DIRECT FROM MIDREX

3RD QUARTER 2008

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Commentary

Technical Services Group: Above and Beyond

Antonio Elliot
Manager
Technical Services

Midrex Technologies has built shaft furnace direct reduction plants using the MIDREX® Direct Reduction Process for nearly four decades. Our innovative DRI process and plants are what Midrex was founded on. We take great pride in each plant's continuing operation and successful production.

Last year, MIDREX® Plants produced 39.7 million tons, nearly 60 percent of the world's total DRI. Cumulative production of MIDREX® Plants surpassed the 500 million ton mark in 2007, and at the current growth rate, one billion tons are projected to be produced by 2015.

The primary function of the MIDREX Technical Services Group is to assist MIDREX® Plant Operators in improving operations and maintenance to maximize plant performance and profitability. This group is backed by an experienced engineering staff.

Maintaining maximum operations often requires input from Midrex specialists with specific areas of expertise, such as process, mechanical, electrical, instrumentation or operations. If information is not available in-house, we resource knowledgeable vendors to ensure our licensees benefit from the required expertise. Other services include providing assistance during temporary plant shutdowns and coordination to get the best person available within Midrex to advise and oversee the individual plant's shutdown needs.

Technical Services visits most plant operations on a yearly basis for discussion that brings together Midrex personnel and plant operations. Starting in 1997, Midrex held an annual meeting for MIDREX Plant operators to discuss plant operations and advancements. Known as the MIDREX® Operations Seminar, the program has grown from six plants to almost 20. As more modules were built, more operators were invited until the annual meeting has become a worldwide event held in diverse venues from North America to the Middle East, Europe to South Africa.

With 56 modules in operation as of late 2008, the MIDREX family continues to grow with new plant operators. With more plants on the way, we are not only focused on plant supply, but also in keeping all our MIDREX Plants at optimum production levels and profitability.

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.

For the latest information, visit www.midrex.com

Improvements in Laboratory Testing of DR Oxides at Midrex Technologies, Inc.

Midrex Technology Center Wet Lab

By Jeffrey Myers, Manager
Technical Center
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Editor's note: This article is based on a paper presented at the 2nd International Symposium on Iron Ore held in September 2008 in Sao Luis, Brazil.

INTRODUCTION

There are three main areas of concern in testing of DR ores: low temperature disintegration, reducibility and clustering. Midrex Technologies, Inc. (MTI) has historically used two tests (Hot Load and Linder) to evaluate these parameters.

The Hot Load and Linder tests have been in use at MTI and by its clients for over 35 years. An extensive historical database has been developed. The Linder test (Figure 1) is designed primarily for low temperature behavior, and is essentially similar to ISO 11257.

Figure 1 - Linder Test for Low Temperature Disintegration

The Hot Load (clustering and reducibility) test (shown in Figures 2 and 3 on the following page) is run at 816° C, which was appropriate for DR operations for many years. Likewise, the ISO test for clustering (ISO 11256) is run at 850° C, and the reducibility test (ISO 11258) is performed at 800° C, all in the same general range.

Figure 2 - Hot Load Test for Clustering and Reducibility

Figure 3 - Hot Load Test Showing Weights for Load

Improvements in coating technology, among other developments, have resulted in significant increases in operating temperatures at many MIDREX® Plants. As a consequence, there is some concern that the results from lower temperature tests may not necessarily be relevant to higher temperature operation. In response to this concern, a study was initiated at MTI to perform a series of higher temperature tests in an effort to define a correlation to actual plant performance.

IMPROVEMENTS IN LABORATORY EQUIPMENT

In order to assure the most consistent and reliable operation of the Hot Load, the control system was upgraded. In addition, data that previously had been manually recorded was directed to an automatic data acquisition system.

New test equipment corresponding to the ISO test procedures is being acquired to provide additional correlations with standardized testing.

COATING PROCEDURE FOR LABORATORY TESTING

The standard HL test uses pellets as supplied, so only pellets with coatings from suppliers can be tested easily. Since many producers add additional coating on site, it is useful to duplicate this in the lab so that the tested pellets more accurately reflect the actual characteristics of the pellets used in the plants.

A series of tests were performed to develop a reliable procedure for applying coatings to pellets on a lab scale. Application rates should be comparable to those in the plant (0.5 to 8 kg/tonne oxide), but the amount of pellets being coated in the lab is only 20-50 kg. Therefore, the amount of coating to be added to any one batch is only around 10 to 400 g, creating the challenge of making sure an even distribution of the coating is achieved on a reliably repeatable (and measurable) basis.

The approach used was to first mix the coating material (e.g., lime) with water to make a slurry, and then use the slurry to coat the pellets. This is similar to how coatings are applied in the commercial process. By weighing the pellets before and after coating, along with the weights of the coating and water, the net amount of coating material on the pellets can be calculated.

CORRELATION OF LABORATORY RESULTS WITH PLANT DATA

The next step was to collect samples and operating data from an operating plant to establish the correlation of laboratory results to actual data. This required collection of the following:

- Samples of oxide pellets, before and after coating (if possible)
- Samples of DRI from the corresponding time period
- Operating data from the corresponding time period

The first series of tests were conducted on uncoated pellets at various temperatures to examine the link between temperature and reducibility. Further testing was performed at test conditions that resulted in DRI characteristics that most closely matched those in the plant.

Coatings were then applied in the laboratory to match the coating amount applied in the plant. If coated pellets from the plant were available, they also were tested. The next step was to test the coated pellets in the laboratory and compare them to plant performance.

It is reasonable to assume that the results of standard lab testing are an indication of the performance of an oxide in a commercial furnace. Nevertheless, establishment of a reliable correlation to data obtained under carefully controlled conditions is an important step in verifying the utility of the test procedure in evaluation of the material.

IMPROVEMENTS IN ANALYTICAL EQUIPMENT

Iron totals and metallic irons have always been performed in-house by potassium dichromate titration. Improved quality assurance techniques, including triplicate analyses, scheduled check standards and automation of data storage and retrieval, have been instituted. New automatic titrators allow addition of the titrant with accuracies of down to 0.05 ml. All analytical procedures have been formalized and documented.

The procedure for metallic iron has been modified from the ISO procedure to improve turnaround time and safety; however, the calculation of metallization is functionally equivalent in both methods.

Improvements in C and S determination have been made through equipment upgrade (new LECO CS-230), improved operator training, triplicate analyses and review before release and improved calibration techniques.

Hot Load and Linder test results have historically been limited to Fe total, metallization, C, and S. Analysis of other oxides was performed at an outside lab and conducted only on the oxide, not on the product.

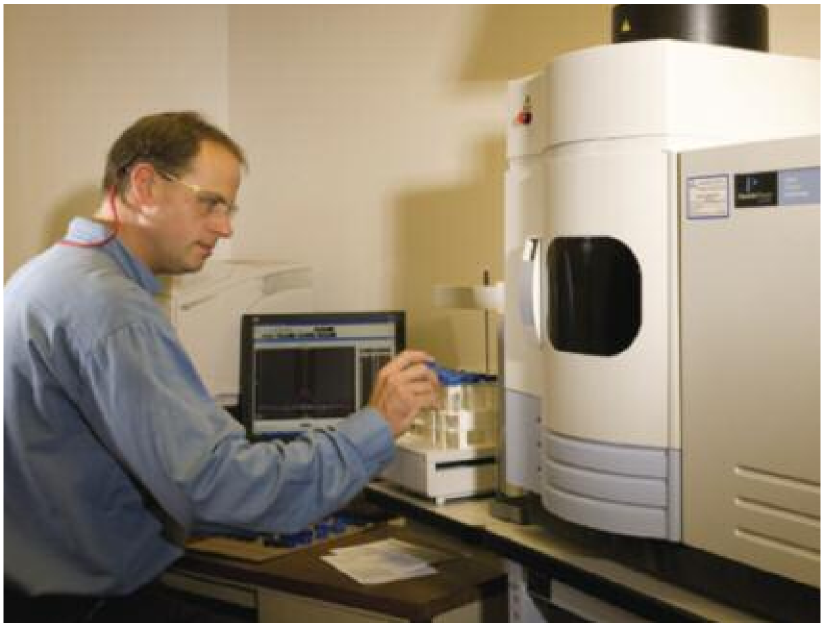


Figure 4 - ICP for Elemental Analysis

An ion coupled plasma (ICP) optical spectrometer was installed in 2007. The ICP (Figure 4) is now used for analysis of several elements on a standard basis for every sample. This expanded capability allows for more detailed reporting of the results and provides information about oxide chemistries, alkalis, volatile elements, such as zinc and lead, and residual metals.

Sample preparation procedures are critical for the ICP. Extensive development went into creating the optimal combination of acid dissolution with microwave treatment (Figure 5)

Figure 5 - Microwave Digestion for the ICP

In June 2008, we added a combination X-ray fluorescence/ X-ray diffraction (XRF/XRD) instrument. This will provide independent confirmation of the elemental analyses performed by the ICP. More importantly, it will provide the opportunity to define the nature of the compounds present in the ores and allow detailed characterization of the mineralogy. Test programs are envisioned in several areas:

First, it is likely that previously unexplained variations and differences in oxide behavior (e.g. reducibility, rate of carbon pickup and strength) may be related to differences in mineralogy. The goal is to determine which mineralogical characteristics are most relevant to these parameters. This is a complex task that will require extensive investigation and analysis.

Second, we should be able to use the elemental analyses, along with the compound data, to “fingerprint” specific ore sources. This would allow identification of the source of an unknown iron ore once a sufficient data base has been established.

CONCLUSION

A major program to improve equipment and test procedures has been undertaken at the Midrex Technologies, Inc. Research and Development Technology Center. Improvements have been made in both laboratory equipment and procedures. Additional improvements have been made in the areas of furnaces and equipment for testing reducibility and clustering, including the capability to perform standard ISO testing, along with other test procedures developed by MTI. Analytical capabilities have been strengthened by the addition of new titration equipment, new carbon/sulfur analyzer, new microwave digester and ICP and new XRF/XRD.

Championing Hot Briquetted Iron, Steel's Most Versatile Metallic

Hot Briquetted Iron Association: Dedicated to Promoting Hot Briquetted Iron

By Alberto Hassan, President
Frank Griscom, Executive Director
Hot Briquetted Iron Association, Ltd. (HBIA)

Editor's note: As both an associate member of the HBIA and a prominent technology supplier in the HBIA arena, we decided to take this opportunity to highlight the Hot Briquetted Iron Association (HBIA) and their work in promoting HBI.

Hot Briquetted Iron is traditionally known as a compacted form of direct reduced iron for use in an electric arc furnace (EAF). Fifty percent denser than DRI pellets and lump and reducing the tendency for reoxidation, the HBI product form was born out of the need for a direct reduction product ideal for ocean transport to distant consumers.

Hot briquetting of DRI has been practiced on an industrial scale for more than three decades, and is now the preferred method of preparing DRI for storage and transport internationally. To promote and champion the established product in a growing steel industry, a group known as the Hot Briquetted Iron Association (HBIA) was formed in 1999.

INTRODUCTION OF HBI ASSOCIATION, LTD. (HBIA)

The HBIA is a not-for-profit, international trade organization whose purpose is to promote hot briquetted iron (HBI) as a preferred source of high quality, merchant iron units and to assist the global steel industry in the effective handling, shipping and use of HBI.

HBIA members include all major producers and exporters of HBI, suppliers of process technology, equipment, materials and services, including transportation to the HBI Industry, and traders and brokers involved in buying and selling HBI worldwide.

HBIA objectives are:

- To promote HBI as the preferred source of merchant steelmaking metallics
- To inform ship owner/operators and charterers and terminal operators of the handling, shipping and storage benefits of HBI
- To assist iron and steel producers in the effective use of HBI

HBIA has four types of members:

- Producers – companies that manufacture HBI or have begun construction of an HBI plant, or have assumed the operations of an HBI plant
- Associates – companies engaged on a continuing basis as either an HBI plant builder or a supplier of technology, goods or services to the HBI Industry
- Traders – companies engaged on a continuing basis in selling or brokering HBI and other steelmaking metallics
- Special – individuals who have made noteworthy contributions to the success of the HBI Industry

HBIA members span the gamut of the HBI supply chain, from iron ore mining to transporting and trading HBI. They are leaders in their business areas:

- Suppliers of more than 90 percent of all DR plants
- Leading supplier of pelletizing plants
- Leading supplier of hot briquetting machines
- Leading suppliers of DR-grade pellets
- Most experienced carriers of HBI
- Most experienced port terminal for shipping HBI
- Inventor of soft loading method and equipment

Members are encouraged to participate in the three standing committees: Promotion, Technical, and Transportation. These committees are involved in HBI market development, industry interaction, production and shipping statistics, HBI standards and certifications programs and environmental awareness.

As an HBIA member, companies have:

- Access to and network with the major producers, suppliers and traders of HBI and other steelmaking metallics
- Representation at major worldwide conferences, trade shows and meetings
- Source of news, information and statistics about HBI and the global steel industry
- Voice in international forums that set guidelines for handling, shipping and storage of merchant steelmaking metallics
- Entry into Members Only area of HBIA Web site (www.hbia.org)
- Roster of member companies and contact information

HBIA is a member or has working relationships with Arab Iron and Steel Union (AISU), Association for Iron & Steel Technology (AIST), Dry Bulk Terminals Group (DBTG), International Pig Iron Association (IPIA), South East Asia Iron and Steel Institute (SEAISI), and Sponge Iron Manufacturers Association (SIMA). HBIA has applied for IMO consultative status to provide a collective voice for the HBI Industry, and is helping facilitate registration of HBI under the REACH regulations.

DIRECT REDUCTION GROWTH

As world steelmaking increases each year, there is a growing global need for metallics and often in areas of the world where metallics are not available or are not available in sufficient quantity.

Between the 10-year period 1997-2007, the production of DRI and HBI skyrocketed 86 percent, reaching 67.22 million tons in 2007. Even more remarkable was the 228 percent increase in shipments of DRI and HBI, which vaulted from 7.50 million t/y in 1997 to 17.06 million t/y in 2007 (figures from *Midrex 2007 World Direct Reduction Statistics)*.

Sixteen countries account for the world's supply of DRI and HBI, and four of these countries (India, Venezuela, Iran and Mexico) together produce more than half of the total output. Russia, however, is emerging as a leading producer of HBI. Venezuela and India also are HBI producers.

In 2007, Venezuela accounted for approximately 3.61 million tons of the 4.81 million tons of HBI produced by HBI Association members. Russia made up the balance of HBI production. Qatar Steel Company became an HBIA producer member in March 2008.

More than 80 million tons of HBI have been shipped worldwide since the Fior de Venzuela plant made its first delivery to the US in 1978. Of that total, approximately 67 million tons have been transported over water (ocean and inland). Plants located in Venezuela have accounted for more than 45 percent of all HBI shipments since 1978.

WHY HBI?

The first modern day direct reduction plants were built adjacent to steel mills with DRI production intended for local use. As demand developed in areas where captive plants were not feasible, merchant shipments of DRI began. Unfortunately, incidents involving DRI cargoes eventually led to increased insurance rates for shippers and a subsequent decline in ocean transport. A safer way to ship DR products had to be found in order for the merchant market for direct reduction products to grow.

The answer was hot briquetted iron (HBI).

The International Maritime Organization (IMO) issues guidelines for safe shipping and handling of various ocean-going cargoes. The IMO Code of Safe Practices for Solid Bulk Cargoes (BC Code) is the basis for national shipping regulations and for setting bulk cargo insurance rates.

Guidelines for shipping HBI or DRI (A), as it is known by IMO, and conventional DRI, known as DRI (B), are included in the IMO BC Code. A new guideline for DRI and HBI fines, which will be known as DRI (C), is under development.

The IMO recognizes HBI as a form of DRI with superior handling and shipping characteristics, which is reflected in the BC Code.

WHAT IS HBI?

HBI is a compacted form of DRI that is manufactured with well-defined, consistent chemical and physical characteristics. Today, dedicated merchant HBI plants are in operation in Venezuela, Russia, India, Malaysia and Libya. Qatar Steel Company operates a hot discharge plant that includes briquetting capability, and is currently exporting HBI.

HBI is manufactured to be shipped over great distances and melted in a variety of iron and steel processes. It is available throughout the year unlike scrap, which tends to have a collection season. The chemical composition of HBI is certified by the producer, and ISO quality standards are strictly followed.

Physical characteristics are the real reasons that HBI was created. Its greater mass allows rapid penetration of the furnace slag layer. HBI is 100 times more resistant to reoxidation than conventional DRI and will pick up 75 percent less water. HBI generates few fines, which provides greater value to users and reduces safety concerns during handling and shipping. Its size and shape is compatible with standard materials handling equipment, and HBI can be batch charged or continuously fed to a melting furnace.

ADVANTAGES OF HBI

Because HBI is produced from natural iron ores with no additives or binders, it is a source of clean, highly metalized iron units. DRI and HBI share these operational advantages:

- Attractive cost structure when compared with price of imported scrap in countries that have abundant and inexpensive natural gas resources
- Availability of annual supply contracts avoids price spikes of spot market
- Year-round production (no "collection season")
- Well-defined, consistent chemistry with guaranteed specifications
- Low residual content (Cu, Ni, Cr, Mo, Sn, Pb, and V)
- Dilutes impurities in lower quality scrap
- Blends with other metallics for best total charge economics
- Applicable for full range of products, from rebar to sheet steel
- Continuous feeding maximizes power-on time; increases bath weight
- Promotes foamy slag and reduces EAF nitrogen level
- Shields refractory to reduce damage
- Excellent for AC or DC furnaces, long or short arc operation
- Increases iron production in BF; reduces coke rate and CO_2 emissions
- Compatible with injected fuels and oxygen
- Metallic yield in BOF similar to hot metal
- Predictable mass and heat balances

HBI possesses unique characteristics that result in these benefits:

- Density greater than 5.0 grams per cubic centimeter (g/cm^3), which allows for rapid penetration of the furnace slag layer
- Higher thermal and electrical conductivity for faster melting
- Less fines generation for added value to the customer
- Less reactive to water for safer ocean and inland transport
- Easy to handle, store and transfer in all types of weather and with standard materials handling equipment

Today, HBI is shipped to iron and steel producers throughout the world. In 2007, 35 percent of the HBI shipped by HBIA producer members was destined for Europe. North America accounted for 25 percent of the HBI shipped, followed by Asia with 18 percent, South America with 14 percent and Africa and the Middle East with seven percent and one percent, respectively.

Direct from Midrex lists more than 20 million t/y of direct reduction capacity capable of producing HBI. Of that total, 13.25 million tons of the 14.15 million tons identified for merchant use is available (operational).

Midrex, Tenova HYL and India's Sponge Iron Manufacturers Association (SIMA) report that almost 21 million tons of new natural gas-based DRI and HBI capacity is either under construction or contract. In addition, a number of projects are under development or preliminary agreement, most notably in Russia and surrounding countries.

Although the primary purpose for these direct reduction plants is to feed a nearby steelmaking operation, the managements of these companies have provided themselves an additional revenue stream and another value-added use of their national energy resources by including the capability to produce HBI for export.

Venezuela is home to the only operating HBI plants in the Western Hemisphere, primarily servicing North America and Western Europe. Russia, with abundant natural gas and iron ore reserves, is emerging as a key exporter of HBI to Europe and the Near East, while new direct reduction capacity in the Middle East will make HBI available both in the immediate region, as well as to export markets. The presence of indigenous iron ores and the prospects of new natural gas allocations make Indian HBI producers potential suppliers to customers in the SEAISI countries and throughout Asia and the Pacific Rim. In addition, HBI is available from Libya Iron and Steel Company (LISCO) and Antara Steel HBI Operation now that The Lion Group has started up its new plant in Malaysia.

CHAMPIONING HBI

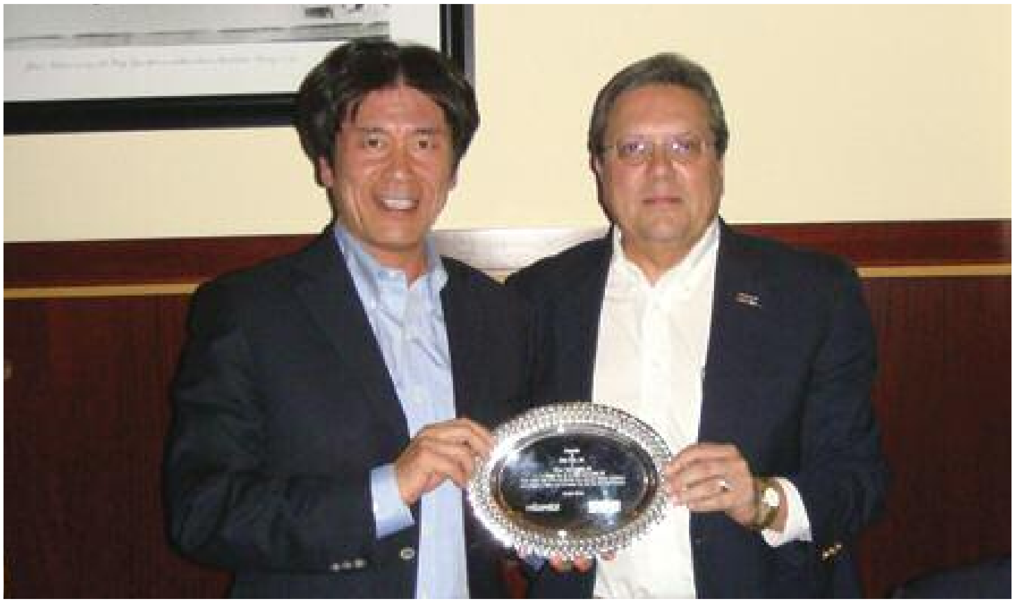
As HBI production and demand continue to increase, further understanding of the product and its benefits are needed. Although initially created for EAF steelmaking, new found uses and practices continue to evolve. For example, HBI currently can be used to reduce CO_2 emissions of a blast furnace to aid in meeting world environmental regulations.

A tried-and-true product like HBI can continue to surprise and benefit the industry. The HBIA mission is to help get this message out to the industry.

Visit the HBI Association Web site at www.hbia.org for information about HBI and HBIA members.

Midrex News & Views

A Quarter-Century Celebration



This fall, Midrex celebrated the 25th anniversary of its acquisition by Kobe Steel, Ltd. For a quarter century, Midrex and Kobe Steel have been major players in the direct reduction industry.

Midrex remains a valuable asset to Kobe Steel as a process technology partner rooted in ironmaking and expanding into other related technology areas.

KOBELCO
KOBE STEEL GROUP

James D. McClaskey (right), President & CEO of Midrex, presents a 25th Anniversary Commemorative Plaque to Shohei Manabe, Head of KSL's Iron Unit Division

Christopher M. Ravenscroft: Editor

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