



SCRAP SUPPLEMENTS & ALTERNATIVE IRONMAKING 7

19–21 FEBRUARY 2017 | WYNDHAM LAKE BUENA VISTA

ORLANDO, FLA., USA

ABOUT THE PROGRAM

This is the seventh in a series of symposia covering scrap substitutes and alternative ironmaking, which originated with a highly successful meeting in Myrtle Beach, S.C., USA, in 1993. This meeting was followed by others in Myrtle Beach in 1996, Trinidad in 1999, and Baltimore in 2004, 2008 and 2012. These were initiated by the predecessor Iron & Steel Society's Process Technology Division's Advanced Technology Committee, and the previous symposia, which were international in scope and participation, were associated with a high level of activity in research, process and project development, plant construction, and start-up of direct reduction and alternative ironmaking processes. This symposium will focus on the following areas: successful projects/processes, the challenges of struggling processes and those still under development, new approaches, and use of products.

WHO SHOULD ATTEND

Those engaged in the production, sale, and use of direct reduced iron, pig iron and scrap; managers and engineers from electric furnace and blast furnace-based steel companies; suppliers of iron ore, coal, and natural gas; and steel company, engineering company, academic and research institute personnel engaged in ironmaking process development.



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AIST's Direct Reduced Iron Technology Committee



SCHEDULE OF EVENTS



SUNDAY, 19 FEBRUARY 2017

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4 p.m. Welcome				

MONDAY, 20 FEBRUARY 2017

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8 a.m. Maximizing DRI Product Flexibility — Advancing the MIDREX® Process	10:45 a.m. Coal Gasification Selection for the Production of DRI	1:30 p.m. Direct Reduction, Alternative Ironmaking and Recycling of Steel Mill Waste on Rotary Hearth Furnace	3:15 p.m. Qualities of Heat and the Role of Heat in Ironmaking Processes	
8:30 a.m. High-Carbon DRI Micro-Module for Mining Companies	11:15 a.m. Identification of Overall Key Performance Indices for Improving Plant Performance of Syngas-Based DRI at JSPL, Angul: An Introductory Approach	2 p.m. Case Studies in the Use of Extrusion Agglomeration in the Steel Industry	3:45 p.m. Advanced Simulation and Control Systems of the ENERGIRON Plants	5:15 p.m. Reception
9 a.m. High Carbon — To Be or Not To Be	Noon Lunch	2:30 p.m. Influence of Raw Material Condition on Behavior of Reactive Coke Agglomerate	4:15 p.m. Progress With AISI's Alternative Ironmaking Projects	
9:30 a.m. Break				
9:45 a.m. Developments in Coal-Based DRI				

TUESDAY, 21 FEBRUARY 2017

7 a.m. Continental Breakfast	9:30 a.m. An Update on Charcoal Ironmaking in Brazil	11:15 a.m. Evolution of Steel Dynamics Inc.'s Iron Dynamics Division Operation	1:30 p.m. Reduction of CO ₂ Emissions and Role of the LKAB Experimental Blast Furnace	3:15 p.m. Experiences and Operation Results of Melting Hot DRI in Ternium Guerrero Plant
8 a.m. Early Results From ESS Demonstration Furnace at Mintek in South Africa	10 a.m. Break	Noon Lunch	2 p.m. Sensitivity of CO ₂ to DRP-EAF Technological Choice	3:45 p.m. Technical and Economic Aspects of DRI/HBI Addition in Integrated Steelmaking
8:30 a.m. FINEX® — Maximizing Its Flexibility	10:15 a.m. Numerical Modeling of Mixing Time and Penetration Depth in the IRONARC Process	1 p.m. CO ₂ Breakthrough Program by COURSE50 in Japanese Steel Industry Sector	2:30 p.m. Break	4:15 p.m. Conference Adjourn
9 a.m. Hlsarna Smelting Reduction — A Solution for Sustainable Hot Metal Production	10:45 a.m. Environmental Leadership in Producing Pig Iron		2:45 p.m. Advancing Performance of Nu-Iron's MIDREX® DRI Plant Operation	

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SUNDAY, 19 FEBRUARY 2017

2–4 p.m.
Registration

4 p.m.
Welcome

4:15 p.m.
Overview of Direct Reduction and Alternative Ironmaking Processes and Products

Joseph Poveromo, Raw Materials & Ironmaking Global Consulting

This symposium covers the development and application of alternative (to the blast furnace) ironmaking processes where the objectives include: hot metal processes to feed oxygen converters or electric arc furnaces; direct reduction processes to feed electric arc furnaces or to produce direct reduced iron (DRI)/hot briquetted iron (HBI) to feed blast furnaces, oxygen converters, etc.; direct reduction or hot metal processes to process waste oxides from either electric arc furnace (EAF) mini-mills or fully integrated plants. Accordingly, in this introductory lecture, an overview is presented of these direct reduction and alternative ironmaking processes and their products.

4:45 p.m.
Why Only Midrex and HYL? Could Something Be Better?

Yakov Gordon, Hatch

This presentation begins with processes in Chernov (Russia) and Wiberg-Soderfors (Sweden) and includes the history of direct reduction of iron oxide encounters from about 120 years. More than 40 various processes of direct reduction were developed and tested at pilot-, demonstration- or even industrial-scale plants. However, only Midrex, HYL natural- or synthetic gas-based processes, and rotary kiln coal-based processes successfully managed their pass to broad implementation to industry with numerous installations. While the amount of moles of reduction agent for various processes is the same, the reasons for failure of the majority of direct reduction processes lies in their technical disadvantages, low efficiency, high capital cost and, as a result of all of this, in poor economics. Local factors also played a negative role for success in the implementation of new DRI processes in countries such as Russia and Ukraine. This paper provides some specific features of direct reduction processes developed around the

globe and probable reasons why they could not win a competition with Midrex and HYL processes.

5:15 p.m.
Importance of Understanding Raw Material Value-in-Use for Steelmaking

Jeremy A.T. Jones, CIX LLC, on behalf of International Iron Metallics Association

As EAF steelmakers have started to use a greater variety of raw materials in the furnace, it has become more important for them to be able to distinguish the value that a particular commodity brings to the operation. There are a number of parameters than can be considered and the ultimate value of any material will vary from one facility to another. The International Iron Metallics Association (IIMA) tries to provide information for ore-based materials (OBMs) to the steel industry. IIMA has worked with Continuous Improvement Experts (CIX) to provide a value-in-use tool to the steel industry. This tool can assist steelmakers in better understanding OBMs and how they can best be used in the EAF. This paper will discuss the key concepts and components of a value-in-use model and will demonstrate how the model can be used in real-life situations.

6 p.m.
Reception

MONDAY, 20 FEBRUARY 2017

7 a.m.
Registration and Continental Breakfast

8 a.m.
Maximizing DRI Product Flexibility — Advancing the MIDREX® Process

Chris Ravenscroft and Vincent Chevrier, Midrex Technologies Inc.

Direct reduction iron production and capacity are expanding and will continue to expand capacity dramatically over the next few decades. Several new MIDREX® DRI plants are under construction or have been recently commissioned throughout the world, including the new voestalpine Texas plant in Corpus Christi. These new DRI plants employ cutting-edge technologies for better operational and product flexibility; this flexibility continues to be a key to the success of modern DRI plants and DRI/EAF steelmaking. The MIDREX process provides the operational flexibility needed to produce DRI with a wide quality range. Depending on the geographical location and the final intended use of the product, DRI produced by the MIDREX process can be tailored to optimize EAF operation at each location. This paper will review several scenarios of optimum DRI quality based on the EAF requirements, such as the availability of scrap and utilities as well as how various DRI product specifications such as metallization, carbon and temperature can impact productivity.



8:30 a.m.

High-Carbon DRI Micro-Module for Mining Companies

Angelo Manenti, Tenova Core

Mining companies, big and small, can add significant value to their iron ore by producing DRI, especially if they are operating in a market with an established EAF presence like the U.S., or in a market with poor scrap availability like some regions of South America. The Micro-Module DR plant, thanks to its compact size, more affordable CAPEX and low OPEX, allows for the production of on-site high-carbon DRI and gives the junior mining company the possibility to enter the DRI merchant market and even to become vertically integrated and produce locally high-grade steel. This paper will examine the cases of two mining companies in South America that will use the Micro-Module ZR technology to produce DRI and analyze the reason and advantages of their choices.

9 a.m.

High Carbon — To Be or Not To Be

Sara Hornby, Global Strategic Solutions Inc.

There has been much controversy surrounding direct reduced iron carbon content over the years. Arguments have ranged from 0% carbon to in excess of 4% carbon. The issue will be analyzed considering not only the steelmaking but also the DRI plant operations, since global optimization must be the end game. This paper will discuss impartially and demonstrate the optimization of the amount of carbon contained in the DRI for use in steelmaking in terms of energy, quality, cost and environmental aspects.

9:30 a.m.

Break

9:45 a.m.

Developments in Coal-Based DRI

Vivek Garg, Jindal Steel & Power Ltd.

The production of iron is only an intermediate step in the production of steel from natural resources like iron ore. In places where coking coal is not available but other solid fuels like non-coking coal or gaseous natural gas are available, an alternative method of ironmaking such as coal-based or gas-based direct reduced iron is widely accepted. India is the world's largest producer of DRI, a key material for the production of steel. Over a period of 20 years, JSPL has created a niche in the production of DRI through this preferred route of coal-based rotary kilns. JSPL started its production on 1991 with one 300 TPD kiln, and added five more kilns to become the world's largest coal-based DRI producer with 0.6 MT per annum production. JSPL further expanded by four kilns, resulting in 1.32 MT production per annum. As the global market has grown very competitive, it has become essential for any sponge iron industry to optimize the use of raw materials and byproducts and minimize the cost of production. JSPL's coal-based DRI plant has adopted many innovative and creative methods, such as being the first to use iron pellets in place of iron ore; optimization of its coal consumption by using high-fixed-carbon coal, which has resulted in reduction in energy consumption; applied best maintenance practices; inventory control; and reduction in waste generation.

10:15 a.m.

Breakthrough Ironmaking Technologies Combined With ENERGIRON, Blast Furnace and Syngas

Hiroshi Ichikawa, Nippon Steel & Sumitomo Engineering Co. Ltd.

In 2013, Nippon Steel & Sumikin Engineering (NSENGI), Tenova HYL and Danieli agreed to combine ENERGIRON DR technology into blast furnace technology and/or with syngas technology. This alliance allows the three companies to combine research and development with their respective expertise in ENERGIRON DR technology, blast furnace technology and syngas technology, with the ultimate objective to develop breakthrough technologies and create such engineering, procurement, and construction (EPC) projects. The breakthrough technologies are: (1) charging high-carbon DRI and optimized blast furnace hardware and operation can increase productivity and decrease hot metal cost dramatically; (2) byproduct gas can be converted from power generation to producing high-carbon DRI, considering gas balance and benefit; even if there is shortage of COG, COG can be fed to ENERGIRON by application of the energy-saving facilities of NSENGI; and (3) combination of coal gasification and ENERGIRON can expand the market to non-natural-gas-producing regions.

10:45 a.m.

Coal Gasification Selection for the Production of DRI

Todd Astoria, Midrex Technologies Inc., and John Winter, SES Technologies LLC

Natural gas has fueled the growth of DRI plants and will continue to be an important driver for direct reduction ironmaking growth in the future; however, many iron- and steel-producing regions are facing limitations on the availability of natural gas and/or increasing natural gas prices. As such, alternative fuels such as syngas produced from coal are gaining popularity for the production of DRI. This presentation will review using various grades of coals via the commercially proven SES coal gasification route to produce quality reducing gas for use with the MIDREX® shaft furnace for DRI production in areas where natural gas is not viable.

11:15 a.m.

Identification of Overall Key Performance Indices for Improving Plant Performance of Syngas-Based DRI at JSPL, Angul: An Introductory Approach

Amiy Srivastava, Sabyasachi Bandyopadhyay and Vikas Agrawal, Jindal Steel & Power Ltd.

The gas-based DRI process generally uses natural gas as a reducing agent for producing direct reduced iron; however, access to natural gas for running gas-based DRI is limited at most of the sites in India. The use of synthesis gas (syngas) in place of natural gas solves the problem of producing DRI where natural gas is unavailable. Syngas-based DRI is a slightly different process from conventional natural-gas-based DRI in terms of handling syngas as a reducing agent. The paper explains the difference in the overall process of producing gas-based DRI when using syngas. The advantages and disadvantages of using this route for producing gas-based DRI are also listed in this paper. Syngas-based DRI at JSPL Angul is almost complete after two years from commissioning.

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The experience of the plant running is also briefly discussed in this paper. In order to understand the DRI shaft furnace performance collectively, effective use of reducing gas was analyzed by implementing a Zero-D model for calculation of gas utilization into the distributed control systems. Theoretical calculation was matched with the gas balance data sheets of different DRI modules. A brief description about the calculation is provided in this paper. Quality of input pellet was also analyzed for the syngas-based DRI process and the reason for the requirement of stringent pellet quality for such process is discussed briefly. On the basis of above-mentioned studies, certain key performance indices have been monitored.

Noon

Lunch

1 p.m.

Use of Standards in Determining Suitability of Iron Ores for Direct Reduction Applications

Thomas Battle, Extractive Metallurgy Consultants

The direct reduced iron industry has grown tremendously in the last 40 years, with up to as much as 75 million metric tons of product per year. This requires more than 100 million metric tons of iron ore. In the current environment of globally traded iron ore, it is possible for any DR plant to use a large number of different ores from different locations, with various physical and chemical properties. How does a facility determine which ore(s) provide the greatest value in use? While ultimately plant-scale tests are required to determine the performance of a particular ore, it is much cheaper and more convenient to conduct tests in the laboratory. Manufacturers' tests evolved into ASTM and ISO international standards that are used worldwide today. The tests developed for analysis of physical characteristics of pellet and lump ores will be discussed, and both successes and failures will be considered. There will also be consideration of recent lab tests that have not yet become standards.

1:30 p.m.

Direct Reduction, Alternative Ironmaking and Recycling of Steel Mill Waste on Rotary Hearth Furnace

Romain Frieden, Vulcanus Consulting LLC, and Giulio Grossi, Anmar

The rotary hearth furnace (RHF) has been one of the leading technologies for coal-based direct reduction,

alternative ironmaking and recycling of steel mill waste since the 1960s. Most of the installations built over the last five decades have shown the same flaws, i.e., they did not reach the design capacity and had operation and maintenance costs higher than planned. This presentation will show how the limitations of the RHF technology can be overcome. The systematic analysis of results of trials on different laboratory furnaces and pilot plants and the operational results of industrial operations has allowed for improvement of the RHF technology so that it can overcome most of the traditional shortfalls that have caused the limited production rates and too-high cost.

2 p.m.

Case Studies in the Use of Extrusion Agglomeration in the Steel Industry

Zane Voss, Voss Metallurgical Solutions, and Mac Steele and Jim Falter, J.C. Steele & Sons

Recovery and recycling of iron-containing byproducts has long been a topic of interest in the steel industry. In many cases, the byproducts are in the form of fines or sludges, making direct use in metallurgical vessels challenging. Various forms of agglomeration have been used to recover these materials for use in blast furnaces, rotary hearth installations and steelmaking furnaces. This paper will review a number of case studies in the steel industry where extrusion is used to effectively and efficiently agglomerate byproduct materials into a valuable, usable product.

2:30 p.m.

Influence of Raw Material Condition on Behavior of Reactive Coke Agglomerate

Staoshi Kogure, Hirokazu Yokoyama, Kenichi Higuchi, Takashi Orimoto and Seji Nomura, Nippon Steel & Sumitomo Metal Corp.

An increase of carbon gasification rate lowers the thermal reserve zone temperature in blast furnaces and reduces carbon consumption of blast furnaces. To increase the carbon gasification rate, the enhancement of coke reactivity and close arrangement of fine iron ore and carbonaceous materials have been investigated. One of them is reactive coke agglomerate (RCA). RCA had high carbon content and showed very high reducibility, and RCA enhanced the reduction of surrounding sinters by mixing RCA in the sinter layer. A reduction in thermal reserve zone temperature and an increase of gas utilization by mixing RCA in sinter layer were confirmed with a long-term plant trial conducted at the Oita Works No. 2 blast furnace. As a result, carbon consumption was decreased 0.36 kgC/THM per 1 kgC/THM of input carbon from RCA.

3 p.m.

Break

3:15 p.m.

Qualities of Heat and the Role of Heat in Ironmaking Processes

Wei-Kao Lu, McMaster University

Heat must be supplied to bring raw materials up to process temperature and to sustain endothermic reactions and melting in high-temperature operations. In order to gain the advantages of high temperature in



kinetics and thermodynamics, adequate supply of heat and heat transfer from its source to reactions sites must be considered. For current successful practice, productivity of blast furnace and shaft furnaces is basically limited by the rate of heat supply. For the well-investigated smelting reduction operations, primary causes of failure, in the author's opinion, are heat supply and heat transfer. Difficulties in rotary kiln and rotary hearth operations originate from the qualities of the heat. The concept of quality of heat, with respect to iron ore reduction, will be introduced, and its importance in the development of new processes discussed.

3:45 p.m.

Advanced Simulation and Control Systems of the ENERGIRON Plants

Dario Pauluzzi and Daniela Dalle Nogare, Danieli Centro Metallics

The ability to properly set and continuously maintain the optimum operating parameters of a direct reduction plant consistently keeps the desired product quality at the lowest production cost. ENERGIRON developed new technologically advanced tools to optimize design and operation control of its direct reduction plants. During the design stage, the implementation of kinetics of the reactions occurring in the direct reduction process into a thermo-fluid-dynamic model allows for the reproduction of the behavior of an ENERGIRON reactor, in terms of solid material flow, metallization and total carbon content of the DRI. Therefore, this is a perfect tool to assess the optimal design parameters for each different project and achieve the highest efficiency. Furthermore, an advanced level 2 control system can be installed on each ENERGIRON plant, comprising virtual sensing, dynamic process simulation for the optimal control setpoints generation and mapping of the internal thermochemical state. In this way, operators can understand what is happening inside the reactor and receive the suggested setpoints to maintain the targeted product quality, while optimizing consumptions and the iron oxide charge mix.

4:15 p.m.

Progress With AISI's Alternative Ironmaking Projects

Lawrence Kavanagh, American Iron and Steel Institute

AISI's collaborative research and development programs include two ironmaking projects. The paired straight hearth furnace is a deep-bed DRI process utilizing a linear hearth and operating with virgin materials and waste oxides. The Novel Flash Smelting project, underway at the University of Utah, utilizes iron ore fines in a reactor vessel with natural gas as fuel. Updates on the progress of both technologies will be provided.

4:45 p.m.

Development of a New Technology for Converting Iron-Bearing Materials to Nodular Reduced Iron (NRI) for Use in Various Steelmaking Operations and the Potential for Converting DRI Into NRI

Donald Fosnacht and Richard Kiesel, University of Minnesota Duluth

For the Minnesota iron ore industry to remain competitive in the near-term future, value-added iron products must be produced to diversify its

portfolio. A process for converting iron-bearing raw materials into highly metallized nodular iron was developed in the course of this development and was previously presented. This product is very similar to iron nuggets produced by other carbothermic processing methods. High-quality nodular reduced iron (NRI) can be routinely produced, provided the right choice of temperature profile, atmosphere control and additives are employed. During the course of development, key knowledge in terms of atmosphere control, carbon dissolution, slag separation and production of low-sulfur nodules was discovered. Simulation of natural gas-based DRI processes and conversion of DRI from natural gas-based reduction processes to NRI through a separate "nuggetizing" furnace will also be discussed.

5:15 p.m.

Reception

TUESDAY, 21 FEBRUARY 2017

7 a.m.

Continental Breakfast

8 a.m.

Early Results From ESS Demonstration Furnace at Mintek in South Africa

Louis Fourie, EnviroSteel

Mintek and EnviroSteel are collaborating to promote the use of the ESS process. A demonstration unit equal to half of a full-scale cell is built with the aim of testing various raw materials that potential customers need to process. The focus is on metal oxide smelting with different reducing agents, with the aim of reducing costs while minimizing specific carbon footprint. Basic principles employed will be described and how each one is taken into account in the design and operation of the furnace. The hybrid process makes use of (1) small particles for rapid heating and short distance diffusion, (2) hot combustion air obtained from exchanging heat with the offgas, (3) single layers of composite micropellets, ensuring high-radiation heat transfer rates, and (4) electrical melting of the reduced metal particles and slag components.

8:30 a.m.

FINEX® — Maximizing Its Flexibility

Sang-Ho Yi, Minyoung Cho and Moo Eob Choi, POSCO

FINEX® has been developed to provide the capability to lower environmental pollution and to promote operational flexibility in response to the challenges toward innovation and development in the ironmaking sector. In less than 25 years, the FINEX process has already shown a high competitiveness compared to the blast furnace route. The process is noted by the following features: economic benefit from the elimination of coking and sinter plants; flexibility in raw material selection by using a wide range of iron ores and non-coking coals; beneficial byproducts by the generation of highly valuable export gas for various purposes (electric power generation, DRI production or natural gas substitution); synergetic combination with the blast furnace in the brownfield application at integrated steel works; and ecological benefit by lowering

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the process-related emission rates (low NO_x, SO₂/H₂S and dust emissions), which will be presented in detail.

9 a.m.

Hlsarna Smelting Reduction — A Solution for Sustainable Hot Metal Production

Jan van der Stel, Koen Meijer and Christian Zeilstra, Tata Steel R&D, and Rod Dry, Rio Tinto

The steel industry is producing about 5% of the worldwide CO₂ emission. Therefore, the European steel industry has defined a research program to reduce the CO₂ emission by 50% per ton: ULCOS. Since its start in 2004, ULCOS has identified four technologies for further development, one being the Hlsarna smelting reduction process. The Hlsarna process reduces the ironmaking route, presently consisting of three steps, to a single step. With this change, some significant advantages can be realized: reduced energy consumption, resulting in less CO₂ emissions; reduced costs of operation, maintenance and sustaining of capital; fewer requirements for the raw materials and increased ability for recycling secondary raw materials and economical at smaller unit size; and increased flexibility. These process characteristics have been confirmed during experimental campaigns with the Hlsarna pilot plant at the Tata Steel site in IJmuiden, The Netherlands. Four such campaigns have been completed since 2010. The main results of the developments and campaigns and the future outlook will be discussed. In the last campaign, a stable production rate of 7 t/h was achieved — 88% of the plant's capacity. A new campaign was planned for 2016. The emphasis of the pilot plant work will shift from testing the process viability with various raw materials to investigation of operational aspects like stability, availability, maintainability and controllability. For this reason, the next campaign will focus on operational aspects in a so-called "endurance test" of the process and the equipment.

9:30 a.m.

An Update on Charcoal Ironmaking in Brazil

José Noldin, Lhoist Group, and Henrique Pfeifer, Minitec Minitechnologies Ltda

Charcoal-based hot metal and pig iron is a raw material of great purity and high value-in-use, which is being increasingly used as a scrap supplement in the EAF, mainly in Brazil. This stresses the point that charcoal-based iron, besides its quality appeal, is economically competitive in countries like Brazil, even without consideration of carbon

credits. Charcoal-based iron production relies on three old processes: forestation, charring or charcoal making, and the blast furnace.

While forestation and the blast furnace have undergone remarkable technological improvements, especially over the last 25 years, charcoal making is still widely based on primitive, millenarian practices, featuring low yield, waste of energy and polluting emissions. New processes under development are attempting to raise the procedure to 21st century level. This paper gives an overview of the evolution and present status of the charcoal-based ironmaking industry in Brazil, highlighting examples on planted forests' general requirements, charcoal fines injection in coke-based blast furnace tuyeres, burden metallization of coke-based blast furnaces using charcoal-based pig iron and use of charcoal-based pig iron in steelmaking.

10 a.m.

Break

10:15 a.m.

Numerical Modeling of Mixing Time and Penetration Depth in the IRONARC Process

Maria Swartling and Matej Imris, SCANARC Plasma Technologies AB, and Kristofer Bolke and Mikael Ersson, KTH

IRONARC is the new process for pig iron production, with high flexibility of the physical properties of the charged material. This process uses plasma generators for the melting and reduction of the iron oxides. The plasma generators heat a carrier gas that is injected through submerged nozzles into the slag bath of the reactor. The process does not require coke and the energy for heating comes from electricity, which gives the opportunity to reduce CO₂ emissions. In this work, computational fluid dynamics (CFD) was used to study both the penetration depth of the injected plasma jet and the mixing time. The numerical findings were compared with results that conformed well to the results from the water models. The mixing process was very fast with a mixing time well below 1 minute.

10:45 a.m.

Environmental Leadership in Producing Pig Iron

Liz MacKenzie and Francis MacKenzie, North Atlantic Iron Corp.

North Atlantic Iron Corp. (NAIC) is a private Canadian company organized to develop North America's first dedicated merchant pig iron (MPI) production facility in Canada. NAIC's mission is to be a value-added manufacturing company that will complement, not compete with, Canada's iron ore miners. NAIC will produce MPI by reducing iron oxide pellets in a gas-based direct reduction module and smelt the resulting direct reduced iron in an electric arc furnace. NAIC will be one of the lowest-cost producers of MPI in the world on a delivered basis to the iron foundry and EAF steel industries of the United States and Europe. NAIC will be able to achieve this due to a production process that utilizes access to low-cost raw materials, iron ore, natural gas and electricity in Canada. The case is further strengthened with immediate proximity to markets in the United States and Europe — delivering significant cost and time savings.



11:15 a.m.

Evolution of Steel Dynamics Inc.'s Iron Dynamics Division Operation

Conrad Fisher and David Bednarz, Steel Dynamics Inc. – Iron Dynamics Division

This paper will outline the development of the Iron Dynamics (IDD) facility from a virgin iron ore and metallurgical coal-based operation to one utilizing steel mill secondary materials to produce liquid pig iron used in Steel Dynamics Inc.'s adjacent Flat Roll Group Butler operation. This process has evolved over the past 17 years, promoting recycling while reducing costs and providing a secure and adequate supply of liquid pig iron. Over the past two years, IDD has consumed 764,000 tons of mill scale and related material sourced from steel mills throughout the region and 53,000 tons of dust that were repurposed as iron units rather than entering a landfill — providing a low-cost, recycled alternative to virgin iron ore.

Noon
Lunch

1 p.m.

CO₂ Breakthrough Program by COURSE50 in Japanese Steel Industry Sector

Koji Saito, Nippon Steel & Sumitomo Metal Corp.

Since FY2008, four Japanese blast furnace steelmakers and one engineering company have been working on the CO₂ Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50 (COURSE50) project, which is one of the national projects commissioned by the New Energy and Industrial Technology Development Organization of Japan, aimed at developing powerful new CO₂ emission mitigation technologies for steel works. The goal is to mitigate those emissions in the steelmaking process by approximately 30% under the pre-condition of establishment of economic rationality of the process and availability of CCS infrastructure. This is done through a technology that reduces iron ore using hydrogen-amplified coke oven gas to curb CO₂ emissions from blast furnaces and that separates and recovers CO₂ from blast furnace gas utilizing unused exhaust heat from steel works. In this presentation, an overview of the COURSE50 project is provided.

1:30 p.m.

Reduction of CO₂ Emissions and Role of the LKAB Experimental Blast Furnace

Nicklas Eklund, LKAB Minerals AB

LKAB is the number one pellet producer in Europe and one of the world's leading producers of upgraded iron ore products for the steel industry. As a mining company, LKAB does not own a commercial blast furnace for ironmaking; instead, the LKAB Experimental Blast Furnace (EBF) was erected to close the knowledge gap between pelletizing and blast furnace operation. At the end of 1997, the EBF was blown-in. With the EBF it is possible to overcome the vast step between laboratory-scale testing and the operation of commercial blast furnaces. The EBF is used successfully not only for developing new blast furnace products; it is also an excellent tool for testing different process conditions. In 2004,

the ULCOS project was launched to explore and develop breakthrough technologies regarding CO₂ emissions. ULCOS stands for "Ultra-Low CO₂ Steelmaking." Results from three campaigns has been successfully tested. In correspondence with the European initiative, blast furnace steelmaking companies in Japan have started the COURSE50 Project (CO₂ Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50). Hydrogen reduction trial using the EBF has been conducted with high H₂-containing gases such as coke oven gas or reformed coke oven gas. Recently SSAB, together with LKAB and Vattenfall, has launched a project called HYBRIT (Hydrogen Breakthrough Ironmaking Technology) to investigate the possibility of hydrogen-based sponge iron production to drastically reduce CO₂ emissions.

2 p.m.

Sensitivity of CO₂ to DRP-EAF Technological Choice

Pablo Duarte, Tenova HYL

Steelmaking is an energy-intensive process where the integrated blast furnace (BF)-basic oxygen furnace (BOF) route represents more than 70% of world steel production. The balance of production comes from the scrap-based EAF route, the gas-based DR EAF and coal-based DR-EAF routes. However, the BF-BOF is the least efficient and most polluting route and represents 82% of steelmaking energy consumption and 88% of steelmaking CO₂ emissions. In the U.S. the situation is the opposite, since the EAF route accounts for more than 63% of the country's total. The path for the future is clearly marked by what is happening in North America, a continuous move to electric steelmaking and the adoption of direct reduction, shifting the steelmaking industry from coal to gas — whether natural gas or alternate reducing gas sources — with the consequence of a drastic decrease in CO₂ emissions. Selective elimination of CO₂ for sequestration, commercialization and use for manufacturing of other products is an added value to further decrease the carbon footprint. In that scenario, the ENERGIRON® DR technology represents a unique process to achieve those results. This technology is designed to comply with the regulations and restriction that the steelmaking industry is facing and will have to face in the future, thanks to the possibility of an impressive reduction of CO₂ emissions to less than 20% compared to the coal-based BF-BOF route. This paper includes the analysis of CO₂ abatement and recovery through the ENERGIRON process and the consequences on a worldwide scale to reduce the concentration of CO₂ in the atmosphere.

2:30 p.m.

Break

2:45 p.m.

Advancing Performance of Nu-Iron's MIDREX® DRI Plant Operation

Curtis Moore, Nu-Iron Trinidad and Tobago

In September 2004, Nucor acquired the Louisiana assets of American Iron Reduction, a 1.2-million-ton-per-year cold DRI (CDRI) plant utilizing MIDREX® DRI Technology. Nucor relocated the plant to Point Lisas, Trinidad, in 2005, and in the process increased the capacity to 1.6 million

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metric tons per year. The new plant, Nu-Iron Unlimited, commenced start-up of DRI production on 30 December 2006. The plant is the largest shipper of CDRI in the world, and has produced more than 14 million tons of CDRI since start-up, which has been successfully shipped to, and melted in, Nucor mills in the USA. Nu-Iron represents the standard for cold DRI production. Looking to push technology and performance even further, Nu-Iron also established a Direct Reduction Engineering and Technology Team in coordination with Midrex Technologies Inc. This paper will introduce Nu-Iron Trinidad and explore measures employed to enhance the operation and productivity of the plant, including both equipment and product modifications.

3:15 p.m.

Experiences and Operation Results of Melting Hot DRI in Ternium Guerrero Plant

Marco Herrera, Juan Martinez, Mohamed Gassemi, Hector Garza and Carlos Rangel, Ternium Mexico

In 1998, the direct reduction iron process was improved with the development of the HYTEMP® system, coupling the HYL 4M direct reduction reactor, with the DC electric arc furnace by a pneumatic conveying of hot DRI. The 4M direct reduction iron plant at Ternium Guerrero was the first industrial installation operating with the HYTEMP system. Since that time, the production of high-carbon hot DRI has been one of the main drivers of the continuous improvement of productivity of the DC electric arc furnaces, increasing the annual production to 2.4 million tons of liquid steel. The present work describes the conceptual considerations regarding the 4M DRI – HYTEMP process, the coordination between the direct reduction plant and the DC electric arc furnace operation, and results of melting hot DRI after 17 years of operation with the HYTEMP system.

3:45 p.m.

Technical and Economic Aspects of DRI/HBI Addition in Integrated Steelmaking

Janice Bolen, Hatch

DRI or HBI production in the United States is of increasing interest due to low natural gas prices. Alternative iron units (DRI, HBI or pig iron) can be added to the electric arc furnace to dilute scrap residuals or replace purchased scrap, added to the BOF to displace purchased scrap, or added to the blast furnace to decrease coke rate and increase productivity. This paper considers the technical issues and economics of production of DRI/HBI using DR-grade iron ore pellets and addition to the blast furnace or basic oxygen furnace. The use of a BF-grade pellet with lower metallization in the DR reactor will also be considered to see if this improves the economics of HBI addition to the blast furnace.

4:15 p.m.

Conference Adjourn

ORGANIZING COMMITTEE

Michael Riley

Praxair Inc.

Joseph Poveromo

RMI Global Consulting

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Tenova Core

Jeffrey Myers

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Frank Griscom

Koji Saito

Nippon Steel & Sumitomo Metal Corp.



REGISTRATION

US\$795
AIST Member

US\$1,010
Non-Member

REGISTRATION FEES

Advance registration by 9 January 2017: Member US\$795, Non-member US\$1,010.

Registration after 9 January 2017: Member US\$895, Non-member US\$1,110.

REGISTRATION INCLUDES

Registration includes a welcome reception on Sunday evening, continental breakfasts and lunches Monday and Tuesday, a reception on Monday evening, and a seminar workbook or flash drive.

HOTEL ACCOMMODATIONS

A block of rooms has been reserved at The Wyndham Lake Buena Vista. Please call the hotel at +1.800.624.4109 by 20 January 2017 to secure the AIST discount rate of US\$159 per night for single/double occupancy.



Association for Iron & Steel Technology
186 Thorn Hill Road
Warrendale, PA 15086-7528 USA
+1.724.814.3000 • Fax +1.724.814.3001 • AIST.org

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UPCOMING EVENTS



- ▶ **Rod and Bar Rolling — A Practical Training Seminar**
20–23 February 2017 | Atlanta, Ga., USA
- ▶ **Cold Rolling Fundamentals — A Practical Training Seminar in conjunction with System Automation Fundamentals**
5–9 March 2017 | Indianapolis, Ind., USA
- ▶ **System Automation Fundamentals in conjunction with Cold Rolling Fundamentals — A Practical Training Seminar**
6–9 March 2017 | Indianapolis, Ind., USA
- ▶ **The Making, Shaping and Treating of Steel: 101**
7–9 March 2017 | Dearborn, Mich., USA
- ▶ **Specialty Alloy and Foundry — A Practical Training Seminar**
13–16 March 2017 | Mobile, Ala., USA
- ▶ **Steel Mill Combustion and Thermal Systems**
21–23 March 2017 | Nashville, Tenn., USA
- ▶ **International Symposium on New Developments in Advanced High-Strength Sheet Steels**
30 May–2 June 2017 | Keystone, Colo., USA
- ▶ **24th Annual Crane Symposium**
11–13 June 2017 | Pittsburgh, Pa., USA

