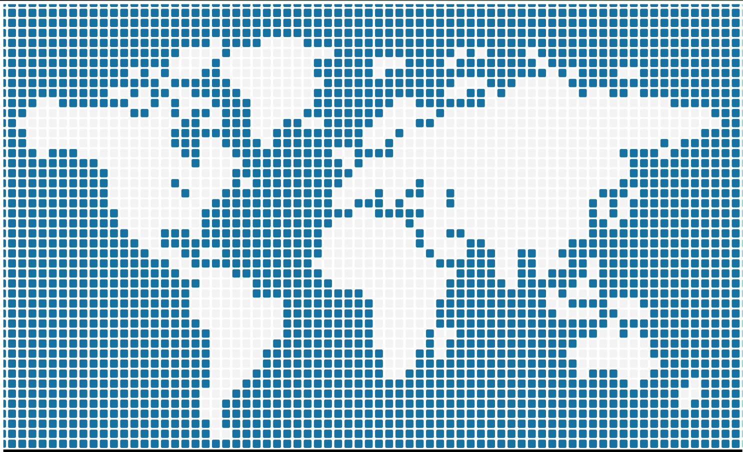

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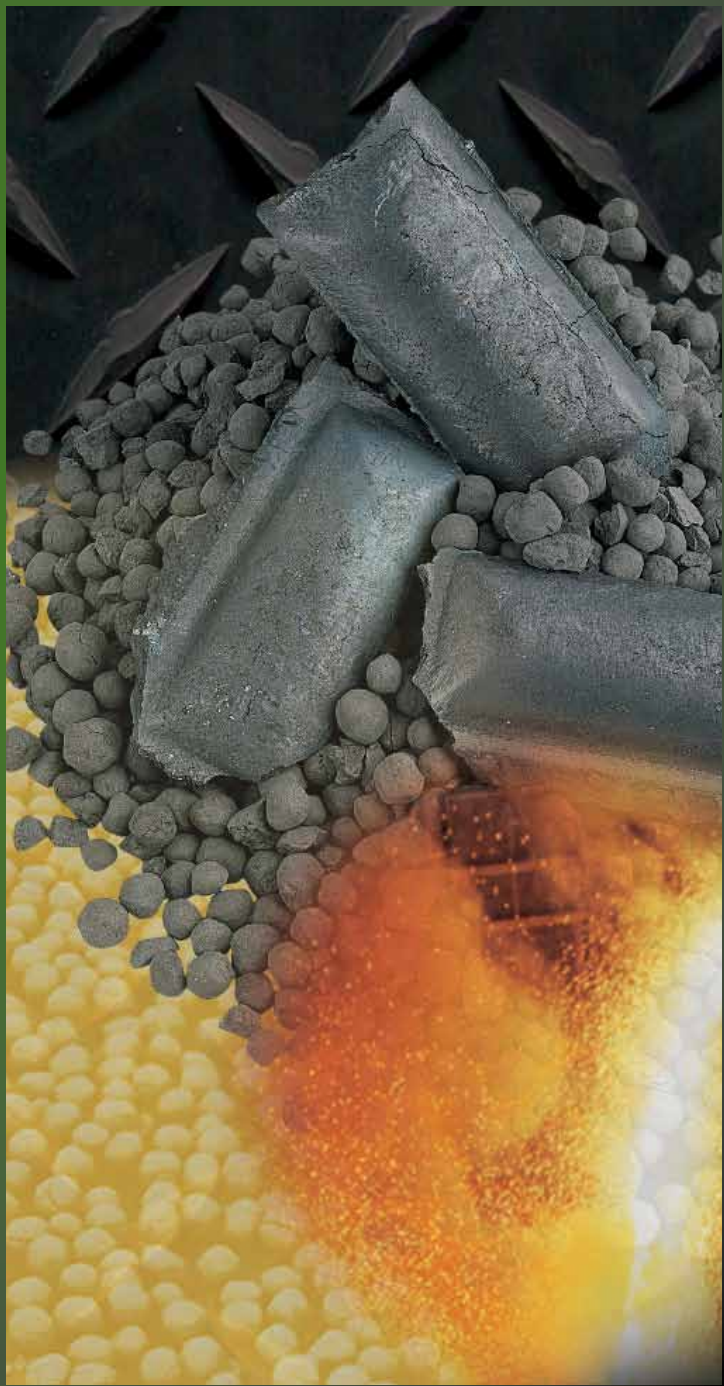

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COMMENTARY

Riding the Cycles or Build in the Valley

By Henry Gaines

Although we all know and understand that steel is a cyclical industry, there are those who are somewhat surprised when we experience a downturn such as the one we are in now. This downturn has been felt especially strongly because it came on the heels of the greatest boom period in our lifetime. From 2004-2008, we witnessed DRI prices grow from about $100/ton in late 2001 up to the $300-$400/ton range in the first quarter of 2008. Then the "lid came completely off" with DRI prices reaching $900/ton in July 2008. This boom was the result of a combination of factors, including Chinese demand and strong economic growth in the developing world. During this time there were some very happy DRI producers and a large number of very anxious "want to be" DRI producers.

Fortunately, for those who had the foresight to plan and build for the future, their facilities operated with very significant profit margins during this boom time. There were a number of MIDREX® Plants that started up in 2006 and 2007 and benefitted from the tremendous steel market in 2007 and 2008. These included Nu-Iron, Hadeed, Qatar Steel and LGOK.

Again, as we all knew (or should have known), those commodity prices were unsustainable and the addition of the financial crisis has resulted in a significant retreat. Now we sit in the valley of the steel business cycle.

Despite the current gloom and doom expressed by many about our business, we know that steel is a crucial component for economic growth and the market will improve over time. Economic development in the emerging market countries, especially China and India, will boost steel demand for infrastructure and consumer goods. Most new steelmaking capacity outside China will be EAF-based and since there is not enough scrap to feed these EAFs, new sources of reduced iron products will be required. These include DRI, HBI and ITmk3® Nuggets.

In today's market with slow economic growth, low steel demand and financial difficulties, it is tempting to stop all project development work and wait until good times return. In the past, that has been the pattern. The problem with that approach is that it can take several years to do the feasibility studies, obtain permits, make financial arrangements, select a technology, negotiate a contract, source raw materials, develop infrastructure and design and construct a DRI plant. By the time the unit is operating, the market can be on the downswing and the owner has lost out on the high prices during the strong period of the market. For a project that has a sound basis, including access to competitively priced iron oxide, low cost natural gas or coal, good infrastructure and a sound market strategy, now is the optimum time to continue or begin the project development phase. The initial work can be done at relatively low cost, but it is crucial to establish a sound basis for the project. Midrex can assist in activities such as pre-feasibility and feasibility studies, raw material testing, plant layout and initial design. Beginning this work now provides the plant owner a head start to insure that the facility will be completed in time to "enjoy the next ride up" out of the valley as the steel market recovers.

Henry Gaines
Director of Plants Sales

Midrex is using this time to ramp up our technology development efforts and we expect to have a number of new offerings for the next wave of projects. This includes technologies to reduce emissions, enhance productivity, reduce energy consumption and produce DRI with higher temperature and quality for hot charging to the EAF.

We cannot change the cyclicality of the steel industry, but we can work within those cycles to optimize profits. Midrex is bullish on the long-term prospects of the industry and the importance of reduced iron products. We look forward to working with visionary plant owners to develop successful projects.

THE LION GROUP & MIDREX EXPERIENCE:

OPERATIONAL ASPECTS OF LION'S MIDREX HDRI/HBI PLANT

By **Antonio Mouer**: Proposal Manager, Midrex Technologies Inc., Charlotte NC, USA
& **Frederick Mah**: Process Manager, Antara Steel Mills Sdn Bhd, Labuan, Malaysia

INTRODUCTION

This paper discusses operating aspects and technology improvements of the LION GROUP's newest MIDREX plant in Banting, Malaysia. The Plant started up in June 2008 and is rated for 1.54 million tons per year of HDRI/HBI. One of the more unique aspects of the LION DR Plant is that it uses hot transport vessels for transferring hot direct reduced iron (or HDRI) from the direct reduction facility to the adjacent melt shop. LION is one of only two operating MIDREX facilities to utilize hot transport vessels.

LION DRI

The new MIDREX plant in Banting is a part of a new family of dual discharge facilities, capable of producing hot briquetted iron (HBI) and HDRI. The HDRI lines incorporate a proven hot discharge and transport arrangement along with HDRI transport vessels designed specifically to meet the capacity and logistics requirements of LION.

Additional technology improvements specific to the new MIDREX plant which will be discussed in this paper include the use of centrifugal compressors, the use of larger briquetting machines and implementation of a new briquette cooling conveyor. However, before a more detailed discussion of the MIDREX Plant, information on the LION GROUP's steel making capability and product mix is reviewed.

The LION GROUP's steel businesses are involved in iron and steel making, rolling of flat and long products and downstream manufacturing of various steel products.

The LION GROUP operates Megasteel, Malaysia's only integrated flat steel mill producing hot rolled and cold rolled coils. Megasteel uses a state-of-the-art Direct Current Electric Arc Furnace - Compact Strip Production (EAF-CSP) process which incorporates thin slab casting technology.

The manufacture of long products such as bars, wire rods and channels, is undertaken by Amsteel Mills, in Banting and Klang, and Antara Steel Mills, in the southern state of Johore, which are equipped with modern facilities comprising electric arc furnaces, ladle furnaces and 6-strand continuous casting machines. These facilities are designed to produce high quality billets including special grade billets for rolling into specialty bars and higher grade wire rods for stringent applications.

The LION GROUP also operates Antara Steel Mills in Labuan that produces HBI for local consumption and for export within the Asia Pacific region. High quality HBI is used as a substitute for scrap to produce high and stringent quality steel.

LION GROUP'S IRON AND STEEL PRODUCT MIX

Product Category	Annual Capacity (million tons)
Iron Making	
Hot Briquetted Iron (HBI)	0.88
Hot Direct Reduced Iron (HDRI)/ HBI	1.54
TOTAL	2.42
Steel Making	
Billets	3.05
Slabs	3.20
TOTAL	6.25
Rolling	
Hot Rolled Coils	3.20
Plates	0.25
Bar, wire rods, sections	2.35
TOTAL	5.80
Cold Rolled	1.45

HDRI & HBI PRODUCTION CAPABILITY AT LION

The new Direct Reduced Iron Plant was built at the Megasteel Facility in Banting, Selangor, Malaysia as shown in Figure 1. The LION plant is based on the well-proven MEGAMOD® Shaft Furnace with a 6.65 meter inside diameter and a proprietary MIDREX® Reformer. All production is based on the use of imported iron oxide. The existing site has the capability of importing 2.5 Mpy of iron oxide and transporting the HDRI and HBI products within the Megasteel facility.

FIGURE 1 *LION'S MIDREX Plant in Banting, Malaysia*

Key Features

The PLANT can produce up to 1.54 million tons per year of high quality hot metallized iron that can be discharged in two forms:

1) HDRI for transport and direct charging to the EAFs, and
2) HBI for storage and cold charging to the EAFs.

Additional features of the new facility include:

- Up to 192.5 tons/hour HDRI
- Two high capacity briquette machines with nominal briquette capacity up to 140 tons/ hour HBI
- Plant discharge of 100 percent HDRI or a combination of HDRI and HBI up to 100 percent of total production.
- Oxygen Injection for increased furnace productivity and high carbon levels
- 8000 hours/year Plant availability
- Sulfur removal from incoming natural gas

Key Benefits

The increased supply of DRI will help to reduce the dependence on scrap as a raw material for steel making by the Group's various steel mills and enable the production of high quality steel.

On site use of HDRI at high discharge temperature reduces utility and maintenance costs (e.g., electrode and refractory costs) and thus steel production costs. As an example, for a typical case, hot charging at 600° C lowers operating costs $5-10/t liquid steel and enables a 20 percent productivity increase. Figure 2 shows a hot transport vessel.

Production of HBI allows continuous operation of the MIDREX PLANT while other site operations might not be capable of consuming HDRI as it is produced. Also, the HBI may be exported safely, thus adding additional flexibility to the plant operation.

FIGURE 2 *Hot Transport Vessel at LION*

Operating Results

Experience to date with the HBI and HDRI systems at LION has been positive with key features of the new design being realized including:

- HDRI discharge temperature from shaft furnace 680° C to 710° C
- Minimal temperature losses from shaft furnace to EAF
- Negligible carbon losses from shaft furnace to EAF.
- Yield improvement
- Power saving approximately 40 kWh/ton (30% to 35% charge of HDRI)
- Improvement in Tap-To-Tap time
- Reduction in copper content in the final product
- Reduction in nitrogen content in the liquid steel

CENTRIFUGAL COMPRESSOR IMPLEMENTATION AT LION

Two single stage centrifugal compressors (see Figure 3) operating in series were selected as the primary choice for the LION plant resulting in:

- A plant layout which is simpler than that required for rotary lobe compressors.
- Lower total installed and operating costs compared to rotary lobe compressors.

Also, process gas flow and pressure rise requirements needed for increased plant designs like LION's are exceeding the capability of the two-stage rotary lobe process gas compressors presently used in older plant designs.

FIGURE 3 *Centrifugal Compressor at LION*

Key Features

Key features of the centrifugal process gas compressors are as follows:

- Two single stage centrifugal compressors, operating in series can deliver the required process gas flow with the required differential pressure.
- Either compressor can be operated alone and deliver more than 60 percent of the process gas flow and pressure rise requirements.
- High efficiency mist eliminators are utilized to remove essentially all water carryover from the top gas scrubber. Most of the dirt in the "dirty" process gas is carried in these water droplets; eliminating the droplets eliminates the dirt.
- Recycle from the compressor discharge to the mist eliminator outlet will ensure no liquid water remains in the gas at the compressor inlet.
- Multiple inlet mist eliminators operating in parallel will allow for online cleaning prior to gas inlet.

Key Benefits

Key benefits of the centrifugal process gas compressors are as follows:

- Total installed cost of the centrifugal system is less than the rotary lobe (e.g., discharge dampeners not required for the centrifugal compressors).
- More efficient operation since the centrifugal compressors require less power than rotary lobes.
- "Dry" compressors do not require water sprays, simplifying the blower area seal leg system and associated sump.
- Simpler foundation design due to two light weight machines as compared to rotary lobes. Also the centrifugal live load is much less than the rotary lobe's inherent rocking motion.
- Centrifugal compressor service parts are much lighter weight than rotary lobe, thus eliminating the need for the compressor maintenance cranes and associated structure.
- Lower maintenance cost for centrifugal compressors as compared to rotary lobe.

LARGER BRIQUETTING MACHINES AT LION

The briquetting system design for LION includes two briquette machines, with briquette strand separators and hot fines recycle systems.

Hot DRI is supplied to each briquette machine by a screw feeder. The briquette machines are roll type machines which produce "pillow" shaped briquettes. Each roll contains dies which form the briquettes as shown in Figure 4. One of the rolls is forced toward the other roll by means of a hydraulic pressure system, which ensures a uniform pressing force. The continuous briquette strand exiting the briquetting machine is fed to the strand separators to break the strands into individual briquettes. The briquettes are passed to the HBI cooling system for slow cooling and discharge to the product handling system. Any smaller chips, fines and dust generated during the strand separation process are recycled via the hot fines recycle system back to the briquetter feed system.

Key Features

The new larger briquetters installed at the LION facility have the following key feature:

- Increased roll diameter of 40 percent compared to the standard briquette machine.

FIGURE 4 *Briquetter Roll at LION at LION*

Key Benefits

Key benefit of the larger briquetters is as follows:

- Production rate of up to 70 t/h per machine

BRIQUETTE COOLING CONVEYOR AT LION

The new briquette cooling conveyor was installed to eliminate operational problems encountered with the standard apron conveyor quench system and improve HBI quality with minimal loss of metallization.

In particular, the system was redesigned to address issues encountered with the standard quench system such as submerged wheels, wheel bearings and seals on the apron conveyor.

Key Features

The new briquette cooling conveyor installed at the LION facility has the following key features:

- The conveyor moves material in a trough type conveyor while slow-quenching the briquettes with water from overflow weirs.
- Material tends to spread out on the trough as it moves down the length of the trough. This spreading helps prevent briquettes on the bottom from being covered by larger sheets of briquettes
- Uses slow horizontal, slow-advance, quick-return motions to advance the material.
- There are no wheels, wheel bearings, or seals on these conveyors.

Key Benefits

Key benefits of the briquette cooling conveyor are as follows:

- The elimination of wheels, wheel bearings, and bearing seals reduces maintenance and increases overall plant availability.
- Most maintenance items on the briquette cooling conveyors are external and accessible for easy inspection and routine service.
- The new conveyor is assembled and tested in the shop. This is then broken down into pieces as large as practical for shipment and re-assembly. This eliminates concerns associated with complex field assemblies.
- The conveyor is supported by a number of pendulum support rods. This system allows free movement of the conveyor and avoids putting horizontal forces into the building's steel structure or foundations.

SUMMARY

LION's new MIDREX Plant provides improved flexibility through its HDRI/HBI dual discharge capability.

Charging HDRI to the EAFs provides major benefits in energy consumption, reduction in EAF maintenance cost, and reduction in tap-to-tap time, while the capability to produce HBI allows continuous operation of the MIDREX Plant while other site operations might not be capable of consuming HDRI as it is produced. HBI may also be exported safely, thus adding flexibility to the plant operation.

Several new features of the MIDREX Plant implemented to improve plant availability include use of centrifugal gas compressors and a new briquette cooling conveyor system.

Hot Charging DRI for Productivity and Energy Benefits at Hadeed

By Gary Metius and John Kopfle
Midrex Technologies, Inc.

FIGURE 1 *Hadeed Modules A, B, C*

INTRODUCTION

The Saudi Iron and Steel Company Ltd. (Hadeed) has a long history of successful operation of natural gas-based direct reduction plants and steelmaking facilities. Hadeed began operations in 1982 with two MIDREX® 400 Series Plants (Modules A/B). A third MIDREX Module, Module C, was added in 1992, and a fourth module (HYL) in 1998. Figure 1 shows Modules A, B and C. Hadeed produces 3.0 - 3.5 Mtpy of cold DRI (CDRI) from these four modules. All the DRI is used on-site and supplemented with scrap steel in a ratio of approximately 70 percent cold DRI and 30 percent scrap to produce 4.0 - 4.6 Mtpy of steel. Hadeed plays a valuable role in producing steel for the growth of the Kingdom of Saudi Arabia and surrounding countries.

TABLE I *Hadeed Module E Details*

MIDREX Module type	MEGAMOD (7.15 m ID)
Start-up	July 2007
Related works	Sea water pumping, oxide storage/reclaim, CDRI storage/reclaim, HDRI conveying, EAF charging system
Capacity	1.76 Mtpy (220 tph)
Reformer	19 bays (570 tubes)
Products	Hot and cold DRI
Target market(s)	100% captive use by Hadeed
DRI cooler	Up to 100 percent capacity
Hot transport system	Up to 90 percent capacity, transporting at ~ 650° C
Oxygen use	Approximately 15 Nm^3/t HDRI

MODULE E – THE WORLD'S LARGEST

In December 2004, Hadeed awarded the contract to the Consortium Siemens VAI - acting as Consortium Leader - and Midrex Technologies, Inc. to build the world's largest direct reduction module, with a rated capacity of 1.76 Mtpy. Module E features a MIDREX® Hot Discharge Shaft Furnace of 7.15 meters inside diameter (the largest shaft furnace in operation to-date). The main plant configuration details are listed in Table I. Perhaps the most significant feature of the facility is the HTS hot transport system which is a joint development of Siemens VAI, Aumund Fördertechnik GmbH and Midrex. This system enables the plant to discharge nearly any combination of cold DRI and hot DRI simultaneously. Hot DRI is transported by conveyor directly to the adjacent meltshop and charged to the EAF.

FIGURE 2 *Hadeed Module E*

GET IT WHILE IT'S HOT

The MIDREX Shaft Furnace is designed to discharge DRI at temperatures around 700° C into a product discharge chamber (PDC), the same design used in MIDREX HBI Plants. The PDC accomplishes three functions: depressurization of the DRI, control of material flowrate, and keeping oxygen out of the system. Hot DRI (HDRI) is discharged from the PDC into a mechanical conveyor provided by Aumund. Aumund has significant experience in conveying equipment and has used the similar designs in other applications worldwide.

The conveyor uses specially designed buckets to transport the HDRI, as shown in Figure 3. The distance is 95 meters, with a lift of 48 meters. The MIDREX Plant has an external DRI cooler to produce cold DRI (CDRI) along with HDRI. CDRI is mainly produced at times when the meltshop is shutdown. The DR plant can switch from HDRI to CDRI production very quickly. In practice, some CDRI is always being produced to keep the cooling system "live."

Module E is shown in Figure 4 and the inclined covered conveyor leading to the meltshop can be seen also. This system has several advantages versus pneumatic transport, including lower investment cost, lower energy and maintenance costs, and less product breakage. The conveyor is covered and insulated to minimize temperature loss and prevent oxidation of the HDRI during transport from the MIDREX Shaft Furnace to the meltshop. HDRI is fed to two buffer bins above the meltshop, then metered into the EAF at a controlled rate. The bins are sized to contain at least one complete charge of HDRI each for the EAF, which facilitates the transition from continuous DRI conveyance to discontinuous EAF charging. As one bin is being emptied into the EAF, the other bin is being filled with fresh HDRI.

The EAF has a tapping weight of 150 t and the estimated annual output is 1.40 Mtpy of liquid steel, assuming HDRI is fed at 650° C. The electric furnace is shown in Figure 5.


FIGURE 3 *Aumund Bucket Conveyor System*


FIGURE 4 *Hadeed Module E, Hot Transport Conveyor and Meltshop*

FIGURE 5 *Siemens VAI Electric Furnace at Hadeed*

BENEFITS OF HOT DRI CHARGING

There are two main benefits of hot charging DRI to the EAF: lower specific electricity consumption and increased productivity. The energy savings occur because less energy is required in the EAF to heat the DRI to melting temperature. In addition to a lower energy requirement, it also takes less time, thus shortening the overall melting cycle. This allows higher production through a given size EAF.

The rule-of-thumb is that electricity consumption can be reduced about 20 kWh/t liquid steel for each 100° C increase in DRI charging temperature. Thus, the savings when charging at over 600° C are 120 kWh/t or more. An additional benefit of the electricity savings is a reduction in electrode consumption, since there is a linear relationship.

The increased productivity from HDRI charging is significant. Use of HDRI reduces the tap-to-tap time, allowing a productivity increase of up to 20 percent versus charging at ambient temperature. There are also environmental benefits of HDRI charging. Retaining the sensible heat in the DRI rather than dissipating it to the atmosphere lowers overall emissions two ways. First, the lower electricity demand reduces power plant emissions per ton of steel produced. Second, for those mills employing carbon injection, reduced energy requirements in the EAF result in less CO_2 given off.

Ultimately, the most important consideration for the steel-maker is that HDRI charging can enhance profitability. The interest shown in hot charging by Midrex clients speaks for itself. Table II shows MIDREX Plants employing hot charging.

TABLE II *MIDREX Plants Employing Hot DRI Charging*

PLANT	LOCATION	START-UP	TYPE SYSTEM
Essar Steel Mods I,II,III,IV	India	1999-2004	Vessels
Hadeed E	Saudi Arabia	2007	Hot Conveyor
Lion Group	Malaysia	2007	Vessels
ESISCO	Egypt	2010	HOTLINK
Shadeed	Oman	2010	HOTLINK

RESULTS AT HADEED

Hadeed has achieved outstanding results in the Module E MIDREX Plant and EAF. From May 15 through October 28, 2008, with all plant equipment operating well, the plant produced 873,000 tons, for an average hourly production rate of 218 t/h. The availability during that time was 98.5 percent and there was no downtime from July 27-October 28, a period of 94 days. Figure 6 shows daily production during that period.

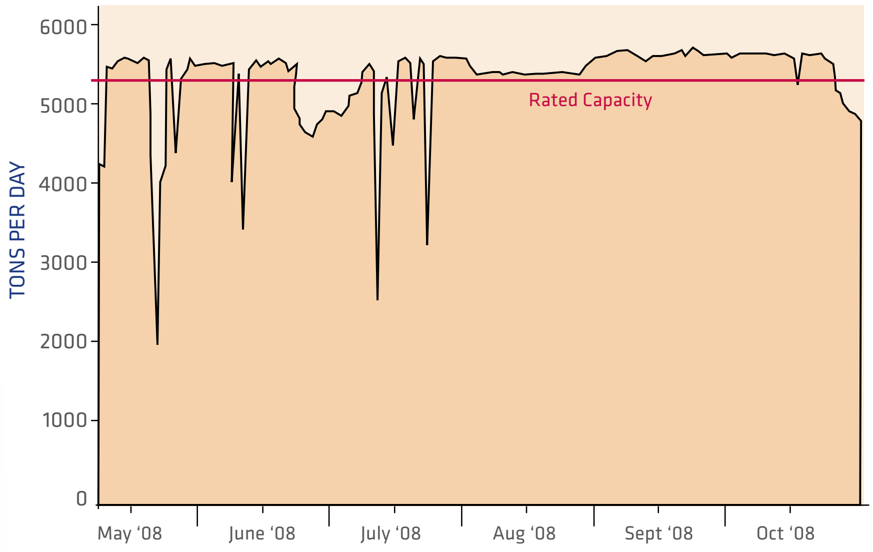


FIGURE 6 *Hadeed Module E MIDREX Plant DRI Production May 15-October 28, 2008*

A 48 hour EAF trial with 100 percent hot DRI was run in May 2008. In June, a multi-day MIDREX Plant HDRI trial was performed. Averages of some parameters during those tests are shown in Table III. During the HDRI trial, eight days of EAF and DR plant operation were carefully monitored. This test was indicative of actual meltshop operations, covering a full weekly cycle, including the EAF shell change.

Over time, Hadeed has adjusted DRI parameters to achieve high productivity in the meltshop. Specifically, carbon content has been increased at the expense of temperature. The June-October period was a good representation of the DR plant and meltshop capability because all demonstration testing was complete, with the plant running in the normal mode, and with good market demand. During this time, the DRI feed to the EAF averaged 95.3 percent metallization, 2.6 percent carbon and about 500° C.

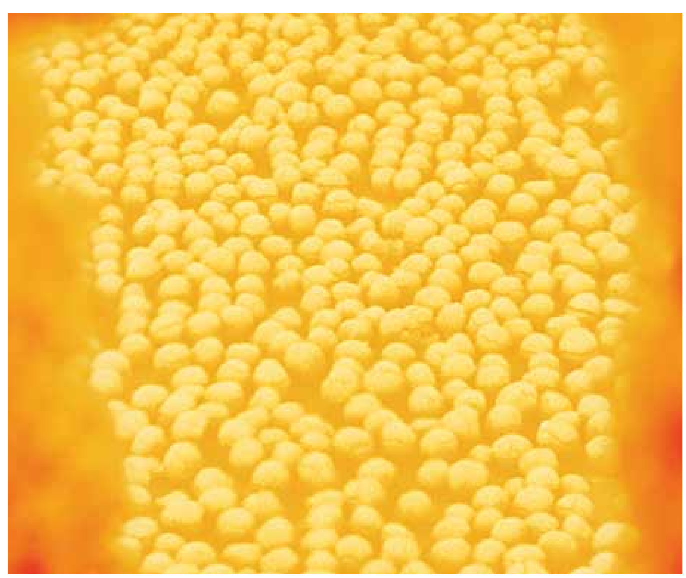
Unfortunately, because of the severe world economic downturn, the DR plant and meltshop have been operating at reduced levels since October.

TABLE III *Hadeed Meltshop Results Using 100% HDRI*

	Trial 1 May 2008	Trial 2 June 2008
DRI into EAF		
Metallization (%)	95	95.4
Carbon (%)	2.1	1.8
Temperature (°C)	579	599
EAF performance		
No. of heats	60	198
Power on time (min.)	40	40
Electricity consumption (kWh/t)	385	398
Oxygen consumption (Nm^3/t)	26	25
Electrode consumption (kg/t)	0.8	-
Productivity (t/h)	188	158

FUTURE POSSIBILITIES

Hadeed has been quite pleased with the performance of Module E and the use of hot DRI in the EAF and is considering an additional DR plant. The substantial benefits of DRI temperature have been shown at Hadeed and at other integrated steel mills employing direct reduction plus hot charging to the EAF. As an example, a 17 percent productivity boost, which is possible by hot charging at 600° C, could be worth an extra $24 to 48 million per year in profit, depending on the profit margin per ton.



CONCLUSIONS

Hadeed's long history of successful DRI and steel production has continued with MIDREX Plant Module E and the system to transport hot DRI to the meltshop. The DR plant has produced at rated capacity for extended periods of time and the EAF performance using hot DRI has been outstanding.

MIDREX News & Views

Midrex announces new Global Solutions Project Manager

Midrex has announced that Wes Marsh has been recently appointed new Project Manager for Midrex Global Solutions, replacing Tom Thigpen who is retiring from project work. Marsh will be responsible for all engineered solutions projects that are designed to help plants increase production and efficiency.

Marsh has been with Midrex since 1997 in several roles and has worked closely with most of our Licensee Plants. He is transferring from Engineering where he has been successfully serving as Chief of the Mechanical Department for the past several years. Earlier in his career, Wes worked as engineering liaison for Midrex Solutions (the precursor of Global Solutions) providing engineering and technical support. His knowledge and experience will be a great asset to Midrex Global Solutions team. Marsh has a Bachelors of Science in Mechanical Engineering from NC State and has worked within related industries since 1984.

Wes Marsh
Project Manager of Global Solutions

Christopher M. Ravenscroft: Editor

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