

# DIRECT FROM MIDREX

1ST QUARTER 2006

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## Commentary

### Challenging and Exciting Times!

The last 18 months have been an exciting period for Midrex. During this current market boom, we signed nine contracts for a total of 11.4 million tons of direct reduction capacity, and we anticipate more to come. The large run-up in steel and metalics prices from late 2001 through 2004, combined with the outstanding economics of the MIDREX® Direct Reduction Process, helped to fuel this surge of excitement. Most of the new projects include hot discharge of DRI, either for production of HBI, or for hot charging to the EAF. Two of the projects are plant relocations and one is a plant expansion.

To put this in perspective, the amount of capacity referenced above is about the same that Midrex contracted during the mid-1990s, but this time around, there was only about 18 months separation between the first order and the most recent. Thus, our project staff has been very busy performing the necessary engineering design, ordering equipment, arranging shipping, monitoring construction activity, and preparing for the start-ups that begin later this year.

We believe this interest in, as well as commitment to, direct reduction indicates how important it has become in today's steel industry. DRI and HBI now comprise more than 13 percent of the charge mix for electric arc furnaces (EAF) worldwide. They are essential charge materials for many minimills that produce low residual products or are located in areas where scrap is scarce. EAF steel production will continue to grow and direct reduction will increase in importance. Beginning with this issue of Direct from Midrex, we are publishing a multi-part series entitled "The New Iron Age: Direct Reduction's Role in the World Steel Industry,"

reviewing the developments in the iron and steel industries over the last five years and their implications.

To fulfill the promise we see in the direct reduction industry, Midrex has reaffirmed its commitment to technology development. This includes dedicating

more human resources to the effort and establishing a challenging program for the coming years. We will continue to enhance the gas-based MIDREX Process in areas such as hot discharge, hot briquetting, catalysts, use of lower quality iron ores, and oxygen use. A major part of the technology development effort will involve coal-based technologies, including FASTMET®, FASTMELT® and ITmk3®. We believe these processes have good potential in areas with abundant coal resources and especially with the use of waste iron oxides. From experience, we know that ironmaking technology development is an intensive and time-consuming effort. That is why we are ramping up these programs immediately, with a goal of beginning to commercialize them in 2007.

The work involved in completing the design and procurement for the projects and plant start-ups, plus our enhanced technology development activity, will be demanding, but our experienced and dedicated personnel look forward to the challenge.



James McClaskey  
President and  
CEO

#### MISSION STATEMENT

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

Christopher M. Ravenscroft: Editor

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# The New Iron Age

## Direct Reduction's Role in the World Steel Industry

### Part One: The Steel Juggernaut

By John T. Kopfle,  
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Product Applications Engineer  
Midrex Technologies, Inc.

*Editor's note: Given the major changes in the world steel and iron industries during the last few years, we thought it appropriate to review the situation and discuss the implications for direct reduction. The first of this multi-part series begins with the world steel industry.*

#### STEEL PRODUCTION GROWTH TO 2005

Over the last 55 years, the world steel industry has seen significant growth. According to data from the International Iron and Steel Institute, production grew from 192 million metric tons (Mt) in 1950 to 1,129 Mt in 2005. This is shown in Figure 1. World production exceeded one billion tons for the first time in 2004.

Since 2001, the growth has been especially dramatic. Production that year was essentially unchanged from 2000, but since then, it has grown at an average rate of over seven percent per year. That equates to an additional 70 Mt of steel each year.

It is also interesting to consider production by process type. From 2000-2005, production via the electric arc furnace (EAF) route increased nearly 30 percent due to its economics, scale con-

siderations, flexibility, and environmental effects. The availability of scrap and alternate iron sources, such as direct reduced iron (DRI) and pig iron, and access to reasonably priced electricity, made this growth possible. However, this has had a major effect on charge material considerations, as will be discussed in Part 2 of this series. Basic oxygen furnace (BOF) production increased almost 40 percent during that period, primarily due to the installation of

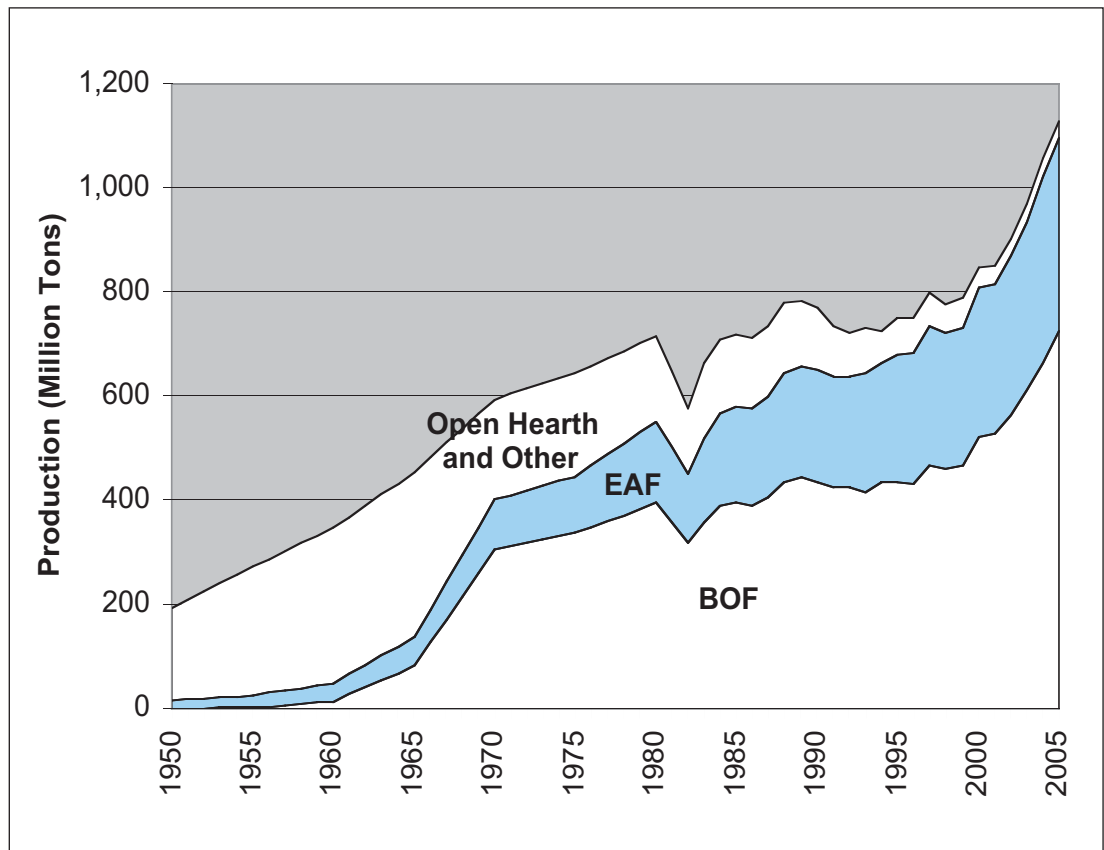


Figure 1 - World Steel Production by Process (Source: IISI)

	Production (Mt)		Growth 2000-2005 (%)
	2000	2005	
China	127.2	349.4	175
Japan	106.4	112.5	6
USA	101.8	93.9	- 8
Russia	59.1	66.1	12
Korea	43.1	47.7	11
Germany	46.4	44.5	- 4
World ex-China	720.4	780.0	8
Total World	847.7	1,129.4	33

Table I - World Steel Production by Country (Source: IISI)

capacity in China. Output via the open hearth process and other steelmaking processes has declined significantly because of poor economics.

Table I shows steel production by country for the largest producers in 2000 and 2005.

Growth in the last five years has been especially dramatic, and total production increased more in that time period than in the previous 15 years. These figures indicate how the world steel industry is evolving. Developing countries with abundant reserves of natural resources and low cost labor (China, Russia) or major industrialization programs (Korea) have increased steel production to feed their growing economies and for export earnings. Steel output in the industrialized countries such as Japan, the USA, and Germany, has stagnated because of slow demand growth and high costs for energy, iron ore, and labor. The developing countries are producing more of the steel they consume.

## REASONS FOR STEEL PRODUCTION GROWTH

### China

By far the major factor in the growth of world steel production has been China. As one commentator noted, China itself has become the "bull in the China shop." Of the 282 Mt increase in world production from 2000-2005, 222 Mt of that increase was due to China. This prodigious growth has been accomplished primarily using blast furnaces and BOFs, the so-called integrated steelmaking route. About 82 percent of China's steel is made via the BF/BOF. Over the last two years, China has been adding integrated steelmaking capacity at a rate of nearly one million tons per week. This increase has enabled China to make use of its reserves of iron ore and coal; it also imports large quantities of those materials. China now produces about 42 percent of the iron used for steelmaking worldwide.

What caused this almost unbelievable rise in steel capacity and production? China's economy has been growing at a rate of greater than nine percent per year for the last 10 years. It is now the world's fourth largest economy, behind the USA, Japan, and Germany. China's growth and export-oriented economy resulted in major

infrastructure needs and increases in steel demand for consumer products. China built 10 one-million-person cities each year for 10 years in a row and 50 percent of the world's cranes are in the country. From 2003-2004, it accounted for fully one-third of the growth in world trade. In addition to steel, China is the decisive factor in world markets for many other commodities, including copper, wood, cement, and cereals.

Until now, nearly all the steel produced in China has been used domestically. In 2004, Chinese exports were just 20 Mt. There is a concern that China has built too much steelmaking capacity and the excess beyond domestic needs will be exported. The government has announced steps to curb continued growth in capacity. There are reports that many state-owned steel companies are losing money because of low prices.

## World Economic Growth

The world's economies were impacted in the late 1990s as a result of the Asian currency crisis and the bursting of the "Dot-Com" bubble. In the early 2000s, the USA experienced a recession and the events of September 11, 2001 negatively affected economic growth. Since 2001, the global economies have done well overall. In 2005, world economic growth, as measured by gross domestic product (GDP), was 4.5 percent.

Many factors are at work here, including the continued expansion of electronic communication and commerce, more free trade, the growth of democracies, and a better ability to manage commodity price swings. Because of the industrial downturn from the late 1990s until post-2001, there was pent-up demand for steel. Barring major disruptive actions, the forecast is for continued solid economic growth in the near future.

## STEEL PRICE TRENDS, 1996-2005

Due to the economic trends discussed above, world steel prices began dropping in late 1996. By November-December 2001, prices plunged to extremely low levels. In all likelihood, these were the lowest prices ever, in real (i.e., inflation-adjusted) terms. The price of hot-rolled coil (HRC) is a benchmark steel price because it is a flat steel grade used for many applications, including appliances and automobiles. As shown in Figure 2 on the following page, the price of HRC delivered to the upper Midwest USA was \$231/t in November-December 2001, below the cash production cost of many mills.

That was the bottom of the market and the price of HRC began increasing. By August 2004, the HRC price had shot up to \$860/t, an all-time record in nominal terms and nearly four times the price just 32 months earlier. As always happens over time, the prices of other steel products and steelmaking charge materials increased at the same general rates.

## REASONS FOR STEEL PRICE INCREASES

### Strong Steel Demand

A principle of economics is that the supply/demand balance determines price. Thus, the strong demand experienced from 2001-2005 played a major role in these record steel prices. Generally, steel has a high "price elasticity of demand," meaning

that small changes in supply or demand result in large price swings. From 2001-2005, world steel demand increased 24 percent, while prices jumped 200-300 percent! There can also be an inverse factor, that prices influence demand. During the strong price run-up from mid-2003 to mid-2004, there was a lot of panic buying by steel users who saw the rapidly rising prices and bought before the price rose any more. This further increased short-term demand.

### Raw Material "Shortages"

Because of the capital-intensive nature of the steel industry, there is a limit to how far output can be increased in the short term. Once operating facilities reach capacity and idled units are brought back on-line (if possible), it takes several years to expand capacity further because of the two to five year lead times for constructing new capacity. This includes not only steel mills, but iron ore mines, coal mines, ironmaking plants, ships, and railcars. With the rise in steel demand beginning in 2002, by 2004 almost all facilities had become strained. Little capacity had been built from 1997-2004 and in fact much was rationalized in an effort to move production more in line with demand and increase profitability.

Prices for all commodities used for steelmaking, including iron ore, coal, scrap, and DRI increased by two to four times. In a few select cases, there were actual shortages, and buyers could not obtain material at any price. In general though, materials were available, albeit at record prices. These high prices further increased prices for steel products. The term "shortages" is placed in quotation marks in the title to this section because in a truly free market, there are never shortages.

Another factor that had an impact on steel prices was the scrap surcharges placed on steel products, pioneered by Nucor in the USA. In the summer of 2000, because scrap prices had risen so quickly and were impossible to predict, Nucor began adding a scrap surcharge to its steel products. This allowed it to capture at least some of the higher raw materials costs, while maintaining base pricing. Another effect was that the surcharges created "cost-push" inflation, thereby putting further upward pressure on steel prices.

### Weakening Dollar

Since steel and its feedstocks are usually traded in dollars, weakening of the dollar tends to raise prices. On February 1, 2002

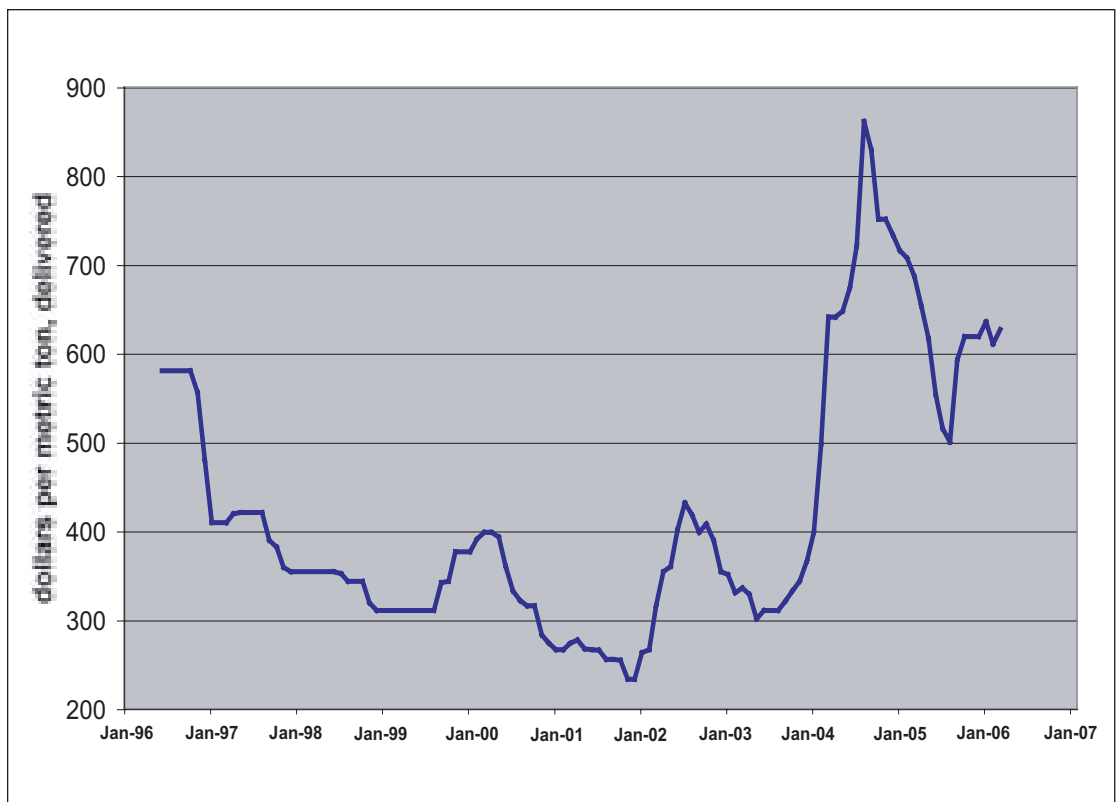


Figure 2 - USA Hot-Rolled Coil Prices

the dollar was trading at 0.86 vs. the Euro. By February 2004, the rate had increased to 1.28, a drop in value of nearly 50 percent. The conversion rate has remained around the 1.2 range since then.

### Freight Rates

Steel and its raw materials are truly international commodities. In 2004, about 38 percent of finished steel products and over 50 percent of iron ore were traded internationally. Many of these shipments are made by water and thus ocean freight rates have an impact on steel pricing. From the mid-1990s until 2001, ocean freight rates remained essentially constant and had a minor impact on the delivered costs of steel and other commodities. With the boom in China beginning around 2001 and the need to import vast quantities of raw materials and energy, demand for ocean shipments took off. Because of the dormant market in the late 1990s and early 2000s, there had been little increase in shipping capacity. With Chinese demand, that capacity was absorbed and rates rose. As an example, from 1996 through 2001, the cost of shipping HBI from Venezuela to New Orleans in "handy-sized" (30,000 t) vessels was around \$15/t. By mid-2004 that rate had increased to \$20/t, and in September 2005, it jumped to \$40/t. Other rates increased in the same manner, including rail and truck. The increase in energy prices also contributed to these freight cost increases.

*Editor's Note: The second part of this series will examine developments in the direct reduction industry over the last five years.*

# MIDREX® Direct Reduction Plants 2005 Operations Summary

Thanks to stable market conditions, MIDREX® Plants produced 35.0 million tons in 2005, almost the same as in 2004. MIDREX Plants accounted for 63% of the 55.8 million tons of DRI produced worldwide in 2005. The one remaining MIDREX Plant in the U.S. (belonging to ISG Georgetown, Inc.) remained shut down throughout the year due mainly to high natural gas prices. Many plants established new production records (17 annual and 17 monthly production records), thanks to the continued good demand for metallics. At least 23 MIDREX® Modules operated in excess of 8,000 hours. Mittal Canada's modules were shut down in 2005 due to high costs of raw materials. Iron ore prices increased significantly due to the extremely high demand worldwide caused by improved steel prices. MIDREX Plants have produced over 440 million tons of DRI/HBI to date.

## ACINDAR

ACINDAR operated above rated capacity for the fourteenth consecutive year, setting a new monthly production record in October.

## American Iron Reduction

Nucor Corporation has dismantled this plant and relocated it to Trinidad, where the expanded plant is scheduled to restart as Nu-Iron Unlimited towards the end of 2006.

## ANSDK

ANSDK set a new annual production record for Module I for the second consecutive year, exceeding the one million ton mark. With oxygen injection use beginning in Module II in 2005, all three of ANSDK's modules now use oxygen to boost production capacity. All three modules combined produced over 2.9 million tons of DRI in the year, and operated over 8,000 hours per year on average in 2005. In early 2005, ANSDK surpassed the 25 million tons produced from all three modules. Module III has produced just over five million tons in the less than six years since its start-up in February 2000.

## COMSIGUA

Despite iron ore and natural gas shortages in Venezuela, COMSIGUA exceeded their annual rated capacity for the sixth consecutive year and operated over 8,000 hours in the year.

## Corus Mobile

These two modules have been dismantled by the Al-Tuwairqi group and a first module is being installed in Dammam, Saudi Arabia.



ANSDK



COMSIGUA

## Essar Steel

Modules I, II, and III exceeded rated capacity. Module IV, which started up in July 2004, produced over 1.0 million tons in its first year of operation, establishing a new annual production record in breaking their monthly production record on three occasions during the year. The four modules have produced over 25 million tons of HBI/DRI since the start-up of the first two modules in 1990, and in 2005, the four modules averaged over 8,160 hours of operation. A significant portion of the DRI produced is charged hot to Essar Steel's EAFs.

## Hadeed

Hadeed exceeded rated capacity for the 21st consecutive year in Modules A and B, and for the 13th consecutive year in Module C. Modules A and B set new annual and monthly production records.



Hadeed

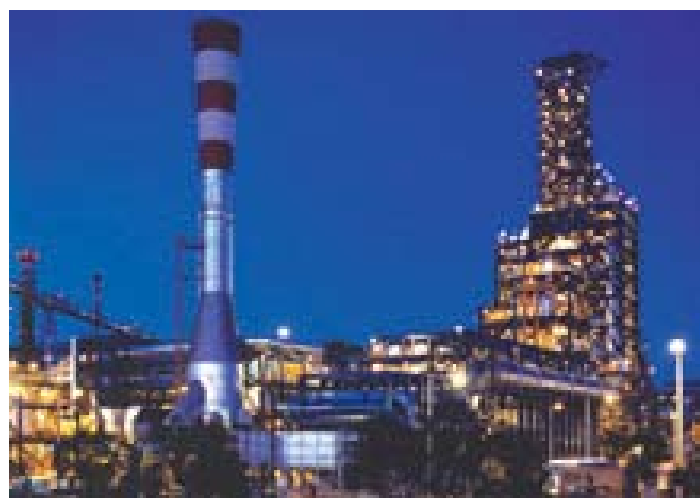
Module C also set a new monthly production record in October. In early 2006, all three modules had collectively produced 40 million tons of DRI since start-up of the first module in December 1982.

### **ISG Georgetown, Inc.**

Georgetown's MIDREX Plant remained shut down the whole year due to the high cost of raw materials.



LISCO



Mittal Steel Lazaro Cardenas



Khouzestan Steel

### **Ispat Industries, Ltd.**

On its 10th anniversary since start-up, IIL of India again experienced limited production due to restricted availability of natural gas. Lump ore usage averaged 60% for the year.

### **Khouzestan Steel**

All four modules exceeded rated capacity again in 2005. Modules II and IV set new annual and monthly production records in 2005, and all four modules have collectively produced over 20 million tons since the start-up of the first module in 1989.

### **LISCO**

LISCO set new annual production records in Modules I and II in 2005. LISCO reached the 15 million ton mark 15 years after the start-up of its first MIDREX Module.

### **Mittal Canada, Inc. (Formerly Ispat Sidbec)**

Due to high raw material costs, Modules I and II were shut down in June and May 2005, respectively.

### **Mittal Steel Hamburg (formerly Ispat HSW)**

MS Hamburg exceeded rated capacity in 2005.

### **Mittal Steel Lazaro Cardenas (formerly IMEXSA)**

MSLC produced over 1.7 million tons in the year, despite short shutdowns for major scheduled maintenance. In May 2005 the plant operated over 238 t/h on average for the month.

### **Mittal Steel Point Lisas**

None of the three modules achieved rated capacity due to major shutdowns. Module III achieved production rates approaching 210 t/h in September. MSPL surpassed the 25 million ton production mark from all three modules.

### **Mittal Steel South Africa (Saldanha Works)**

Saldanha achieved over 7,600 hours of operation in the year in their DR Plant and averaged 65% Sishen lump usage for the year.

### **Mobarakeh Steel**

For the second year running, Mobarakeh Steel set annual and monthly production records in all five modules in 2005, produc-



Mobarakeh Steel



OEMK

ing a total of almost 4.3 million tons, with an operating availability in excess of 8,300 hours on average.

**OEMK**

With four modules that operated on average over 8,200 hours, OEMK produced over 2.25 million tons in 2005. OEMK started using OXY+ Center Injection® in Module IV around mid-2005 and set a new monthly production record in August 2005, as well as a new annual production record for the year.

**OPCO**

Production was restrained by iron ore availability and to a lesser extent by natural gas availability.

**QASCO**

In 2005, QASCO almost reached their previous year annual production record, and set a new monthly production record, as well as surpassed the cumulative 15 million ton production mark in the month of January.

**SIDOR**

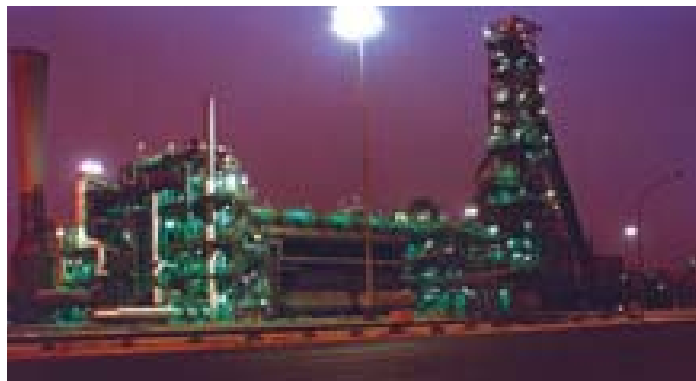
SIDOR's MIDREX I and MIDREX IIC modules set new annual production records, as well as new monthly production records. After a major revamp to increase production at the end of 2004, SIDOR's MIDREX I module is the first plant with a 5.0 meter Shaft Furnace nominal diameter to have produced over one million tons in a year, thanks to a plant availability in excess of 8,300 hours. Production from all four of SIDOR's MIDREX Modules exceeded 3.5 million tons in 2005.

**TenarisSiderca**

After the plant expansion carried out in August 2004, TenarisSiderca exceeded their previous annual production record by 14% in 2005 through increased hourly productivity with excellent plant availability. The plant also set a new monthly production record in November with an hourly production rate of 121 t/h.

**VENPRECAR**

VENPRECAR's annual production was above rated capacity, but it was negatively affected by the limited availability of iron ore pellets and natural gas in Venezuela.



QASCO



SIDOR



TenarisSiderca

# Midrex Research & Development

## *Enhanced Mineral Processing Laboratory*



Midrex has a long history of innovation and technology development that has made it the world's technology leader in the direct reduction of iron ore. For more than 30 years, Midrex has been a leader in research and development and technology applications. A large part of our success has been through ongoing R&D capabilities that are continually being enhanced.

The Midrex Technical Center, which is the focus of all R&D activities, is located in Pineville, NC, about 8 km from the corporate headquarters. During the last year, Midrex has made a significant investment in the Technical Center facilities, including



continuing expansion of our mineral processing laboratory capabilities. Midrex is now in a position to offer clients beneficiation technology and flow sheet development to provide "one stop shopping." Services include development of traditional and unconventional ore sources and alternative materials, such as those that may

currently be considered waste, into valuable products.

The Mineral Processing Lab is the technological bridge that will enable ferrous and non-ferrous raw materials to be linked to the MIDREX® Direct Reduction Process, FASTMET® / FASTMELT® and Kobe Steel's revolutionary ITmk3® iron nugget technology.

Midrex Mineral Processing Lab equipment currently consists of two jaw crushers, a disc and vibratory pulverizer, a Ro-tap shaking screener, a dry drum magnetic separator, a Simpson 20 kg mixer-muller, and one modern and one traditional (airplane tire) pelletizing drum. Pilot-scale mineral processing equipment includes a three-foot diameter pilot-scale ball mill, a Simpson 60 kg mixer-muller, and a drum pan pelletizer.

Table I lists the new liberation equipment that is being installed and Table II is a list of the new separation equipment.

The equipment listed to the right and below represents most of the common liberation and separation technologies used in mineral processing plants and will provide Midrex with excellent capabilities to analyze and characterize raw materials. The new Mineral Processing Lab will enable Midrex to thoroughly evaluate ores and other materials in order to provide clients with the best possible solutions to their mineral processing requirements. Please contact Jayson Ripke at 704-378-3361 to discuss your testing / analysis needs.

### NEW LIBERATION EQUIPMENT

#### 1. Dual Roll Crusher

Used for crushing materials finer than the jaw crusher.

#### 2. Rod and Ball Mills

Includes rod and ball charges and has variable speed roller drives and revolution counters. These mills grind materials to liberate valuable material from less valuable ones (e.g., iron ore from silica gangue).

#### 3. F. C. Bond Work Index Ball Mill

Used to determine the work index,  $W_i$ , of an ore or material needing comminution. The  $W_i$  is used in engineering calculations to determine the specific energy required for grinding.

Table I

### NEW SEPARATION EQUIPMENT

#### 4. Mineral Jig

Separates relatively coarse materials in slurry based on density differences.

#### 5. Spiral Concentrator

Used to separate medium-size materials in slurry based on density differences.

#### 6. Hydroclassifier

Separates relatively fine materials in slurry based on density differences.

#### 7. Vibro-Energy Screen

Classifies (separates) materials according to their size determined by the screen size(s) selected.

#### 8. Wet Drum Magnetic Separator

Used to magnetically concentrate materials such as magnetite.

#### 9. Wilfley Concentrating Table (with sand and slime decks)

Separates materials of different sizes on a table, which is similar to panning for gold.

#### 10. Denver Froth Flotation Machine

Separates minerals in slurry based on their surface chemistry differences. Hydrophobic minerals attach to air bubbles that float and overflow from the hydrophilic minerals. For example, silica modified by a "collector" reagent becomes hydrophobic and is floated away from the iron ore that becomes a concentrate.

#### 11. Outokumpu High Tension/Electrostatic Separator

This is cutting edge technology; Midrex will have the second such machine in the world. With this separator, dry materials are electrically charged and separated based on differences in their electrical conductivity. For example, hematite is conductive and is separated from non-conductive silica. The silica sticks to a drum, while the hematite "bleeds" its charge to the drum and falls off.

#### 12. Centrifugal Concentrator

This apparatus operates like a washing machine on its spin cycle and separates very fine and dense materials in slurry from less dense materials. For example, silver, platinum, and gold are separated from silica gangue.

#### 13. Eriez Dry Drum Magnetic Separator

Used to magnetically concentrate magnetic materials, such as magnetite, in slurry.

Table II



Midrex News & Views

# Al-Tuwairqi Group Concludes Contract for HDRI MIDREX® Plant 1.28 Million TPY of New Capacity to be Located in Karachi

Al-Tuwairqi Group, Dammam, Kingdom of Saudi Arabia, has announced a signed contract with Midrex Technologies, Inc. to build a new MIDREX MEGAMOD® Hot Direct Reduced Iron (HDRI)/Hot Briquetted Iron (HBI)/ Cold Direct Reduced Iron (CDRI) Plant in Karachi, Pakistan.

The new DR plant capacity will be 1.28 million metric tons per year and initial production will be 100% cold DRI. The plant will be configured to allow the possible addition of briquette machines in the future to produce HBI.

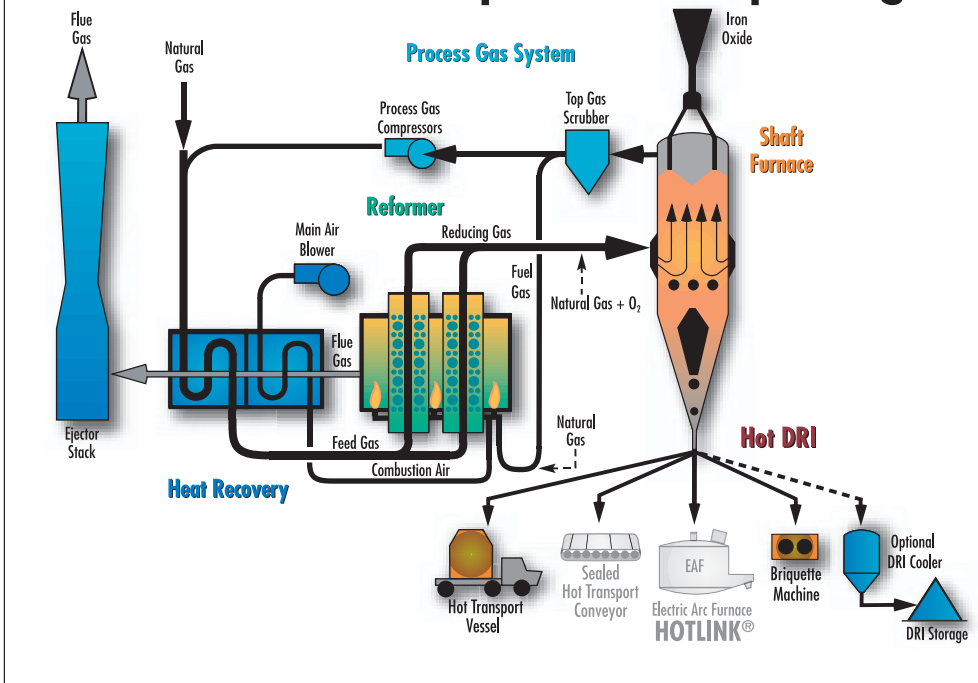
The facility will employ many of the latest Midrex innovations to minimize energy consumption and control product quality. Al-Tuwairqi selected the MIDREX® Process because of its documented proven reliability, its ability to consistently produce high quality DRI, HBI and HDRI, and its remarkable history of fast start-up periods.

Tuwairqi Steel Mill, a member of the Al-Tuwairqi Group, will operate the new plant.

Last year Al-Tuwairqi signed a licensing agreement to operate a recently purchased MIDREX® Module that is currently being



## Hot Discharge HOTLINK®/Hot Transport/Hot Briquetting



renovated and rebuilt adjacent to Al-Tuwairqi's Al-Ittefaq Steel Factory in Dammam. This plant will be known as Direct Reduction Iron Factory.

Al-Tuwairqi acquired two MIDREX DR Plants in Mobile, Alabama from Corus Group, Plc. in December 2004. The two plants each had an original production capacity of 400,000 metric tons per year. The modules will have a new rated capacity of 500,000 mtpy through equipment replacement and new process engineering advancements. No plans have been announced for the second module at this time.

Al-Tuwairqi's steel plant produces steel bar from billets manufactured in their new melt shop that began operations in 2004. The new DR plants will enable the Al-Tuwairqi Group to better manage raw material costs and ensure a supply of iron units for their existing facilities in Dammam, as well as future planned operations.