

DIRECT FROM MIDREX

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Commentary

Old Math: Direct Reduction Plant Contracts On The Way!!!

"One plus one equals two."

- Bertrand Russell.

Sometimes, it's necessary to prove the obvious.

In 1998, after the onset of the Asian crisis, and the resultant collapse of steel scrap prices (and DRI/HBI prices), one of our competitors was quoted in the press as saying that sales of direct reduction plants have no correlation to the value of their product, DRI. That is, he was saying the industry sells plants in times of low scrap steel prices just as it does in times of high scrap steel prices.

Admittedly, this statement seemed true. Midrex had signed contracts for construction of MIDREX® Direct Reduction Plants at times when the prices of scrap steel and of DRI were at painfully low levels.

But, it just didn't feel right believing that the sales of our plants occurred randomly, without any need for economic justification. There had been quite a number of direct reduction units sold to governmental entities; entities which, once they had made a decision, could and would, go forward without any recognition of economics. Are we working in a field where the whim of politicians created good and bad fortune?

So, I went to the Midrex World Direct Reduction Statistics book to obtain a list of all operating gas-based DR plants, then to both Midrex and my files to find the contract date for each unit. For those that I couldn't find a date, I used the start-up date and backed up by thirty months (or, if I remembered it to be a quick or a slow project, I backed up by twenty-four or by thirty-six months, respectively).

A comparison to steel scrap prices, using American Metal Market's #1 HMS three-city composite, showed a good, strong correlation. Whenever scrap prices rose, contracts tended to be signed about one or two years later. Adjusting the scrap prices for inflation made the correlation clearer. But the rate of additional capacity added-on grew far more quickly in recent years than in the early years of the industry.

This is apparently an effect of the maturity of the technology. It is easier to trust, and easier to finance, a well proven technology than a new and unproven one.

Let's look at a graph of the data.

The y-axis is newly contracted capacity as a fraction of prior existing capacity. That is, at a time when existing capacity was 10 million tons per year, a contract for a new one million ton per year facility would be 0.1 on this axis. But, once 50 million tons per year of capacity are built, a contract for a new one million ton per year facility would only register 0.02 on the axis. This odd axis is used to 'compensate' for the "proven technology" effect mentioned above.

Then finally, to pull in outliers and to make the correlation more visually appealing, both the x-data (scrap steel prices) and the y-data (fraction of existing capacity added) have been smoothed by using a three-year running average.

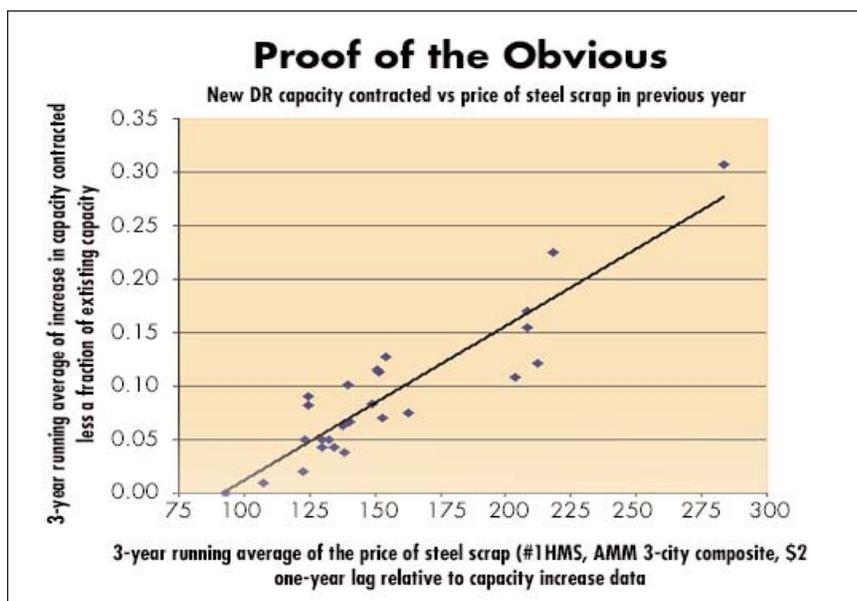
The overall conclusion from this graph and exercise?

Scrap prices have been relatively high for nearly a year and it's time to begin selling plants again.

In fact, Midrex has already signed an MOU with Al Gaith Holdings in the UAE for the first gas-based plant of the new millennium. This plant will be the first HOTLINK® MIDREX Direct Reduction Plant and no doubt the first of many more yet to come.



Robert Hunter
Product Marketing and
Applications



Status of Developing Iron & Steelmaking Technologies

New Technologies Nearing Commercial Reality

By Rob Cheeley, P.E., Sales Manager
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Introduction

The realities of worldwide economics and environmental challenges have created demand for new iron and steelmaking processes that are environmentally sensitive, represent a low investment cost, and demonstrate the least cost of operation. These new technologies are suited for different economic, geographic and fuel scenarios, providing solutions for the current realities of the market.

This article discusses the status of new technologies nearing commercial reality, including ITmk3[®], HOTLINK[®], FASTEEL[™], and FASTOx[™]. Projections of greenhouse gas emissions and energy requirements for these new ironmaking / steelmaking routes will be compared to the conventional routes of making high quality steel via integrated steelmaking (BF + BOF) and electric steelmaking (mix of cold metallic iron and scrap steel as feed).

New Ironmaking Technologies

For more than a decade Midrex and Kobe Steel have been actively working together on new technologies for iron and steelmaking that are environmentally sensitive, represent low investment costs, and demonstrate low costs of operation around the world. These technologies include both natural gas-based direct reduction and rotary hearth furnace technologies based upon commercially proven technologies.

Rotary Hearth Technology

Midrex and Kobe Steel have been actively developing rotary hearth furnace (RHF) based DRI technologies for more than 10 years. The basic RHF technology, FASTMET[®], has been commercially proven with two plants operating in Japan.

Currently, the commercialization of the next generation of RHF-based technologies is under way. These new RHF technologies include ITmk3[®], FASTOx[™] and FASTEEL[™]. Each is designed to meet the specific project requirements to enable the plant operator to maximize production efficiency and profitability. All three of these technologies take advantage of the knowledge gained from the development and operation of the FASTMET Process.

For those unfamiliar with the RHF-coal-based direct reduction concept, the rotary hearth furnace is a flat, refractory hearth rotating inside a high temperature, low pressure, circular tunnel kiln. A water seal is used to "seal" the interface between the rotating hearth and the tunnel kiln preventing air or flue gas leakage. Prepared feed to the RHF consists of a composite agglomerate (either pellets or briquettes) made from a mixture of iron oxide fines and a fine carbon source, such as coal, coke fines, charcoal or other carbon-bearing solid. The agglomerated feed is placed on the hearth evenly, one layer thick.

Burners located above the hearth provide heat required to raise the feed agglomerates to reduction temperature and start the



Hirohata FASTMET



Kakogawa FASTMET

process. The burners are fired with natural gas, fuel oil, waste oil, or pulverized coal. Most of the heat required for maintaining the process is supplied by combustion of volatiles, which are liberated from the heated reductant, and combustion of carbon monoxide, which is produced by the reaction of carbon reducing metallic oxides. The agglomerates are fed and discharged continuously and stay on the hearth for less than one revolution, typically 6 to 12 minutes, depending on the reactivity of the feed mixture and target product quality.

New Midrex/Kobe Steel RHF Technologies:

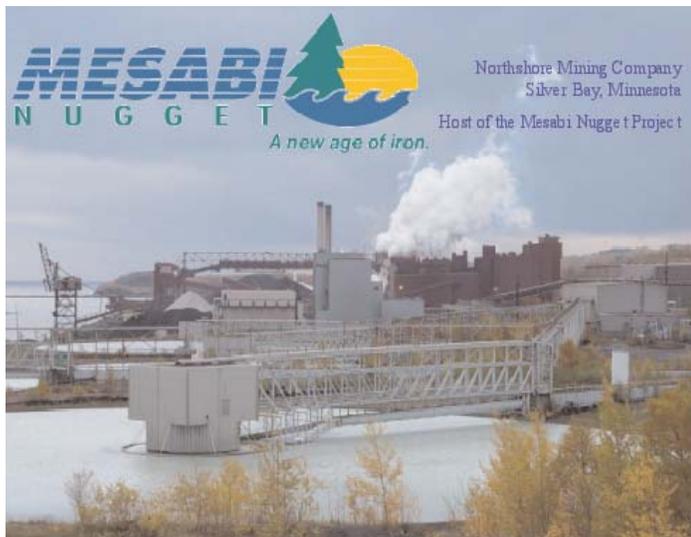
ITmk3®

The Process/Technology

ITmk3 represents the next generation of modern ironmaking technology, processing iron ore fines into almost pure pig iron nuggets in only ten minutes. The result is a conveniently-sized, slag-free material ideally suited for further processing by conventional technologies into high quality steel products and foundry iron castings.

Purpose/Market

The ITmk3 Process is the ideal vehicle for iron ore mining companies to supply pig iron grade nuggets directly to the EAF steel-making industry. ITmk3 nuggets are a metallurgically clean, dust-free source of alternative iron for high quality EAF steel-making. ITmk3 nuggets are not prone to reoxidation and do not require special handling during shipment. Because of their convenient form, they can be continuously fed for higher productivity and lower liquid steel cost.



Commercial Status

The Mesabi Nugget demonstration plant at the North Shore taconite plant in Silver Bay, Minnesota, USA is now operational. The 25,000 tpy plant successfully operated 24 hours per day for 35 days in June and July 2003, meeting its targets for productivity and product quality. The high quality iron nuggets have been

successfully used by Steel Dynamics in their EAF located in Butler, Indiana, USA. The Mesabi Nugget plant was restarted in September after making some minor equipment modifications.

The next step is to build a commercial scale ITmk3 plant. Negotiations are underway for a full-scale (between 300 and 500 kt/y) plant to be built in the USA.

FASTEEL™

The Process/Technology

FASTEEL is the result of collaboration between Midrex, Kobe Steel and Techint Technologies, merging the hot metal producing benefits of FASTMELT with the continuous scrap feeding and preheating of CONSTEEL® to produce high quality steel. These processes working together provide a new method of steel-making that offers significant environmental improvements, higher quality product, lower capital cost and less expensive operation than traditional methods of production.

Purpose/Market

FASTEEL provides both economical and environmental benefits for current and potential steelmakers. FASTEEL offers an alternative to future shutdowns of blast furnaces, coke ovens and sinter plants. It is more environmentally friendly because there is a reduction in the overall emissions of the steel mill, and iron units are recovered from waste oxides. Economic benefits include cost reduction of raw materials, elimination of need for BF pellets and coke, reduction of energy required for liquid steel and reduction of waste through recovery of iron units from waste oxides. Higher quality grades of steel can be produced than with scrap alone, and at more economical costs. Furthermore, FASTEEL combines 1/3 FASTIRON hot metal from FASTMELT with 2/3 preheated scrap from CONSTEEL to produce as much as 2.2 million tonnes of liquid steel from only one EAF. Projected FASTEEL capital cost is in the range of \$125/tonne liquid steel.

Commercial Status

Hot metal additions to the CONSTEEL process have already been successfully developed at Shaoguan Iron and Steel in China. Hot Metal from FASTMELT can be produced using the EIF® (Electric Ironmaking Furnace) as developed by Midrex and EMCI (now Techint Technologies, Inc. – CORE Furnace). The EIF has been proven at pilot plant scale and has its advantages over conventional EAFs and SAFs. It has been designed for extended refractory life, high availability and to handle the higher levels of slag expected from coal-based hot DRI.

FASTOx™

The Process/Technology

FASTOx is a new integrated steelmaking process combining FASTMELT Ironmaking with Basic Oxygen Steelmaking. Conventional blast furnace pelletizing, sintering, and cokemaking are eliminated. Significant reductions in ironmaking energy consumption and greenhouse gas emissions are realized compared to other ironmaking processes.

Purpose/Market

The FASTOx Process provides a new integrated method of high quality steelmaking for areas without economical scrap supplies, or clients with pre-existing BOF equipment. The FASTOx Process can use locally available iron ore fines and non-coking coals, coke fines or charcoal. Sufficient waste heat can be made available to allow for self-sufficient cogeneration of electrical power. FASTOx may be applied for either carbon steel or stainless steel production. FASTOx modules range in capacity from less than 200,000 tpy to more than 500,000 tpy of liquid steel production, and even higher with multiple FASTMELT units feeding a single BOF.

Commercial Status

Kobe Steel is discussing a project with the Nigerian Federal Ministry of Power & Steel to install a FASTOx plant at the Ajaokuta Steel Company steelworks. This steelworks was built with assistance from the Soviet Union in the 1970's, but was never operated. The integrated steelworks consists of a blast furnace, three 150 t BOF's, and related downstream steelmaking operations.

The FASTOx plant will be used in-place of the out-dated blast furnace. The hot metal produced in the EIF will be decarburized by the existing BOF's. Production of liquid FASTIRON at Ajaokuta is expected within 30 months of contract effectiveness.

Natural Gas-Based Technology

In 2002 the MIDREX® Direct Reduction Process was the leading direct reduction technology. For the 16th consecutive year, MIDREX Plants produced over 60 percent of the world's DRI. The MIDREX Process is about to take another leap forward. Optimization of DR/EAF production and energy efficiency has taken an evolutionary step with the close coupling of a MIDREX Shaft Furnace and an EAF to achieve increased productivity and energy savings in the production of high quality steel. The concept, HOTLINK®, provides a simple, reliable and economical means for hot charging DRI to an adjacent electric arc furnace using gravity to transport the high quality hot DRI (HDRI).

HOTLINK®

The Process/Technology

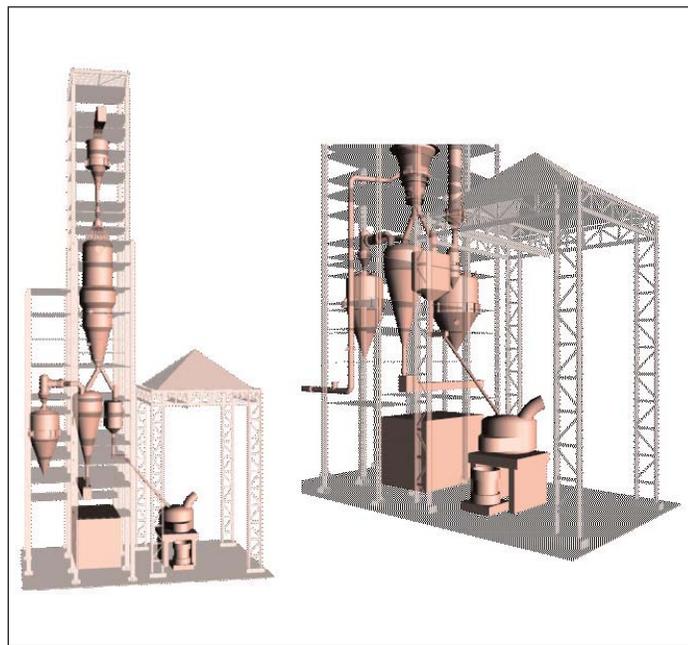
HOTLINK is based on proven technology and simple design philosophy. By using gravity transport, HDRI degradation, metalization and temperature losses are minimized. Easy to operate, the HOTLINK system allows no HDRI re-oxidation and has the flexibility to produce any combination of DRI or HDRI based on proven MIDREX® Technology.

HOTLINK delivers HDRI to the EAF between 700°C and 750°C. Midrex pioneered the continuous gravity-flow direct reduction plant design, as well as the hot discharge furnace feature. HOTLINK places a MIDREX Hot Discharge Furnace just outside and above the exterior wall of the meltshop.

This provides the opportunity to discharge directly from the shaft furnace to a hot DRI surge bin and then from the surge bin directly to the EAF by gravity. This configuration of gravity-fed

hot DRI has been used on all MIDREX HBI plants to produce more than 55 million tons since 1984.

HOTLINK Modules are equipped to handle any upset conditions via the hot DRI surge bin. The primary goal of the arrangement shown is to supply hot DRI to the EAF as the demand requires it. However, the plant must also be capable of switching to the production of cold metallics for stockpiling without any interruption in production of hot DRI.



3D Hotlink Models

Purpose/Market

The benefits from hot charging DRI are very well known and obvious. These include reduced power and electrode consumption as well as lower refractory wear, and most importantly, increased EAF productivity.

The concept of hot charging is not new. In fact, several facilities have successfully charged HDRI into an EAF and have realized significant savings. These hot charging facilities have either used hot transport containers, hot inclined conveyors, or pneumatics to deliver the hot DRI to the EAF. While these hot transport methods work, they all suffer from mechanical wear issues, loss of DRI temperature, higher fines generation and availability problems.

To address these problems, Midrex has developed the HOTLINK design, which is the ideal hot DRI transport solution for a new DRI plant / EAF combination. HOTLINK utilizes gravity as its main transport mechanism to deliver hot DRI directly into the EAF. By close linking the MIDREX DR Plant and the EAF and utilizing gravity, the problems with availability, DRI temperature loss and mechanical wear are significantly reduced.

HOTLINK is designed so that any hot DRI not being hot charged can be cooled to ambient temperature or briquetted to make HBI. This design feature allows maximum DRI production without reliance upon the EAF availability.

Commercial Status

Midrex and Al-Ghaith Holdings (UAE) have signed a pre-engineering contract to start work on a new mini-mill and MIDREX® Direct Reduction Plant using the industry's first HOTLINK® system to feed Hot Direct Reduced Iron (HDRI) to the new mini-mill. (See following article on page 7)



In addition, the HOTLINK System is offered as a feature in several recent proposals for new MIDREX DR Plants.

Energy Use and Carbon Emissions

Today's steelmakers are under increasing pressure to minimize net energy consumption per ton of liquid steel and reduce CO² emissions. The new Midrex technologies discussed here are all capable of accomplishing both of these goals.

The calculated energy consumption and CO² emissions for several steelmaking processes are compared here. All of the processes evaluated are capable of making high quality steel.

Production Processes

The production processes evaluated include:

- Conventional integrated steelworks (BF/BOF) feeding 90% hot metal and 10% scrap steel to the BOF
- Typical U.S. mini-mill making high quality steel with a feed mix to the EAF of 30% cold DRI and 70% scrap steel.
- Mini-mill with a captive DRI plant and an EAF feed mix of 80% cold DRI and 20% scrap steel
- Mini-mill feeding 30% iron nuggets produced by the ITmk3 process and 70% scrap to an EAF
- Mini-mill using FASTEEL, a combination of 40% FASTIRON and 60% Consteel as its feed to an EAF
- Mini-mill using FASTOx, a combination of 90% FASTIRON and 10% scrap as its feed to a BOF
- Mini-mill with a captive DRI plant utilizing the HOTLINK System. The EAF feed is 80% hot DRI, 15% cold DRI, and 5% scrap steel

For the purposes of the energy and CO² emissions calculations, the blast furnace and DRI processes include the required upstream pelletizing process.

The energy requirements include all typical electricity, coke, coal, natural gas, fuel oil, oxygen and limestone inputs to convert the raw materials into liquid steel. The CO² emissions are based on standard energy to CO² conversion factors (see Table 1).

Conclusion

Midrex and Kobe Steel's new technologies for iron and steel-making are on the verge of commercial reality. These processes include both natural gas-based direct reduction and rotary hearth furnace technologies based upon commercially proven technologies; and for the past decade they have been developed to meet

PROCESS COMPARISON

Process	Energy Consumption (GJ / t liquid steel)	Carbon Emissions (kg CO ₂ / t liquid steel)
BF/BOF	16.8	1959
30% cold DRI/ 70% scrap	10.4	702
80% cold DRI/ 20% scrap	18.2	1163
30% ITmk3/ 70% scrap	11.9	876
FASTEEL	10.2	895
FASTOx	16.4	1467
HOTLINK (100% HDRI)	18.9	1209

CONVERSION FACTORS

Input	Units	Energy Value (kcal / input unit)	Carbon Emission (kg C / input unit)
Electricity	kWh	2,646*	0.153**
Natural Gas	Nm ³	9,518	0.065
Coke	kg	7,149	0.122
Coal	kg	7,492	0.106
Fuel Oil	kg	9,801	0.087
Oxygen	Nm ³	3,175***	0.184
Limestone	kg	0	0.12

* Equivalent thermal energy required to generate delivered electricity

** Carbon conversion based on standard OECD data

*** Based on 1.2 kWh of electricity required to generate 1 Nm³ of oxygen

Table 1

the realities of worldwide economics and environmental challenges of iron and steelmakers.

Projections of greenhouse gas emissions and energy requirements for these new ironmaking / steelmaking routes are favorable when compared to the conventional routes of making high quality steel via integrated steelmaking (BF + BOF) and electric steelmaking (mix of cold DRI and scrap steel as feed).

These new technologies also represent environmental sensitivity, low investment costs and demonstrate least cost of operation suited for coal and gas-based direct reduction solutions.

This paper was originally presented at the final AISE Conference in September 2003 in Pittsburgh, PA.

HAMIL STEEL to Construct MIDREX HOTLINK®-based Mini-Mill

Midrex Technologies, Inc. (USA) and Al-Ghaith Holdings (UAE) have signed a pre-engineering contract to start work on a new mini-mill and MIDREX® Direct Reduction Plant using the industry's first HOTLINK® system to feed Hot Direct Reduced Iron (HDRI) to the new mini-mill.

The new facility named HAMIL STEEL will be the Middle East's newest electric-arc-furnace-based mini-mill and will utilize HOTLINK's HDRI to produce approximately 300,000 tpy of steel billets. HDRI will be delivered at over 700°C to a newly designed VAI/FUCHS electric arc furnace for the production of high quality, low-cost liquid steel.

The HAMIL STEEL DR-EAF combination will be the world's first to utilize the patented and proprietary HOTLINK® Technology. About half of the HDRI will be fed directly to the EAF and about half will be delivered to a hot briquetting system for the production of approximately 250,000 tpy of HBI.

"This project represents the next evolutionary step forward for DR-based mini-mills" Robert Klawonn, VP of Commercial for Midrex Technologies, Inc. said. "We are confident that our close relationship with VAI will assure smooth project execution and maximum benefit for the client."

The half-million tpy MIDREX® Plant will be Midrex's ninth plant designed and constructed to discharge HDRI. Since 1984, MIDREX® Hot Briquetting Plants in Malaysia, India, Venezuela

and Libya have produced more than 55 million tons of HDRI in the form of HBI. Hot transport and charge of HDRI has been further proven using the MIDREX® Direct Reduction Process in recent years by Essar Steel. Essar has been transporting its HDRI directly to the nearby meltshop by container in batches up to 90 tonnes.

The details of the MIDREX/FUCHS agreements and launching of HAMIL STEEL were announced at the Metal Bulletin 7th Middle East Iron & Steel Conference on December 17, 2003.

"Al Ghaith elected to work with Midrex because of our proven reliability and demonstrated performance history in the iron making industry," stated Jim McClaskey, President and COO of Midrex. "We are extremely pleased that they have decided to work with us on an exclusive basis and as our partners, we also appreciate the fact that the Al-Ghaith group will help Midrex pioneer our breakthrough HOTLINK Technology into the steel making industry."

According to Midrex, HAMIL STEEL will benefit from the proven reliability of the MIDREX

hot discharge furnace and the FUCHS EAF. Relatively low capacities, in comparison to other recently announced projects, will be complemented with an even lower total investment cost as HAMIL STEEL will rely upon project execution leadership by Advance Projects Development (Al-Ghaith's EPC arm).



Midrex Awarded Patent for KWIKSTEEL™

New Technology for Continuous Steelmaking

In late November, Midrex was awarded a patent for KWIKSTEEL™ a new environmentally-friendly technology to implement continuous steelmaking, the next evolution for competitive steelmakers.

KWIKSTEEL is the combination of the proven MIDREX Hot Discharge gas-based plant technology and the new RHF technology of Kobe Steel's ITmk3® to produce a continuous stream of very low carbon steel nuggets.

This technology has application where DR grade pellets / lump are available with cheap natural gas. The bulk of the reduction and heating will be done with gas, while the RHF will be fed with some solid carbon and natural gas to finish the reduction and separate the gangue from the metallic iron. KWIKSTEEL will produce a continuous stream of low-sulfur steel nuggets without gangue at 1000°C. This can then be fed to a continuous melter.

Once ITmk3 is commercialized, all components of KWIKSTEEL technology will have been demonstrated.

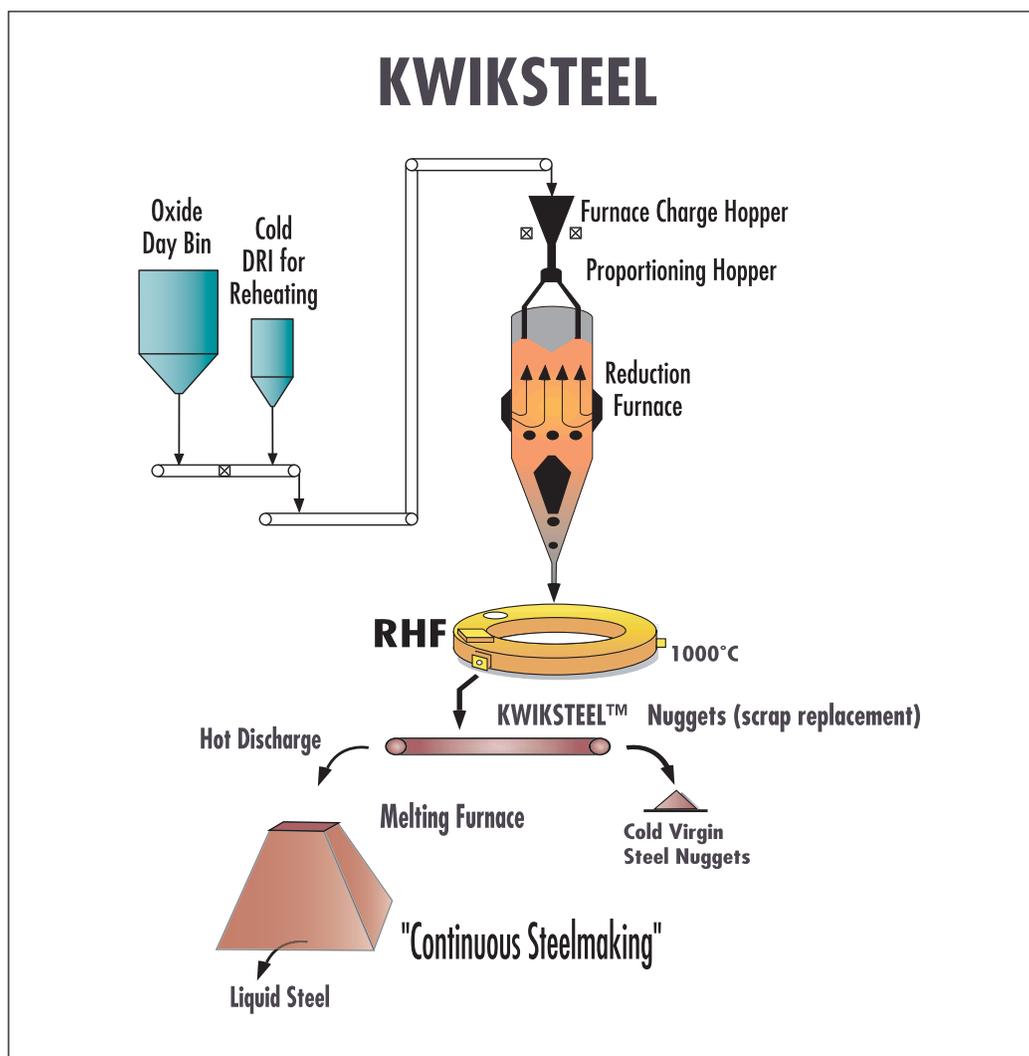
More about KWIKSTEEL

KWIKSTEEL's nugget temperature will be considerably higher than ITmk3's and this higher temperature will make the product very attractive from a re-melting standpoint. There is plenty of sensible heat contained in the discharged product that can be utilized in a connected melter. Thus, the power required to finish melting hot steel nuggets into liquid steel would be very low.

The major advantage of KWIKSTEEL is that steel can be

produced without oxygen. Another benefit is that very little slag is evolved. The iron yield from DR oxide pellet and/or lump through the KWIKSTEEL process is expected to be very high. The RHF will act to remove sulfur from the iron.

All other steelmaking processes (BOF and EAF) are discontinuous (i.e. batch) and use oxygen injection and oxy-fuel burners to generally reduce the carbon and silicon content in the heat, melt the slag components and supplement the electric energy.



COMSIGUA

ACHIEVES FIVE YEAR PERFORMANCE MILESTONE



More Than Six Million Metric Tons and Counting

In October Complejo Siderurgico de Guayana, C.A. (COMSIGUA) celebrated the fifth anniversary of its MIDREX® HBI Plant. Located in Puerto Ordaz, Venezuela, COMSIGUA is the world's largest DR module for the production of HBI and continues to exceed HBI product quality targets with 93.5% metallization and 1.0 - 1.2% carbon content.

In addition to celebrating this milestone, COMSIGUA also reached the 5,000,000 ton production mark in February earlier this year only four and a half years after start-up and despite years of historically low metallics prices. To date COMSIGUA has produced more than six million metric tons of product. The plant has also averaged nearly 120% of production capacity during its first five years of operation and achieved over 130% of its annual rated capacity during 2003.

COMSIGUA was established in May 1996, and the Plant Supply Contract was signed in June 1996 between COMSIGUA and Kobe Steel Ltd. (Japan), to build a merchant MEGAMOD® (one million ton/year production) hot briquetted iron (HBI) plant. Construction of the plant was completed in July 1998

(25 months after signing the contract), and the commissioning work started in August 1998. The plant was constructed by Kobe Steel Ltd. on a full turnkey basis. The construction period lasted from June 20, 1996 to July 23, 1998 (25 months), which is one of the shortest times on record in building this type of plant.

COMSIGUA began commercial production of HBI on October 1998, shipping its first commercial product on October 22, 1998. More recently COMSIGUA set a new monthly record of HBI production of over 126,000 tons during October 2003.

During the past five years the plant has steadily reported excellent performance, setting the standards high for the iron making industry while making a significant contribution to Venezuela's HBI export market.

Last year COMSIGUA set another new annual production record that was 1.2 percent higher than its previous record through improvements in availability, notwithstanding the Venezuelan national crisis, which curtailed the local natural gas supply at year-end 2002.

Midrex News & Views



AIR

Nucor Announces Option to Purchase Assets of American Iron Reduction

Nucor Corporation has entered into an option to purchase the assets of the idled American Iron Reduction ("AIR") plant in Convent, Louisiana. The AIR facility consists of a 1.2 million tpy MIDREX MEGAMOD that was initially commissioned in January 1998 and due to economic factors, including historical high natural gas prices, ceased operations in September 1999.

Nucor is the largest steel producer in the United States and is the nation's largest recycler. Nucor and affiliates are manufacturers of steel products, with operating facilities in fourteen states. Products produced are: carbon and alloy steel — in bars, beams, sheet and plate; steel joists and joist girders; steel deck; cold finished steel; steel fasteners; metal building systems; and light gauge steel framing.

SIMA Holds 11th Annual General Meeting

The 11th Annual General Meeting of the Sponge Iron Manufacturers Association (SIMA) was held this September in New Delhi, India. At the meeting SIMA appointed new officers including Sandeep Jajodia as Chairman and P. R. Dhariwal as Vice Chairman of SIMA for a two-year term (2003-2005). Jajodia is currently Vice Chairman and Managing Director for Monnet Ispat Limited and Dhariwal serves as Executive Director for Essar Steel Limited.

MISSION STATEMENT

Midrex Technologies, Inc. will be a leader in design and integration of solids and gas processes. We will meet or exceed performance expectations, execute projects on time, enhance existing product lines, and provide value-added design, procurement, logistics and field services to our clients. We will develop new business opportunities that will challenge our employees and maintain the economic vitality of our company. Our employees are the key to our success, and we are committed to encouraging them to grow professionally and personally.

Christopher M. Ravenscroft: Editor

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