DIRECT FROM MIDREX

4th Quarter 2001

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DIRECT FROM MIDREX is published quarterly by Midrex Technologies, Inc., 2725 Water Ridge Parkway, Suite 100, Charlotte, North Carolina 28217 U.S.A., Phone: (704)373-1600 Fax:(704)373-1611, Web Site: http://www.midrex.com under agreement with Midrex International B.V. The publication is distributed worldwide free-of-charge to persons interested in the direct reduced iron (DRI) market and its growing impact on the iron and steel industry. ©2001 by Midrex International B.V. Printed in U.S.A.

Commentary

Upkeep in a Down Market: Plant Scheduled Maintenance

Jim Helle
Manager - Midrex Solutions

Improving performance, reliability and maintenance while enhancing environmental impact will help improve plant profits. During prosperous times, the implementation of plant improvements is desirable for a variety of reasons. Due to high demand for continuous production from the customer or melt shop located next door, implementation is almost impossible to schedule. During economic downturns, however, the situation is reversed. Production demands are moderated, but financing such improvements is difficult. Nevertheless, emergency repairs, scheduled maintenance, and preparation for shutdowns must be accommodated.

For most of its almost 30-year history, Midrex has primarily focused on advancing the standards of technology development, process innovation, and general improvements to existing processes. With the establishment of Midrex Solutions™, Midrex has made a solid commitment to executing small project work including plant scheduled maintenance, de-bottlenecking studies, and other problem solving issues that require engineering or unique experience.

This project work includes regular and preventative maintenance, de-bottlenecking and other trouble-shooting assistance to optimize plant performance, and specialized Midrex Field Services. Midrex Solutions has also developed a curriculum of DR and melt shop training programs to aid operations personnel (from basic level training to advanced training topics).

Formed at the end of last year, Midrex Solutions has received a great response from MIDREX® Plant personnel. It has already completed contracted work for various MIDREX Plants and has provided dozens of proposals ranging from a single drawing revision, to detailed plant de-bottlenecking studies.

In this issue of Direct From Midrex, we examine OXY+™, a new equipment design/technology available from Midrex Solutions. OXY+ is a form of advanced oxygen use, which produces a reducing gas to supplement the reformer and significantly increase productivity in a MIDREX Plant. Utilizing partial oxidation from the OXY+ Reactors to optimize the MIDREX Plant performance provides unmatched operating flexibility with minimum capital expense.

As the technology leader in iron ore reduction, Midrex continues to innovate and to improve the MIDREX® Process. Fully optimized MIDREX Plants can demonstrate productivities in the range of 13 – 14 tons/day/m3 of effective reduction zone volume. Environmental improvements can also be achieved in parallel with productivity gains.

The new role that Midrex is adopting is part of an effort to redefine Midrex for the present and the future. We see Midrex Solutions as a great opportunity to further strengthen our relationships with Midrex Licensees by solving problems, which is something Midrex does best.

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.

The MIDREX OXY+™ System at Georgetown Steel: A Source of Additional H_2 and CO

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Georgetown Steel Corporation

Russ Kakaley, Senior Process Engineer
Midrex Technologies, Inc.

Georgetown Steel Corporation (GSC) has successfully demonstrated the MIDREX OXY+™ technology as a source for additional hot hydrogen and carbon monoxide in a MIDREX® Direct Reduction Plant.

Georgetown Steel Corporation (GSC) produces high quality steel wire for specialty users. To obtain the high quality end product, GSC uses a large proportion of virgin iron in its process that comes from direct reduced iron (DRI), typically produced by an on-site MIDREX Direct Reduction Plant. Over the last decade, GSC's MIDREX Plant has seen increasing demand for DRI by the steel shop. The MIDREX Plant has been modified and optimized to such an extent that it can consistently achieve production rates 50-60 percent above the original design capacity; however, the steel shop could still use more DRI.

GSC has realized that one way to obtain greater production of DRI is to make more reducing gas. The reducing gas made in a MIDREX™ Reformer consists of H_2 and CO and is used in the MIDREX Plant to convert iron ore to metallic Fe. The usual way to obtain more reducing gas is to enlarge the reformer; however, enlarging the reformer presents several problems. First, the room for expansion must exist. Second, it requires a large capital expenditure. Third, it requires the plant be shut down for a month or two while the reformer expansion takes place.

The innovative solution that eliminated all of these problems was the MIDREX OXY+ system, a partial oxidation system that does not require expansion of the plant boundaries. Also OXY+ requires significantly less capital than an equivalent reformer expansion project, and the majority of OXY+ installation can occur while the plant is running, with final tie-ins occurring during normally scheduled short-duration shutdowns.

What is OXY+

OXY+ is a patented system developed for partial combustion of fuel with oxygen to produce a gas rich in H_2 and CO. The heart of the system is the OXY+ reactor, where fuel and oxygen are mixed and burned in two stages. By proper staging, OXY+ provides stable combustion, eliminates soot generation, converts fuel to H_2 and CO, and protects the materials of construction from extreme temperatures.

Important to the success of OXY+ is its control system, which accurately meters oxygen and fuel to each stage of the reactor. Accurate metering is important to

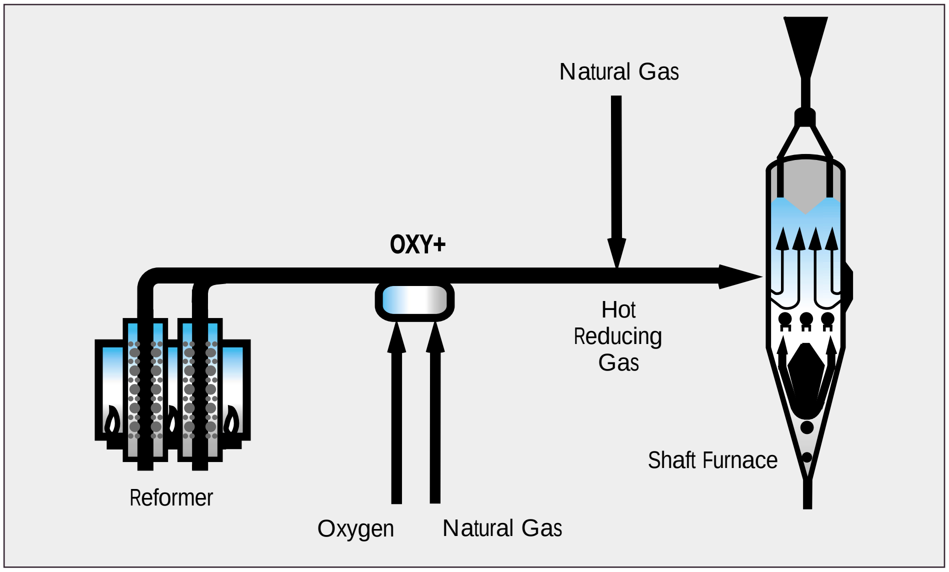

Figure 1 MIDREX OXY+™ flow chart

prevent overheating of the reactor. The control system also has adequate safety features and interlocks to protect personnel and plant equipment from the dangers associated with using oxygen.

Results

The reactors were first fired on December 16, 2000, and were operated when the proper personnel were on site (day shift). On December 30, the reactors were shut down when the DR plant began a regularly scheduled maintenance outage. Although the tests were short in duration, they proved OXY+ a success. Reducing gas was generated and the reactors were controllable. Upon inspection, the reactors were found to be in "as good as new" condition.

Control of Reactors

The reactors were started up slowly, with low gas flows, to ensure there would be no problems with overheating the metal components of the reactor. Temperature at any point within the reactor is largely a function of the oxygen-to-fuel ratio that exists at that point. With the two-stage reactor design, it is easy to control local oxygen-to-fuel ratios in order to maintain a desirable temperature profile within the reactor.

Once it was determined that temperature was easily controlled, the flows were increased to design conditions and above.

Gas Generated

In all tests, the OXY+ reactors consistently generated a gas that contained 69 percent (by volume) H_2 plus CO. The overall reaction for these gases is:

$$CH_4 + 1/2\ O_2 \rightarrow CO + 2\ H_2$$

The remaining 31 percent was largely hot H_2O, CO_2, and CH_4. These other three gas species are useful in a DR plant because upon entering the DR furnace hot, they reform and make more H_2 and CO according to the following reactions:

$$CH_4 + H_2O \rightarrow CO + 3\ H_2$$

and

$$CH_4 + CO_2 \rightarrow 2\ CO + 2\ H_2$$

After these additional reactions take place the OXY+ gas contains 90 to 95 percent H_2 plus CO.

Table I summarizes the results of the tests. The reactors were tested at flow rates ranging from 34 percent to 106 percent of design capacity. 100 percent of design capacity is taken to be 1,600 Nm^3/h natural gas input to the OXY+ system. The reactors were stable and produced a consistent gas quality throughout the range of flows tested. At 106 percent of design, each of the two reactors was producing over 2000 Nm^3/h of gas. It should be noted that this is not the maximum flow possible, but it was as far as the tests proceeded before the plant was shut down for the scheduled maintenance.

At the 106 percent level, the OXY+ system was generating enough gas to reduce an additional 3,350 kg/h of metallic iron. Considering that DRI is roughly 86 percent metallic iron, the gas generated by both reactors was enough to increase production of DRI by almost 4 metric t/h.

Results of OXY+ Tests at GSC DR Plant

Test No.	% of Design Capacity	OXY+ Gas Produced [Nm^3/h]	H_2 + CO at OXY+ Outlet [volume %]	Equivalent DRI Production [t/h]
1	34	1,320	69.0	1.3
2	83	3,266	68.7	3.2
3	105	3,818	68.8	3.2
4	106	4,092	69.4	3.9
5	102	4,006	69.7	3.9

Table 1 Results of OXY+ at Georgetown Steel Corporation DR Plant

Other Benefits

For the duration of the tests, the OXY+ reactors were operated for the sole purpose of making more H_2 and CO reductant to increase production. It is also possible to run the OXY+ system so furnace temperature is increased in addition to making more reductant. In the latter mode, higher temperatures will create even more production. The production increase due to higher temperatures would be in addition to the increase obtained by making additional H_2 and CO. Midrex has found that increasing the temperature in the furnace 10°C will increase production of DRI by 1.5 to 2.0 percent.

There are two main operating costs associated with OXY+, natural gas and oxygen, which are relatively low when considering the entire plant. The OXY+ reactors consume natural gas, but consumption is partially offset by savings by other natural gas users in the plant. Natural gas savings in the reformer burners, in bustle gas enrichment, and to the reformer feed gas will substantially offset OXY+ natural gas consumption and must be considered in a valid economic analysis. Likewise, if the plant has other oxygen users, one must consider the savings by those users when determining the oxygen cost associated with OXY+.

Design and Implementation

Safety

Safety was the primary consideration during the design of the OXY+ system because combustible gases can pose a fire and explosion hazard. The typical MIDREX Plant is designed to contain the combustible gases, prevent them from mixing with oxygen, and thereby, prevent burning in a location where burning is not desired. The Midrex design challenge was to ensure that stable, controlled combustion occurred in the OXY+ reactor whenever the oxygen was on so oxygen would never build up in the reformed gas duct. In addition, a special purge system was also designed to prevent combustibles from mixing backwards into the oxygen lines. A Hazards and Operability Analysis (HAZOP) study was performed by GSC and Midrex on the design to ensure adequate protection of personnel and property.

Midrex engineered the OXY+ system for compatibility with the MIDREX Plant. The OXY+ system could only be started when conditions were safe for personnel and plant equipment. Likewise, OXY+ would be shut down if the safe signal ceased.

Midrex embarked on a computational fluid dynamics (CFD) modeling program and through several iterations, modified the reactors to prevent overheating while maximizing the conversion of fuel to H_2 and CO.

Installation

GSC has an on-site oxygen plant, which supplies oxygen, nitrogen, and argon to the melt shop. GSC constructed a piping run of about 1000 feet from the melt shop to the MIDREX Plant. Oxygen and nitrogen pipes were run in parallel. Nitrogen was for use as the purge gas for the OXY+ system. All oxygen piping was cleaned per a rigid procedure written specifically for oxygen piping.

Installation of the OXY+ reactors occurred in several stages. First, flanged nozzles were installed on the reformed gas duct. These nozzles would be used to mount the OXY+ reactors. The second step was to modify the reactors per the results of the CFD modeling and to install the reactors at the previously mentioned flanged nozzles. The third step was to run the connecting piping from the flow control skid to the reactors. During each of these three steps, the plant was necessarily shut down (or at least depressurized) to allow the work to be accomplished. But with careful planning, all work was done when the plant was shut down for other regularly scheduled short-duration shutdowns. No special long-duration shutdowns were taken to install OXY+.

The Future

GSC

Because of the high cost of natural gas in early 2001, the DR plant at GSC remained shut down after the maintenance outage. But as natural gas prices moderated during the later half of the year, GSC restarted the DR plant in October 2001. The OXY+ system is able to run in either of two modes, whichever best support the needs of the DR plant.

The first mode is making additional reducing gas as was done during the tests of December 2000. The tests showed that enough reducing gas was being made to produce almost 4 t/h of DRI, and the limit on the OXY+ reactors was not reached due to time constraints.

The second mode is using the OXY+ system to make additional reducing gas and to increase temperatures inside the DR furnace for more efficient and faster reduction of the iron. The increased furnace temperatures will give 1.5 to 2.0 percent production increase for each 10°C, in addition to a 4 t/h or more production increase due to additional gas flow. The furnace temperatures will be limited to below the temperature at which the iron will sinter and form clusters.

The OXY+ system gives GSC additional capacity to produce DRI and also presents options when running at less than maximum capacity. GSC will have the option of turning down its OXY+ system, or the option of turning down its reformer, or both. Turning down the OXY+ system will reduce oxygen consumption. Turning down the reformer is accomplished by operating it at reduced temperatures, thereby, decreasing maintenance costs on the reformer.

Future Applications

Midrex has scaled-up the OXY+ reactors for use in its larger MIDREX MEGAMOD™ plants. The scaled up reactor is dimensionally twice as large as the reactors at GSC, and the larger unit is capable of generating four times the gas. Therefore, one larger unit could be expected to produce enough reducing gas to give a 7 t/h DRI production increase. Adding two of these scaled-up reactors to a DR plant would give the same gas generating capacity as expanding the reformer by one bay.

Midrex also has plans to market the OXY+ system for uses other than supplementing the output of a reformer. One such use would be making a hot reducing gas for injecting into the center of the DR furnace. Typically the center of a DR furnace runs cooler than the outside. But by injecting hot reducing gas into the center, the temperature would increase, thereby, increasing the kinetics of the reduction reactions in the center of the furnace. The advantage of using an OXY+ system for center injection is that supply pressure of the OXY+ reducing gas can be greater than the outlet pressure of the reformer. Therefore, the OXY+ gas has a high enough pressure to be injected into the center of the furnace.

Another use for OXY+ gas would be to make a hot gas for injection into the lower portion of a hot briquetted iron (HBI) furnace. The HBI furnace is similar to a DR furnace with the exception that the HBI furnace has no cooling zone at the bottom. For proper densification of the briquettes, it is desirable that the product is discharged from the HBI furnace to the briquetting machines at a temperature above 700°C. OXY+ gas would be a good choice for injecting into the lower portion of an HBI furnace to keep the product hot. It has sufficient pressure to be injected, sufficient temperature to keep the iron hot, and sufficient reductant to prevent re-oxidation of the iron. The OXY+ gas composition could be tailored to add carbon to the product through hydrocarbon cracking or through deposition from CO.

Midrex is also planning to develop the OXY+ system for uses outside of the direct reduction industry. The OXY+ system is well suited for any process that uses hot H_2 and CO, where the required H_2/CO ratio is approximately two.

Direct Reduction/ EAF Steelmaking: The Environmentally Friendly Route

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[Ed. Note: The following article is a follow-up to the Green Steelmaking Article that appeared in the 3rd quarter Direct From Midrex. This article continues the topic with additional potential EAF practice information. The full unedited paper that was originally presented at the EF 2001 November 12th Conference in Phoenix, Arizona is available as a PDF from www.midrex.com]

The issue of greenhouse gases emissions is of growing world importance mandating greenfield primary metals production facilities incorporate technologies with lower greenhouse gas generation potential. Brownfield steelmills, striving to improve their worldwide competitiveness, are adopting technologies to lower costs and improve efficiencies, while maintaining or improving product quality.

In the electric arc furnace (EAF) sector, some of these technologies involve the increased use of chemical energy to reduce electrical energy requirements and increase productivity, and alternative iron units, to achieve high steel quality. Although efficient operation of metals production facilities should decrease the generation of greenhouse gases, significant further emissions reduction requires a better understanding of how and where the greenhouse gases originate and what the impact of the new technologies and changing charge materials will be.

The methodology used to analyze the alternative production routes is as follows. The BF/BOF route uses published data for energy inputs and outputs throughout the steelmaking operation. For the EAF route, an in-house EAF melt program has been used to predict major operating parameters, from first principles fine-tuned using practical experience, (for example, electrical, flux, oxygen, yield, thermal efficiency of melting and liquid steel sulfur levels – Table I) given the input alternative iron unit (AIU) composition, percentage charged, EAF slag "V" ratio, final carbon level in the steel, and the tap temperature desired. (It should be noted that productivity changes are partially reflected in the thermal coefficient of melting).

For each charge scenario, except the FASTMET® waste oxide, FASTIRON®, and high (4 percent) carbon direct reduced iron (DRI) scenarios, the practices reflect actual industrial data. In the case of FASTMET, FASTIRON and the 4 percent C DRI, two internal mass balance design programs have been used, one for FASTMET and FASTIRON, which incorporates the Kakogawa demonstration plant results, and one for gas based DRI/HBI, which combined current operating data with prior results for 3.5 percent C DRI10 and extrapolates to 4 percent C DRI production. The results from each individual process' energy balance computations are then converted to greenhouse gas emissions using the conversion factors found in the complete presentation available at www.midrex.com. Other than pig iron, the AIUs considered are assumed to be produced by MIDREX® Processes.

Production Processes

Process Options considered herein reflect North American operations and fall into the following groups:

- *80 percent DRI/20 percent scrap representative of a captive DRI plant steelmaking practice*
- *50 percent AIU/50 percent scrap representative a non-captive high quality steel producers maximum usage*
- *30 percent AIU/70 percent scrap representative of the optimal AIU quantity for high quality steel production*

Additionally, three other scenarios were examined:

- *20 percent AIU/80 percent scrap, recently defined as the most economical AIU level in Asia*
- *10 percent AIU/90 percent scrap representing the likely sustainable on-site waste oxide based DRI/HBI feedstock*
- *100 percent scrap representing the EAF baseline*

All of these are compared to 80 percent hot metal/20 percent scrap use in the BOF, representing the BF/BOF baseline.

The process combinations represent the desire for hot and cold, high percent C (high chemical energy), charges as well as cold "low" percent C (conventional) charges. Additional carbon has been added to the EAF to maintain the oxygen usage at around 20Nm^3/t, though this is computed to be significantly higher for the 80 percent hot and cold high percent C DRI scenarios. Table I outlines the EAF feeds' blended analyses and the predicted thermal efficiency of melting as well as the quantities of lime, oxygen and electrical energy required for steel production, using a quaternary slag "V" ratio of 1.75.

The combination of processes is not an exhaustive list of possible ironmaking/steelmaking routes available to the EAF operator, rather it presents the typical performance characteristics for each respective

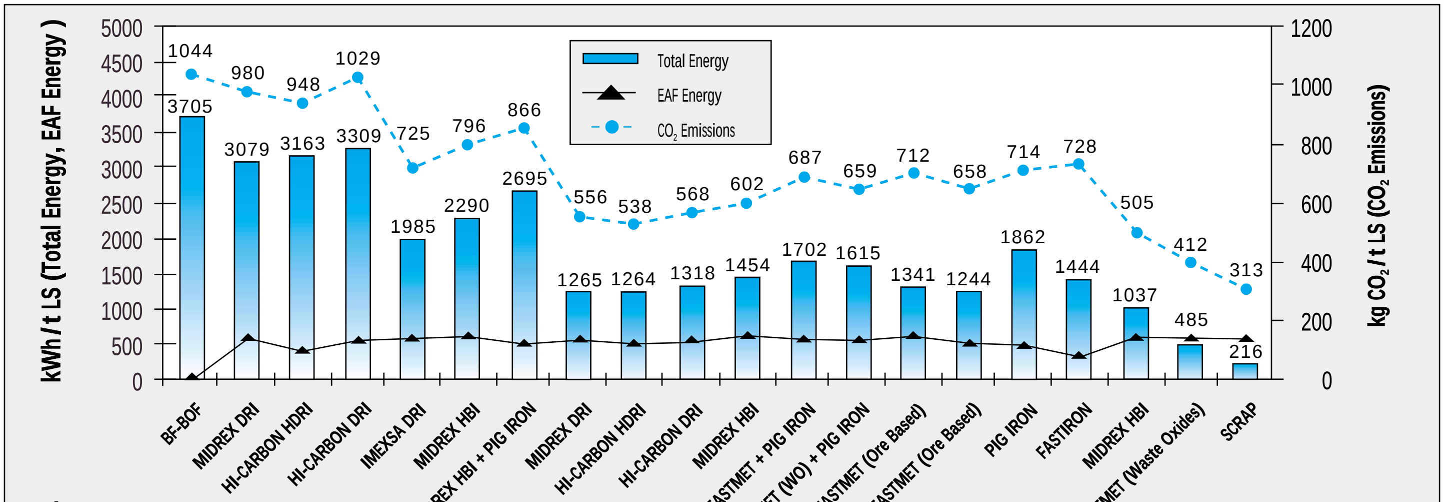


Figure 1

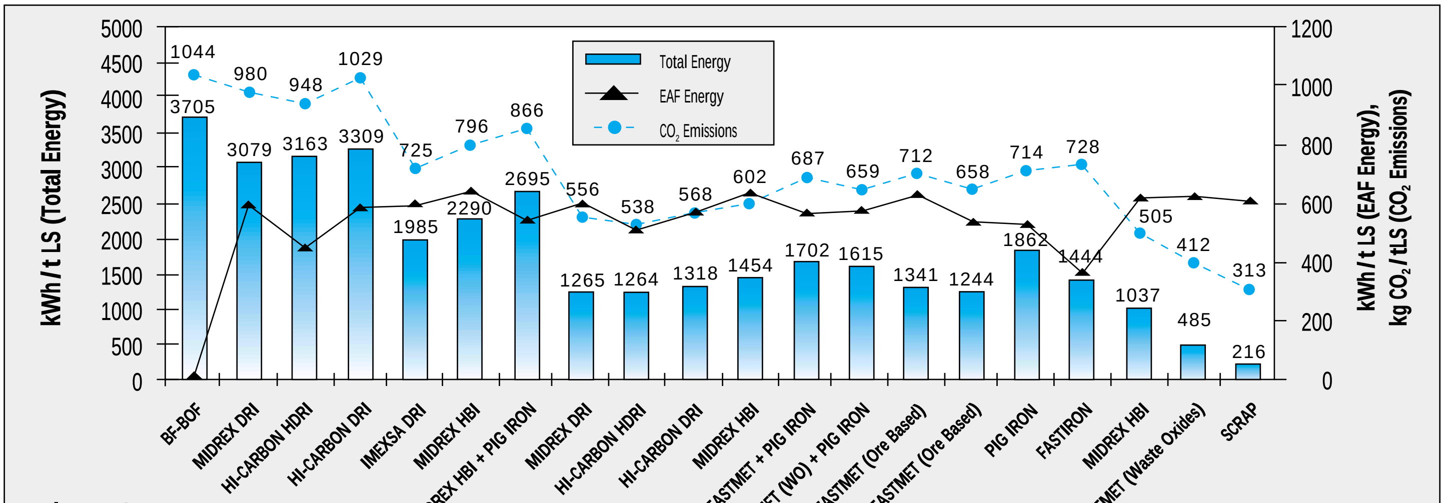


Figure 2

Figures 1 and 2 Total Energy, EAF Energy and Carbon Emissions

option. The scope of the processing incorporated into each of the production methods begins with the receipt of raw metallics (iron ore and scrap), reductants (coal, natural gas, etc.), and energy (coal, natural gas and electricity) and ends with the tapping of a ladle of liquid steel (0.04 percent carbon and 1620°C) prior to any ladle furnace processing. The energy contained in the tapped liquid steel is a credit to the system.

Energy & Emissions Results

Figure 1 summarizes the results of the energy and emissions evaluation for the production methods indicated. The graph includes the total energy required to produce the liquid steel, the carbon dioxide emissions generated throughout the production process, and the EAF energy input required (displayed on the same scale as total energy). The units of energy are given in kWh/Tonne of liquid steel, and the emissions are given in kg-CO_2/Tonne liquid steel.

In order to highlight the significant impact of feed materials on the EAF energy balance, in Figure 2, the EAF energy line has been expanded by using the same scale as for the CO_2 emissions. The numerical indicators in the body of Figure 2 refer to the overall total energy balances and the carbon emissions.

Results

The study's results indicate that for a 100 percent iron ore-based steelmaking facility, the MIDREX Process provides lower energy consumption and carbon emissions than the BF/BOF technology because of its efficiency and the use of natural gas. EAF production routes have lower total energy and carbon emissions than the conventional BF/BOF route. To minimize total energy consumption and carbon emissions, the maximum possible amount of scrap must be used. Since many steel products cannot be made with a 100 percent scrap feed, a portion of alternative iron is charged to the EAF to meet quality requirements.

As the amount of AIUs charged to the EAF increases, so do the total energy consumptions and carbon emissions. Gas-based AIUs promote lower total energy consumptions and carbon emissions than pig iron. The use of waste oxide-based FASTMET HBI reduces the impact of pig iron total energy and carbon emissions more than ore-based FASTMET HBI.

In general, carbon emissions decrease as total energy consumption decreases. Comparing the 80 percent high C HDRI with the 80 percent low C DRI, the carbon emissions are lower due to the significantly lower

EAF energy. However, in terms of the total energy figures, a higher energy (O_2 and NG) is required in the DR plant to increase the DRI carbon level. From an economic and productivity, standpoint the high C HDRI is the best option in the EAF.

At the 30 percent AIU charge level, the best total energy scenario is ore based hot FASTMET, but carbon emissions are higher due to higher energy requirements for DRI processing. 4 percent C hot DRI at the 30 percent charge rate has lower total energy consumption and carbon emissions than the 2.5 percent C cold DRI and lower carbon emissions than the hot ore-based FASTMET.

If one considers the EAF in isolation, the hot charging processes are the most energy efficient, but the carbon emissions vary (Figure 2). In the 30 percent AIU Group, the most energy efficient process is 30 percent FASTIRON, but the carbon emissions are the worst.

The next most energy efficient is the 80 percent high C hot DRI. The least energy efficient scenarios are 20 percent HBI (low C) and 10 percent waste oxide-based FASTMET (gangue). For the AIU combinations in excess of 10 percent, the EAF energy balance represents from 10.6 percent to 24.4 percent of the total energy balance. The 10 percent waste oxide FASTMET EAF energy was 52.8 percent of its total energy balance (gangue content). Thus, EAF operations need to consider the global picture rather than operate in isolation.

SUMMARY

The most greenhouse gas and energy friendly steelmaking process is EAF melting of 100 percent scrap. As this practice is not conducive to high quality steelmaking, alternative iron units must be employed. FASTMET and FASTIRON offer advantages in raw material flexibility and lower energy consumption (due to their pre-reduced oxide form) with a minimal increase in carbon emissions over pig iron. Steelmaking waste oxide streams will not only facilitate zero waste operations but will reduce energy and emissions especially for a pig iron-based practice.

It is difficult to draw a long-term conclusion from the data presented herein, partly because of the impact of site-specific factors (economy, environmental, productivity value, and infrastructure), but also because of undefined financial consequences of carbon taxes worldwide. Currently, the major industry concern is for lowering quantifiable energy costs. That would indicate non pig iron AIU sources at the 30 percent level required for high quality steel production. Depending upon the future steel demand and the economic impact of the threatened carbon tax, the best available option(s) might change or improve. Also, the use of product from a gas-based MIDREX Process in natural gas rich countries could present the opportunity for industrialized countries to “buy” emissions credits from these natural gas rich countries thus lowering overall energy use and carbon emissions.

In order to define the best available technology route for high quality steel production, a method enabling the global analysis of carbon emissions, total energy use and productivity must be defined.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the kind support of Midrex Technologies, Inc., Kobe Steel, MIDREX Process Licensees, and contributing steelmakers for providing their operating data to enable the continued improvement in steelmaking operations.

Some EAF Melt Program Specifics

Process	%Met	Total Iron (%)	Blended %C in AIU Charge	Carbon (kg / t) Charged	Carbon (kg / t) Injected	Thermal Melting Efficiency	Lime (kg / t)	O_2 (Nm^3 / t)	KWh / t
80% CDRI	94	91.5	2.5	0	1	82.1	17	20.8	560.6
80% HiC HDRI	94	90.1	4.0	0	1	86.3	17.1	35.6	391.6
80% HiC CDRI	94	90.1	4.0	0	1	83.5	17.1	35.6	538.0
50% DRI	94	91.5	2.5	2.5	3	82.9	22.9	20.4	515.6
50% HBI	93	92.5	1.5	8	3	81.2	28.7	20.2	500.2
20% HBI / 30% PI	97.2	94.3	3.0	0	1	81.0	27.1	19.7	511.7
30% DRI	94	91.5	2.5	5.5	3	83.6	26.8	20.1	482.4
30% HiC HDRI	94	90.1	4.0	1	3	85.2	26.9	20.2	451.9
30% HDRI	94	90.1	4.0	1	3	84.1	26.9	20.2	505.9
30% HBI	93	92.5	1.5	9	3	81.6	30.3	20.3	476.1
10% FM^O / 20% PI	97.4	92.6	3.5	1	3	81.2	31.7	20.1	501.8
10% FM^W / 20% PI	95.1	90.7	3.5	1	3	81.0	30.5	19.8	511.4
30% CFM^O	92	86.9	2.5	4.5	3	80.8	38.1	20.5	523.6
30% HFM^O	92	86.9	2.5	4.5	3	82.5	38.1	20.5	431.1
30% PI	100	95.4	4.0	0	3	84.8	28.9	20.4	468.5
30% FI^O	100	94.9	4.5	0	1.5	87.7	28.7	20.4	319.6
20% HBI	93	92.5	1.5	9	3	81.8	31.0	19.7	468.2
10% FM^W	85	81.1	2.5	9	3	81.7	33.2	20.6	473.7
100% Scrap	93	92.1	0.4	10.5	3	82.3	32.6	20.3	440.8

CDRI - Cold DRI , HDRI – Hot DRI, FM^O – FASTMET Ore Based, FM^W – FASTMET Waste Oxide Based, FI^O – FASTIRON Ore Based

Table 1 Some EAF Melt Program Specifics

Kobe Steel Signs MOU With Mesabi Nugget LLC: ITmk3® Process to Make Iron Nuggets Will Be Studied

Kobe Steel, Ltd. signed a memorandum of understanding (MOU) on November 14, 2001 with Mesabi Nugget, LLC for the construction and operation of a demonstration plant in northeastern Minnesota (USA) using its new proprietary ironmaking technology known as ITmk3® – a breakthrough process that turns iron ore into nearly pure iron.

Following successful completion of a feasibility study, the final agreement is expected to be signed by the end of this year. Plans would then call for construction of a demonstration plant to begin at the taconite plant of the Northshore Mining Company at Silver Bay, Minnesota. (Northshore Mining is a wholly owned subsidiary of Cleveland-Cliffs Inc.) Successful operation of the demonstration plant will establish the commercial viability of the new process and allow for the start-up of a commercial-scale plant in 2005.

Overall construction and operating costs for the demonstration plant are expected to amount to $22 million. Mesabi Nugget, LLC is seeking a loan from the Minnesota Minerals 21st Century Fund for a portion of the project funding.

In addition to Kobe Steel, other participants in the Mesabi Nugget project are Cleveland-Cliffs Inc., Steel Dynamics, Inc., Ferrometrics, Inc. and the Minnesota state government.

Kobe Steel and its subsidiary Midrex Technologies, Inc. began research on the ITmk3 Process in 1996. A pilot plant with a production capacity of 3,000 metric tons per year was built at Kobe Steel's Kakogawa Works. Test operations carried out between October 1999 and December 2000 successfully produced iron nuggets under continuous operation. The Mesabi Nugget project presents an opportunity for the ITmk3 Process to be demonstrated at a scaled-up level in anticipation of commercial operation.

Kobe signing of the MOU with Mesabi Nugget, LLC on November 14, 2001.

The Mesabi Nugget project is anticipated to provide an attractive mineral processing alternative for iron ore in northeastern Minnesota. The project would help promote development and employment in the state, while providing a value-added product for mining companies. For a relatively low investment, iron ore can be turned into iron nuggets on site and supplied directly to electric and blast furnace steelmakers as an alternative or supplement to pig iron.

Information on the Participants

Mesabi Nugget, LLC is the project owner for the Mesabi Nugget project. Cleveland-Cliffs, Steel Dynamics, Ferrometrics, the Minnesota state government, and Kobe Steel will provide funding or equity for the project.

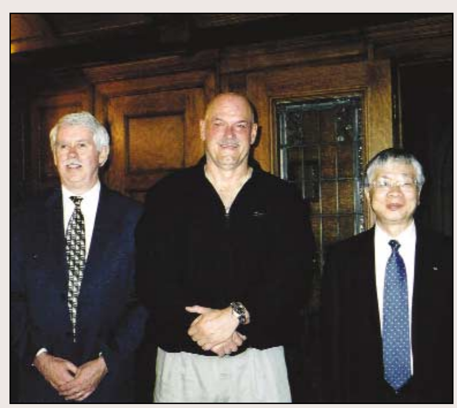
Cleveland-Cliffs Inc. is the leading supplier of high-quality iron ore products to the North American steel industry. Based in Cleveland, the company produced 20.3 million tons of iron ore products in 2000 from mines in Minnesota. Cleveland-Cliffs will provide the project site, materials and supplies for the project, and will undertake the operation of the plant. Participation in the Mesabi Nugget project will enable Cleveland-Cliffs to offer a value-added iron product.

Steel Dynamics, Inc. is an electric steelmaker based in Fort Wayne, Indiana. In 2000, the company produced 2 million tons of steel. Steel Dynamics will offtake the iron nuggets.

Ferrometrics, Inc. is a consulting company for reduced iron who originally founded Mesabi Nugget, LLC and has served as the coordinator and promoter of the project.

The Minnesota state government's involvement in the project is through the Minnesota Department of Trade and Economic Development and the Iron Range Resources & Rehabilitation Agency (IRRR). The IRRR promotes economic development and diversification in northeastern Minnesota. The state is providing funding to the Mesabi Nugget project, as the project is anticipated to increase employment and contribute to the economic development of the region, in addition to its financial return.

For information regarding ITmk3 visit www.midrex.com.



Winston L. Tennies, Midrex Technologies, Inc., Minnesota Governor Jesse Ventura, and Akuri Uragami, Kobe Steel, at the Governor's Mansion in Minnesota.

Midrex Reaches Agreement with Techint on EMCI Purchase

Midrex Enterprises, Inc. of Charlotte, North Carolina has announced that it has reached agreement with Techint Technologies, Pittsburgh PA, on the sale of steel industry equipment supplier EMC International, Inc.

Techint's acquisition of EMCI will allow Midrex to better focus its resources on ironmaking technologies and on Midrex's new business development group as the company diversifies within the steel industry and develops new technologies in other industries. EMCI will now be an integral part of Techint Technologies meltshop operations division increasing Techint's range of steel making process equipment supply.

Since 1987, EMCI has been supplying electric arc furnaces, ladle furnaces, and other systems, equipment and services to the steel industry. Current EMCI president Jim Simmons will join Techint Technologies as Senior Vice-President of the Meltshop Division.

This acquisition further strengthens the relationship between Techint and Midrex's parent company, Kobe Steel. The agreement includes future cooperation related to Kobe and Midrex's ironmaking technologies and Techint's meltshop expertise.

Midrex Technologies, Inc. is an international engineering and technology company that provides global process technology solutions to various industries and is principally known for the MIDREX® Direct Reduction Process that converts iron ore into a high-purity direct reduced iron product for use in steelmaking, ironmaking and foundry applications. Midrex continues to develop new technologies relating to its traditional iron and steel roots including eco-friendly technologies such as FASTMET®/FASTMELT® steel waste recycling processes and ITmk3®, a breakthrough process for producing a pig iron substitute material.

Techint Technologies, is a designer and supplier of a wide range of meltshop equipment, including electric arc furnaces, the Consteel® continuous scrap feeding and preheating system, Köster lances and digital regulations systems.

HBI Association Appoints Smailer First Executive Director

The HBI Association recently announced that Ralph M. Smailer has been appointed as its first executive director. Smailer is well known to the DRI / HBI industry having been involved in electric furnace steel making with DRI/HBI since 1965 at the former Lukens Steel Company now Bethlehem Steel and has been involved in the design, engineering and start up of several HBI facilities. He also spent nineteen years with Kvaerner (formerly Davy) and has published numerous technical papers in the field of DRI / HBI steelmaking.

The HBI Association is a not for profit organization chartered under the laws of Venezuela in the year 2000. The purpose of the HBI Association is to gather and exchange information to further the interests of the members, to assist the personnel of the members to more effectively perform their assignments, and to otherwise associate and jointly support activities and projects to promote the general well being of members of the HBI Industry. The HBI Association will conduct its activities in compliance with the anti-trust laws of the United States.

The initial charter producer members are: BHP Direct Reduced Iron, Ltd., Cliffs & Associates, Ltd. (CAL), Complejo Siderurgico de Guayana, C.A. (COMSIGUA), C.V.G. Ferrominera Orinoco, C.A., Operaciones al sur del Orinoco, C.A. (OPCO), Orinoco Iron, C.A., Venezolana de Prereducidos del Caroni, S.A. (VENPRECAR); and the charter associate members are: HYLSA, S.A. de C.V., Kobe Steel, Ltd., Lurgi Metallurgie, GMBH, Midrex Technologies, Inc., VAI and Köppern.

ILAFA 42

The ILAFA 42nd Congress
October 21-24, Lima, Peru

Midrex at ILAFA Expo - Lima, Peru

The ILAFA 42nd Congress held from October 21 to 24, 2001 in Lima drew industrialist and iron and steel specialists from around the globe. For more than 40 years, the Latin American Iron and Steel Institute has held ILAFA providing a valuable, globally-renowned forum of international industries, presenting the opportunity of exchanging opinions of learning who is who in the iron and steel industry, and, above all, of listening to the point of view of top-level industrialists and specialists. Midrex was represented at the conference by Midrex President Winston Tennies and Anthony Elliot, Manager Technical Services.

Midrex at EF Conference in Phoenix, Arizona, USA

Midrex both exhibited and presented at The Iron & Steel Society's 59th Electric Furnace Conference and 19th Process Technology Conference held in Phoenix, Arizona, USA. The Conference featured 16 technical sessions and more than 80 papers on Environmental Issues, Foundry Operations, Maintenance as a Process, Refractories, Special Arcs, and Steelmaking and Solidification as well as two sessions on Energy Efficiency. Copies of Midrex's presentation from this conference as well as a library of other topic is available at www.midrex.com in the Information Center.

59th
Electric Furnace Conference & 19th Process Technology Conference

!!! IMPORTANT NOTICE !!!
Direct From Midrex Goes Digital

After much discussion and planning, Midrex has decided to take *Direct From Midrex* and the *World Direct Reduction Statistics Book* to the next progressive level. Starting with 1st Quarter of 2002, the 2002 *Direct from Midrex* and the 2001 *World Direct Reduction Statistics* will be available exclusively online from www.midrex.com providing for quick access to the much anticipated and requested publications and technical articles.

The move to full online distribution and posting will enable quick access to data and updates as available. For both publications, issues will be available in easy to download PDF format. These changes will allow us to focus more on the stories that will be of the most interest to our readers while providing an easy to access archived library of technical materials.

The format change will allow for added supporting materials to be linked to the current issues and articles.

By converting *Direct From Midrex* to a fully digital media and distributing electronically via e-mail, it presents an immediate, effective way to deliver your *Direct From Midrex* despite the event of a possible shutdown or delay of the U.S. Postal Service. This will also enable readers to get the issue as it is published rather than weeks or months later due to international mail.

However, in an increasing digital communications age this was also inevitable as the next natural progression for our publications.

To meet the greatest number of reader needs, we are working hard to keep file sizes small for quick and easy download, but we need to build a new updated e-mail database. Please be sure to re-subscribe at www.midrex.com/info/direct_sub.asp.

Re-subscription will let you know of when the latest issue of Direct From Midrex is posted automatically by e-mail and will also provide exclusive notification of when Midrex's latest technical presentations and papers will be available.

We at *Direct From Midrex* expect good results from this change of format and see the great potential for growth in editorial scope and functionality to our readers. To find the latest issue and other information please please regularly check www.midrex.com.

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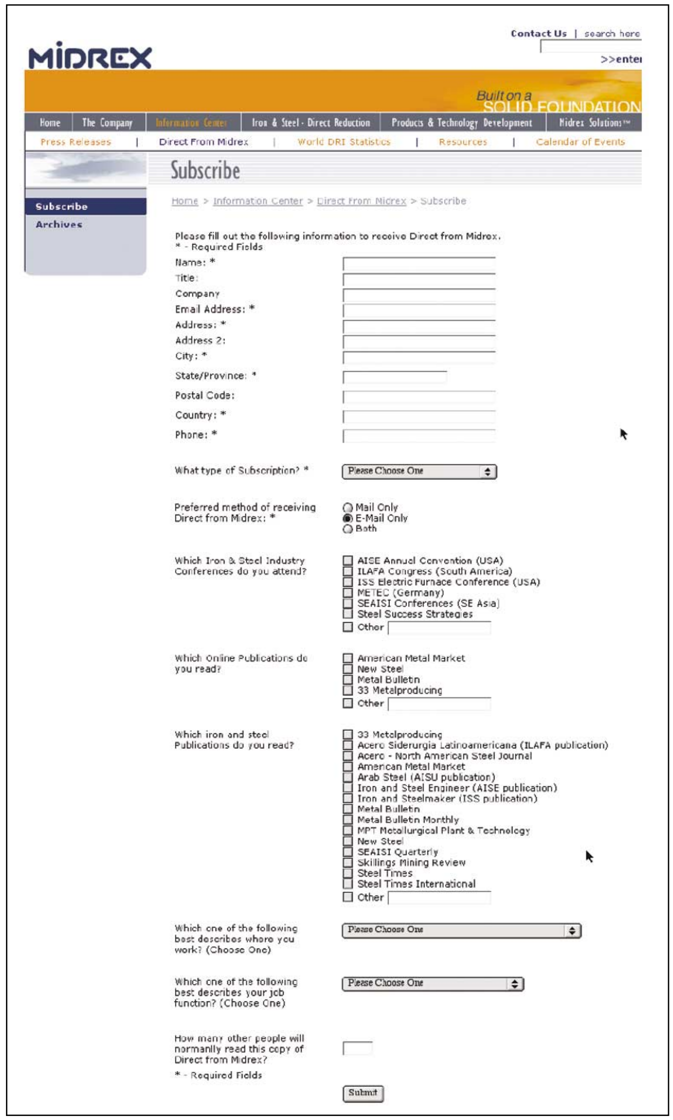

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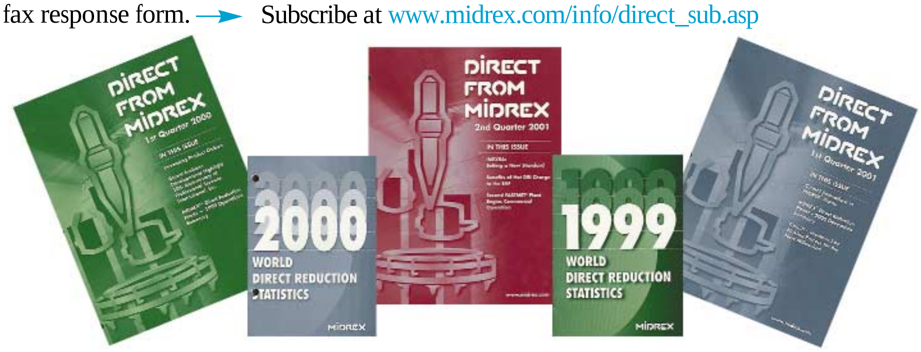

Direct from Midrex and the 2001 World Direct Reduction Statistics Book will be available exclusively in digital form starting in January 2002.

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