CONTENTS

2 COMMENTARY: 
The Heart of the Matter: 
Paving the way for HBI

4 HOT BRIQUETTED IRON: 
A new surge of growth in the industry

10 MIDREX® Direct Reduction 
Plants – 2012 Operations 
Summary

15 NEWS & VIEWS: 
voestalpine signs contract with 
Siemens and Midrex for DR Plant

16 Midrex Pioneers honored for innovation

17 74 Million Tons of DRI produced in 2012

Tuwairqi Steel’s MIDREX® Plant Begins 
Operation

18 Midrex and JSW Steel to convert 
DR Plant to utilize coke oven gas

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COMMENTARY

THE HEART OF THE MATTER: PAVING THE WAY FOR HBI

By Henry Gaines
Director of Marketing, Midrex Technologies, Inc.

It is no secret now. The USA’s first ever HBI plant is on its way to becoming reality, and it is using Midrex and Siemens to make it happen! As detailed in this issue of DFM, voestalpine has announced that it will use MIDREX® Direct Reduction Technology for its much publicized and first of its kind plant here in North America.

Along with our partners at Siemens, we have worked long and hard to provide voestalpine with the best direct reduction solution for its new venture. Midrex and Siemens are fully committed to this endeavor and we think that this project will be of great benefit to all involved.

This is an important contract not only for Midrex, but moreover for the whole steel industry. voestalpine is paving the way for a future that will benefit voestalpine’s operations in Austria as well as strategically positioning the company in North America for HBI.

In short, voestalpine is leading the shale gas revolution in North America by building a MIDREX® HBI Plant. This new plant will be able to capitalize on the low natural gas costs in the United States to produce a value added metallic for internal company use as well as an additional high quality metallic source for the regional and global marketplace.

It’s been a long and winding road, but our journey has just begun.

With that said, I was quite elated when I read what Wolfgang Eder, Chairman of the Board of voestalpine AG and head of their steel group, had said of their technology and partner choice.

“With Siemens and Midrex, we will have highly competent partners with a tried and tested technology at our side.....”

-Wolfgang Eder, July 4th 2013

Mr. Eder’s words get right to the point of describing why voestalpine selected the Siemens-Midrex consortium to build their exciting new HBI plant near Corpus Christi, Texas, USA.

Midrex is a technology company, and its product quality is shown through its MIDREX® Plants both past and present. Simply put DR industry data shows that the MIDREX® Process is the best operating direct reduction technology available. Our track record of successful MIDREX Plants, DRI production, raw material flexibility and continuous hours of operation is not a list for us to boast about past accomplishments, it is a CV that describes what a company can expect from Midrex, its partners and most importantly our technology solutions.

Many companies today try to make themselves look better by diverting attention away from the “big picture.” Frequently it is done by focusing on theoretical rather than real world numbers or defining data parameters to imply better results than are actually correct. It is a game that some companies are quite good at, however; when focus is consumed on inconsequential issues,
COMMENTARY

(Continued from page 2)

sometimes the big picture is lost and quite often people jump to the wrong conclusions. Much like a mosaic, each individual piece on its own does not give you the whole picture and in most cases the picture inferred is not an accurate one.

In the end, consumers want the best and expect more in return for their investment. That means quality, flexibility, performance and most of all a reliable plant that works day in and day out.

MIDREX® Plants are designed to help owners and operators best deal with real world market changes. There are several factors that can affect the profitable operation of a direct reduction plant such as ore costs, energy costs, labor and the unpredictability of the steel market. But, out of all the variable factors, the choice of process technology is the only one that the owner can truly control. More importantly, it is the one that can affect profitability in both good and bad economic times.

The technology itself does not reside in a vacuum. It takes core competency to make the process and equipment perform to the highest standards and be reliable through and through. Midrex and Siemens have a proven track record with projects ranging from the coal-based COREX®/MIDREX® Process to plants that feature the latest in hot discharge technologies for HDRI and HBI production.

We wish voestalpine the best and look forward to working on this project. We will also keep our readers informed as this notable project progresses. In the meantime Direct From Midrex will continue to bring you the latest on other important technologies and milestones that will no doubt affect the industry in order to give our readers the big picture.
HOT BRIQUETTED IRON:

A new surge of growth in the industry

By Henry P. Gaines,
Christopher Ravenscroft
& Robert Hunter

INTRODUCTION

The steel industry is seeing a renewed interest in direct reduced iron (DRI) and DRI products because of new available energy sources and more incentives for product use in not only Electric Arc Furnaces (EAFs), but also integrated mills. Low cost natural gas resulting from the boom in shale gas production, together with the benefits provided by using DRI have generated interest in building new plants. In particular, there is greater interest in hot briquetted iron plants that allow safe and easy transport of the iron; transport from the location where gas is low cost to the location where the metallic is needed.

After following a steady pattern of plant construction in which the ability to produce HBI together with another product, either Cold DRI (CDRI) or Hot DRI (HDRI) there is now interest in building plants whose primary purpose is to manufacture HBI. This has been brought about by the falling price of natural gas in North America coupled with the value of HBI for integrated steelmaking. The concept is to make HBI where the gas is low cost and ship the HBI to its market. This article will delve into the subject first by examining HBI's long history bringing the reader up to date on progress and accomplishments. From there we will ponder the future which will no doubt include more and more HBI.

A (NOT SO) BRIEF HISTORY OF HOT BRIQUETTING OF DIRECT REDUCED IRON

The story of HBI on a tonnage scale begins with a direct reduction plant built in Venezuela in the mid-1960’s. It was a fluidized bed process that used iron ore fines smaller than 2 mm. Once the fines were reduced to metallic iron, they needed to be agglomerated into larger particles that could be fed to either a blast furnace or to a steelmaking furnace (otherwise fines would get caught in gas flows or in slag and cause the yield of DRI to liquid steel to be very low). Laboratory tests began as early as 1952; following the lab tests, pilot plant operations proved successful. The commercial plant was built; however, when tried at full scale the process was not able to achieve high metallization nor was the facility able to operate consistently enough to produce the desired tonnage. It proved difficult to produce product with greater than 75% metallization and the production which had been planned at 0.9 million tons per year was limited to only about one-third of that. After a few years of gallant efforts to make it work as planned the process was abandoned.

After that plant, another fluidized bed process facility was constructed in Venezuela: the FIOR de Venezuela plant. The FIOR acronym stood for Fluidized Iron Ore Reduction. The process had originally been developed by Esso Research, a division of the company now known as Exxon Corporation.
The laboratory scale research began in 1955. The commercial scale plant (about 400 thousand tons per year) began operation in 1977. It was necessary to agglomerate the fines to make pieces large enough to successfully be used in steelmaking; FIOR used briquetting.

A large share of the early FIOR product was shipped to various locations around the world, but mostly to the United States (Bethlehem Steel’s Indiana Harbor works) where it was used as trim coolant (added in the liquid steel ladle).

Throughout the 1970’s the DR industry was growing rapidly. At the beginning of the decade 730 thousand tons of DRI was produced worldwide and growth averaged over 25% per year to end the decade with 7.14 million tons of production—a nearly ten-to-one increase. None of these DR plants had been built with the intent to ship the DRI. All of them were constructed primarily to supply DRI to a near by steelmaking melt shop; however, interest in DRI was high and many other steelworks were purchasing DRI from the existing DR plants. On average, at this point about 10% of all DRI produced was being transported to other steelworks, some by land transport (truck or rail) but most by water-borne transport (barge or ship).

DRI in large, bulk shipment quantity when wetted has the potential to heat-up from the heat of oxidation (rusting) and can actually catch fire. This happened repeatedly during the 1970’s quickly getting the attention of the insurance companies and the shipping industry. Obviously a cargo fire in a ship at sea is a serious problem. Thus it was clear that a solution was needed to ship DRI.

The first attempt did not meet expectations. A process to coat DRI in sodium silicate was developed. Two 400 thousand ton per year plants were constructed on the North German coast at Emden with the intent of selling and shipping DRI within northwestern Europe; locations where it could be shipped via truck, rail, and barge. All water-borne shipment was to be done via fresh water by river barges. Despite the plan, some shipments were sent by sea. As soon as an ocean going vessel was caught in high seas and seawater washed into the holds, a cargo caught fire.

Other attempts have been made by increasing the iron carbide, or cementite content of the DRI. While in theory this might be helpful, the reality is that the relatively small increase in iron carbide content possible has very little if any effect on resistance of the DRI to re-oxidize (See Direct From Midrex, 4th Quarter 2007).

The proper solution to this problem was to reduce surface area of the materials by compacting or briquetting the DRI. It would be necessary to adapt the briquetting technology already well developed for agglomeration and compression of DRI fines to also handle pellet and lump DRI. This process would later be known as “hot briquetting” producing what is known as “hot briquetted iron” or HBI. Midrex and Maschinenfabrik Köppern GmbH & Co. KG (Köppern) worked closely together and had the technology ready in time for the 1984 start-up of the next merchant DRI plant built on the island of Labuan off the coast of Borneo in Malaysia (about 110 kilometers southwest along the coast from Kota Kinabalu). Then known as Sabah Gas Industries (SGI), and owned by the government of the province of Sabah, it is today owned by Antara Steel Mills Sdn. Bhd., a division of the Malaysian company The Lion Group. Soon SGI was shipping HBI to electric arc furnace steelworks throughout Southeast Asia. Since start-up, the Antara Steel Mills plant has dispatched more than 17.5 million tons of HBI, all of it sent over salt water on ocean going vessels.
TWENTY MORE HBI PLANTS BUILT

With the concept of the merchant HBI plant proven, a number of other such projects were developed. The next plant was the Operaciones al Sur del Orinoco (OPCO) in Puerto Ordaz, Venezuela. OPCO emerged out of the remnants of a previously failed plant. Much of the original plant was remodeled into a MIDREX® Direct Reduction Plant by incorporating a MIDREX® Direct Reduction Furnace while continuing to use much of the existing gas handling, materials handling and water treatment equipment. Along with the MIDREX® Furnace, modern, new briquetting machines from Köppern were installed. OPCO later added a MIDREX® Reformer to improve operation, increase productivity and provide higher carbon content of the HBI. OPCO began operation in 1990 and was built by a consortium of Japanese investors to take advantage of the rich Venezuelan iron ore deposits, abundant supplies of natural gas and the low cost hydroelectric power. Today, under the ownership of the Venezuelan government iron mining company, Ferrominera Mining (FMO) this facility is now called Planta de Briquetas. FMO Planta de Briquetas sends HBI throughout the global marketplace as does its sister plant Comsigua (Complejo Siderurgica de Guaya- na) which started up in 1998.

Combined these two plants are capable of producing over 2.4 million tons per year of HBI, albeit they have been seriously restricted in recent years by difficulties in obtaining supplies. Another MIDREX HBI Plant started up in Venezuela in 1990, the Venprecar Plant designed to make 820 thousand tons per year for the SIVENSA group of companies. It is now also owned by the government of Venezuela. Also, an Hyl HBI plant was built nearby, originally built by POSCO and Raytheon, it too is now government owned and known as Briqven. It has suffered a somewhat difficult history; designed to make 1.5 million tons per year and having begun operation in 2001, its total production to-date is less than 1.5 million tons.

A series of MIDREX Plants making HBI were also brought into operation in the 1990’s in India by Essar Steel Ltd., with headquarters in Mumbai and with the MIDREX Plants in Hazira in Gujarat. Beginning, by purchasing two used modules from northern Germany and remodeling them to be able to produce HBI, Essar built an additional three MIDREX Modules with ability to make HBI. Combined these five plants have a nameplate capacity more than 3.8 million tons per year but have demonstrated the ability to make nearly 4.9 million tons per year. Although originally built to make HBI, these plants have stopped doing so since they have been modified to be able to make and transport Hot DRI (HDRi) to adjacent steelworks. Obviously, if the melt shop can receive the iron as HDRi, there is little reason to continue to produce the iron as HBI.

In 1997, the Libyan Iron and Steel Company (LISCO) started its third MIDREX Module. The first two were built to produce solely CDRI for LISCO’s melt shop next to the DR plants in Misurata, but the third plant was built as an HBI plant to allow the possibility of export shipping which has proven useful as LISCO dispatches HBI each year to customers who are mostly at nearby Mediterranean ports.

Another locale where multiple HBI plants have been built, or are being built is at Gubkin in Russia. Gubkin is in Belgorodskaya Oblast, not far from Kursk. There, an Hyl plant to produce HBI was brought on line in 1999 and a MIDREX HBI Plant began operation in 2007. Currently a third plant, Lebedinsky GOK HBI
III, another MIDREX HBI Plant is under construction and will begin operation in 2016.

Yet a third location with multiple HBI plants is Malaysia, where, in addition to the Antara Plant discussed above The Lion Group built another MIDREX HBI plant which can make either HBI or HDRI. The HDRI is for the melt shop alongside the DR plant and the HBI is for export shipment. The capacity of the plant is 1.54 million tons per year. This plant, called Lion DRI, is located at Banting, not far from Kuala Lumpur.

The ability to make either of two products, in this case HDRI or HBI, is called a Combo Plant. Midrex builds Combo Plants so they can be shifted back and forth between product types without any need to halt operation and they can produce multiple products simultaneously. This feature is unique within the direct reduction industry as other DR plant suppliers’ technologies require interruption of production in order to execute the switch between products and they are not capable of simultaneously producing multiple products.

HARDSHIPS MET BY THE INDUSTRY

It would not be the entire story if we did not address difficulties being met by the HBI industry. In 2011 and 2012, a shortage of iron ore combined with extremely high prices of natural gas caused production in India to be seriously curtailed. Also as stated earlier, the HBI production by Essar Steel’s plants was displaced by converting that production to HDRI. The HBI output by plants in Venezuela has declined markedly over the past few years due to difficulties in obtaining pellets and supplies. 2012 production of HBI in Venezuela was only 2.5 million tons, down to less than half of the 2005 output of 5.4 million tons. Despite these two areas of decline, in India and in Venezuela, the overall world production of HBI has held steady due to the growth in other areas. This can be seen in the graph of world HBI production by year which is shown as Figure 1.

MORE & MORE HBI – FORCES DRIVING THE IRON AND STEEL INDUSTRY TO BUILD ADDITIONAL HBI CAPACITY

Up until very recently, some of the world looked at HBI as an “old” technology; however, this was quite an odd conclusion to jump to especially when considering that no better or safer technology/technique has been successfully introduced to allow safe ocean going shipping of DRI without special and expensive safeguards. Furthermore HBI is still the only recognized way to safely ship DRI by water according to the International Maritime Organization (IMO) (see sidebar on page 9).

It is mostly likely that this misconception was caused in part by some people’s observations of the EAF industry’s evolution of using HDRI in the EAFs to increase the product’s value in use. As the EAF is the world’s primary user of DRI, this could be seen as a trend, but not a truly accurate one. HDRI usage is gaining popularity in any area when the EAF is close enough to hot charge
products; yet, HBI & CDRI use is growing as well. More and more companies are factoring HDRI usage into long term EAF production and planning; however, in many of these sites the alternate or additional products stream is still HBI. Plants such as Jindal Shadeed in Oman and LION DRI in Malaysia are two recent examples of newer plants that are utilizing both technologies.

OUTSIDE THE EAF

The EAF industry is not the only user of HBI. Conventional wisdom has always dictated that DRI could not be used as a significant feed material for a blast furnace. However today more and more integrated steelmakers are considering the use of HBI for their blast furnaces on a regular basis, rather than just on occasions when one furnace may be down to increase hot metal output of the other furnaces.

The benefits of charging HBI to a blast furnace (BF) are great.
- Greater productivity
- Lower blast furnace fuel consumption
- Lower coke consumption
- Greatly decreased CO2 generation

As a matter of fact, for each 10% metallization increase of the blast furnace burden (such as metallic iron being added as HBI) the productivity of the blast furnace is increased by 8%. Simultaneously, each 10% metallization increase decreases specific fuel consumption by 7%

HBI, rather than un-briquetted CDRI is the preferred and actually almost the only form of DRI usable in a modern blast furnace because the crush strength of CDRI is simply too low to make it a good choice for large, modern, high production blast furnaces.

There are two new economic forces that are driving this reconsideration of HBI as feed for blast furnaces. In a number of advanced economies, impending closure of BF capacity is expected over the next few decades, driving steelmakers to seek out alternate ways to keep business alive. Simultaneously, international pressure to decrease CO2 emissions is leading steelmakers to make better use of existing coal/coke sources and to find a way to lower overall emissions. DRI production in both cases is gaining popularity as new innovative technologies come to market, such as MXCOL®, which uses a gas originating from coal via either a dedicated coal gasifier, or coke oven off gas after processing by Midrex/Praxair’s Thermal Reactor System® (TRS®).

Areas rich in low-cost natural gas will also encourage traditional use of natural gas-based direct reduction technologies such as the MIDREX® Process to make HBI for use in the integrated steel works.

Although this last topic has been discussed regularly over the past few years, nothing seemed to gain much traction. But today the ice has been broken. It is well known that DRI/HBI projects are being planned. One of the most publicized is the one gaining momentum in Corpus Christi, Texas. The voestalpine Group recently signed an agreement with the consortium of Siemens Industry Inc. and Midrex Technologies, Inc. to build the world’s largest HBI production facility. The plant to be built near Corpus Christi, Texas, USA will take advantage of the low natural gas prices available in North America due to the massive new supplies of gas brought on due to development of shale gas reserves. The MIDREX® Plant will be designed to produce 2.0 million tonnes per year of HBI. Approximately 50% will be shipped trans-Atlantic to Europe where it will be used by voestalpine at their integrated steel works at Linz and Donowitz, Austria to increase the productivity of the blast furnaces as well as lower their fuel consumption.

In addition, use of HBI made from natural gas vastly lowers the CO2 footprint of the iron that is made. This technique is a more powerful means of limiting CO2 than any other technology under consideration.

Reduction by natural gas generates only one-third of the CO2 as reduction by conventional blast furnace technology. Further, the use of pre-reduced material, such as HBI, as part of the BF charge lowers the CO2 footprint of that iron passing through the direct reduction furnace and the BF to only about one-half of
conventional BF-only smelting; this is over the entire cycle, iron mining through finished steel.

Other companies are also considering use of HBI in their blast furnaces, but they have not yet made their plans available for the public.

The combination of these factors, (1) increased productivity, (2) decreased fuel consumption, (3) greatly decreased CO₂ production (4) low cost natural gas in certain areas of the globe, and (5) the demand for DRI in other locations, all tend to drive industry toward construction of more HBI capacity. It is also very likely that some production will be specifically targeted for the integrated industry. This last idea could have even further ramifications as DR plants could use lower grade ores, which could lower raw material cost by up to 10%. Since most DRI used is specifically made for the EAF market, typical beneficiated ‘DR-Grade’ pellets are aimed to lessen the gangue content to increase the tap to tap times within the furnace. The BF can easily slag off this gangue content, thus there is no great need to beneficiate pellets for this market. As the market grows for integrated HBI production, potentially some HBI plants could run entirely on BF-grade pellets. The MIDREX® Process has experience using these lower grades of raw materials to produce DRI Products.

CONCLUSION
HBI has been here for decades; however, its true impact is yet to be fully realized by the steel industry. Low cost natural gas, a mainstay of the shaft furnace DR technology has encouraged DR production in North America and elsewhere. The benefits of producing HBI for shipping along with the environmental and productivity impact for integrated steel production will mean greater demand for HBI over the next few decades. HBI usage, in fact, may be the best alternative to keep certain integrated steel works in operation for years to come as its collective benefits will lead to better more profitable and cleaner steelmaking operations.

Guidelines by the International Maritime Organization (IMO)

Low gas costs in some areas and high demand for direct reduced iron in other regions create a need for DRI to be shipped. It must be noted that the guidelines written by the International Maritime Organization (IMO) for transportation of HBI are considerably less restrictive than those written for Cold DRI (CDRI). The IMO refers to HBI as “Direct Reduced Iron (A): Briquettes, hot-molded” and to CDRI as “Direct Reduced Iron (B): such as lumps, pellets and cold-molded briquettes”. The main restriction is that DRI (B) cargoes must have the holds inerted with a non-reactive gas such as nitrogen. Maintaining the nitrogen inerting can be costly over long voyages, such as across the Pacific Ocean. In addition, the cost of insurance for DRI (A) cargoes (HBI) is considerably less than for DRI (B) cargoes (CDRI). General handling of HBI is much easier than of CDRI in that HBI can be stored in almost any location, much like scrap steel. On the other hand, caution must be taken with CDRI to be certain that it is not wetted. Not only must it be kept out of the rain but it also must be kept off the ground, away from any possibility of moisture ‘wicking’ up into the stack of CDRI. Otherwise, there is a strong risk of rusting and of burning.
With the world economy slowly improving, MIDREX® Plants produced an estimated 44.8 million tons in 2012, 0.8% more than in 2011 and 6.5% more than in 2010. Estimated production is based on 33.18 million tons confirmed by MIDREX Plants outside Iran. An additional 11.58 million tons of DRI production in Iran, all of it from MIDREX Plants, was reported by the World Steel Association.

MIDREX Plants continued to account for 80% of the worldwide production of natural gas-based DRI. Several plants achieved production records despite slow demand growth and iron ore prices that were lower than 2011 levels but still remained high. Seven plants outside of Iran continued to establish new production records with seven annual and monthly production records set. In addition another seven plants came within 5% of their record annual production values, and 15 MIDREX® Modules operated in excess of 8000 hours.

In mid-2012, there were some downward iron ore price pressures but iron ore prices rose again by year’s end to early 2012 values. Three new modules are reported to have started up in Iran belonging to South Kaveh Steel, Ghadir Steel and ARFA Steel.
ACINDAR
Despite typical mid-year winter natural gas curtailments, ACINDAR’s MIDREX® Plant came within 5% of breaking their annual production record, achieving monthly average production rates of 146-147 t/h. This plant reached the 25 million ton production mark in the first half of 2012, the most DRI produced by any single direct reduction module to date.

ANTARA STEEL MILLS
The first MIDREX Plant designed to make HBI, Antara produced under its rated annual capacity in 2012 due to a scheduled major maintenance shutdown and external constraints.

ARCELORMITTAL HAMBURG
AM Hamburg’s MIDREX Plant comfortably exceeded annual rated capacity in 2012, returning to pre-recession production levels.

ARCELORMITTAL LAZARO CARDENAS
In its 15th anniversary since start-up in August 1997, AMLC operated over its rated capacity of 1.2 million tons using iron ore pellets made exclusively with Mexican iron ores.

ARCELORMITTAL MONTREAL
After restarting in June 2011, Module II exceeded rated capacity and operated within 10% of its record annual capacity in 2012. Module I remained shut down throughout the year, but is being refurbished to restart operations in 2013 due to competitively priced natural gas and oxide pellets sourced locally.

ARCELORMITTAL POINT LISAS
Modules 1 and 2 restarted at the beginning of the year. All three of AMPLE’s Modules operated for most of 2012, with production constrained in part by the price of iron ore.

ARCELORMITTAL SOUTH AFRICA (SALDANHA WORKS)
Saldanha’s COREX/MIDREX® DR Plant operated limited by the availability of export gas from the COREX Plant. The plant almost equaled its operating hours record and averaged more than 66% local lump ore usage for the year.

COMSIGUA
COMSIGUA’s production of HBI remained below rated capacity due to the limited supply of locally produced pellets and lump ore.
DELTA STEEL

The two Delta Steel modules did not operate in 2012.

DRIC

In their 5th anniversary year of operation in their new location, DRIC's two modules in Dammam, Saudi Arabia continued to increase production to satisfy the demand of its adjacent steel shop. Module 1 established a new annual production record this year, operating more than 8200 hours. These DR Plants (DRIC 1 & 2) are limited to about 50% of their maximum capacity by the existing steel mill's capacity to take DRI. This will change when Al-Tuwairqi Group's new steel mill starts up in 2013.

ESSAR STEEL

Twenty years after the startup of their third MIDREX Module, Essar's sixth MIDREX Module (designed to produce only cold DRI) set a new annual production record for a second year in a row with more than 8000 hours of operation, and a new monthly production record established in January. Essar's MIDREX Modules surpassed the milestone of 50 million tons of DRI produced in early 2012 despite minimum DRI production from the older four modules due to shortage of iron ore to produce pellets.

EZDK

EZDK's three modules exceeded rated capacity, producing more than 2.8 million tons of DRI (limited by natural gas availability in Egypt). The plants averaged 8179 hours of operation in 2012. Module 3 set a new annual production record in excess of 1.0 million tons while operating more than 8300 hours. EZDK's Module 2 has averaged 8087 annual operating hours over its 15 full years of operation.

FERROMINERA ORINOCO

Ferrominera Orinoco's HBI producing facility in Puerto Ordaz, Venezuela operated at reduced capacity throughout the year, restrained by oxide pellet availability.

HADEED

Hadeed exceeded rated capacity for the 28th consecutive year in Modules A and B, and for the 20th consecutive year in Module C. In its 20th anniversary year, Module C produced more than 1.1 million tons within 5% of their annual production record, operating 8647 hours. Since initial startup in 1992, Hadeed's Module C has produced more than 20 million tons of DRI. It has averaged 8085 hours of operation since its first full year of operation.
**Jindal Shadeed**
Jindal Shadeed produced a record 1.46 million tons of HBI and HDRI in its second year of commercial operation after expanding hot briquetting capacity in October 2011. The plant, designed to produce mainly HDRI (with HBI as a secondary product stream), operated more than 8000 hours and set a new monthly production record averaging over 186 t/h in October. Jindal Shadeed produced mainly HBI and dispatched more than 100,000 tons of HDRI (Hot DRI) via hot transport vessels to a nearby steel shop while its adjacent steel shop is under construction.

**JSW Dolvi Works**
JSW Dolvi Works, formerly JSW Ispat Steel, exceeded rated capacity in 2012, and as in 2011 was within 1% of their record annual production, operating 8285 hours in the year with only 32 hours of unscheduled downtime. This module has operated on average more than 8000 hours per year since its startup in September 1994. The plant surpassed the 20 million ton production milestone last year, in only 18 years. Its initial rated capacity was 1.0 million tons per year. Production was restricted by the increased price for natural gas in India.

**Khouzestan Steel**
No DRI production information was received from Khouzestan Steel for 2012.

**Lebedinsky GOK**
Also in its 5th anniversary year of operation, Lebedinsky GOK’s second DR module exceeded its rated capacity of 1.4 million tons of HBI, and was within 5% of their annual production record. LGOK 2 broke their monthly production record in January and again in August with an average production rate of more than 189 t/h. Even after a shutdown for major maintenance, the plant had operated at more than 193 t/h by the end of the year.

**Lion DRI**
In its fourth full year of operation, the production of the Lion DRI plant in Malaysia continued to be limited by demand. HDRI production was more than 78% of the tons produced last year, with the remainder being HBI.

**LISCO**
After shutting down in February 2011 due to political unrest in Libya, LISCO’s modules restarted production. Module 3 restarted in February; Module 1 restarted in May; and Module 2 restarted in December 2012. Module 1 surpassed the 10 million ton mark and the three modules together surpassed the 25 million ton mark in 2012.
NU-IRON
In its sixth full year of operation, Nucor's MIDREX Plant in Trinidad established a new annual production record, exceeding their previous annual production record by 6.9%. Average metallization of the DRI produced was 96.4% with more than 2.8% carbon.

OEMK
With its four modules operating on average 8399 hours in the year, OEMK produced more than 2.7 million tons again in 2012. Module 1 set a new annual production record exceeding 900,000 tons of cold DRI production, while Module 2 came within 0.5% and Module 4 came within 5% of their respective annual production records. Twenty five years after the start-up of Modules 3 and 4, OEMK surpassed the 50 million ton production mark in early 2012.

QATAR STEEL
In its fifth full year of operation, Qatar Steel's dual product (CDRI and HBI) Module 2 set a new annual production record that is 8.5% over its rated annual capacity. Both Module 1 and Module 2 operated more than 8120 hours with DRI metallization averaging 95.4% and 95.7% respectively.

SIDOR
Production from all four of Sidor's MIDREX Modules was 2.1 million tons with all four DR modules operating limited by outside causes. Sidor is set to surpass the 70 million ton milestone in 2013.

TENARISSIDERCA
TenarisSiderca operated at reduced levels throughout most of 2012, limited by the demand for their DRI due to the high price of iron ore and natural gas curtailments during the winter.

VENPRECAR
VENPRECAR's production continued to be restricted by the limited availability of iron ore pellets for HBI production in Venezuela.
The voestalpine Group has announced the signing of a contract with Siemens Industry Inc. and consortium partner Midrex Technologies, Inc. to build a new MIDREX® Direct Reduction Plant for its previously announced DR project in North America.

After deciding to locate the plant on the La Quinta Trade Gateway in San Patricio County near Corpus Christi, Texas (USA) and signing the memorandum of understanding with its first customer, Mexican company AHMSA, voestalpine has taken another step toward the realization of the planned direct reduction plant. As the technology decision was made in favor of the MIDREX® Process, a supply agreement was signed July 3rd with Siemens Industry Inc. and its consortium partner, Midrex Technologies Inc. This means that, contingent on the final official permits, the green light has been given for the construction of the new direct reduction plant.

The new MIDREX® Direct Reduction Plant is designed for an annual capacity of two million tons of hot briquetted iron (HBI) and will be the largest single HBI producing module in the world.

The consortium of Siemens and Midrex will provide engineering, supply of mechanical and electrical equipment as well as consulting services for the plant for the MIDREX® Plant.

Total investment volume will come to around EUR 550 million and, in addition to the MIDREX facility, will include comprehensive infrastructure improvements for the project location, particularly the necessary harbor facilities. The launch of production is planned for early 2016; once it is up and running, the plant will have around 150 employees.

"With Siemens and Midrex, we will have highly competent partners with a tried and tested technology at our side. By choosing a U.S. partner company, we are also making a significant contribution to the desired local value added," stated Wolfgang Eder, CEO and Chairman of the Management Board of voestalpine AG.
Top-tier technology for the voestalpine direct reduction plant

The new MIDREX® Plant will provide the Austrian steel production sites in Linz and Donawitz with access to cost-efficient and environmentally-friendly HBI, ensuring their competitiveness over the long-term. The site, strategically located on Corpus Christi Bay, covers an area of almost two square kilometers (500 acres), and has direct deep-sea access to the Gulf of Mexico.

The planned MIDREX® Plant will produce high quality HBI from iron ore pellets. HBI is comparable to the highest quality scrap or pig iron and is therefore an excellent pre-material for the manufacture of crude steel. In contrast to using purely coke-based blast furnaces, the planned direct reduction plant will only use natural gas as the reducing agent, which is much more environmentally friendly. The use of natural gas in the reduction process will help to significantly improve the carbon footprint of the voestalpine Group and will be an important step in the achievement of the Group's ambitious internal energy efficiency and climate protection objectives. The price of natural gas in the USA is about one quarter of the price in Europe. According to The voestalpine Group, around half of the planned two million tons of HBI will be supplied to the Austrian steel plants in Linz and Donawitz; the other half will be sold to partners interested in a supply over the long term.

In May of this year, voestalpine announced that its first potential customer has signed a memorandum of understanding to purchase HBI. From 2016 onwards, Altos Hornos de Mexico (AHMSA), Mexico's largest steel manufacturer, will source several hundred thousand tons of high quality HBI from the new voestalpine location annually. Discussions are underway with a series of other interested parties, some of which are already at an advanced stage.

MIDREX News & Views

Midrex Pioneers honored for innovation

Midrex pioneers Bruce Kelley and David C. Meissner were awarded the prestigious Tadeusz Sendzimir Memorial Medal at the Association for Iron and Steel's (AIST) annual Iron & Steel Technology Conference and Exposition, held in Pittsburgh earlier this year. The award is presented in recognition of an individual who has advanced steel-making through development or application of new manufacturing processes or equipment.

Kelley and Meissner received the honor as respected leaders in the industry for their instrumental roles as pioneers and promoters of the MIDREX® Process, providing an alternative iron-making process previously unavailable to some developing economies.

In the mid-1960s, MIDREX® Process inventor Donald Beggs conceived the idea of combining stoichiometric natural gas reforming—the process of converting hydrocarbons with a minimum excess of carbon dioxide and water—with a shaft furnace for induration of oxide pellets. Often simplicity is the purest form of science: Beggs realized that by feeding the reformed gas into a shaft furnace filled with iron oxide pellets, the pellets would reduce and he could even recycle the gas back to the reformer for remarkable efficiency. This became the genesis of the MIDREX Process.

Kelley, an expert in catalysts and reforming, and Meissner, an expert in iron ore characterization were an instrumental force behind the development and commercialization of this breakthrough direct reduction technology. The two also continued to develop the FASTMET® process later on in their careers.

Tadeusz Sendzimir was a Polish engineer and inventor of international renown with 120 patents in mining and metallurgy, 73 of which were in the United States. His revolutionary methods of processing steel and metals are used in every industrialized nation of the world. Ninety percent of the world’s stainless steel production went through the “Sendzimir process” by the 1980s. The award bearing his name was established in 1990 in memory of his many achievements and engineering contributions to the steel industry.
The world's total DRI production in 2012 topped 74 million tons, setting yet another new record for the industry according to data compiled by Midrex Technologies, Inc. and audited by World Steel Dynamics. Growth slowed in some areas of the world, primarily in India due to domestic factors influencing natural gas and ore, but in other regions increased production more than offset this decline.

Almost all of the world's DRI is produced using either shaft furnace or rotary kiln technology. Rotary Kiln technology is largely exclusive to India; however, most new growth in India and the remainder of the world is using Shaft Furnace technology because of reliability and higher product quality. Shaft Furnace DRI production in 2012 was led by MIDREX® Direct Reduction Plants once again, which produced 44.8 million tons, followed by Energiron (HYL) plants, which produced 11.7 million tons. The fluidized bed based process Finmet made more than five hundred thousand tons. The remaining 17.1 million tons was produced using various rotary kiln technologies found in India and in other areas of the world.

For more information and the detailed World DRI Statistics Booklet, visit www.midrex.com.

Tuwairqi Steel’s MIDREX® Plant Begins Operation

DR Plant exceeds expectations in performance test

Al-Tuwairqi Holding, Dammam, Kingdom of Saudi Arabia, has announced that its new MIDREX® MEGAMOD® Direct Reduction Plant at Tuwairqi Steel Mills, Ltd. in Karachi, Pakistan has successfully completed its Plant Demonstration Test (PDT), achieving or exceeding all operational targets.

The PDT took place May 24th and the Tuwairqi Steel Mills MIDREX® Plant performed at more than 100% of its capacity, producing 163.6 tons per tons of DRI per hour, while exceeding their target metallization by 0.9%, and achieving all other operational targets.

Tuwairqi Steel Mills Ltd.’s is Pakistan’s first modern DR facility. The plant is located in an industrial complex at Bin Qasim in Karachi, Pakistan. With a capacity to produce 1.28 million tons of DRI per year, the plant can produce Hot Direct Reduced Iron (HDRI) and/or Cold Direct Reduced Iron (CDRI) simultaneously. The plant is also configured to add briquette...
machines later on to produce Hot Briquetted Iron (HBI).

The new MIDREX Plant will help reduce the country's dependence on imported raw material as it provides Tuwairqi Steel Mills Ltd. with the capability to better utilize domestic iron ore reserves.

Al-Tuwairqi also owns and operates two additional MIDREX Plants at Direct Reduction Iron Factory adjacent to Al-Tuwairqi’s Al-Ittefaq Steel Factory in Dammam, Kingdom of Saudi Arabia. Al-Tuwairqi acquired these two MIDREX DR Plants located in Mobile, Alabama from Corus Group Plc. in December 2004. The plants were originally located in Hunterston, Scotland prior to being moved to the USA. The two plants each have a production capacity of 400,000 metric tons per year.

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**MIDREX News & Views**

**Midrex and JSW Steel to convert DR Plant to allow use of coke oven gas to supplement NG for DRI Production**

Midrex Technologies, Inc. and JSW Steel Ltd. have announced the signing of a contract to modify the existing MIDREX® Direct Reduction Plant located at JSW-Dolvi Works (formerly JSW Ispat, Ltd.) to utilize coke oven gas (COG) to supplement its natural gas supply for production of direct reduced iron.

Strategically located on the coast in the state of Maharashtra, India, the JSW-Dolvi Works 1.0 MTPY MIDREX® Plant began operation in 1994 producing cold DRI for use on site utilizing 100% natural gas. With the continuing escalation of natural gas pricing, combined with infrequent availability of consistent gas supply in India, JSW Steel has looked to Midrex for use of coke oven gas to create better sustainability for the plant and overall site.

The project, scheduled to be completed within 16 months or less, will use COG as a supplement to its natural gas intake so that the DR plant will be able to efficiently operate under a wide range of operating parameters, offering maximum flexibility to JSW Dolvi Works.

JSW Dolvi Works is owned by JSW Steel Ltd. (India’s largest privately owned steel company) and has a long history of implementing technological enhancements to boost productivity, lowering costs and improving environmental performance. These include the induction of an automated Lime Coating System and an Oxygen Injection System.
A Fresh Look: Midrex unveiled its new booth at the AIST 2013 Iron & Steel Technology Conference and Exposition held earlier this May in Pittsburgh, Pennsylvania, USA.

At this year’s convention, Midrex founders received awards for innovation and advancements to steelmaking. In addition Midrex presented papers on topics such as using lower grade ores in the MIDREX® Shaft Furnace and answered numerous questions raised by the renewed interest in DRI and the MIDREX® Direct Reduction Technology for North America. Exciting new DR technologies including the Midrex/Praxair TRS® for utilizing coke oven gas to fuel a MIDREX® Plant to produce DRI product were also discussed.