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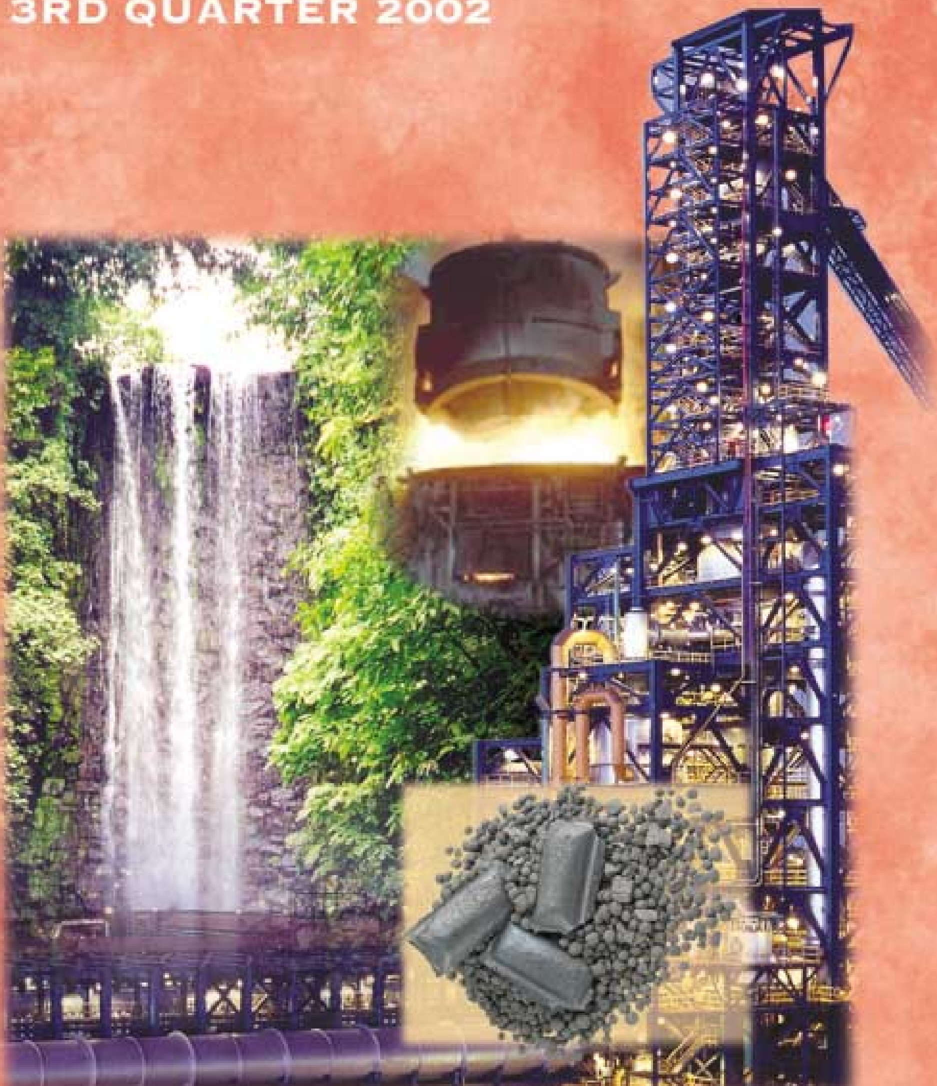

Educated Use Of DRI/HBI EAF: Energy Efficiency and Yield

FASTEEL™: Examining the Potential for the Steel Industry

Kobe Steel Signs Basic Agreement for FASTMELT® Plant

Mesabi Project Gets Department Of Energy Funding

www.midrex.com

Commentary

Metallics Solutions for Steelmaking… Thinking Outside The Box

Sara Hornby Anderson
Manager
Steelmaking/Melting Programs

A Renaissance in steelmaking thinking is needed to ensure global competitiveness and survival. Downsizing, amalgamation and globalization of survivors will not be enough. The industry must "look after the pennies; the pounds (of steel, that is) will look after themselves."

For years, dedicating manpower to use in-house tools for process monitoring and practice optimization has been a low priority for all but a few. Apart from the obvious energy balance issues (low efficiency from charged or injected C and significant energy losses to the fume system), potential energy sources from charge materials and other process details are overlooked (see "Educated Use of DRI/HBI" in this issue of *DFM*). With full operational understanding, a true "value in use" for charge materials can be defined, including the cost of adjusting standard operating procedures to reflect the different chemical inputs and downstream yield benefits.

To satisfy future metallic charge material needs, alternative iron units (AIU) must be considered (see "Whassup" paper at www.midrex.com). "Outside of the box" options can significantly reduce total energy use to produce a tonne of liquid steel and increase productivity, as well as to have a positive effect on greenhouse gas emissions.

In the past decade, Midrex has ventured beyond the traditional gas-based process to ensure its ability to satisfy site-specific needs. With a "smorgasbord" of AIU sources from which to choose, Midrex offers steelmakers the broadest range of options in the industry – from conventional natural gas-fired, shaft furnace-based cold or hot DRI and/or HBI to coal-fired, rotary hearth furnace-based (RHF) options including FASTMET® DRI, FASTMELT® Hot Metal, FASTEEL™, FASTOx® liquid steel, ITmk3® pig iron pellets, and KWIKSteel® low C steel pellets. In short, Midrex can assist steelmakers to optimize their processes in both natural gas- and coal-rich countries.

The RHF processes can convert landfill or steel mill wastes (EAF and BF/BOF dust, sludges, scale, etc.) either on-site or, for economies of scale, at a centralized/regionalized processing plant, into hot metal (HM), pig iron (PI), or DRI/HBI that are specific to the end-users' wishes and logistics. This assists in achieving "Zero Waste" mandates, as well as provides an economical, high value AIU source, which can reduce steelmaking costs. Integration of FASTMET RHF technology into EAF steelmaking (FASTOx and FASTMELT/FASTEEL) takes the RHF to the next level – a true steelmaking process. Integrated mills can augment or replace blast furnace HM and become more competitive with EAFs. Integrating the RHF (ITmk3) with an iron ore mining operation, produces a merchant PI pellet, which combines benefits of high C pig iron and DRI/HBI without the gangue or handling issues. EAF steelmakers can capitalize on continuously feeding these "pig pellets" or choose HM, hot DRI/HBI and/or hot scrap/HM to further increase their low cost advantage.

Even the original MIDREX® Process offers a new approach to steelmaking, HOTLINK®, which can be retrofitted to current MIDREX Plants located adjacent to steel mills. Direct discharge of hot DRI to the EAF capitalizes on all the sensible heat, making steelmaking more efficient and less costly.

All these new technologies provide steelmakers the opportunity to capitalize on inherent high energy value AIUs (high C and/or heat from hot metal, scrap or DRI/HBI) or low gangue levels (ITmk3 "pig pellets" and low C steel pellets), which result in EAF steelmaking energy requirements as low as 89.83k Wh/tonne liquid steel and low greenhouse gas evolution.

This "smorgasbord" of processes exceeds the traditional, conditioned, image the iron and steelmakers have of Midrex. Nonetheless, these proven technologies, backed by the process technology expertise of Midrex, offer significant economic, quality and environmental benefits to the global steelmakers wanting to invest. Details of savings afforded will be presented by this author at the Iron and Steel Society's EF 2002 Conference, which will be summarized in *4th Quarter Direct from Midrex* and posted on *www.midrex.com* after November 13 2002.

The future is yours; in the future take the risk, think outside the box.

Educated Use of DRI/HBI:

EAF Energy Efficiency and Yield

By Dr. Sara Hornby Anderson
Manager – Steelmaking/Melting Programs
Midrex Technologies Inc., Charlotte, North Carolina, USA

[Ed. note: "The Educated Use of DRI/HBI improves EAF Energy Efficiency and Yield and Downstream Operating Results" paper was presented at the 7th European Electric Steelmaking Conference in Italy. This article demonstrates EAF improvements with additional data from Georgetown Steel Company (formerly Georgetown Steel Corporation) to emphasize some key points. (Note DRI and HBI are synonymous unless specified).]

Historically, using DRI in the EAF was practiced for production of high quality, low residual steels at the anticipated expense of kWh/tonne (t), tap-to-tap time (T-T), and liquid steel yield .

The educated use of DRI/HBI requires an understanding and appreciation of the feed materials' unique properties and necessitates new, or modified, operating practices and/or melt procedures. With these changes, DRI use can actually reduce operating costs and bring significant meltshop and downstream benefits.

The need for cost effective steel production has renewed interest in chemical energy sources. These include high carbon (C) and hot DRI (HDRI), which reduce electrical energy costs due to improved contained C efficiency (up to 95 percent)[1]. C efficiency, coupled with DRI's inherent low residual properties, can mean improved and often earlier foamy slag, lower nitrogen ([N]) in the steel, reduced energy use and electrode wear; increased yield, quality and productivity (< 34 percent), and reduced operating costs (–$9.72/t liquid steel (t/s)) in the meltshop.

There are other advantages resulting from better economic residual control. The meltshop benefits, especially tighter chemistry control, translate into downstream benefits such as tighter process control and optimization due to the less variable chemistries, ultimately leading to improved yield and quality.

Value in Use (VIU)

Educated DRI use causes one to rethink the industry's historical ideas of DRI's low Value in Use. VIU is defined as "a comparison of operational benefits combined with the physical and chemical properties and price." It will be site-specific, dependent upon the local infrastructure and the availability and cost of many process variables.

However, before being able to quantify and qualitatively analyze the in-house VIU, steelmakers need to understand and quantify current operating efficiencies (especially C, whether inherent in the charge or charge/injected to the bath), optimize their practices by charge mix and accurately define yield. Other variables to assess are the safety and ease of handling (shipping, transfer, sorting, storage, and charging), the ability to continuously charge, and other, often un-quantifiable, benefits such as [N] removal, capacity and cost of practice changes required to accommodate DRI use. Only then will the true VIU of DRI be revealed.

For example, most steelmakers are unaware their specific in-house carbon efficiency (percent of theoretical C combustion energy realized) is between 25 and 75 percent (often < 43 percent) for charged or injected C versus 95 percent efficiency for C contained in DRI. The technical and cost effectiveness of this far outweighs the minimal DRI plant cost for new technologies to increase DRI productivity and C^2, as will be seen.

Pig iron, the alternative iron source (AIS) of choice in many shops, has limitations. It is favored due to its high energy/C content, ease of storage/handling, and current, perceived VIU versus gas-based DRI (+$8 to +$30/tonne). However, negatives such as potential high sulfur (S) and phosphorous (P) levels, bag-house capacity required for rapid C blow down (to preclude T-T delays), inability to continuous feed (sizing and shape), and restricted O_2 equipment and/or supply are reducing its favored position and VIU.

Data below show how some international steelmakers have evolved practices that enable them to charge 50 percent DRI more cost effectively than 100 percent scrap. These practices were assessed to define "best cost for quality" charges and to realize substantially more benefits from high C and hot charged DRI than initially predicted, as well as to quantify real downstream impacts, which have heretofore been substantially un-quantified.

This data points to a need for a philosophical change in steel mill economics to one of a more global nature to ensure full realization of these global benefits.

MAIN CONSIDERATIONS FOR MELTING

The main parameters impacting EAF energy use are composition of raw materials (percent gangue/chemistry, metallization, percent C, percent P and energy content), operating practices (power profiles, "V" ratios, foamy slag and melting practices) and furnace design (heel, O_2 use and tools, OGS, charging system and AC/DC)[3]. Without attention to these factors, DRI melting can be detrimental to the steel mill's bottom line, by increasing the required melting power above that nominally required. Informed, intelligent, use can significantly benefit the operating results, as will be seen.

When comparing DRI with scrap, gangue is viewed as a major detriment to DRI use (i.e., increased oxide content/lower metallization, lower yield and productivity, and higher melting energy requirements). However, one should not overlook the scrap

	Total Fe	%FeO	%C	%Gangue
IMEXSA DRI	90.80	6.77	2.08	4.47
Ave. Scrap	93.85	1.80	0.47	4.25

Table I Comparison of Scrap and DRI Composition at IMEXSA

Cost in $US / Tonne HBI Added to the EAF					
Gangue	+Fluxes	+Power	Yield Loss	Slag Cost	TOTAL
SiO_2 / 0.1%	0.156	0.062	0.135	0.015	0.368
$Al2O_3$ / 0.1%	0.114	0.062	0.135	0.015	0.326
CaO / 0.1%	(0.071)	0.028	0.135	0.001	0.093
MgO / 0.1%	(0.071)	0.028	0.135	0.001	0.093

Table II Cost Associated with Various Gangue Components as Defined by BHP for Asian Mills

"gangue" content, low quality (rebar) or obsolete scrap, which can be as high as 10 percent.…

Table I shows an analysis Ispat Mexicana SA (IMEXSA) performed on their average grade scrap.

Increasing the DRI acid (SiO_2 and $Al2O_3$) gangue content by 1 percent increases the basic fluxes (MgO and CaO) by 2.5 percent to satisfy the desired quaternary EAF "V" ratio and increases power requirements by 20 kWh/tonne, and adds to the slag volume.Table II shows the Asian cost penalties associated with various gangue components as defined by BHP for Asian Steel Mills[4].

A certain amount of iron oxide is required in the system to help flux or dissolve the lime and/or dolomitic lime, thus promoting an early liquid slag. Also, as 67 percent of the iron oxide (FeO) will be reduced by C, the CO gas evolved will promote an earlier, better foamy slag. A 1 percent increase in metallization would allow steelmills to realize savings of 10 to 25 kWh, 0.425 kg refractories and 0.0375 kg electrodes/ t/sl and to increase yield by between 0.3–2.0 percent.

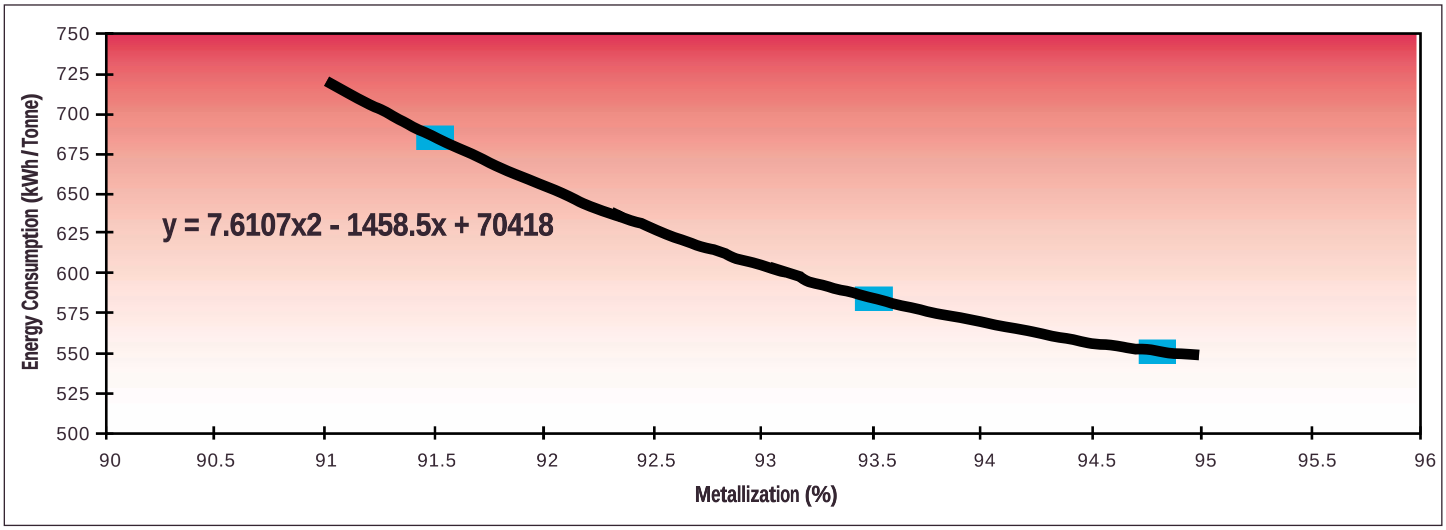

Figure 1 Energy Consumption vs. Metallization at Acindar

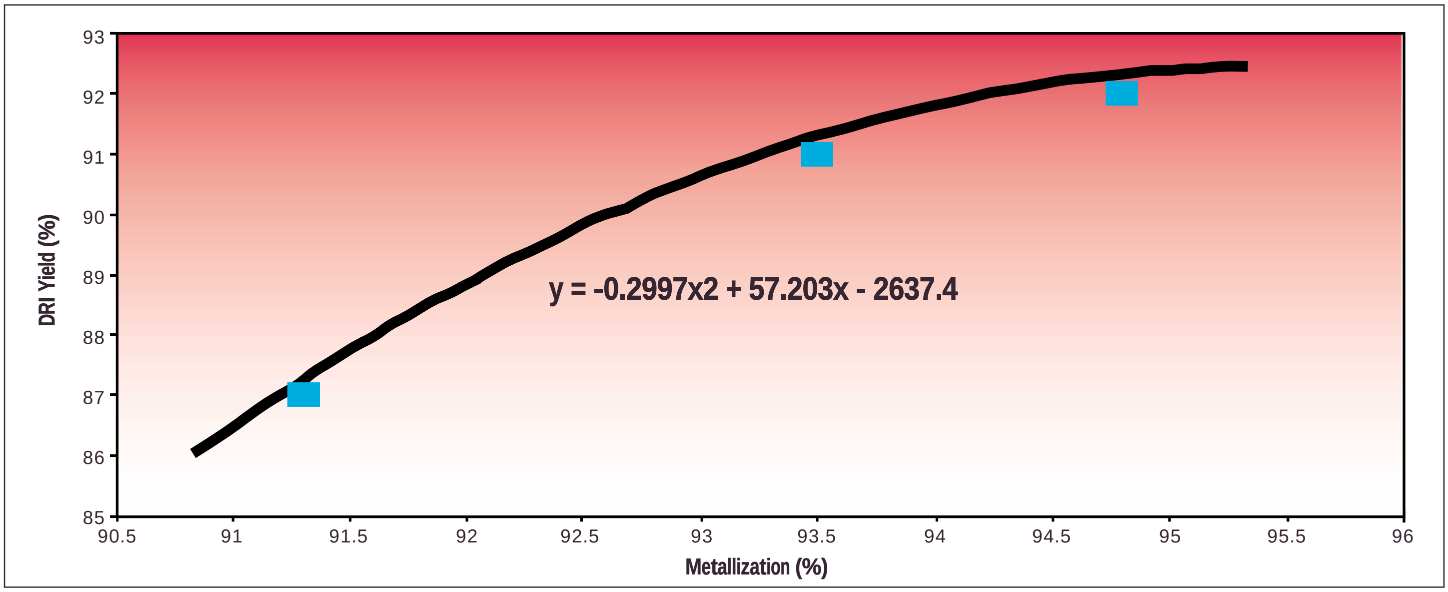

Figure 2 DRI Yield vs Metallization at Acindar

Figures 1 and 2 show the impact on energy consumption and yield of changing metallization, and Table III shows the cost savings realized at Acindar[3] in Argentina. The results, based on 100 percent DRI, 8 percent briquettes and 17 Nm_3 O_2/t are better than the conservative numbers above; i.e. – 40 kWh/t and 1.5 percent yield increase/1 percent increase in metallization from 91 – 95 percent.

The carbon question remains a controversy in the minds of steelmakers primarily because they perceive they are "paying DRI prices for carbon." However, whilst the benefits will remain site-specific, IMEXSA's high C DRI results and associated economics prove the C efficiency benefits actually reduce costs[3, 5]. Further, today's O_2 supply and use technologies have overturned the 1980s' 1.6–1.8 percent optimum contained C mandate proffered by mills suffering from the lack of these tools (see 3rd Quarter 2000 *Direct From Midrex*).

A certain amount of the DRI's carbon is required to reduce (neutralize) the FeO in the DRI:

$$\text{\% C required for FeO neutralization} = (100\,\% - Fe_{total}) \times \frac{\text{\% metallization}}{100} \times 100\,\%^{1}$$

Productivity	+≤5%
Energy Consumption	-Ò25 kWh / tonne
Electrode Consumption	-0.15 kg / tonne
Metallic Yeild	=1%
Refractories	-$0.70 / tonne
Coke Charge	-5.80 kg / tonne
Total Cost savings*	-$6.00 to $8.09 / tonne

*Including Productivity

Table III Cost Benefits Realized by Acindar Increasing Metallization from 93.5% to 94.5% [3]

1.4 percent C is required to neutralize the FeO in DRI with 93 percent metallization and 93 percent total iron. As the FeO melts and is reduced by the contained C, CO evolution creates an early foamy slag reaction. Any excess C is available for (FeO)slag reduction and combustion, whilst the combustible C varies dependent upon the (FeO)slag (Table IV)[6]:

Where CT is the total C and Cf the C to reduce the FeODRI or FeODRI and FeOslag

Benefits of C contained in DRI are varied; i.e., reduction of (FeO) reduces refractory wear, O_2 combustion lowers the kWh/tls and increased CO production improves foamy slag practice and increases arc stability (especially important for the long arc DC operators). The DRI's inherent 95 percent combustion efficiency provides a 4.1 kWh/t premium over the average (50 percent) efficiency from injected or charged C, which is inherently low due to early combustion without heat transfer, loss to the 4th hole or lack of slag penetration. This will significantly impact site-specific C cost savings, provided mills can capitalize on the high energy. The substantial flat bath conditions are nonconducive to oxy fuel burner (OFB) use and favor high velocity oxygen lances. High C will require more rapid decarburization to prevent delays/penalties in achieving final C, and OGS capacity must be sufficient (might require assessment of fan operation and alteration of same).

C_T %	(FeO)	92.5% Met	95% Met
1.8%	-	0.30% C_E	1.45% C_E
2.4%	-	0.95% C_E	1.45% C_E
2.0%	20%	0.90% C_E	1.45% C_E
2.0%	35%	1.25% C_E	1.75% C_E

Where C is the Total C and C_f the C to reduce the FeO_{DRI} or FeO_{DRI} and FeO_{slag}

Table IV Impact of Excess and Combustible Carbon

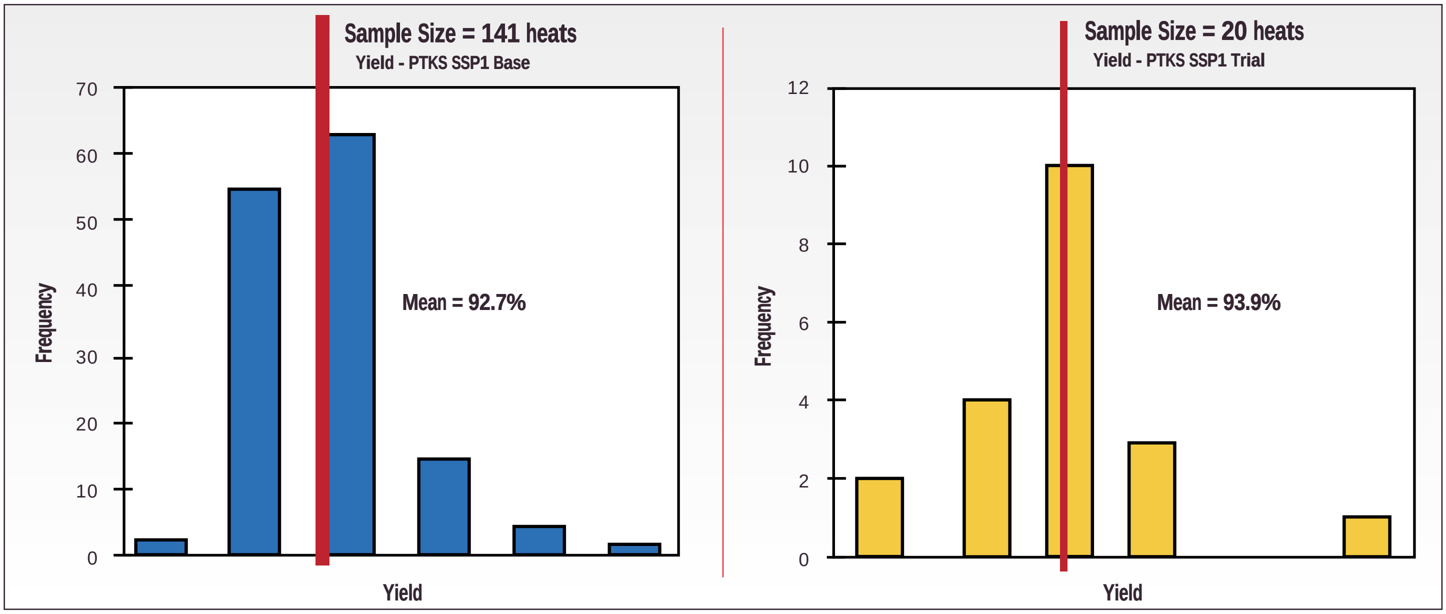

Figure 3 14% HBI Replacement of Local Scrap Increases Yield at PT Krakatau Steel

For effective DRI use in the EAF, steelmakers first need to understand and optimize current practices first[7, 8] and then, knowing the DRI chemistry to modify the standard operating procedures (SOPs) to ensure optimum performance. Adoption of modified SOPs has significantly improved productivity, power usage, yield and reproducibility of heat chemistry; hence, production costs.

The impact of DRI on energy and time is shown below[3]. Contrary to popular belief, educated use of DRI (even at 50 percent and batch charged) can reduce kWh/t charged and T-T time to below that for 100 percent scrap (Table V), for a DRI composition of 93 percent Fetotal, 93 percent metallization, 1.8 percent C, 1.5 percent (CaO + MgO), 1.9 percent $(SiO_2 + Al_2O_3)$, 0.003 percent S. Continuous charging of 33 percent DRI rather than batch charging saves 50.6 kWh/tonne and 4 minutes T-T time. Increasing DRI usage to 43 percent with 33 percent continuously charged, adds 11 kWh/t and 1 min. T-T time but still saves 33 kWh/T and 3 mins, T-T time versus batch charging (Table VI).

% DRI	kWh / t	T-T (min.)
0	463	61
25	-50.6	-9
50	-14.3	-2

Table V Impact of batch Charging DRI

Charge method	%DRI	kWh / t	T-T (min.)
2 bucket charge	33	468.6	58
Continuous feed	33	-50.6	-4
10% batch 33% continuous	43	-33.0	-3

Table VI Impact of DRI Continuous Feeding

Power Profile	kWh / t	T-T (min.)	Lime (lbs / t)	T_{tap} (°C)
PP1	429.0	54	55	1626
PP2	-14.3	-4		

Table VII Impact of Power Profile at 30% to 35% DRI

Table VII shows the importance of power profile. The use of a multi-tap profile (PP2) improves operations over a single-tap profile (PP1) because it creates a better scrap bore-in, thereby, producing a better DRI feed area. The ability to continuously feed significantly reduces the EAF energy requirement, as it offers a closed-door operation, which negates heat and time loss for roof swing(s) and charging, not to mention the potential [N] pick-up that can arise from the air ingress.

PT Krakatau Steel[4], having only low quality local scrap available to them, decided to assess the impact of using higher quality HBI. As shown in Figure 3, a 14 percent replacement of the local scrap by HBI increased their mean yield from 92.7 to 93.9 percent (1.2 percent).

Modification of SOPs was required when wire producer Georgetown Steel Company, a 30-year user of on-site produced DRI, closed the DRI plant in 2001 (due to runaway NG pricing) and bought multi-sourced merchant HBI[9]. Despite modifications to the continuous feeding system, HBI caused significant delays in the feeding system, which led to a lower than usual AIS usage (43 percent versus 60 percent).

While HBI was found to be as effective as their DRI in reducing residuals, this was not the case with sulfur and N. Also, as the initial HBI had low C and metallization, they required more flux and charge C (to reduce the FeO), which led to higher kWh/t, refractory wear (not strongly statistically significant) and POT/T-T. They also experienced loss of foamy slag control, low charge C efficiency (25–40 percent) and increased electrode wear and high reactivity with large, low C steel heels due to the high O_2 content.

Carbon in DRI	2.08%	3.10%	3.10%
Charge %DRI%scrap (t_{DRI} / t_{scrap})	94.4 / 5.6 (252 / 15)		
DRI Temperature (°C)	25		700
Scrap Temperature (°C)		25	
% Metallization		95	
% Yield		90	
Power on Time (minutes)	66	57	38.9
Tap to Tap Time (minutes)	80	71	53.9
Total Energy (kWh / t_{ls})	585.9	527 (-58.9)	419.1 (-191.1)
Productivity (t / h)	163	177 (+ 14)	222 (+ 59)
Savings @ $0.035 / kWh		$4.64	$9.27
@ $0.050 / kWh		$5.53	$12.14

Table VIII Economic Impact of 3.1% HDRI (Economics Assigned by this Author)

The high P Venezuelan ore resulted in high percent P HBI, which required an adjusted SOP regarding internal charge make-up specifications (dropped from <0.015–0.008 percent P). The lower HBI feed rate aggravated the situation by reducing bath temperature control for de-phosphorization and required more flux. Larger slag volumes were produced, which required more frequent deslagging to prevent carry over. Added to all of this was the increased charging of scrap, which aggravated the S and N control (especially as lower in-situ C reduces the inherent CO flushing action for N removal).

It should be noted that HBI with equivalent chemistry to Georgetown Steel's own DRI does not present these challenges. Knowing the differences allowed them to modify SOPs to fit each situation. A paper with more details will be presented at the AISE conference in October.

Modification of SOPs was required when IMEXSA began melting high C (2.7–3.1 percent) DRI[3, 5] (3Q 2002 *Direct From Midrex*). Procedural changes included negation of charge/injected C, earlier O_2 use, faster DRI charge rate due to the improved and earlier foamy slag, better heat transfer, and improved bath reactions achieved from in-situ C. Table VIII shows the operational benefits realized by IMEXSA when increasing from 2.08 percent C to 3.1 percent C with 94.4 percent DRI charged heats. The economic data, assigned by the author, shows savings of $4.64/tls at a power cost of $0.035/kWh without accounting for the 14 t/hour productivity benefit.

The savings (Table VIII), when combining these results with hot charging DRI at 700° (using the results from Essar Steel at 600° C DRI as a basis[1, 3, 5] (1Q 2001 *Direct From Midrex*) and including the 191kWh/t savings increases production savings to $9.72/tls. It also increases productivity 59t/h (+32.6 percent) over 2.08 percent C cold DRI. The dollar amount is not included in the $9.72 t/ls figure.

Both IMEXSA and Essar found it was necessary to slow the DRI feed rates to prevent the C boils resulting from the high C and heat charged, respectively.

CONCLUSIONS

Effective use of DRI requires the steelmaker to know the composition of the DRI feedstock and to modify the standard operating procedures (SOPs) to insure optimum performance is achieved. DRI should not be melted without recourse to new melting procedures, which will afford the steelmaker benefits including economic control of residuals, lower nitrogen levels, improved (often earlier) foamy slag practice and reduced electrode wear.

Significant EAF savings are a reality. When used correctly, DRI improves EAF energy efficiency and yield, reduces tap to tap times and increases productivity compared to 100 percent scrap.

C contained in the DRI is a more efficient, cost effective C source than charged or injected C. The VIU of C and DRI must be determined for local and site-specific, prevailing conditions and must accurately reflect the cost of current practices, requisite practice changes, C efficiency and yield data.

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FASTEEL™

Examining the Potential for the Steel Industry

*By: Hidetoshi Tanaka, General Manager - Technical, Ironmaking and Industrial Plant, Kobe Steel, Ltd.
Kyle Shoop, Senior Metallurgist - Melt Shops, Techint Technologies Inc.*

[Ed. Note: In the 1990s, Kobe Steel, Ltd. (KSL), Midrex Technologies, Inc. (Midrex) developed the FASTMET® Process, a coal based direct reduction technology, and the FASTMELT® Process, which melts and further reduces FASTMET® DRI to produce high quality hot metal. (See 2Q 2002 Direct From Midrex and www.midrex.com for more information). In 2001, Kobe Steel and Midrex entered into a strategic alliance with Techint Technologies for the marketing and supply of FASTMET and FASTMELT Projects. This alliance gave birth to the FASTEEL™ Process, which combines the FASTMELT Process with Techint's CONSTEEL® system for continuous scrap feeding and preheating. This paper continues our series on "Not All RHFs Are Created Equal" with FASTEEL and its potential sustainable success for the steel industry. All tons are metric unless otherwise noted].

TREND IN STEEL INDUSTRY

Globalization of the steel market has required steelmakers to continuously reduce production costs, improve quality standards and promote an environmentally friendly plant. To reach low production costs, the steelmaking plant must have maximum flexibility in raw materials and energy sources. In order to fulfill all these requirements, Techint, Kobe Steel and Midrex developed FASTEEL, a new process for making steel that merges the hot metal benefits of FASTMELT with continuous scrap feeding and preheating of CONSTEEL. The typical layout of FASTEEL is shown in Figure 1.

FASTEEL

CONSTEEL (see Figure 2) is a patented system that continuously charges scrap into the melting furnace by means of a conveying device loaded by the scrap yard cranes. The oscillating conveyor moves the scrap, preheated by the hot gases exiting the electric arc furnace (EAF), and feeds it continuously to the EAF.

The 14 operating CONSTEEL Plants annually produce 9 million metric ton of steel and demonstrate the validity of the process (see Figure 3) for energy savings, electrode consumption, improved metallic charge handling and minimization of disturbance to the power supply network. The most important result is reducing the steel production costs while meeting the increasingly more severe environmental requirements.

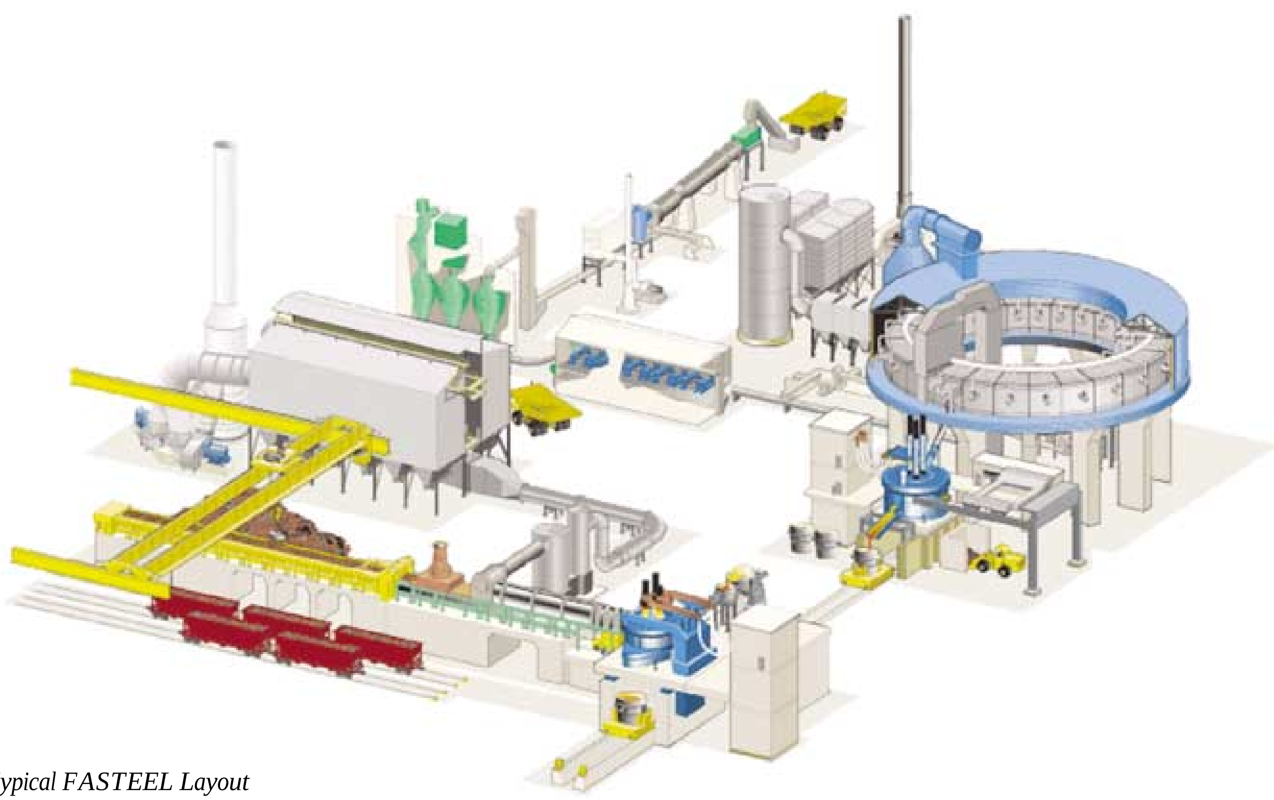


Figure 1 Typical FASTEEL Layout

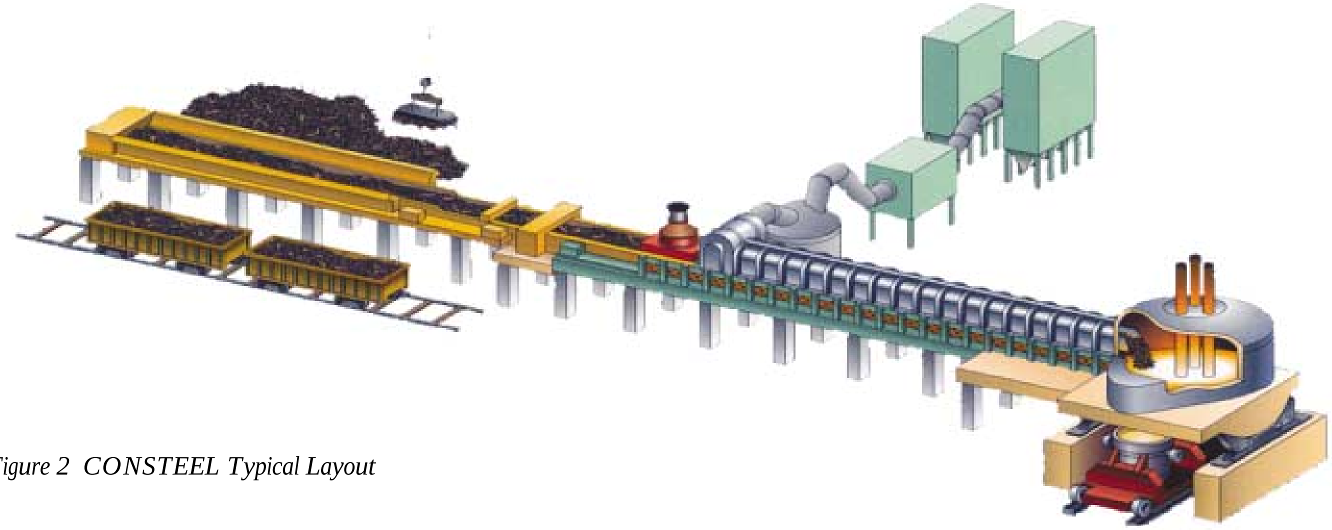


Figure 2 CONSTEEL Typical Layout

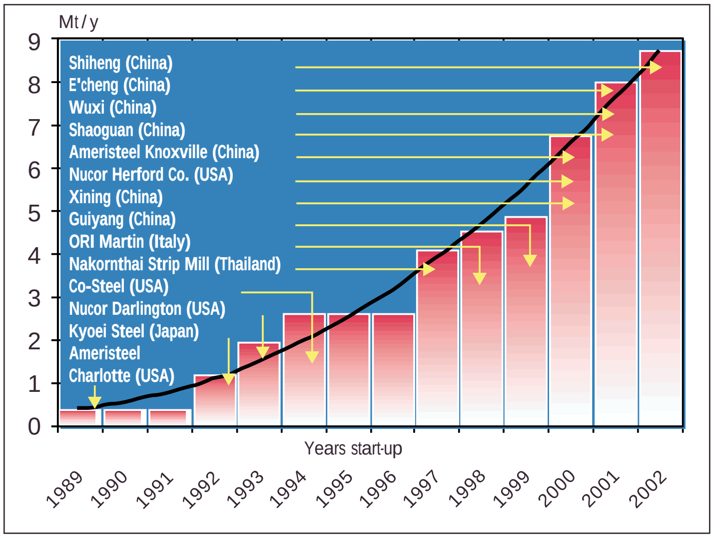


Figure 3 CONSTEEL Installed Capacity

Hot Metal Charge

During CONSTEEL operations, it is possible to continuously charge hot metal through a special runner on the side of the EAF for optimum efficiency and without any violent reactions. In addition to the typical advantages of pig iron, the hot metal delivers thermal energy to the furnace, thus reducing energy consumption and increasing productivity.

A charge mix of 70 percent scrap, 30 percent hot metal is normally used in the CONSTEEL plant at Shaoguan Iron and Steel (Guangdong) in China. Achieving an electrical consumption of 260 kWh/t, Shaoguan operates an AC furnace, 90 t heat size, rated for production of 760,000 t/y (106 t/h). This unit started operations in December 2000.

Key Benefits of FASTEEL

The aim of FASTEEL is to significantly reduce operating costs and provide high quality products by utilizing the proven FASTMELT® and CONSTEEL technologies.

The key benefits of FASTEEL for an integrated steelmaker can be summarized as follows:

Economical advantages
- Reduction in cost of raw materials (i.e., lower quality iron ore fines and coal instead of blast furnace pellets and coke)
- Reduction in the quantity of energy needed
- Recovery of iron units from steel mill waste oxides

Production flexibility
- Steel production time of 2 hours compared to 8-10 hours for a BF/BOF
- Scrap usage is optimized based on market conditions
- Easy start up and shutdown for maintenance or for market demands (the production capacity can be easily adjusted to the market conditions)
- Bottlenecks in the primary area (BF/BOF) can be eliminated with low specific investments

Environmental benefits
- Shutting down aging blast furnaces, coke ovens and sinter plants
- Reduction of overall steel mill emissions
- Reduction in wastes (i.e., recovery of iron unit in the FASTMELT Process)

Figure 4 Shaoguan Furnace

Integrated Produce	15.9 MMBTU / net t. of l.s. at caster
Mini-Mill	6.3 MMBTU / net t. of l.s. at caster
FASTEEL 30% Hot Metal 70% Scrap	8.51 MMBTU / net t. of l.s. at caster

Table 1 Energy consumption comparison – (short tons)

Electric Energy	$35 / MWh
Scrap	$105 / t
Hot Metal Cost From FASTMELT	$100 / t
l.s.cost from BOF	$190 / t

Table 2 Base Economical Data Inputs

l.s. produced with FASTEEL	$135 / t
Cost saving compared to l.s. from BOF / BF	$55 / t
Annualized Operating Cost Savings (1,500,000 t / y prod.n)	M$ 82.5

Table 3 Results

Energy Comparison

Integrated producers consume more energy overall than mini-mill steelmakers: According to the data of U.S. Department of Energy, relevant to energy consumption by the pricipal steel-making routes, EAF and BF/BOF, Table 1 shows how FASTEEL can reduce energy requirements.

Economical Evaluation of FASTEEL

Tables 2 and 3 show an economical analysis of a proposed FASTEEL facility located in the United States vs. the more traditional route of steelmaking (BF/BOF). The project case is for a FASTEEL unit to replace a BF/BOF for a production of 1,500,000 t/y of steel.

CONSTEEL® EAF furnace feeding mix is 70 percent scrap and 30 percent hot metal.

We assume economic result can be improved further by increasing the hot metal feeding to more than 30 percent.

Evaluation of the Emissions from FASTEEL

A major source of air emissions from the FASTEEL facility is the RHF off-gas. Off-gases and fumes from the electric ironmaking furnace (EIF) are collected and consumed as fuel within the RHF. Emissions from the coal pulverizer, revert dryer and other ancillaries are negligible or within established BACT (best available control technology) limits.

The sensible heat of the EAF offgases and the combustion of the CO by an automatically controlled air injection system are used to preheat the scrap prior to entering the EAF. The progressive and controlled combustion of CO and the generation and combustion of VOCs (volatile organic compounds) in the preheater greatly enhance compliance with environmental regulations (i.e. EPA). At the end of the preheater, the gases are directed to a fume cleaning system where post-combustion of CO, VOCs and other undesirable gaseous emissions is completed. A comparison of typical emission values for a FASTEEL plant and BF/BOF are given in Table 4.

	FASTEEL	Blast Furnace / BOF
NOx (kg / ton of liquid steel NO_2)	0.33	6.0
SOx (kg / ton of liquid steel SO_2)	0.81	15.6
CO_2 (kg / ton of liquid steel)	883	1576
PM_{10} (kg / ton of liquid stee)	0.025	19.2
Dioxin (Ng - TEQ / Nm^3)	<0.1	No Data

Notes:
- Typical emissions are for 500,000 ton HM / y FASTMELT® Plant
- SOx is dependent on Sulfur content in Coal FASTEEL emissions data is based on no de-SOx nor de-NOx .
- Blast Furnace emissions do not include coke making or sinter plant.
- Blast Furnace NOx , SOx, and PM10 emissions data from US DOE August 2000 report.
- EAF CO_2 emissions data from US DOE March 2000 report.

Table 4 Comparison of FASTEEL vs. BF/BOF Steelmaking Emissions

Conclusion

FASTEEL using the FASTMELT rotary hearth-based technology in conjunction with CONSTEEL has created a new steelmaking route for today's progressive producers. Based on proven technologies, FASTEEL provides low capital and operating cost iron and steel making that fits the requirements of stricter environmental regulations and challenging economic environments. The technologies intrinsically provide increased flexibility depending on market conditions, allowing for various feed materials and the management of hot metal-to-scrap ratio to meet desired steel quality. Reduction of environmental impact makes these technologies attractive to new areas of development. Furthermore, complete recycling of all steel mill waste is possible.

MIDREX and QASCO Sign Contract for Oxygen Use Project

Midrex Technologies, Inc. has been awarded a contract by Qatar Steel Company, (QASCO) to design and implement various technological improvements to increase capacity via oxygen use in the company's MIDREX® Direct Reduction Plant.

Midrex and QASCO will modify the existing plant to raise capacity to approximately 800,000 metric tons/year by adding the use of oxygen in the process flow and installing an oxide coating system.

Oxygen injection provides more energy to the MIDREX® Shaft Furnace, thus improving reformed gas utilization and overall plant efficiency/performance. Oxygen use will result in higher furnace bed temperatures, thus providing higher rates of in-situ reforming of the natural gas, which leads to higher productivity, increased carbon content in the product, and improved natural gas utilization efficiency.

These process changes will allow QASCO to produce direct reduced iron (DRI) at the rate of at least 96 metric tons/hr. or 11.5 metric tons/day/m3 of effective reduction zone volume. The average DRI quality is expected to remain unchanged at 95 percent metallization and a minimum of 2 percent carbon content. Additional modifications are under consideration to remove equipment bottlenecks in the plant.

These modifications will be performed during a scheduled shutdown in December, with commissioning to occur immediately afterwards. Midrex will provide commissioning assistance and training on the new systems to assure a smooth start-up of the modified plant.

QASCO will use the additional DRI in their recently upgraded steel shop, which includes three electric arc furnaces (EAFs). Since 1990, QASCO's MIDREX Plant has consistently demonstrated operational availability rates exceeding 8,000 hrs/year. The plant, which began operation in 1978 as a 400,000 metric tons/year facility, produced a record 734,000 metric tons of high quality DRI in 2001 for use in the adjacent QASCO steel mill.

QASCO plant

Kobe Steel Signs Basic Agreement for FASTMELT® Plant for Nigeria's Ajaokuta Steel

Kobe Steel, Ltd. signed a basic agreement with Nigeria's Federal Ministry of Power & Steel on May 31 to aid in revitalizing Ajaokuta Steel Company Limited by constructing a FASTMELT Plant. President Olusegun Obasanjo has initiated plans to revitalize the steel industry, which includes this project.

The project includes constructing a FASTMELT Plant with a production capacity of 500,000 metric tons per year. The agreement also calls for rehabilitation of the steelmaking facilities.

The value of the project is an estimated $280 million. Local studies and detailed planning would have to be carried out before a final agreement can be reached.

Although Nigeria has a number of rolling mills, it has to import blooms and billets to make finished steel products. The shortfall in semi-finished products is one of the reasons that operating levels have remained low. The hot metal produced by the FASTMELT Plant would contribute to meeting Nigeria's demand for semi-finished steel products.

Ajaokuta Steel Company Limited is an integrated steelmaker of wire rod and sections. The 100 percent government-owned steel complex is designed to have a crude steel capacity of 1.3 million metric tons. Construction began in the late 1970s by the former Soviet Union, but the facility is still non-operational. Major equipment consists of a blast furnace, three 150-ton basic oxygen converters, bloom casters, a billet mill, a medium section mill, a light section mill, and a wire rod mill.

IMEXSA Plant Operates Above 125% Capacity

In First 5 Years, Produces 7.5 Million Ton Of DRI

Despite some of the worst market conditions in recent history, Ispat Mexicana (IMEXSA) has produced almost 7.5 million metric tons of direct reduced iron (DRI) with its MIDREX® Direct Reduction Plant since operations began in August 1997. The IMEXSA plant has set numerous annual records including averaging more than 125 percent of production capacity during its first five years of operation.

A History of Achievements

IMEXSA produced its first DRI on August 25, 1997, one month ahead of the contracted schedule. This established a new record for engineering, construction, and start-up of a MIDREX Plant (23 months from contract effectiveness to first production). The plant's installed cost per ton of DRI is among the lowest ever constructed. It has operated at some of the lowest sustained natural gas consumption figures (2.2 net Gcal/t) and electricity consumption figures (90 - 95 kWh/ton) in the industry.

IMEXSA easily exceeded rated production capacity in 2001, which was filled with obstacles; i.e., record low steel prices, a remarkable spike in natural gas prices (peaking nearly 400 percent above the customary rate), and a prolonged labor strike. The high natural gas prices led to the shuttering of nearly all North American direct reduction capacity until the gas prices moderated. The MIDREX Plant at IMEXSA was the only direct reduction plant in North America that continuously operated throughout the year.

Other records set by the IMEXSA DRI plant in its five years include monthly production of 164,400 metric tons in March 1998, and annual production of 1.68 million tons in 2000. Like many other MIDREX Plants worldwide, IMEXSA has implemented the use of oxygen in its flow sheet to boost plant performance.

"From the construction phase until now, IMEXSA has achieved outstanding results including record project schedule, lowest capital cost, highest production capacity, and lowest energy consumption, as well as high product metallization and carbon content to meet the demands of the melt shop's electric arc furnaces," Robert Klawonn, Midrex vice-president of sales, said. "We look forward to other significant achievements in the next five years of operations."

IMEXSA Plant at Lázaro Cárdenas, Mexico

ITmk3® Project Gets Department of Energy Funding

Mesabi Nugget, LLC has been awarded funding from the U.S. Department of Energy (DOE) to demonstrate the commercial viability of the new Kobe Steel ironmaking technology, ITmk3.

The ITmk3 Process uses a rotary hearth furnace to turn iron ore fines and pulverized coal into iron nuggets of the same quality as blast furnace pig iron. Energy efficient and environmentally friendly, the ITmk3 Process emits 20 percent less carbon dioxide than blast furnace operations. Reduction, melting, and slag removal take only about 10 minutes. In addition, capital investment is projected at roughly half the cost of conventional ironmaking technologies. Iron nuggets could also provide an attractive mineral processing alternative for mining companies.

"Northeastern Minnesota has been hit hard by the downturn in the steel and iron mining industries. The Mesabi Nugget demonstration project illustrates our continuing efforts to modernize and diversify the economic base of the Iron Range," said United State Congressman James Oberstar. "Through the hard work, collaboration, and support of many people, we will be able to develop a more energy efficient, environmentally-friendly way to make iron."

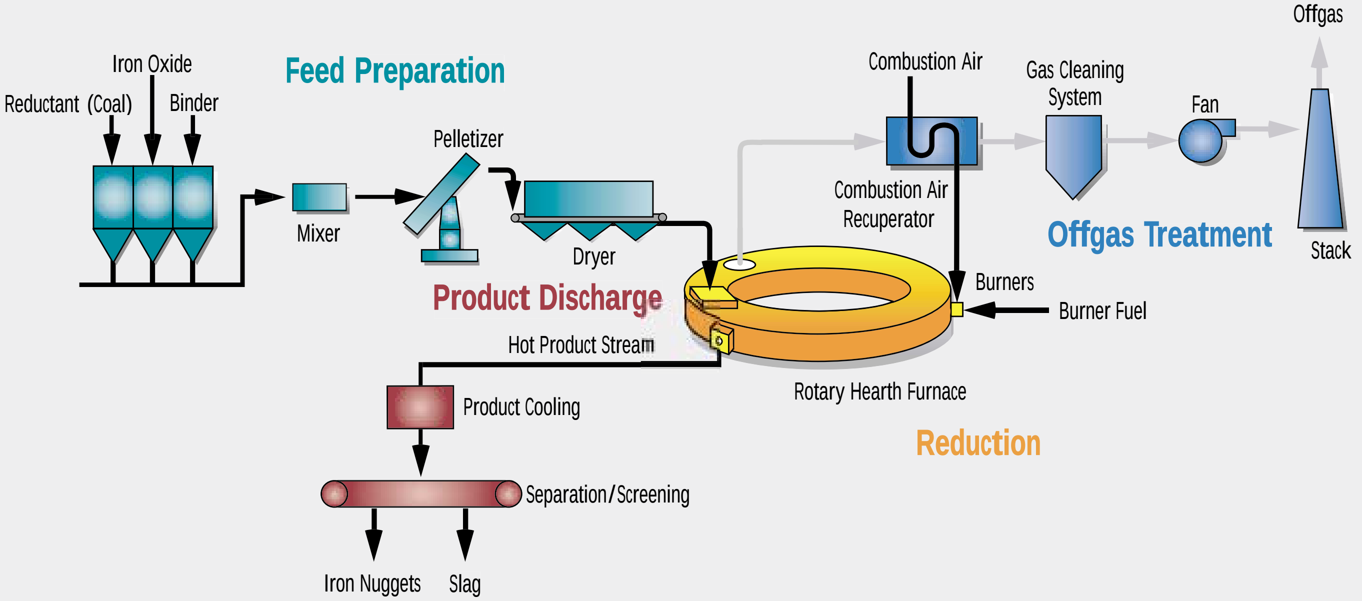
The Mesabi Nugget project marks the first commercial adoption in Minnesota of a technology that creates a more pure iron product than a conventional taconite pellet. The pilot program will demonstrate a new iron production process that will produce nuggets with 97 percent iron, compared with 67 percent iron in taconite pellets. This project holds great hope for a significant number of jobs on the Minnesota Iron Range.

ITmk3 Product

Funding, which is expected to be $2 million in the first year, will be provided under a DOE program that encourages the development of processes that will enable the commercial deployment of several emerging ironmaking technologies. The goal is to provide the domestic steel industry with additional high quality alternative iron sources (AIS) that are less dependent on the availability of coke.

"The Mesabi Nugget project represents the type of innovative, efficient, and cost-effective endeavor Northeastern Minnesota needs," according to government supporters of the project. "This program will bring jobs to the Iron Range, and it is a step towards modernizing the iron making industry in Minnesota."

The 25,000-ton-per-year demonstration plant is under construction at the Northshore Mining Company taconite plant in Silver Bay owned by Cleveland-Cliffs Inc. The project is funded by Kobe Steel and other equity investors, as well as loans from the Minnesota Minerals 21st Century Fund and Minnesota's Iron Range Resources and Rehabilitation Agency.



ITmk3 Process Flow

Midrex News & Views

Midrex Calendar of Events

Sept 29th – Oct 2nd – AISE Annual Conference – Nashville, TN

Midrex will present and co-author a total of three papers – FASTMET®, Impact of Charge Materials at Georgetown Steel Corp., and Not All RHF Technology Is Created Equal.

October 20-23 – ILAFA EXPO, 2002 – Cancun, Mexico

November 10-13 – 59th Electric Furnace Conference

Midrex will present the following papers – Using Oxygen to Make Reducing Gas in the MIDREX® DR Process, Influence of AIS Chemisrty on EAF Steelmaking Economics, Not All Rotary Hearth Furnaces Are Created Equal, and FASTMET® - Proven Process for Steelmill Waste Recovery

Christopher M. Ravenscroft: Editor
Adgroup Creative: *Graphic Design/Production*

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Contacting Midrex

General E-mail:
info@midrex.com
phone: (704) 373-1600

Sales

MIDREX® Process – The world's leading direct reduction process.

FASTMET®/FASTMELT® – Commercially proven processes for providing DRI and hot metal from steel mill wastes and iron ore using coal.

ITmk3® – A revolutionary coal-based technology whose product is a premium nugget.

OXY+™ - A partial oxidation system for increasing productivity in ironmaking and other processes.

MIDREX® Reformers for Gas-to-Liquids - A proven, proprietary means for generating syngas from natural gas.

Robert Klawonn
Sales@midrex.com
Phone: (704) 378-3326

New Business Development

Applications of Midrex's process design and intergration, and project execution expertise in industries other than iron and steel.

Frank Griscom or John Kopfle
BizDev@midrex.com
Phone: (704) 378-3383 (Griscom)
Phone: (704) 378-3306 (Kopfle)

Marketing

Information gathering, analysis and worldwide marketing of MIDREX Technologies for the production and use of DRI and HBI.

Sara Hornby-Anderson
sanderson@midrex.com
Phone: (704) 378-3316

General Press / Media Inquiries

Christopher M. Ravenscroft
cravenscroft@midrex.com
Phone: (704) 378-3380

MISSION STATEMENT

Midrex Technologies, Inc. will be a leader in design and integration of solids and gas processes and will supply to our clients superior quality services that provide value. We will meet or exceed performance expectations, execute projects on time, enhance existing product lines, and develop or acquire new technologies. Our employees are the key to our success, and we are committed to encouraging them to grow professionally and personally.