The Value of DRI: using the Product for optimum Steelmaking

NEWS & VIEWS: ESISCO HOTLINK® Plant gets ready for Commercial Operation

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People have often asked me the question “how would you define Midrex?”

That is tough to do in just a few words, but I’ll try.

From the beginning, Midrex set out to be its own type of company. The engineers who developed the MIDREX® Direct Reduction Process were the ones who went to the field for the installation, start-up and optimization of the first plants. That tradition continues today and is a big reason why Midrex is known for providing innovative, practical ironmaking solutions.

Another early business decision, to license the technology rather than own the plants, is a cornerstone of the success that Midrex has experienced over the last 45 years. The synergistic relationship of our Technical Services experts and Midrex Global Solutions staff with the operating plants keeps MIDREX® Direct Reduction Technology on the cutting edge. It allows us to deliver sound solutions to the business challenges customers might face throughout the lifetime of their plants.

Through the years our goal has been to provide the most effective pairing of technology innovation and practical experience so our customers can meet and often exceed their business objectives. This means designing durable equipment and reliable systems that provide the performance and flexibility a plant owner needs to keep pace with changing market conditions. We like to say that MIDREX® Plants have no expiration dates or geographic boundaries.

So, again, what is Midrex? Regardless of the company tag you put on Midrex, it comes down to the people. People are our most important resource, and in a manner of speaking, our most valuable product. It was our people who took an idea of how to innovate the direct reduction of iron ore and made it into the most widely used DRI technology in the world. Today Midrex’s people can be found throughout the world working closely with Construction and Process Licensees and key suppliers to discover the next innovation of direct reduction technology.

In this issue of Direct From Midrex, we kick off a series of articles that will introduce the human side of Midrex. Throughout 2015, we will profile four key groups, Engineering (in this issue), Global Solutions, Research & Development and Commercial (Marketing & Sales), and feature some of the rising leaders of the company.

We are pleased to publish an article by ArcelorMittal Montreal describing how they use high quality DRI to produce steel in the most cost effective way possible. The MIDREX® Module 1 at ArcelorMittal Montreal’s Contrecoeur, Quebec, Canada, works has been in operation since 1973.

Rounding out this issue is an update on the progress toward start-up and operation of the latest MIDREX® HOTLINK® Plant in Sadat City, Egypt, owned by Egyptian Sponge Iron and Steel Company (ESISCO), an operating unit of Beshay Steel.

Midrex was founded on the idea of combining process, people and performance to innovate how iron metallics for steelmaking are made. Through the years this synergy of purpose has established a corporate culture based on ingenuity, initiative and experience, which when put into motion, has delivered value for our customers unparalleled in the industry.

Midrex is by design a process technology company, but it is also a company that finds innovative solutions for its customers. Midrex is a project development/management company as well as a plant services company. In short, Midrex is whatever it needs to be for its customers. Our aim is to provide our clients with the most beneficial paring of technology and expertise.

Midrex is successful because of its human factor. It’s our people who rise to the challenge day in and day out to provide sound technological and engineered solutions and to bring even greater value to our customers.
Midrex engineers are as accustomed to being at a plant site as they are to being in the office behind a computer. From the start-up and commissioning of the first plant in 1969, Midrex engineers have run calculations, devised control loops and designed specialized equipment and then gone to the field to put them into action.

Midrex attracts a special breed of engineers – people who question how things are done, but are eager to learn; people who are adventurous, but responsible; and people who strive for individual achievement while contributing to the success of the team.

Within Midrex Engineering there is a culture of personal “ownership” of the technology and a camaraderie borne of a common purpose: to maintain the technical excellence the industry has come to expect of MIDREX® Direct Reduction Technology.

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Midrex is first a technology company. Most similar type and size companies are content to license their technology and have a passive role in how it is used. Midrex is different because it also is an engineering and technical services company, which allows Midrex to take an active role in every project.

The involvement of Midrex from basic design through the supply of aftermarket services and materials assures customers that their MIDREX® Direct Reduction Plants will have long and productive lives. For example, some plants, such as Arcelor Mittal Hamburg (formerly Hamburger Stahlwerke, GmbH), ArcelorMittal Montreal 1 (formerly Sidbec-Dosco I) and Tenaris Siderca (formerly Dalmine Siderca) are into or entering their fourth decade of reliable operation.
CONTINUING THE MIDREX TRADITION

Although computers have replaced drawing boards and e-mail has supplanted the fax machine, the development of engineers within Midrex remains true to tradition. The leads in three of the groups within the Engineering Department are good examples of how Midrex insures its technology remains in touch with the realities of plant operations and performance while striving for the next innovation and improvement.

Let’s start with Geoff Wallwork, Chief of Process Engineering for Midrex. Wallwork developed an early appreciation for the theory of the MIDREX® Direct Reduction Process through interaction with senior Midrex process engineers and a propensity for computer modeling. His deep understanding of process fundamentals and control loops has been honed in the office and the field, where Wallwork has been involved in numerous task forces assigned to troubleshoot and optimize plant systems.

Wallwork has participated in the start-up or optimization of every type of direct reduction plant that Midrex designs, from shaft furnace-based plants utilizing natural gas or syngas from coal to rotary hearth furnace-based plants. His chemical engineering background, office training, and field experience with real-life operation of MIDREX® Plants has served him well in recognizing process and safety aspects associated with the plant design, construction and improvement.
“How often do you get to come up with an idea, see it take shape, and be part of putting it into action?” asked Wallwork. “That, and the opportunity to travel to interesting places that most people don’t know exist are for me what makes Midrex a special place to work.”

Brian Voelker is Midrex’s Chief of Proprietary Equipment. Voelker joined Midrex with a degree in mechanical engineering and experience designing equipment and systems for pre-heating, conveying and melting scrap steel. Early in his Midrex career, Voelker participated in the start-up and commissioning of the MIDREX® Hot Briquetted Iron (HBI) Plant for COMSIGUA in Venezuela. His hands-on experience with a MIDREX® Hot Discharge Reduction Furnace coupled plus his involvement with methods for handling and charging heated scrap have produced patents for charging hot DRI (HDRI) to a melter and a system for combination discharge of cold DRI (CDRI) and HDRI from a reduction furnace.

Voelker also has been instrumental in the design and optimization of rotary hearth furnace (RHF) technology at Midrex. Again, true to Midrex tradition, he followed his equipment designs for the RHF-based FASTMET® Process and ITMk3® Process from computer to pilot plant in Japan to commercial plant in Minnesota.
The make-up of his group reflects the nature of Midrex Engineering. ‘I have people with 39 years to less than three years of experience,’ Voelker remarks. Their interaction and mutual respect are what keep us sharp and productive.’

CHRIS HAYES
Chief - Mechanical Engineering

FIELD ROLES
Project Engineer/Manager & Auditor
Lead Mechanical/Project Engineer
Lead Mechanical/Project Engineer & Mechanical Engineer
Mechanical Engineer
Commissioning & Start-up/Upgrades & Additions Project Manager
Project Manager
Project Engineer/Manager
Project Manager
Lead Mechanical/Project Engineer
Lead Mechanical Engineer & Project Manager
Lead Mechanical Engineer & Start-up/Field Service/Engineering Support
Project Engineer
Project Manager
Project Engineer
Project Engineer
Project Manager – Commissioning & Start-up

PROJECT (MIDREX NG™ unless noted)
Antara Steel Mills
COMSIGUA NG Pre-Heat System
Hadeed A, B, C Studies, Upgrades & Additions
Hadeed E
Shadeed Iron & Steel LLC† (HOTLINK™)
JSW Dolvi Works COG Study
LISCO 1, 2, 3 Studies, Upgrades & Additions
Lion DRI Dust Collection Engineering
Qatar Steel I Upgrades & Additions
Qatar Steel II Upgrades & Additions
OEMK I, II, III Upgrades & Additions
Tenaris Siderca Production Upgrade
Tenaris Siderca Water System Study
Nu-Iron Study & Expansion
Nu-Iron Furnace Reline
Tuwairiqi Steel Mills

SITE
Labuan, FT, Malaysia
Matanzas, Venezuela
Al-Jubail, Saudi Arabia
Al-Jubail, Saudi Arabia
Sohar, Oman
Raigad, India
Misurata, Libya
Banting, Malaysia
Mesaieed, Qatar
Mesaieed, Qatar
Gubkin, Russia
Campana, Argentina
Campana, Argentina
Point Lisas, Trinidad & Tobago
Point Lisas, Trinidad & Tobago
Karachi, Pakistan

† now Jindal Shadeed
Rounding out the profiles is Chris Hayes, Chief of Mechanical Engineering for Midrex. Hayes has first-hand appreciation of the seemingly unlimited potential of MIDREX® Direct Reduction Technology. He spent most of his first 10 years with Midrex designing and optimizing in the field equipment and systems to boost the performance of existing MIDREX® Plants. With a mechanical engineering degree and knowledge of civil engineering, Hayes has served as project engineer, project manager or mechanical lead on 13 greenfield and brownfield Midrex projects in 12 countries.

Hayes has built strong relationships with key vendors to facilitate a seamless transition of plant needs into practical solutions. His experience in new plant design and commissioning & start-up teams, as well as in a broad range of engineering assignments for Global Solutions, the field and technical services arm of Midrex, has prepared Hayes to transform situations into opportunities for the mutual benefit of Midrex and its Process Licensees.

“Working shoulder-to-shoulder builds respect and confidence. This holds true whether in the office or in the field,” Hayes observed. “It’s what we do with the earned respect and confidence that produces value.”

ENGINEERING, THE MIDREX WAY
Midrex Engineering has a long tradition of attracting talented technical people and totally immersing them in the process of creating innovative technologies and using them to design, start-up and commission the direct reduction industry’s most successful plants.

A Midrex engineer is surrounded from the start by seasoned professionals, both within Midrex and from among its Construction Partners and Process Licensees. It’s the resulting interaction and mentoring that instills a sense of belonging and the perception of ownership of the technology.

Go to the site of a MIDREX® Plant currently under construction or in start-up & commissioning and most likely you will meet a future Midrex executive or maybe even a president. Then stop by the Midrex offices because on any given day, you will find several generations of Midrex engineers working side-by-side. That’s “the Midrex way”.

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**DIRECT FROM MIDREX**
INTRODUCTION

The use of direct reduced iron (DRI) and DRI products is constantly on the rise and will be for the foreseeable future. DRI production in 2013 hit 75.22 million tons compared to only 23.65 million tons twenty years prior in 1993 and only 49.5 million tons in 2003. Accordingly there are very few individuals even remotely associated with the iron and steel industry that do not know of DRI and its forms as Hot DRI (HDRI), Cold DRI (CDRI) and Hot Briquetted Iron (HBI). But DRI like other metallics can vary in its makeup. There are numerous product properties but only a few that have an immediate, direct and significant effect on the overall iron/steel production process, especially in the electric arc furnace (EAF). Optimizing these variables relative to one another is critical to reducing the total operating cost of iron and steel production. The question often asked is, “What are the properties of the best DRI?” Although some would have us to believe there is one utopian answer, the truth is remarkably different. The better question to ask may be “how can DRI best help our operations.” At AM Montreal, our objective is to maximize liquid steel output while reducing the utility costs to an optimum level. The past four decades of operations has led us to determine that metallic content and physical quality are paramount.

SITUATION

To set the stage, ArcelorMittal not only has the largest capacity for DRI production in the world, the company also has the complete suite of DRI process technologies, operating both MIDREX® Process and HyL Process shaft furnace/reactor plants as well as rotary kiln plants. Further, our history of DRI production is extensive. Our MIDREX® Module 1 at Arcelor Mittal Montreal has been in operation since 1973. The reason we operate these direct reduction plants is very simple; we need high quality low residual metallics for production of steel via the most cost effective route possible.

The use of DRI for ArcelorMittal in general, and more specifically at ArcelorMittal Montreal, is dependent on several factors including; costs versus that of comparable scrap, utility price of natural gas and electrical power, specification for the steel being produced and environmental impact. As with any issue, there are both positive and negative aspects of using DRI. Figure 1 (following page) indicates the relative movement of the price for DRI versus Busheling. One can easily see that there is in most cases a raw cost advantage with charging DRI versus scrap and at this time the total operating cost of steel production with DRI is $50 per ton less than that using Busheling.
USING DRI

The advantages of DRI include: predictable chemistry, low tramp material content, carbon and foamy slag formation, lower capital and operating costs, relatively uninterrupted continuous iron making, EAF feed adjustment via blending with lower quality feed material (usually scrap), and less back charging. Figure 2 indicates EAF yield variation when charging DRI compared to scrap loading. It is quite obvious that charging DRI is advantageous to hot metal quality.

Notwithstanding these advantages there are disadvantages as well. These include; additional energy to melt gangue material, increased slag handling, potential for DRI chute blockage, increased bag-house dust and fines, higher refractory costs, lower yield and, in the case of CDRI versus HBI, there are additional procedures that must be taken for storage, handling and transportation.

With all of this being said, the advantages of DRI in regards to its value to steelmaking operations far outweigh the disadvantages. Being in a position of supplying DRI primarily for internal use we frequently monitor and test the quality of our DRI to assure we are meeting the needs and expectations of our “customer” which in this case are our own meltshops.

Of course DRI is not 100% Fe. It inherently contains some portion of non-reduced iron oxide, carbon and any other components contained within the feed material. Whatever the case, the primary reason for feeding DRI is its iron content. Normally DRI produced from an “EAF grade” iron oxide material, formally referred to as “DRI grade”, will contain 91% to 93% total iron depending on the initial feed material properties. Direct reduction, as the name implies, reduces these pellets into metallic iron by removing oxygen from FeO to produce a product that is typically 92% to 96% metallized (Fe). Metallization is the percentage of metallic Fe out of the total iron content.

The rate of metallization depends on the DRI process and how it is operated, typically the higher the metallization rate, the lower the production rate and higher the specific consumptions rates for natural gas and electrical power. Further, in addition to gangue materials, the DRI will contain some quantity of carbon. In the EAF, this carbon can be used to first complete the reduction of the final fraction of the 4% to 8% iron oxide not reduced after which carbon in the product, can be useful for the formation of CO to produce...
foamy slag above the EAF’s melt line. Carbon is also of course needed to meet the required carbon content in the final steel produced, and it also, can be used to add chemical energy to the EAF to lower the electrical consumption of the EAF. Figure 3 indicates the composition of typical DRI produced at AM Montreal.

One must look at the requirements of the meltshop and the economics of the DRI plant operation to determine what chemistry is optimum for his/her overall operation. Specifically the total iron content, degree of metallization and carbon content must be controlled to optimize the overall cost and throughput of the total cycle. Minimizing gangue content and reducing fines, (<5%) are beneficial regardless of the balance of the chemistry. Accordingly, for all practical purposes, the DRI quality can be defined based on two types of characteristics: those that are created by the DRI process such as degree of metallization, carbon content, and those that reside independent of the process such as the gangue content in the raw materials and fines concentration. See Figure 4*.

The relationship of changes in any one of these variables upon the EAF are indicated in Figure 5.

Ultimately the purpose of using DRI is to provide metallic iron to the meltshop, thus DRI is of better value to us if we can get more Fe to the meltshop. Metallization, fines, gangue and carbon all represent potential limitations to this goal.

When addressing these properties, metallization, carbon and fines may be effected by the process. Whatever gangue, predominantly silica, is fed to the DRI plant is discharged as part of the product as the reduction process only removes oxygen from the product, not gangue materials. In any case, less is better when considering the total gangue in the DRI feed material. For reference see Figure 6 (following page) indicating the cost of increasing gangue content by one percent.

It should also be noted that fines can be created in the DRI process itself, but in this case we are referring more to the generation cause in normal handling of the raw materials and finished product. In any case, the more fines generated can be viewed as a loss of iron that could otherwise be utilized in the steelmaking process.

To minimize electricity consumption and increase efficiency, the goal is to have as much metallic iron as possible.

* There are other items that could be included as part of these two characteristics, but these list the main items that effect our operation.
meaning having a high rate of metallization (%Fe out of FeO). For every additional percent of metallized iron charged to an EAF there will be improvements in EAF yield, EAF productivity, EAF power consumption, refractory degradation and electrode degradation. Based on our experience at AM Montreal these relative effects are indicated in Figure 7.

As just stated, the real reason one uses or buys DRI is for its metallized iron content. Addition of any other component such as gangue materials and even carbon decreases the total iron in a charge. With that said, carbon is necessary in the EAF. The primary reasons are: reduction of the remaining non-metallized iron oxide in the DRI, formation of foamy slag, to meet the carbon specification in the steel being produced, and as additional chemical energy to the EAF thus reducing the electric power requirement. Figure 8 indicates the benefit of adding one full percent carbon to the EAF based on our experience at AM Montreal.

CONCLUSION

The value of the DRI is based on at least four major qualities, none of which are uniform, but all affect every operation. Our objective is to maximize liquid steel output from the EAF while reducing the utility costs to an optimum level. Over decades of operations we have determined that metallic content and physical quality are paramount. In any case we wish to start with the best raw materials (iron oxide feed materials) possible in order to have the least possible gangue and minimize fines generation. After that we need to maximize our Fe content even further through making DRI with high metallization. Based on our current utility, ore and scrap prices along with the production and quality demands of our onsite customer we are producing DRI at 94% to 95% metallization and 2.0% to 2.2% carbon. Ideally the EAF melt shop would prefer 95% to 96% metallization, but our DRI plants must do a continuous balancing act to assure optimum operations. Other AM DRI plants run at similar metallization rates with carbon levels ranging between 2.2% to 2.7% so even within our own company the optimum rates differ, yet the primary focus is still the Fe first. Please also note that in our scenario at AM Montreal we are looking at CDRI only, as that is reflective of our operations. HBI & HDRI share similar favorable qualities as CDRI, however, in the case of HDRI, temperature of the product is a major factor to increased EAF efficiency, without sacrificing metallic content.
MIDREX News & Views

NEAREST DRI PLANT IN EGYPT BEGINS COMMISSIONING:

ESISCO HOTLINK® Plant gets ready for Commercial Operation

The auxiliary burners of the MIDREX® Reformer were lit in mid-March at the MIDREX® HOTLINK® Plant in Sadat City, Egypt, beginning the refractory dry-out process. This is a major milestone in the plant start-up, which is expected to result in the first DRI production in several weeks. The 1.76 million tons per year (Mt/y) plant supplied for Egyptian Sponge Iron and Steel Company (ESISCO) is designed for simultaneous discharge of hot DRI (HDRI) and cold DRI (CDRI). The HOTLINK® plant configuration allows HDRI to be charged directly into an adjacent electric arc furnace (EAF).

ESISCO is an operating unit of Beshay Steel.