ABSTRACTS OF ICGSI – 2024

International Conference on

GREEN & SUSTAINABLE IRON MAKING

January 17 – 18, 2024

Jointly Organized By:
Tata Steel Ltd. and Indian Institute of Metals
Jamshedpur

ICGSI – 2024

Technical Committee

Technical Committee Members:

1. Dr. Samik Nag, TSL
2. Mr. Shubhashish Kundu, TSL
3. Dr. Saurabh Kundu, TSL
4. Dr. Sabuj Halder, TSL
5. Mr. Vidya Prasad, TSL
6. Mr. Gyan Ranjan Pothal, TSL
7. Mr. Sanjiv Kumar, TSL
8. Mr. Bhupendra Kumar, TSL
9. Mr. Jagdish Patra, TSL
10. Mr. Rajat Singh Chouhan, TSL
11. Ms. Anwesha Bhattacharya, TSL

THEMES OF PRESENTATION

Wednesday 17th January 2024	
Common Session	
Session 1: Keynote Lecture on Green & Sustainable Iron Making	
Parallel Session	**Parallel Session**
Session 2: Decarbonization Initiatives-I	**Session 3:** Green initiatives in Iron & steel
Session 4: Decarbonization Initiatives-II	**Session 5:** Alternative fuels
Session 6: Process Innovation-I	**Session 7:** Hydrogen / CCU in Blast Furnace

Thursday 18th January 2024	
Parallel Session	**Parallel Session**
Session 8: Process Innovation-II	**Session 9:** Digital Innovations
Common Session	
Session 10: Future Ironmaking Prospects	

ICGSI 2024 – Schedule for Sessions

Tuesday 16th January 2024				
Start	**End**	**Duration (HH:MM)**	**Activity**	
15:00	19:30	04:30	Registration of delegates followed by networking dinner	
19:15	22:00	02:45	Networking Dinner	
Wednesday 17th January 2024				
08:00	09:00	01:00	Registration of delegates	
S1: common session			**Speaker**	**Activity**
09:00	09:05	00:05		Lighting of lamp
09:05	09:10	00:05	Inauguration ceremony	Welcome Address by Organizing Chairman, Mr. Padmapal
09:10	09:15	00:05		Welcome and Introduction of Brigadier Arun Ganguli (Retd), Secretary General IIM by Dr. Ashok Kumar, Chairman IIM Jamshedpur chapter. Secretary General IIM to play the Video bite of Mr. Satish Pai, President IIM & then address the gathering.
09:15	09:20	00:05		Address by the Guest of Honour – Mr. Rajiv Mangal, Vice President Safety, Health & Sustainability
09:20	09:25	00:05		Address by the Chief Guest – Mr. Uttam Singh, Vice President Iron Making
09:25	09:30	00:05		Vote of thanks by Convener ICGSI, Mr. Debaprasad Chakraborty
09:30	10:00	00:30	Keynote speaker (Dr. Atanu Ranjan Pal, TSL)	Fifth Industrial Revolution: Reimagining Iron making
10:00	10:30	00:30	Keynote speaker (Dr. Christian Hoffman, McKinsey)	Green Steel – Current dynamics, opportunities and challenges
10:30	11:00	00:30	Keynote Speaker (Dr. Ashok Kumar, TSUK)	The Low Carbon Blast Furnace - Why it matters and How to get there
11:00	11:25	00:25	Coffee break and move to parallel sessions	

17th Jan'24 Day 1 Parallel Sessions | Location: Main Hall				
S2: Decarbonization Initiatives-I				
Session chair			**Mr. Jan Vander Stel**	**Topic**
11:25	11:45	00:20	Mr. Cristiano Castagnola, SMS	Smart combination of new Midrex DR plants in existing BF based integrated plant solutions for lowering OPEX and CO2 emissions vs the stand-alone approach
11:45	12:05	00:20	Dr. Mahesh Venkataraman, 1414 Degrees Ltd.	Present and future opportunities in green steel production: A green heat perspective.
12:05	12:25	00:20	Mr. Kapil Bansal, EY	Value Realization through NetZero Implementation
12:25	12:45	00:20	Dr. Henrik Saxén, Abo Akademi	Modelling of hydrogen reduction of iron ore fines
12:45	13:05	00:20	Dr. Viswanathan N Nurni, IIT Bombay	Towards reducing carbon emissions from Blast Furnace through tuyere injections: RAFT-Rist approach.
13:05	14:05	01:00	lunch	
14:05	14:50	00:45	**Panel discussion**	Benchmarking for identifying best practices
S4: Decarbonization Initiatives-II				
Session chair			**Mr. Ujjal Ghosh**	**Topic**
14:50	15:10	00:20	Dr. Peter Kinzel, SMS	Future of green ironmaking using BF/BOF route Blue Blast furnace & EASyMelt
15:10	15:30	00:20	Mr. Peter Klut, Danieli Corus	Latest Generation Dry Blast Furnace Gas Cleaning Technology
15:30	15:50	00:20	Dr. Mark Hattink, TSN	Sustainable BF process at Tata Steel Netherlands
15:50	16:10	00:20	Mr. Kunal Singh, MECON Ltd.	De-carbonisation in Blast Furnace & Sinter Plant
16:10	16:20	00:10	coffee	
S6: Process Innovation-I				
Session chair			**Dr. Viswanathan N Nurni**	**Topic**
16:20	16:40	00:20	Mr. Jan Vander Stel, TSN	Developments of the ULCOS Top Gas Recycle Blast Furnace Process
16:40	17:00	00:20	Dr. P. Chris Pistorius, CMU Pittsburgh	Gas-based DRI production using natural gas and hydrogen as reductants
17:00	17:20	00:20	Mr. Massimiliano Zampa, Danieli Corus	Energiron ZR: Fit-for-Future Direct Reduction Technology
17:20	17:40	00:20	Dr. Stuart Southern, TSUK	Recent Process Innovations through Tata Steel UK blast furnaces
17:40	18:00	00:20	Dr. Nachiappan Arumugam, NALCO Water India Pvt. Ltd.	Nalco's Nahyati – An Additive for Pellet
19:30	Culture Programme followed by Gala dinner (Venue: BOC Pavilion, Beldih Golf Course, Sonari, Jamshedpur)			

17th Jan'24 Day 1 Parallel Sessions | Location: The Grand				
S3: Green initiatives in Iron & steel				
Session chair			**Dr. Sabuj Halder**	**Topic**
11:25	11:45	00:20	Mr. Amit Banik, TRL Krosaki Refractories Ltd	TRL Krosaki initiatives towards greener environment
11:45	12:05	00:20	Mr. Bradford G. True, Nucor	Scrap Based Steel Making Opportunities and Challenges
12:05	12:25	00:20	Dr. Edward Long, Primetals	Failure Resistant Copper Staves
12:25	12:45	00:20	Mr. Paladugu Srinivasa Rao, Vesuvius India Ltd.	Green Tap hole clay: A Cleaner & Greener solution for future generation
12:45	13:05	00:20	Mr. S N Dominic, Nellikuru Innovations Pvt. Ltd.	Green initiatives in Hot Metal Handling Area
13:05	14:05	01:00	lunch	
S5: Alternative Fuels				
Session chair			**Dr. Pratik Swarup Das**	**Topic**
14:50	15:10	00:20	Mr. Kurada Rohit, Tata Power	Technology Strategy for attaining CO2 target for Power Generators
15:10	15:30	00:20	Mr. Sanjeev Manocha, Lanzatech	Harness the capabilities of biology to transform carbon-rich waste gases into ethanol and valuable chemicals
15:30	15:50	00:20	Dr. Pravin C Mathur, Linde	Clean Energy for Steel Decarbonization
15:50	16:10	00:20	Dr. Devkumar Gupta, Thermax Global	Generation of Biochar and Green electricity from biomass for utilization in blast furnace
16:10	16:20	00:10	coffee	
S7: H2 / CCU				
Session chair			**Dr. Saurabh Kundu**	**Topic**
16:20	16:40	00:20	Mr. Praveen Chaturvedi, Tenova	Direct Reduced Iron and its future in Steelmaking: The use of Hydrogen for Green Steel Production
16:40	17:00	00:20	Mr. Shiromani Kant, ACME	ACME's Green Hydrogen and Ammonia Initiatives: A Leap Towards a Sustainable Future
17:00	17:20	00:20	Mr. Jeff Holyoak, AWIPL	CCU technology, Biomass and other green & sustainability-based technologies
17:20	17:40	00:20	Mr. Rajesh Kumar, Kalfrisa India Pvt. Ltd.	Real situations in utilising Green hydrogen
17:40	18:00	00:20	Mr. Vibhor Sharma, Sreechem Resins Ltd.	Design and Synthesis of Hydrogen Donor Polymers for Steel Making: Use cases in Coke Making & Beyond
19:30	Culture Programme followed by Gala dinner (Venue: BOC Pavilion, Beldih Golf Course, Sonari, Jamshedpur)			

18th Jan'24 Day 2 Parallel Sessions | Location: Main Hall				
S8: Process Innovation-II				
Session chair			**Mr. Shailendra Rai**	**Topic**
09:00	09:30	00:30	Coffee/Tea	
09:30	09:50	00:20	Mr. John Lester, CISDI	Clever Carbon innovations, strategy and progress towards the goal of low carbon Iron making
09:50	10:10	00:20	Mr. Giuliano Copetti, RHIM Alumina Monolithic Solutions	Advanced and Reliable Refractory Solutions for a Green and Sustainable Approach to Blast Furnace Iron Production
10:10	10:30	00:20	Mr. Damion Catterall, CISDI	Low carbon blast furnace
10:30	10:50	00:20	Mr. Jayachandra Nag, JSW Vijayanagar Works	Reduction of fuel rate by using Direct Reduced Iron in Blast Furnace
10:50	11:05	00:15	Coffee/Tea and move to common session	
S10: Future Ironmaking Prospects (Common session)				
Session chair			**Mr. Subash Sinha**	**Topic**
11:05	11:25	00:20	Mr. Udi Giladi, Helios	Intro to the Helios Cycle, a novel method to reduce iron ore
11:25	11:45	00:20	Mr. Biswadeep Bhattacharjee, Primetals	HYFOR Technology
11:45	12:05	00:20	Mr. Koen Meijer, TSN	HISARNA : Alternate Ironmaking
12:05	12:25	00:20	Dr. Kisoo Kim, POSCO	POSCO's Green & Digital Transformation; HyREX & Intelligent Factory
12:25	12:45	00:20	Mr. Anirban Mukharjee, BCG	Climate and sustainability trends: Global policy and regulatory moves and implications for Indian industry
12:45	13:05	00:20	Closeout by Convener ICGSI	
13:05	14:05	01:00	Lunch	
14:05	17:05	03:00	Plant visit	

18th Jan'24 Day 2 Parallel Sessions | Location: The Grand				
S9: Digital Innovations				
Session chair			**Mr. Anil Kumar Kothari**	**Topic**
09:00	09:30	00:30	Coffee/Tea	
09:30	09:50	00:20	Mr. Pallab K. Dutta, Accenture	Digital and AI in green steel
09:50	10:10	00:20	Dr. Jagabondhu Hazra, IBM	AI intervention to accelerate Sustainability Roadmap
10:10	10:30	00:20	Mr. Kanchan R Chatterjee, Bechem India	Decreasing Carbon Footprints by Reducing lubricant consumption & using biodegradable cleaners.
10:30	10:50	00:20	Mr. Bhagyaraj D, JSW Salem	Blast Furnace process optimization for sustainable Iron making
10:50	11:05	00:15	Coffee/Tea and move to common session	

KEYNOTE LECTURE

Fifth Industrial Revolution: Reimagining Iron making

Atanu Ranjan Pal
Chief Technology Officer, Tata Steel
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Industrial revolutions have transformed the manufacturing from water and steam powered machines to digital automated processes. Earlier industrial revolutions were focused on mass and efficient production, the fifth industrial revolution focuses on sustainability, human-centeredness, and environment. Therefore, the concept of Industry 5.0 will foster transformation and drive change in industries to make more sustainable and human centric. For sustainable and human centricity, it is necessary to empower human beings, improve their skills in cooperation with digital technologies, good health and well-being, affordable and clean energy etc. In addition, environment friendly technologies and process innovations are required to address the climate actions. In this view, numerous developments and initiatives will take place in near future to make ironmaking industry 5.0. The presenter discusses recent developments and initiatives in the ironmaking process driven by the industry 5.0.

KEYNOTE LECTURE

Green Steel – Current dynamics, opportunities, and challenges

Christian Hoffmann
Partner in McKinsey & Company
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Green steel is gaining momentum globally driven by growing customer demand for reduced CO2 materials, tightening regulation in combination with increasing CO2 cost as well as by new players entering the market. Yet the speed of decarbonization varies across core steel regions like China, USA, Developed Asia, India and Europe. There are several technologies available to decarbonize the steel industry including direct-reduced iron towers in combination with electric arc furnaces or pre-melters, scrap based electric-arc furnaces or carbon capture and storage facilities to be added to existing integrated steel mills. However, the economics for green steel conversions / investments continue to be challenging due to higher production cost for many of those technologies which will require a green premia or rising CO2 cost. At the core of the higher production cost is the increased demand for energy in green steel production. In order to make the green steel transformation work new partnerships and forms of collaboration will be needed which go beyond the traditional steel value chain.

KEYNOTE LECTURE

The Low Carbon Blast Furnace - Why it matters, and how to get there...

Ashok Kumar
Head of Strategic Technical Development, Tata Steel UK
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It is now agreed that climate change, is being caused by excess accumulation of GHG emissions in the earth's atmosphere—majorly as CO2 from use of fossil fuels for meeting humanity's needs over the last two centuries. Steel production, a vital industry, needs to transition to lower a carbon footprint.

Globally, almost 90% of CO2 emissions of 'primary steelmaking' come from use of coal/coke in the blast furnaces. More than half of the energy from this carbon is used to provide energy for heating and generation of electricity.

Innovations in clean energy provide several avenues for both heating and electricity generation—without use of the carbon energy. Interesting possibilities for changing the BF process can be found at the intersection of clean energy innovations and insights from the BF process - when it is freed of the burden of exporting energy to rest of the steel plant.

Given that BFs constitute 90% of the capacity of ironmaking, this existing capacity – when overlaid with ideas for incorporating low carbon intensity energy into it - can deliver faster reduction in emissions as against widespread replacement of ironmaking by, as yet evolving new processes.

Smart combination of new Midrex DR plants in existing BF based integrated plant: Solutions for lowering OPEX and CO2 emissions vs the stand alone approach

Cristiano Castagnola
Senior Vice President - Centre of Excellence Metallurgy, Paul Wurth-SMS Group
Email: cristiano.castagnola@sms-group.com

The urgent need to reduce the CO_2 footprint of steel production has induced different integrated steel producers to decide for the installation of Gas Based Direct Reduction plant (DRP) within the boundaries of existing Blast Furnace (BF) based steel production facilities. This is the readily available solution to perform the iron ore reduction through green hydrogen as soon as available.
In these scenarios, Blast Furnaces and Coke Oven Plants will operate in the same site of a new Midrex plant.
Paul Wurth (PW) and Midrex Technologies Inc. (MTI) have jointly analysed this configuration exploiting their respective expertise in BF and DRP to identify the opportunities resulting from the contemporary availability of gases arising from these 2 processes. This presentation introduces a new concept: the exchange of gases from BF to DRP and from DRP to BF . To exploit the gas coming from DRP, the Blast Furnace must incorporate the hot syngas injection at shaft which is a distinctive feature of the Blue Blast Furnace marketed by PW. The cold gas received from DRP becomes hot syngas through proven technologies that PW and MTI can offer already today.
The resulting CO_2 emissions of this combination are significantly lower (10-15%) than the ones associated with the standard set up. The operating cost¬ also decreases in the newly introduced configuration, which is also more flexible in reacting to changing costs of Natural Gas vs coal.

TRL Krosaki initiatives towards greener environment

Amit Banik
Vice President - TSS (Ironmaking), TRL Krosaki
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Making the environment safer for all of us and our future generations is vital responsibility of all of us. Organizations have higher responsibility in this regard. Recent report published by UNEP (United Nations Environment Program) indicated that all countries have failed again to meet the norms of emission which led to the increase of temperature all over the globe. This means that the emission of Greenhouse gases (GHGs) like carbon di-oxide (CO_2), methane (CH_4), nitrous oxides (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) could not be brought in control as per agreed UN convention while one more year has passed by. Year 2023 is surely the warmest year on record. The report also said that in the month September

2023, the global average temp was 1.80C higher than the pre-industrial levels which is a record. Greenhouse gas emissions in 2030, based on policies in place, were projected to increase by 16 per cent at the time of the agreement's adoption. Today, the projected increase is 3 percent. So, progress since the Paris Agreement was signed in 2015 has shown that the world is capable of change. TRL Krosaki Refractories Ltd, as a responsible corporate entity, has considered developing a greener environment as its topmost priority. Refractory industry is one of the contributors of GHGs emissions along with its major customers mostly Iron-Steel and Cement industries. So, the focus of TRL Krosaki to contribute to greener environment is not only concentrated in its own manufacturing activities but also at customer premises through development of products and applications which can contribute towards this effort in sustainable manner.

TRL Krosaki' s efforts in this regard are elaborated in this presentation. This paper will describe in detail on the actions already implemented and planned for near future on a) reduction in energy consumption, b) reduction of CO2 emissions, c) recycling of used refractory, d) recycling of wastewater and e) increasing the green belt.

Present and future opportunities in green steel production: A green heat perspective

Mahesh Venkataraman
Chief Technology Officer, 1414 Degrees Ltd
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The presentation will cover the work from 2 organisations: (1) 1414 Degrees, a thermal storage technology developer and (2) HILT-CRC, a collaborative venture with 50+ industrial partners and research organisation. First part will discuss the innovative SiBox thermal storage technology which can be integrated as a green-heat source in even the most difficult-to-decarbonise high temperature applications. Subsequently, HILT-CRC's work on several future green steel pathways, specifically for lower-grade goethite/hematite ores in Australian Pilbara region will be discussed, including the role of energy storage.

We will discuss our findings from our end-to-process process techno-economic model for estimating the cost of green steel for different ore grades, via different process pathways, including: (1) beneficiation to varying extents, (2) Fluidised Bed (FB) and Shaft Furnace (SF) reduction, (3) EAF and smelter-BOF steelmaking. The smelter-BOF pathway shows promise particularly for lower-grade ores and can unlock a wider body of ores suitable for green steelmaking. There is strong potential for cost-competitive green steel from Pilbara due to co-location of iron ore with low-cost renewables. The HILT CRC team also analysed the integration of thermal energy storage with H2-DRI to achieve the least cost system providing "hot-hydrogen" with up to ~12% reduction in energy cost vs the no-storage scenario.

In conclusion, thermal storage and promising alternative pathways to DRI-EAF are under development for green steel production and further work through a more concerted effort from technology providers, steelmakers and research organisations will unlock the true potential of emissions-free steel.

Scrap Based Steel Making Opportunities and Challenges

Bradford G. True
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Starting with the start-up of a small EAF in Darlington, South Carolina in 1969, Nucor began operating its first scrap-based steel mill producing rebar and merchant bar needed to supply its growing steel joist business. At the time, Nucor was the smallest steel producer in the US. Now, Nucor is the most diversified producer of steel and steel products in the North America with merchant bar, engineered bar, plate, sheet, tubes, joists; hollow structural section tubing; electrical conduit; steel racking; steel piling; steel joists and joist girders; steel deck; fabricated concrete reinforcing steel; cold finished steel; precision castings; steel fasteners; metal building systems; insulated metal panels; overhead doors; steel grating; wire and wire mesh; and utility structures

Nucor's success with the EAF resulted in competitors choosing to follow our footsteps. By 2030, it is expected that steelmaking in USMAC (US, Mexico and Canada) will reach 80% EAF, with only 20% produced via traditional integrated coke and blast furnace operations. This incredible transformation from blast furnaces to scrap-based EAF is not without challenges, but brings opportunity as well. In this presentation, we will discuss how Nucor has dealt with quality limitations of scrap-based steel making, founds ways to take advantage of EAF's high productivity and substantial flexibility to switch between scrap and scrap substitutes, achieve industry leading carbon emissions, all while staying profitable and increasing annual dividends for the past 50 years.

Value Realization through NetZero Implementation

Kapil Bansal
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Decarbonizing the iron and steel industries is of paramount importance for several compelling reasons, spanning environmental, economic, and societal dimensions. As the industry transitions towards low carbon steelmaking, it is important to have a comprehensive overview of key strategies for decarbonizing the highly carbon intensive value chain of the sector i.e., Ironmaking. Out of numerous possible ways to do so, the potential solutions recommended include analysing technologies & creating pathways for emission reduction, entity restructuring, and the integration of cutting-edge technologies such as Artificial Intelligence (AI) and Machine Learning (ML) to optimize processes & mitigate emissions are key strategies to meet these goals.

The decarbonization optionality's explores pathways for decarbonizing ironmaking in terms of TATA Steel's short- & long-term plans. In the short term, with an upcoming 5 MTPA expansion plan of TATA Steel at Kalinganagar through BF-BOF route, it is important to analyse methods like usage of Coke Oven Gas with H2 enrichment in Blast Furnace, and usage of scrap & HBI in BOF. For the long-term goals, considering non-availability of high-grade iron ore required for DRI process, TATA Steel may like to explore global supply options for Green DRI/HBI. It is necessary to analyse different factors like resources availability, policy support, cost, infrastructure to decide between two models viz. Co-location and Geo-split approach for future expansion.
Entity restructuring is opted by various global companies as an option with an advantage of low investment solutions. Restructuring can help in alignment of short, medium and long-term corporate goals to have lower carbon footprint with optimal gearing to make the business future ready from compliance perspective. Restructuring of highly emitting units like Blast Furnace, Captive Power Plant, FAD etc could be one of the steps in the process. However, this has to be looked from multiple angles covering financial, commercial, regulatory and taxation implication.
The decarbonization strategy, roadmap and implementation for Iron making explores EYP's framework for decarbonizing operations across the value chain, along with the integration of AI and ML in process optimization and reducing emissions in Iron & Steel production. By leveraging data analytics and advanced algorithms, these technologies offer insights for enhancing process/ energy efficiency, ultimately abating CO2 emissions over the NetZero duration.

Failure Resistant Copper Staves

Edward Long
Product Owner - Furnace Cooling at Primetals Technologies
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Blast furnaces are forecast to be in operation for years to come while alternative steelmaking routes and their supply chains become established enough to replace virgin ironmaking at scale. The shell of the blast furnace is often protected by copper staves in the highest heat zones to allow it to last for multiple campaigns without change. It is therefore important that the copper staves can resist the two main failure mechanisms of stave bending and stave wear. Primetals Technologies offer proven solutions to resist both of these phenomena, based on extensive studies and knowledge of stave operation.
By controlling stave expansion due to the different thermal effects on the hot and cold sides, stave bending can be prevented. Our solution has prevented stave bending on blast furnaces without the need for time consuming changes to the blast furnace shell.
Primetals Technologies have developed a solution which traps burden material at the front of the stave whilst still allowing liquids through to the copper face – the result is a more stable skull which prevents stave wear by abrasion.

Results from regular monitoring of current wear-resistant installations have validated the continued presence of the wear-resistant solutions and demonstrate the potential for many decades of copper cooling staves life. Additionally, the data reveals that copper staves with wear-resistant solutions retain more stable and lower heat loads through the range of operating conditions. The conclusion from this is that an additional benefit of fuel saving can be realised.

Modelling of hydrogen reduction of iron ore fines

Henrik Saxén
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Iron and steel are key materials for mankind and for developed societies, but the iron- and steelmaking sector today faces enormous challenges due to the large carbon dioxide emissions of the present production processes: it is estimated that iron- and steelmaking contributes by 7-8 % of the global CO2 emissions. Since the main process in ironmaking, the blast furnace, cannot be operated without coke, new production concepts that drastically reduce the emissions must be developed. A potential solution is to change the main reductant, carbon monoxide, to hydrogen in a gas-based direct reduction process. In order to understand how the alternative hydrogen-based reduction processes of iron ores should be designed and operated, deep knowledge of the reaction kinetics is needed. The present work describes the development of a mathematical model based on the key assumptions of the Shrinking Core Model of the kinetics and mass transport phenomena in a small bed of iron ore fines that is reduced by a hydrogen-containing gas that flows through the bed. Results from corresponding reduction experiments performed in laboratory scale act as a reference and validation of the mathematical model. The presentation outlines the model and presents an analysis of the effect of some key parameters of it on the reduction behavior, Finally, a comparison between simulation and experimental results is provided to demonstrate the validity of the model.

Green Tap hole clay: A Cleaner & Greener solution for future generation

Paladugu Srinivasa Rao
Product Development Sr. Engineer - THC COE at Vesuvius Refractory India Pvt Ltd
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The conventional iron-making process using blast furnaces involves a significant source of greenhouse gas emissions and pollution. This has led the growing world to adopt sustainable ironmaking practices. Therefore, the world of steelmaking demands high efficiency and low emission technologies to take their path towards sustainability. In this context, the design aspect of taphole clay (THC) become increasingly important owing to the high hazardous emissions.

The typical binding systems incorporate tar, resin and/or pitch binders, which are the primary sources of unsafe components in THC. However, taphole clays with emission-free binder systems have become more attractive regarding health, safety, and the environment. Vesuvius has initiated a substantial initiative to develop taphole clays that prioritize health and environmental safety. They are seeking to employ an environment-friendly binder for their operations. The development of this greener technology offers an equivalent performance to conventional binders. Besides, the environment - friendly binder does not require any reworking of the THC formulations. The newly developed Green Taphole clays are phenol-free, formaldehyde-free, and PAH-free. Successful field trials of the green clays were carried out for the European & American markets.

Towards Reducing Carbon Emission Through Tuyere Injections in Blast Furnace – A RAFT-RIST Approach

Viswanathan N Nurni
Sajjan Jindal Steel Chair Professor & Head, Department of Metallurgical Engineering and Materials Science, IIT Bombay
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Whenever other alternative iron processes challenged blast furnace process, it re-invented itself to remain tall and hopefully continue to remain tall for another 2 or 3 decades, at least in our country. Blast furnace is unique that it operates close to thermodynamic efficiencies which no others process could achieve. Fortunately, this also allows us to predict fuel rate and to some extent production rate using relatively simple heat and mass balance approach. Typically, blast furnace operator optimizes the oxygen input to maintain a desired RAFT for various tuyeres injectants possible. Plants have been injecting PCI more than 200 kg per ton of HM produced. For any hydrocarbon injectant, once the injectant is converted completely to CO and H2 while leaving the raceway, the blast process remains quite steady. Therefore, injecting Hydrogen through tuyeres is not expected give any unexpected results if the RAFT is maintained and the top gas temperature is not allowed go below the dew point. Based on this approach, coke rate, blast rate, oxygen enrichment and the total fuel rate can be predicted using simple RAFT-RIST model. In this talk some of these findings for Hydrogen injection into the blast furnace will be presented.

The speaker would like to acknowledge the M.Tech project work carried out by Mr. Jagdish Patra towards this investigation.

Green initiatives in Hot Metal Handling Area

S N Dominic
Managing Director, Nellikuru Innovations Pvt. Ltd.
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The cooler the hot metal when it moves for subsequent steps in hot metal handling, the more fuel is required to further heat the metal to required temperature, resulting in more CO2 emissions.

It is estimated that every 10°C heat loss per ton of liquid hot metal will increase CO2 emissions by 0.01MT.

Using torpedo ladles generally reduces the heat loss in the liquid metal as it moved from the blast furnace to the SMS converters. However, there is still roughly a 100- 200 °C heat loss in most steel plants in this area depending up on the logistic support.

Most of this heat loss happens due to the non availability of a high temperature insulation material from the ladle bottom where major turbulence happening during the ladle filling itself. Another reason is the extended holding times of partially filled ladles in both BF or COREX areas for subsequent casts.

We have developed an Iron based high temperature insulation material to reduce the heat loss by up to 40°C (depends on the ladle holding time), and that is almost at zero cost. This compound insulates the liquid material right from the start of ladle filling. Other benefits are improved metal throughput from ladles, lesser fugitive emissions, and almost NIL metal jamming in ladles.

Future of green ironmaking using BF/BOF route Blue Blast furnace & EASyMelt

Peter Kinzel
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The future of green ironmaking using the BF/BOF route is not only desirable but absolutely necessary, because of the global need for virgin ore green steel, while severely lacking the green hydrogen and high grade iron ore for alternative routes. Especially Indian iron ore, prone to high alumina content, is much more suited for smelting in a reducing environment of a blast furnace than an oxidizing electric arc furnace atmosphere. Thus the blast furnace technology is due to face a major rebirth as the EASyMelt technology, which is intended to be co-industrialised by SMS Group and TATA Steel to reduce CO2 emissions by 50% compared to a traditional blast furnace. The electrically assissted smelter (EASyMelt) technology uses dry reforming, to recycle carbon dioxide, with the possible integration of hydrogen, to reduce iron ore. The ore is smelted with electrically powered plasma torches instead of traditional coke burning, significantly reducing CO2 remissions. To achieve climate targets however, it is also imperative to also reduce emissions in auxiliary plants such as the sinter plant or the reheating furnaces, which can be achieved with efficient biomass integration if biomass is available locally. Alternatively, sinter plant emissions can be reduced using a mixture of sinter feed and charcoal, to source biomass from a distributed network at advantageous prices using the SMS green sinter concept. Coke plant emissions will directly be reduced due to the reduced coke requirement but there is additional potential for improvement by implementing systems such as coke dry quenching, onboard dedusting systems and the CokeXpert level 2 system. SMS thus has a realistic and holistic decarbonization strategy for the entire steel plant.

Technology Strategy for attaining CO2 target for Power Generators

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As the global energy landscape undergoes a paradigm shift towards sustainability and decarbonization, TATA Power is more than committed to align its operations to surpass the environmental challenges. With sustainable development at our heart, we are enhancing our clean energy portfolio & focussing on an entire gamut of alternate clean sources of power, enabling customers and stakeholders with sustainable and smart energy solutions. This strategy focuses on leveraging advanced technologies and innovative approaches to mitigate carbon emissions throughout the entire value chain.
The proposed approach encompasses various key elements:

- Renewable Energy Augmentation: Prioritizing the expansion of renewable energy sources, such as solar and wind, to enhance the share of clean energy in Tata Power's portfolio. This involves investing in advanced solar and wind technologies, energy storage solutions, and grid integration to ensure reliable and sustainable power generation.
- Energy Efficiency and Optimization: Implementing cutting-edge technologies and practices to improve the overall energy efficiency of power generation, transmission, and distribution processes. This includes technological interventions in existing thermal power plants, deploying smart grid technologies, adopting advanced monitoring and control systems, and optimizing operational processes to minimize energy losses.
- Carbon Capture and Storage (CCS): Exploring and investing in carbon capture technologies to mitigate emissions from fossil fuel-based power generation. CCS technologies can capture CO2 emissions at the source and store them underground, reducing the carbon footprint of traditional power plants.
- Electrification of Transportation: Encouraging the adoption of electric vehicles and investing in charging infrastructure to contribute to the reduction of carbon emissions in the transportation sector. This complements our efforts to create an integrated and sustainable ecosystem.
- Research and Development: Investing in research and development initiatives to stay at the forefront of technological innovation. This includes collaborating with research

institutions, startups, and industry partners to explore emerging technologies that can further enhance the efficiency and sustainability of power generation.

- Community Engagement and Education: Involving local communities and stakeholders in Tata Power's sustainability journey through awareness campaigns, education programs, and partnerships. Engaging the community fosters a shared commitment to environmental stewardship and can contribute to the success of the overall CO2 reduction strategy.

This approach would aid us to position as a leader in sustainable energy solutions, contributing significantly to global efforts to combat climate change while ensuring long-term business viability. This strategy not only aligns with environmental and social responsibilities but also presents opportunities for innovation, growth, and competitiveness in the evolving energy landscape.

Latest Generation Dry Blast Furnace Gas Cleaning Technology

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Dry blast furnace gas cleaning technology offers great economic advantages when compared to traditional wet gas cleaning owing to its improved energy efficiency, lower cost, reduced plot space, and practically eliminated water consumption. Given the improved operational economics and – in some areas – the physical or economic scarcity of water, steel producers are shifting towards the application of blast furnace gas cleaning systems, in which the wet scrubber is replaced with a dry second gas treatment stage.

The Danieli Corus solution is based upon proven technology that has been applied numerous times for cleaning aluminium smelter gases and anode baking fumes. The system consists of a gas conditioning tower, reagent injection system and (pressurized) filter modules with low pressure pulse cleaning. Currently, Danieli Corus is implementing this technology for three greenfield blast furnaces in India.

Harness the capabilities of biology to transform carbon-rich waste gases into ethanol and valuable chemicals

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LanzaTech groundbreaking technology harness the capabilities of biology to transform carbon-rich waste gases into ethanol and valuable chemicals, serving as crucial building blocks for essential products like textiles, plastics, and sustainable aviation fuel. This innovative process not only empowers steel producers to extract economic and sustainable value from off-gases but also exhibits remarkable adaptability, seamlessly integrating with various gas streams without necessitating extensive modifications to existing equipment or processes.

As steel plants transition from blast furnace production to Direct Reduced Iron (DRI), LanzaTech's technology effortlessly accommodates the new gas streams generated by these evolving processes. By repurposing carbon that has already undergone primary use in activities such as Steelmaking, the approach not only generates value by producing raw materials for other sectors but also curtails reliance on fossil extraction throughout the entire value chain for these materials. This establishes a more resilient energy paradigm and champions the concept of a circular carbon economy, where carbon is continually reused and recycled to minimize environmental impact.

A recent milestone underscores LanzaTech's success, with the achievement of commercial-scale production of "Steelanol" at one of the largest integrated steel mills in Belgium. This signifies a transformative step towards a sustainable and circular approach, illustrating the potential for industries to contribute significantly to mitigating environmental challenges by repurposing carbon emissions for valuable applications.

Sustainable BF process at Tata Steel Netherlands

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Optimized Blast Furnace ironmaking processes will contribute to the sustainability strategy of Tata Steel in the Netherlands (TSN), focusing on Clean, Green and Circular steel production. The reduction of CO2 emissions (green) is directly dictated by lower reducing agent or coke rate. In the previous years the IJmuiden site managed to be amongst the best performing sites with respect to CO2 emissions per ton of steel. An overview will be given how this is achieved in specifically ironmaking during the last years, which includes increase of coal grinding capacity, improvements in hot blast capacity and process improvements. The usage of scrap in the blast furnace contributes to both CO2 reduction as well as circularity. A successful trial and the challenges of scrap usage will be presented.

The short-term initiative for further improvements needs to be in line with the longer term plans of decarbonization of TSN. TSN aims for reduction of 40% of CO2 in 2030 and CO2 neutral in 2045. Starting with a Direct Reduction Plant (DRP) and Electric Arc Furnace (EAF) to replace one of the two Blast Furnaces in 2030. In the route towards 2030 the sustainable initiatives should still be in line supporting the longer-term plans.

Clean Energy for Steel Decarbonization

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The pressure to decarbonize industrial production has led many steel producers to set carbon neutral goals over the 2030-2050 timeframe. But how will these goals be met? Linde, as the world's largest industrial gases company, is not only working to reduce our own carbon footprint but helping to accelerate the decarbonization of our customers around the world.

Four key areas of focus for industrial decarbonization are:

- Large scale Clean H2 supply to meet steel industry requirements, derived either from world-scale hydrogen plants fitted with CO2 capture (Blue H2) or by electrolysis (Green H2)
- CO2 capture, sequestration and utilization opportunities. Solvent (amine) based and adsorbent (PSA) based technologies are available for CO2 capture from steel mill gases.
- Low carbon fuels/syngas derived from biomass and other low carbon feedstocks, using Linde's Hot Oxygen Technology
- Use of industrial gases for near-term, incremental steel decarbonization, specifically deploying oxy-fuel combustion across the steel production chain

The transition of the industry will span decades due to techno-economic challenges, but significant lighthouse projects are already in development around the world.

De-carbonisation in Blast Furnace & Sinter Plant

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The per capita steel consumption is considered as the barometer of growth for any country. The steel sector contributes over 2.0 percent to the GDP of the nation and provides 6.0 lacs jobs in the country. The substantial growth in steel sector comes with a price as the industry alone contributes around 7-8% global carbon dioxide emission. If we consider only India, the contribution is more than 10%. Indian steel sector has an emission intensity of ~2.55 tonnes of CO2/tonne of crude steel compared with global average emission intensity of 1.85t CO2/tcs. Out of total emission in BF-BOF route, the Blast furnace contributes nearly 45 to 50% and sinter plant nearly 8 to 10%. As such, it becomes vital & imperative to lower down the CO2 emission in these areas. Presently, the ironmaking is mainly dependent on carbon-based fossil fuel which is responsible for emitting CO2 in atmosphere. The main sources of carbon emission in Blast Furnace & Sinter plant are burning of carbon / heat sources like coal or coke and indirectly through generation of electrical power in conventional coal-based power plants.

The BF-BOF route of steel making primarily uses fossil fuel like coke, pulverised coal, coke breeze in Blast Furnace and Sinter plant. The fossil fuel is main source of energy / reductant and as such CO2 emission is inevitable, but some measures can be introduced for further emission reduction of the same. This paper dealt with roadmap of de-carbonisation in steel industry, particularly in Sinter plant and Blast Furnace. There is no single solution to drastically reduce CO2 emission from our steel industry. However, in Indian perspective, a proper roadmap is required.

Some of the measures taken in sinter plant are use of alternate fuel like biochar, charcoal and installation of waste heat recovery in sinter plant. In Blast Furnace, the measures adopted are TRT, waste heat recovery plants, maximising PCI injection, increase in use of pellets, dry gas cleaning plant, efficient process with modern instrumentation & models, using VVFD in electrical motors, use of energy efficient electrical appliances, implementation of level-2 monitoring system, K-factor monitoring, dead-man cleanliness index, charge models, etc.

It is also evident that most of the earlier installed plants still do not have implemented above mentioned measures. It is high time that these measures shall be horizontally implemented across various plants in India to further reduce CO2 emission. Further, in view of ongoing technological intvention to reduce the carbon footprint and substantial step taken towards decarbonisation, an entirely new transformative approach to ironmaking is required. Several promising initiatives like use of renewable energy sources, carbon capture, utilisation and storage (CCUS), substituting hydrogen inplace of carbon as reductant in Blast furnace, using electrical energy through electrolysis-based processes, HYBRIT (Hydrogen breakthrough Ironmaking Technology), a Swedish govt initiative are under development for implementation on large scale.

In all together, we shall strive together for green steel and fulfil the target of carbon neutrality much before the set target of year 2070.

Generation of Biochar and Green electricity from biomass for utilization in blast furnace

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Thermax along with its partner has developed downdraft pyrolyzer for production of biochar. It can provide typically 22% to 30% biochar production from dry woody biomass. This technology offers added advantage as it does not generate any tar oil along with biochar which has multiple handling issues. Also it does not require any external fuel for it operation. The downdraft pyrolyzer is able to convert volatile material (VM) of biomass into producer gas having CV value between 950-1050 kcal/Nm3. This producer gas is cleaned by using simple process and then sent to gas engines for generation of green electricity. Hence providing additional stream of revenue to compensate the operating cost. The standard module is 50 TPD of biomass handling plant. The biochar generated from this plant is used as partial replacement of PCI used in blast furnace. Hence providing opportunity as replacement to fossil fuel.

Developments of the ULCOS Top Gas Recycle Blast Furnace Process

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In the European Ultra Low CO2 steelmaking (ULCOS) consortium of steel compagnies, suppliers, universities, institutes and plant engineers (2004-2014) one of the developments was the ULCOS-BF, better known as the Top Gas Recycle Blast Furnace (TGRBF), to minimize CO2 emissions in blast furnace ironmaking.
This process is based on the replacement of hot blast by oxygen and recycled decarbonated top gas, which is injected into the lower shaft and normal hearth tuyeres, the capture of CO2 and its storage in a geological trap (full CCS process). This paper highlights the main features of the development of the TGRBF process from mathematical models to an industrial application, and the expected benefits for CO2 mitigation. This technology has been demonstrated during three campaigns of 7 weeks by coupling the LKAB's experimental blast furnace in Lulea to a pilot Vacuum Pressure swing adsorption (VPSA) unit for CO2-removal. The concept, preparation and results of the campaigns are described. Following the success of these experiments, studies for the construction of an industrial demonstration unit at ArcelorMittal Florange will be discussed.

Direct Reduced Iron and its future in Steelmaking: The use of Hydrogen for Green Steel Production

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The steel business is one of the major industrial sources of climate pollution. It is responsible for 7% to 9% of all direct fossil fuel emissions. Reversing the emissions course is more urgent than ever. The viable pathway to reduce the emissions from making steel relies on hydrogen technologies. As the notion of replacing fossil fuels with green hydrogen in steelmaking has recently been gaining traction, Tenova and its partners have already taken some big and concrete steps.
Currently there are various ways of approaching the decarbonisation of the steelmaking industry. The main trend is the progressive conversion of BF-BOF steelmaking facilities to direct reduction-electric arc furnace (DRI-EAF). The reduction of CO2 emissions can be

further enhanced by the partial or total use of hydrogen (H2) for DRI production. There is, however, an alternative approach which allows the integrated mill operator to optimise investment costs by keeping its downstream facilities in operation while replacing only the BF ironmaking installation using a direct reduction-open slag bath furnace (DRI-OSBF) for hot metal (HM) production. This is also an attractive possibility for a new steelmaker looking to produce pig iron with a minimum carbon footprint. Tenova iBLUE® is the only proven technology to substitute any Blast Furnace: produce Liquid Pig Iron while massively reducing emissions. iBLUE® combines production of high carbon DRI using hydrogen from blast furnace grade iron ore pellets with electric arc melter to produce Hot Metal & granulated slag.

Critical parameters of gas-based direct reduction

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Increased use of gas-based direct reduction is one potential component of future low-carbon ironmaking. In this presentation, the main consumption parameters of direct reduction using natural gas and hydrogen are summarized. Whether natural gas or hydrogen is used as reductant, recycling of the top gas is essential because of the inherently low utilization (around 50%) of the reductant during a single pass through the process. The utilization is limited by the reduction equilibrium (summarized in the familiar Chaudron diagram), and reaction stoichiometry. Approximately 200 kg of natural gas is consumed per tonne of metallic iron produced, equivalent to 0.6 tonne of carbon dioxide. In the Energiron process, carbon dioxide is captured from the gas recycling stream; sequestering or using that carbon dioxide would lower the carbon intensity of ironmaking. For hydrogen-based reduction, the stoichiometric hydrogen requirement is 54 kg per tonne of metallic iron. The actual consumption could be much higher - around 80 kg per tonne - if hydrogen were also burnt to provide the energy requirements of the process. Because hydrogen reduction is endothermic, careful design of the inlet gas temperature and the relative flow rates of solid and gas is essential.

ACME's Green Hydrogen and Ammonia Initiatives: A Leap Towards a Sustainable Future

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ACME Group, a leading global sustainable and renewable energy company founded in 2003 by Mr. Manoj K. Upadhyay and headquartered in Gurugram, India, has made significant contributions to renewable energy. They broke barriers by achieving a subsidy-free tariff of INR 2.44/kWh for solar power, accelerating solar adoption in India.

Acme has developed over 6.62 GWdc of renewable projects across 12 states in India and divested 1.45 GWdc out of the same. The current under construction and development pipeline is more than 10 GWdc, which includes RE projects for green hydrogen and ammonia plants in Odisha, Tamil Nadu and Oman. ACME aspires to be a major global green energy provider by 2032, producing 10 million tonnes/year of Green Ammonia and equivalent-Green Hydrogen.

ACME Group is dedicated to sustainability in challenging sectors like food, agriculture, steel, shipping, cement, and aluminum.

Energiron ZR: Fit-for-Future Direct Reduction Technology

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Out of all the production routes available, Direct Reduction technology offers the highest CO2 emission reduction potential of all the routes available for steel production using virgin iron sources. Given the elimination of a reformer, the Energiron ZR process is the only option that is fully hydrogen-ready: whenever the required volumes of hydrogen become available, there is no requirement for high-cost modifications to the plant, as is the case with competing processes. On top of this unparalleled flexibility with respect to the source of gas, the process also allows the use of Coke Oven Gas when implemented in a hybrid configuration combined with Blast Furnace Ironmaking capacity.

CCU technology, Biomass and other green & sustainability-based technologies

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Decarbonizing hard to abate industries will require innovation and investment in utilization technologies. We can't "decarbonize", we must recycle and reuse carbon in order to reduce reliance on fossil fuel-based carbon. Change the narrative, change the focus, change the future.

Recent Process Innovations through Tata Steel UK blast furnaces

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'Necessity is the Mother of Invention' is the modern proverb based on Plato's 'Our need will be the real creator' written circa 380BC.

It was as true then as it is today. The blast furnace process is and has always continuously evolved to adapt to local cost pressures, material availability, environmental requirements, government policy amongst many other drivers.

The Innovations reviewed in this paper are of recent themes collected from multiple technologists from the Tata Steel UK plant at Port Talbot. Several are interlinked due to local targets and issues. General themes include

- Enhanced recycling capabilities and improved circularity
- Cost reductions but also cost avoidance
- CO2 reductions and process efficiency improvements

Each plant works and country will always have their own drivers and some from the UK will be reviewed. Not all will be necessarily applicable on all sites, but as Plato professed, the local needs will always drive innovation. The technology standing still is simply not an option.

Utilisation of green energy sources and different energy management

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Moving from fossil fuels to green energy sources is the future of our planet. Hydrogen represents a great opportunity as it's carbon-free, sustainable and, perhaps most importantly, abundant.
But the task is hard and have challenges like -

- What could be time we may take to make hydrogen as our partner in industry?
- Are we taking sufficient measures?
- How we can save available energies, or we can say, how to utilise our available resources sensibly?
- Most importantly, are we future ready? As we need to have highly skilled workforce. We need to equip our Industry Training program standards. As well as this, our universities should come up to the Energy Technology Partnership with steel industries.

Nalco's Nahyati - An Additive for Pellet

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Pelletisation process utilizes binding aids to assist in the formation of suitable iron ore pellets. Pellets of consistent quality is of utmost significance for better overall process efficiency of the pelletization as well as steel making process. The traditional additives have been bentonite clays act as a binding agent thus helping agglomeration process. However, bentonite have certain limitations typical to its usage. Few of the side effects that come along with its usage are as follows:

- Bentonite is a structure of silica and alumina and as a result of its use in iron ore pellets, additional fluxes are required in the blast furnace for its removal
- Additional silica and alumina also demands high fuel rate in blast furnace
- Additional bentonite reduces the percentage of iron ore in the pellet, and is a significant factor in total iron ore processing rate
- The water that is absorbed by the clay is electrostatically held in its structure and this feature retards the drying rate of the pellets & cracks formation leading to overall pellet rejects.

To support the productivity of pellet plant, Nalco developed a novel technology "Nahyati" that helps in replacing bentonite partially to yield better quality pellet & thus making the overall process of pelletization more efficient. This technology offers a way of overcoming the disadvantages that accrue with the usage of bentonite as a binder. They contain zero levels of silica, can be of consistent supply and are effective at much lower dose levels than Bentonite.

The other benefits of using this technology in pellet making process are captured at a plant level are as follows

- Partial replacement of Bentonite with use of Nalco's technology reduces Alumina and Silica levels (reduces slag generation) and helped the plant to increase the iron levels in pellets, improving blast furnace performance.
- This technology improved the correct size % & shape of the pellets resulting better bed permeability and reduced recirculation load & increased productivity.
- Nahyati improved the quality of both green and dry pellets

In short, the inorganic bentonites have now been replaced partially with Nalco's organic molecule enhancing the pellet qualities & plant productivity. The usage of bentonite for making pellets in future would gradually decrease and will be shifting towards organic additives which will also reduce the fuel demand in iron making process thereby reducing carbon footprint of the plants.

Design and Synthesis of Hydrogen Donor Polymers for Steel Making: Use cases in Coke Making & Beyond

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Within the scope of sustainable iron-making, our company Sreechem Resins Ltd. presents two polymers, NR-40 which is able to generate Hydrogen (H2) in the plastic zone of 300-600°C while co-pyrolyzing with coal to improve the coking potential of non-coking coals and CRI-MAX coke coating polymer which designed to enhance the reactivity of nut coke used in blast furnaces. It's formulated to lower the Thermal Reserve Zone (TRZ) temperature in the furnace from 1100°C to 900°C, thereby increasing the reaction efficiency. These polymers have the potential to significantly enhance the efficiency and environmental footprint of the steel industry. NR-40, a proprietary patented polymer, facilitates the replacement of prime coking coal with inferior grades while sustaining the baseline coke quality and reducing costs.

The integration of these polymers into the iron-making process not only paves the way for greener steel production methods but also aligns with the industry's move towards reducing carbon emissions. Their deployment could potentially transform the landscape of iron production, leading to a more sustainable and economically viable process. The thrust area of our Research & Development is decarbonization and sustainability.

"Sustainability and profitability go hand in hand. That's how you build a resilient company, whether you're an incumbent or starting from scratch. The cost of doing nothing is just too high because everybody has this at the top of their agenda."

Clever Carbon innovations, strategy and progress towards the goal of low carbon Iron making

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Paper will discuss strategies to first allow plants to understand and identify there own unique targets and road map to reducing carbon emissions by considering not only the carbon emissions themselves but also the route contributing causes by analysing the 5 the key plant flows of Fe, Energy, waste, material and data throughout the plant. Conduct the "cradle-to-gate" life cycle carbon footprint analysis of steel products, analyse the carbon reduction potential of steel production and its upstream and downstream, so as to provide a basis for the construction of carbon reduction measures for the entire industrial chain. The paper goes on to introduce and discuss the options available to systematically reduce carbon emissions considering Raw material storage and logistics, Low Carbon Blast Furnace (already introduced our earlier paper) the CISDI shaft furnace and short process super Arc IGBT EAF route, waste and recycling and an introduction to the more than 20 CISDigital plant control systems now in operation.

Advanced and Reliable Refractory Solutions for a Green and Sustainable Approach to Blast Furnace Iron Production

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The struggle to achieve a green, sustainable route for the steel production has been characterizing the industry in the most recent years, and it is expected to shape more and more our technological horizon in the medium-long term.

Nevertheless, the blast furnace technology still seems to play a fundamental role in the ironmaking process, without any sign of decline in the short-medium term.

Therefore, application of innovative, advanced and reliable refractory solutions is paramount in letting the blast furnace keep on exerting its role with a deeper and deeper focus on environment, health and sustainability.

Environmentally friendly taphole clay, free from any carcinogenic compound – to provide health conditions for the blast furnace casthouse; new generation castables with higher degree of recycled raw materials – to lower the carbon footprint of the whole process; castables with alternative bonding systems – to reduce the energy consumption during the heating phases; protection/insulation systems for the blast furnace hearth – to reduce the comprehensive energy

needs of the process; are just some examples of what our technology can offer to today's industry to meet the demanding target of our challenging times.

AI Intervention to accelerate sustainability roadmap

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As the sense of urgency regarding climate change continues to mount with growing regulatory pressure across the globe, it has become increasingly crucial for enterprises and governments to align their goals with sustainability values. They face a crucial imperative to act on climate change mitigation by disclosing their GHG emissions and committing to reduction and optimization of emissions from their industrial activities including operations, infrastructure, logistics, and supply chains. Notable, while many of the world's largest enterprises have committed to ambitious net-zero targets, they often lack a holistic understanding of how their crucial business processes contribute to their overall journey, which makes it difficult for them to embark on a well-planned journey to achieve their sustainability goals.

In light of recent advancements, the integration of artificial intelligence (AI) and remote sensing technologies has emerged as a critical enabler for accurately measuring, tracking, and optimizing environmental, social, and governance (ESG) performance. This presentation will delve into the transformative potential of these technologies for enterprises across diverse industries. We will showcase how AI-driven models, coupled with real-time data from remote sensing platforms, can be leveraged to precisely estimate carbon footprints across all three scopes (1, 2, and 3) with granular detail, identify and localize emission hotspots within complex production systems and supply chains, unravel the underlying factors contributing to these hotspots, and enabling targeted intervention to guide and accelerate the enterprise's sustainability roadmap.

Low carbon blast furnace

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In May 2023, the world's first highly efficient reduction 3R low-carbon blast furnace technology independently developed by CISDI was officially applied and put into operation on two 2300m3 blast furnaces in China. It marks that the new low-carbon smelting process of large-scale blast furnaces with significant carbon reduction effect has entered the stage of industrial application. CISDI has innovatively proposed a new process technology coupling injection of H2 rich gas and CO rich gas, which makes full use of the enhancement advantages of hydrocarbon coupling reduction, maximizes the synergistic effect of the two reducing agents, and realizes a breakthrough in the ultimate energy utilization efficiency.

Decreasing Carbon Footprints by Reducing lubricant consumption & using biodegradable cleaners

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We have developed our special lubricant which reduces greasing of Plumber Block from every 15 Days / 30 Days to approx. 6 times or more which leads into decreasing grease consumption which reduces almost 6-10 times carbon footprint in production of lubricant as well as it also reduces Co-efficient of friction which reduces which reduces power consumption and leads to decrease carbon emission.

In addition, we have developed cleaners which are readily biodegradable which saves energy in their production process and reduces pollution and emissions as well as decomposes easily and naturally without toxins.

Reduction of fuel rate by using direct reduced iron in blast furnace

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In Blast Furnace Iron making Process, Carbon plays a pivotal role, as it helps to meet the energy requirement of the process as well as it acts as a reducing agent for smelting the Iron ore to Pig Iron. The most widespread form of carbon used for this purpose is Metallurgical coke.

As the world is aggressively finding the new ways and developing new strategies for cutting down the carbon footprint in steel sector. Enhancing the process efficiency and as a De carbonization initiative in Blast furnace, the usage of Direct Reduced Iron will cut down the fuel rate and bring down the carbon footprint through sustainable approach and be a part of green steel production.

The competitive edge of producing pig iron, while primarily focusing to bring down the cost of production, by maintaining the techno economics. The challenge always remains to bring down the fuel rate required for producing Iron.

As Major portion of cost incurred in production of hot metal is accounted by the usage of Coke and it is nearly 40-50 %. Developing systems and strategies to cut down its consumption is focus of attention.
Usage of DRI with Fe metallic of 80 %, by keeping 3 % in burden, has proven to reduce the fuel rate and increase the productivity of the furnace.
It is found that using 1 % of DRI in burden, has brought down the fuel rate 0.6% in the coke consumption, and enhancing the productivity by 0.7%. In JSW Vijayanagar BF#3 we have achieved the fuel rate of 518 kg/thm and a reduction of nearly 19 kg /thm with 215 Kg/thm PCI in Burden. By reducing 1 kg of fuel rate contributes 3 kg of Co2 reduction, and annually it accounts for nearly 0.2 million Tons of CO2 reduction. Which engraves the path towards green iron making.
Continued research, development, and implementation of innovative technologies like DRI integration, along with other efficiency-focused strategies, will be crucial in further reducing carbon emissions and improving the sustainability of iron and steel production.

Blast Furnace process optimization for sustainable Iron making

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JSW Steel Ltd, Salem is 1.15 MTPA integrated special alloy steel plant with two Mini Blast Furnaces (BFs) with useful volume of 402m3 and 640m3. A stable and efficient operation of the Blast Furnace is prerequisite to reduce the greenhouse gas emission. JSW Steel, Salem have been proposed many projects to reduce greenhouse gas emission, for example Higher O2 enrichment, Green H2 gas injection, Waste plastic injection, Natural gas and use of biomass reductant. Additionally, the operation stability and efficiency have a large influence on gas utilization and the rate of reductants and emissions, which are all important and mutually interdependent factors. This study leveraged advanced statistical tools, mathematical models, and technical research to assess the blast furnace process and detect anomalies. Subsequent to this analysis, a series of optimization measures were implemented, driven by the study's insights. These actions targeted blast furnace process enhancement, leading to heightened production rates, reduced fuel consumption, and diminished greenhouse gas emissions. This work epitomizes the commitment to harmonizing iron production efficiency with environmental sustainability in mini Blast Furnaces.
This research and work using statistical tools and mathematical models is testimony of mini Blast Furnaces to achieve lower fuel rate with higher productivity in order to reduce GHG emission even though automation and advanced technologies are not available as compared to Bigger Blast Furnaces with superior technology.
In addition, digitalization projects and AI / ML (Artificial Intelligence and Machine Learning) models are being explored for further reduction of greenhouse gas emission by reducing the fuel rate.

Intro to the Helios Cycle, a novel method to reduce iron ore

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Helios has developed the "Helios Cycle", a novel technology for iron ore reduction process that substitutes sodium for carbon. The Helios Cycle economically yields metallic iron powder, which can later be formed into HBI/CBI. The process is zero direct CO2 emission, with Oxygen being the only process byproduct besides gangue-related compounds. The reducing agent is thermally recycled, ensuring a cost-effective, and sustainable solution.
Helios is focusing on a two-stage process with inputs of iron ore, sodium, and thermal energy. The full process operates at temperatures ranging between 300 to 700°C, with competitive energy consumption, compared to BF or DRIs.
In the first stage, sodium is used as a reducing agent to produce pure metallic iron powder. In the second stage, sodium oxide is thermally decomposed into metallic sodium and oxygen, enabling sodium reclamation for reuse.
The process development can effectively handle high-grade and low-grade ores in various sizes, from fine powder to larger lumps. The process has already demonstrated an impressive metallization rate of up to 90%.
The Helios Cycle is currently being demonstrated at a TRL-5, a scale-up reactor producing 1kg/h iron to achieve a more commercially viable process.
In conclusion, the Helios Cycle offers a sustainable and efficient iron ore reduction method to produce green iron. It brings economic benefits, lowering energy needs and dependencies, while minimizing environmental impact. Advancements and partnerships will drive the steel industry forward and promote a sustainable future.

HYFOR – A newly developed direct reduction process for any type of iron ore concentrate

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The steel industry is one of the main contributors to industrial CO2-emissions and has been targeted to transform into a low carbon economy till 2050. One promising approach to reach this target is the hydrogen based direct reduction.
The integrated BF-BOF and the DR shaft-based EAF route require lumpy input materials as feed stock ensuring a sufficient gas permeability inside the BF or the reduction shaft. Therefore, additional agglomeration steps, e.g., sintering or pelletizing, are required, leading to additional costs (Capex and Opex) and significant CO2-emissions. To overcome these problems, the ongoing HYFOR-process development by Primetals Technologies, is based on the fluidized

bed technology which allows the exclusive use of green or low-carbon hydrogen (H2) as reducing agent, avoiding the formation of CO2 during reduction and the direct use of ore fines without prior agglomeration.

No technology existed till today to directly feed iron ore concentrates (pellet feed) as main iron source without prior agglomeration. The quality of ore from mines is continuously becoming lower (iron content and grain size), while huge amounts of fines (concentrates) are available.

Primetals Technologies developed a direct reduction process, which is suitable to handle charging of iron ore concentrates (grain size <150 µm) directly into the process without need of prior agglomeration and using hydrogen as a reducing agent, named HYFOR (Hydrogen-based fine ore reduction).

Primetals Technologies has a long-lasting experience in the area of direct reduction, smelting reduction and fluidized bed-based solutions (Finored direct reduction process, FINEX® pre-reduction). Based on these competences, the HYFOR process is developed as the most flexible and lowest carbon emission direct reduction technology.

The HIsarna Ironmaking process

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The HIsarna ironmaking process produces liquid carburized hot metal directly from fine iron ore and fine (non-coking) coal in a single step. This means that a single furnace can replace a production route consisting of ore agglomeration, coking and ironmaking.

The process uses pure oxygen (95-99 %) and therefore the off gas is concentrated CO2 which is not diluted with nitrogen. After cleaning and compression the off gas is suitable for CCU/CCS. Furthermore all ironmaking emissions are concentrated at a single stack.

A pilot plant is operated at the IJmuiden site of Tata Steel in the Netherlands to test and further develop the HIsarna ironmaking process. The pilot plant can operate at a capacity up to 8 tons of hot metal per hour.

In the pilot plant a range of raw material qualities has been tested. Low grade iron ores can be used and recycling of waste oxides in possible. LD slag has been added to the process as alternative flux. Because phosphorous mainly reports to the slag this can be done without increasing the phosphor in the metal. The hot metal phosphor is typically as low as 0.03 %.

The HIsarna pilot plant has been operated on a 50/50 mix of coal and bio char (thermally treated biomass) and with steel scrap partially replacing iron ore. This combination of has reduced the use of fossil carbon with more than 50 %.

POSCO's Green & Digital Transformation; HyREX & Intelligent Factory

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The steel industry is providing the bases for modern civilization, producing globally 1.8 billion tons of steel, which results in around 7% of CO2 emissions from the global steel sector. Notably South Korea's steel industry is responsible for 14% of domestic CO2 emission because of the strong manufacturing industry such as automotive and shipbuilding. POSCO equipped with 8 blast furnaces has therefore launched out the innovative R&D project for a green ironmaking, called HyREX (Hydrogen Reduction Ironmaking) that has stemmed from the FINEX technology (Fine Iron Ore Reduction) that is an innovative ironmaking process based on the direct use of fine ore and non-coking coal. In the FINEX process, fine iron ore is directly charged at the top of a cascade of fluidized-bed reactors, where it is heated and reduced to direct-reduced iron (DRI) by means of a reduction gas derived from the gasification of the coal in the melter gasifier. 2.0 and 1.5 million tonnes of commercial FINEX has been successfully operating. In the seminar the concept of HyREX and economic advantage will be discussed.
Further POSCO has applied AI (Artificial Intelligent) technology to more than 90 factories in 2016, which will increase the efficiency and the level of safety. AI enables autonomous operations in several iron-making processes; AI combined with existing physical models and operators enhances productivity, quality, and reduces CO2 emission. Exemplary use-cases for Smart Factory in the steel industry will be shown.

Climate and sustainability trends: Global policy and regulatory moves and implications for Indian industry

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At the United Nation's 26th Conference of the Parties (COP26), India set ambitious targets and committed itself to further boosting its transition towards sustainability. In turn, it has also pushed organizations to begin lowering their emissions. Encouragingly, Indian organizations feel that although India's climate goals are challenging, they can be met with the right regulatory framework and government support. In this, there is a significant potential to generate new green business opportunities and increase their competitiveness in the global market.
Over the past decade, sustainability has emerged as an important issue for organizations. Companies are facing pressure from national and international agencies and acknowledging climate risks & setting sustainability goals. Companies are also recognizing that embracing sustainability helps them attract investments, create new investment opportunities, attract better

talent, and reduce regulatory interventions. The renewable energy value chain has especially emerged as an attractive investment opportunity for companies across industries. Companies are also increasingly driven by consumer demand for more sustainable products. As consumer awareness increases about climate change, they're more likely to demand and be willing to pay a premium for sustainable alternatives.

However, there is a wide variance among companies when it comes to their climate ambitions. While most organizations aim to comply with regulations and have plans to mirror India's commitments, there is a sizeable share of companies that seek to become sustainability leaders in India and across the globe. When it comes to setting climate goals, half the companies surveyed have already started measuring their emissions with clear targets for abatement. Apart from emissions reduction goals, organizations also remain keen on investing in sustainable community development and social inclusion.

The key challenges faced by the organizations in their climate ambitions are multifaceted. Most companies find it difficult to measure, monitor and, impact emissions from their upstream supply chain, especially from lower-tier suppliers. As a result, most organizations haven't yet begun measuring or setting targets for scope 3 emissions. There is also a lack of standard regulations and accounting standards for emissions as well as financial challenges in funding their climate goals.

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