oxygen lance equipped with secondary holes located above the lance tip and fed by a dedicated oxygen circuit. The aim is to promote post-combustion, developing additional energy inside the BOF, transferring it to the bath, fostering scrap melting and thus decreasing Hot Metal Ratio and thus global CO2 emissions.
A first step of this study was based on CFD simulation describing oxygen jet and combustion inside the BOF vessel. We investigated the effect of distance to the tip from 15 to 100 cm, several angles with vertical line and several oxygen flow rates. Expected post-combustion rate and temperature conditions in the vessel were checked for selecting the candidate designs to be tested industrially.
A dynamic model describing the evolution of the blow was also developed. It describes kinetics of oxidation reactions, scrap melting and fluxes dissolution. The model relies on gas analysis and flow rate measurements to assess oxygen and carbon balance evolution. The model is installed in the plant to analyze the performances of the Post Combustion with and without the lance.
Various campaigns of industrial trials were performed with selected designs, varying distance to the tip from 15 to 75 cm, angles from 15 to 25° with vertical line and with dedicated oxygen flow rates between 80 and 135 Nm3/min.
Performances were proven to be around 8 –15 kg of extra Fe molten per ton of hot metal (= Hot Metal Ratio).
The next phase of the project will focus on the lifespan of the lance. Further research will be conducted to develop solutions to ensure that the lance meets the expected reliability standards, thus avoiding premature wear and possible water leakages.

Energy savings and energy efficiency optimization / 71

Reduction of energy losses of steel ladles by improved castables for the permanent lining

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The major challenges facing steel production today are reducing energy consumption and greenhouse gas emissions. Part of the solution is an improved refractory lining concept. A mostly overlooked element for better energy efficiency is the permanent lining of the steel ladle. In this study, the influence of the composition of monolithic permanent linings on thermal conductivity is investigated, using a new method to determine thermal conductivity up to 1600 ℃. FEM simulations show that the energy losses through the refractory lining are reduced by improved castables for the permanent lining. With these castables, it is possible to optimize the lining concept and achieve further reduction of energy losses.

Plenary Talk / 75

Zero-emission, low-cost hydrogen –Methane pyrolysis as game changer in metallurgy

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Methane pyrolysis offers a cost-effective and CO2-free method for producing hydrogen, which is critical for transforming the steel industry towards climate neutrality.The newly inaugurated research center for hydrogen and carbon at Montanuniversität Leoben enables advanced exploration of methane pyrolysis using both metal bath reactors and thermal plasma technologies. INTECO, a renowned technology supplier for the steelindustry, is collaborating to scale up methane pyrolysis to an industrial level. This presentation provides an in-depth overview of current research activities and the progress toward scaling this innovative technology for industrial applications.

Industry 4.0: Automation, modelling and on-line process analyses / 76

Characteristic analysis of mold level fluctuation in continuous casting Based on Wavelet Transform

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The mold level fluctuation plays an important role in controlling the quality of the slab. Abnormal fluctuations can easily increase the frequency of entrainment slag, directly affecting the proportion of defects in hot-rolled and cold-rolled steel sheets. In addition, it will affect the uniform growth of the shell of hypo-peritectic steel and raise the incidence of center segregation and internal cracks.
As a popular signal processing technique in the communication industry, the wavelet transform offers special benefits when processing non-stationary signals. The wavelet transform can perform accurate time-frequency analysis on mold level fluctuation with multiple influencing and complex instantaneous factors. The feasibility of the proposed method has been verified using a water model and compared with traditional analysis methods (significant wave height, Fourier transform). The industrial data of the mold level fluctuation was analyzed using wavelet transform. It was discovered that abnormal fluctuations would be caused by clogging on the submerged entry nozzle, biased molten steel flow, and abrupt changes in the stopper rod position and casting speed in the continuous casting of the IF steel. This information is difficult to identify using traditional methods. Moreover, the bulging can be quickly identified using the wavelet transform method in the mold level fluctuation of the peritectic steel. Thus, it is possible to precisely identify sources of abnormal fluctuations and thereby control them by using the wavelet transform in the analysis of mold level fluctuation.
Furthermore, it is also expected to be used for online prediction of abnormal fluctuations and quality prediction of slabs from the characteristics of mold level fluctuation based on the wavelet transform method.

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Development of a fuel-flexible ladle preheating system

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The Paris Climate Agreement and the European Green Deal are two of various agreements and climate plans that all aim to reduce global greenhouse gas emissions. With around 7% of total emissions from the energy sector, the steel industry plays a decisive role in the realisation of global climate targets. Reducing CO2 emissions is possible through innovation and the development of new technologies. One important approach here is technologies for burning hydrogen-based fuels instead of fossil fuels.
An essential process step in steel production is the preheating of the transport ladle in so-called ladle preheaters. In electric steelmaking plants, e.g., the transport ladles carry the molten steel from the electric arc furnaces (EAF) to the ladle furnaces and on to the casting plant. They consist of a crucible-shaped steel shell and are lined with multi-layer refractory. The lining varies depending on the plant. For example, it can consist of a layer of permanent bricks with a refractory concrete layer sprayed on top. The concrete is exposed to constant thermal and mechanical stress and abrasion. Therefore, the concrete needs to be relined after around 100 use cycles. Only after drying and preheating in ladle preheating systems the newly lined ladle can be returned to the plant. Preheating of the ladle reduces temperature losses of the molten steel and the thermal shock of the refractory. Currently, ladle preheating stations with natural gas/oxygen burners are state-of-the-art, which are operated with outputs in the megawatt range.
As part of the project, a ladle preheating system is being developed whose fuel-flexible oxyfuel burner can use hydrogen and ammonia and their mixture to preheat transport ladles in an electric steel plant. Innovative burner technology, digital process models and optimised control and regulation systems are designed to achieve high process stability, safety, energy efficiency and low NO_x emissions despite the fluctuating availability of hydrogen-based fuels. In addition to setting up a demonstrator system in a steelworks environment, a detailed process model is being developed on the basis of computational fluid dynamics (CFD) simulations. In the first phase of the project, reference measurements were carried out to analyse the status quo and to collect validation data. Initial model configurations for the flow simulations were tested to support the development process of the new burner. In addition to the vision and approaches of the project, the first experimental and numerical results will be shown in the presentation.

Transformation towards electric steelmaking (EAF, SMELTER) / 80

Transformation of TŘINECKÉ ŽELEZÁRNY - Together for the generations to come

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TŘINECKÉ ŽELEZÁRNY, a.s. is on the threshold of strategic changes related to sustainable business. The new phase of operations will dramatically change the current form of steel production. The steelworks has already launched a transformation project that will lead to an environmentally friendly steel production process. The aim is to further reduce greenhouse gas emissions into the air. A key part of the transformation process is the construction of a modern electric arc furnace (EAF), which will produce steel mainly from scrap. We have prepared a study for the construction of the EAF and we provide the necessary infrastructure, in particular the connection to the electricity grid

and the supply of scrap. We are working with a planned production capacity of 2.6 million tonnes of steel, using both BOF and EAF technology. This technology should be commissioned at the end of 2028. The total cost of the project will be in the order of several billion crowns.The overview of transformation in TŘINECKÉ ŽELEZÁRNY, a.s. is described in this paper.

Industry 4.0: Automation, modelling and on-line process analyses / 81

Accelerating decarbonization in the steel industry through process design and optimization

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The steel industry is a major contributor to global greenhouse gas emissions. As the world transitions to a low-carbon economy, the steel sector faces increasing pressure to reduce its environmental impact.

In this presentation, we will explore how process digital twins, powered by advanced modelling and simulation tools, can be leveraged throughout the steel manufacturing lifecycle to drive sustainability initiatives.We will discuss using digital twins to model and optimize steel production processes for improved cost and energy efficiency, integrating CCUS technologies, as well as green hydrogen process design and scale-up to support the transition to hydrogen-based steelproduction. By attending this session, participants will gain insights into how process digital twins can transform the steel industry's journey towards decarbonization, helping producers achieve their ambitious sustainability goals.

Energy savings and energy efficiency optimization / 82

Reducing Site Utilities Emissions and Energy Costs with Artificial Intelligence and Real Time Optimization.

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In this presentation we will show that even for already 'optimized'systems, significant opportunities exist to reduce emissions from integrated sites and associated energy costs.This is achieved by combining proven real-time optimization technology with artificial intelligence, based on deep process knowledge and data driven elements. 3-5% savings are achievable without significant capital expenditure.

Impact of changed raw material mix on BOF process and secondary metallurgy / 83

Simulation of Mixing Efficiency in a Large-Scale Dephosphorization Converter with Combined Top and Bottom Blowing

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To investigate the impact of combined blowing parameters on mixing behavior and dephosphorization efficiency in a dephosphorization converter, laboratory water model experiments were conducted on a 300t duplex dephosphorization converter based on similarity principles. The study examined 21 different configurations of bottom-blowing elements (varying in quantity and arrangement patterns), along with the effects of top-blowing intensity, oxygen lance position, and bottom-blowing intensity on bath mixing efficiency. Numerical simulations were performed for further comparative analysis. The results indicate that, under the condition of equal total gas supply intensity, adopting a symmetric and concentrated arrangement of 8 bottom-blowing elements, along with maintaining a high bottom-blowing flow rate, can significantly enhance the stirring effect in the molten pool. Industrial trials demonstrated that the average phosphorus content in semi-steel decreased from 0.0249% to 0.0173%, with dephosphorization rate improving from 75.3% to 85.4%, effectively enhancing both bath mixing efficiency and overall dephosphorization performance.
Key words: dephosphorization converter; top and bottom blowing; bottom blowing arrangement; water and numerical simulation; mixing time;

CO2 mitigation in iron and steelmaking / 84

CO2 reduction at Tata LD3 using Tallman Technolgies focus post cubustion technolgy

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Tata Steel is committed to reduce CO2 emissions in their steelmaking facilities. Tallman Technologies have developed a blowing technology to increase the Post Combustion Ration (PCR) and the Heat Transfer Efficiency (HTE) in the BOF resulting in the ability to increase the scrap to hot metal ratio. Oher than the reduction of CO2 due to the reduction in hot metal, other potential benefits identified include, reduction in blow times and improvements in other BOF parameters.