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The Two Million Ton Milestone
Hadeed’s Module E Surpasses 2.0 MTPY

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

Last year Hadeed’s MIDREX® Module E accomplished a truly noteworthy feat by becoming the first ever single module DR plant to produce more than two million metric tons of DRI product in a single calendar year.

Hadeed’s Module E at Al Jubail, Kingdom of Saudi Arabia was commissioned in late 2007 as a 1.76 million ton per year (Mtpy) combination plant, making both HDRI and CDRI. The plant is the newest of five DRI modules on site and incorporates the newest hot charging technologies available. By name plate capacity, Module E is one of the largest DRI facilities in the world, but its true production over the past few years has made it the largest annual producing plant to date.

We congratulate Hadeed and their operation and maintenance people throughout their organization that have pushed the MIDREX® technology through optimum operation and minimizing unscheduled downtime.

This was an incredible milestone not only for Hadeed and its maintenance and operations staff, but for the entire industry as it has made rhetoric a reality. The idea of production at such a large scale from a single DR plant is no longer hypothetical.

The earliest DRI Plants built more than three to four decades ago were designed to produce nominally 400,000 to 600,000 tons per year. At this capacity multiple DRI modules were needed to match the capacity of even a small blast furnace (BF). At the same time, the technology of the era required multiple electric arc furnaces (EAFs) to match the capacity of even a comparably sized integrated steel mill. In the 1960’s most EAFs were designed to tap 30 to 60 tons; typically producing 100,000 to 200,000 tons per year. Over the past few decades many things have changed.

A modern DRI Plant coupled with a modern EAF can now produce steel on both a quantity and quality basis than can replace conventional BF/BOF integrated steelmaking operations. Today’s modern EAFs can tap 150 tons and produce 1,500,000 tons per year when operating with 100% HDRI feed.

Using nominal values common for today’s DRI and EAF processes, 1,500,000 tons of molten steel will require 1.75 million tons of DRI if no scrap or pig iron were used. If the same productivity values are scaled to a 2.0 Mtpy year HDRI Plant, the EAF capacity should be approximately 1.7 million tons.

Surpassing the two million ton per year milestone means that not only is it feasible to reliably produce a large consistent supply of virgin iron for EAF steelmaking, but it also shows that continued responsible scale up will no doubt make 2.5 Mtpy and larger DRI modules a reality as well.

One thing is certain, there has been and will continue to be growing interest for DRI products in EAF production. DRI products have shown their increasing value as virgin iron units to provide metallics for EAF steelmaking. Charging DRI as a supplement to scrap to dilute tramp elements in EAF steelmaking has allowed EAFs to produce high quality steels that compete with or replace those made by the conventional integrated steel mills. DRI products can supplement scrap at any quantity up to 100% of the charge. Larger DRI module sizes will help the EAF industry be more and more competitive as larger production capacity becomes reality.
Midrex® Plants produced an estimated 47.56 million tons in 2013, 1.0% more than in 2012 and 7.2% more than in 2011. The production for 2013 is estimated from the 33.1 million tons confirmed by MIDREX Plants outside Iran and the 14.46 million tons within Iran reported by the World Steel Association, all from MIDREX Plants. MIDREX Plants continued to account for more than 80% of the worldwide production of natural gas based DRI. Despite slow demand growth and continuously high iron ore prices (similar to 2012 levels), at least eleven plants established new annual production records, and seven plants established new monthly production records. Eleven MIDREX Modules came within 10% of their record annual production values, and fifteen MIDREX Modules operated in excess of 8000 hours.

2013 saw again the mid-year downward iron ore price pressures, but prices rose again at the end of the year nearly to early 2013 values. The overall trend seems to indicate a slow decline in iron ore prices. Two new MIDREX Modules started up: a cold/hot DRI plant belonging to SULB in Bahrain, and a cold discharge plant belonging to Tuwairqi Steel Mills in Pakistan. MIDREX Plants have produced a total of more than 780 million tons of DRI/HBI through the end of 2013.
ACINDAR
ACINDAR’s MIDREX Plant broke their annual production record in 2013, exceeding 1.0 million tons despite the typical mid-year winter natural gas curtailments, averaging more than 133 tons per hour for the year and achieving average monthly production rates of 145 to 146 tons per hour. On its 35th anniversary, ACINDAR’s MIDREX Plant reached the 26 million ton production mark, the most produced by a single MIDREX Module to date.

ANTARA STEEL MILLS
The first MIDREX Plant designed to make HBI produced under annual rated capacity in 2013 due to market constraints.

ARCELORMITTAL HAMBURG
AM Hamburg's MIDREX Plant, the oldest MIDREX Plant in operation, comfortably exceeded annual rated capacity in 2013 while producing the DRI tonnage budgeted for the year, with metallization averaging more than 95.1%.

ARCELORMITTAL LAZARO CARDENAS
AMLC operated 34% over its rated capacity of 1.2 million tons and within 10% of its record annual capacity, using iron ore pellets made exclusively with Mexican iron ores. In early 2014, AMLC surpassed the 25 million ton production milestone, achieved in 16.5 years since starting up in August 1997.

ARCELORMITTAL MONTREAL
Module II set a new annual production record in excess of 915,000 tons in 2013 after restarting production in 2011, surpassing the 20 million ton production milestone in early 2013. Module I restarted operations in June 2013 at full capacity due to competitively priced natural gas and oxide pellets sourced locally. Module I initially started production in April of 1973 and is now forty years old.

ARCELORMITTAL POINT LISAS
All three of AMPL’s Modules operated in 2013 producing more than 1.8 million tons of DRI for their steel shop and for export, surpassing the 40 million ton production milestone in early 2014. The metallization of the DRI product of Module 3 exceeded 95.8% on average for the year, with an average 2.76% carbon.

ARCELORMITTAL SOUTH AFRICA (SALDANHA WORKS)
The COREX Export Gas-based MXCOL® Plant’s operation was limited by the availability of export gas from the COREX Plant. The plant was within 7% of its operating hours’ record and averaged more than 65% South African 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 2013.

**DRIC**

DRIC’s two modules in Dammam, Saudi Arabia continued to increase production to satisfy the demand of its neighboring steel shops, and both modules set new annual production records. Module 1 set a new annual production record for the fourth consecutive year.

**ESSAR STEEL**

The three largest of Essar’s six MIDREX Modules operated at reduced production rates due to the shortage of iron ore and the very high natural gas prices in India. The three smaller modules remained shut down for the whole year.

**EZDK**

Although limited by the natural gas availability in Egypt, all three of EZDK’s modules exceeded rated capacity, produced more than 2.6 million tons of DRI, and averaged exactly 8200 hours of operation in 2013. EZDK’s three modules reached the 50 million ton mark in 2013, averaging more than 870,000 tons per module per year.

**FERROMINERA ORINOCO**

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

**HADEED**

Hadeed exceeded rated capacity for the 29th consecutive year in Modules A and B, and for the 21st consecutive year in Module C. Having started in 1983, 2013 marks Module A’s 30th Anniversary. Module A set a new monthly production record in December 2013. Module E established a new DR plant production world record of 2,000,458 tons of HDRI and CDRI produced in 2013, operating 8453 hours in the year and surpassing the 10 million ton production mark. All four of Hadeed’s MIDREX Modules averaged 8494 hours of operation in 2013. Hadeed’s four MIDREX Modules have produced more than 70 million tons of DRI to date.
**JINDAL SHADEED**

JindalShadeed again set a new production record of 1.469 million tons of HBI and HDRI in their third year of commercial operation. The plant, designed to produce mainly HDRI (with HBI as a secondary product stream), operated more than 8100 hours in 2013. In January, they set a new monthly production record, averaging 189 tons per hour. JindalShadeed produced mainly HBI and dispatched more than 150,000 tons of HDRI via hot transport vessels to a nearby steel shop while its adjacent steel shop neared the end of construction.

**JSW STEEL (DOLVI)**

JSW Steel, formerly Ispat Industries, Ltd., again comfortably exceeded rated capacity in 2013, was within 10% of their record annual production, and operated an exceptional 8669 hours in the year, with only 7 hours of unscheduled downtime. Production was restricted by the increased price for natural gas in India. Excluding the first partial year of production, JSW Steel’s plant in Dolvi has averaged 8044 hours of operation per year since 1995.

**LEBEDINSKY GOK**

In 2013, Lebedinsky GOK’s second DR module established a new annual production record that was almost 10% above its rated capacity of 1.4 million tons of HBI. They also broke their previous monthly production record, reaching 190 tons per hour in January. Operational availability was 8125 hours this year.

**LION DRI**

The production of the Lion DRI plant located near Kuala Lumpur in Malaysia continued to be limited by steel shop demand. 2013 production consisted of 82% HDRI and 18% HBI.

**LISCO**

After restarting production in 2012, all three of LISCO’s MIDREX Modules in Misurata, Libya continued ramping up production. Modules 1 and 2 have produced 20 million tons since their startups in 1989 and 1990, respectively.

**NU-IRON**

In August 2013, Nucor’s MIDREX Plant in Trinidad established a new monthly production record. For all of 2013, they were within 5% of their 2012 record production level. Average metallization of the DRI produced was the highest of all MIDREX Plants at 96.4%, with more than 2.8% carbon in their DRI product.
OEMK
Thirty years after the start-up of Module 1, OEMK produced more than 2.7 million tons again in 2013. Module 2 set a new annual production record while operating more than 8400 hours, whereas Module 1 operated 8396 hours and came within 1% of the annual production record that they established in 2012. Module 3 established a new monthly production record in October after restarting from their August shutdown for major preventive maintenance, and Module 4 operated 8355 hours in 2013.

QATAR STEEL
In its sixth full year of operation, Qatar Steel’s dual product (CDRI and HBI) Module 2 set a new annual production record for the third consecutive year, now 11% over its rated annual capacity, while operating 8085 hours. Most of the product from Module 2 was CDRI, with metallization averaging 95.5% for the year. Qatar Steel has produced more than 30 million tons of DRI since the startup of Module 1 thirty-five years ago.

SIDOR
Production from all four of Sidor’s MIDREX Modules was 1.75 million tons in 2013, with all four DR modules limited by the availability of oxide pellets. Sidor surpassed the 70 million ton milestone in 2013.

SULB
The 1.5 million ton per year combo MIDREX Plant belonging to United Steel Company (SULB) in Bahrain started up in January 2013 in Cold DRI (CDRI) mode, feeding their new steel shop, which was also in its start-up phase. In mid-August, the HDRI transport system to deliver HDRI to the steel shop was commissioned. Production in the MIDREX Plant has been following the steel shop’s learning curve.

TENARISIDERCA
TenarisSiderca operated below maximum capacity throughout all of 2013, limited by their steel shop’s demand for their DRI and by natural gas curtailments during the winter months. Their CDRI metallization averaged 95.8% for the year.

TUWAIRQI STEEL MILLS
The Tuwairqi Steel Mills combo plant, located near Karachi, Pakistan, designed for an annual production of 1.28 million tons of HDRI/CDRI, started up in early 2013 in CDRI mode. Their production has been minimal due to market-related limitations.

VENPRECAR
VENPRECAR’s production continued to be restricted by the limited availability of iron ore pellets for HBI production in Venezuela.

EDITOR’S NOTE:
No DRI production data was received from the following plants: South Kaveh Steel, Mobarakeh Steel, Khouzestan Steel, Khorasan Steel, IMPADCO, IGISCO, and Hormozgan Steel.
In the world of Heavy Industry, as in most areas of business, the fastest way to inspire, install and instill a change is to illustrate how that change will positively impact the bottom line. A plant Safety Program is a necessary expense and a cost of doing business; however, an effective safety program increases the morale of all employees, increases the overall efficiency of the plant and decreases both the direct and indirect operating costs. Achieving a zero lost time safety record at your facility has the potential to provide a savings to the company that reaches into the millions of dollars. The goal of this article is to quantify to some extent, the massive savings that is afforded to any manufacturer that achieves and maintains a zero-lost-time safety program over the long term.

**POSITIVE EMPLOYEE MORALE**

Beyond all of the catchy slogans, colorful banners and training sessions, there is a necessity for employees to embrace safety. The most complete safety program - implemented within the confines of the safest working environment possible and lead by the foremost authorities within the safety industry - will totally fail without first securing the buy-in of the worksite employees. From top management, all the way down to temporary staff – everyone must take responsibility for their own safety, and be actively engaged in ensuring the safety of their fellow workers.

Comprehensive, ongoing safety training is the pathway that leads to workforce buy-in of the safety program. Ownership of the principles heralded by the plant site's program will create a self-policing team that not only takes responsibility for their own safety, but also looks for ways to improve upon the program in place. Participation, encouragement and updates on the basic training from the executive level will instill a confidence in the workforce. It also communicates that the company cares about the individual safety of all employees and values their contribution to the corporation's success. The healthy morale created by a successful safety program that employees
trust provides the company with shift after shift that is confident, disciplined and ready to perform.

Companies that have an underperforming safety program are generally found to have a management team that fosters an unsafe environment by labeling the company’s chosen safety program as just another cost of doing business. Repeated minor injuries communicate to the rank and file employee that the company does not really care about their personal safety and well-being – and a major lost time accident (hereafter referred to as an LTA) can leave an employer with a workforce that is demoralized, unmotivated and unproductive.

Low employee morale and trepidation can cost companies far more than the cost of implementing a good safety program. Team members with low morale that are fearful for their own well-being while at work are significantly less productive and potentially more dangerous to those around them. If safety is not put forward as an absolute by company leadership, experienced employees are more likely to be looking for another job and more likely to have unscheduled absences. Much of the direct costs associated with low morale, higher turnover rate, and unscheduled absences are difficult to fully quantify, but consider the following:

- According to the Gallup Organization, low employee morale and trepidation costs employers an estimated $350 billion per year in lost production. (1)
- The Saratoga Institute estimates that the cost to the company associated with the turn-over of an experienced employee is 2 times that employee’s salary and benefits. (2)
- The total cost to an employer for unscheduled absences averages a full 9% of total payroll. (3)

**INCREASED PRODUCTIVITY**

“Workplaces with active, visible safety leadership have fewer injuries, are often rated as better places to work, and have more satisfied, more productive employees who are less likely to change jobs” (OSHA, 2002) (4)

The most productive shops employ an experienced and motivated work force. If a successful corporation’s most valuable asset is its employees, it only makes sense that the company would be willing to make every investment in order to keep the most valuable asset as safe as possible.

Consider the cost of hiring, training, and guiding a new employee along the learning curve needed to serve a key role at your facility – an expense of 1.2 to 1.4 times that employee’s base salary (5). Combine that with loss in productivity and the impact of the new hire on other members of the team and the expense adds up quickly. When management takes a look at the real costs of losing experienced employees, an investment in the existing workforce by way of a continually improving safety program always makes the most sense.

Looking at Figure 1 above, the highest ROI from an effective worksite safety program comes in the form of increased productivity.

As a real world example of how a zero LTA safety program impacts overall facility production, consider the MIDREX® modules owned and operated by Qatar Steel. Employee safety is...
an absolute at Qatar Steel, and their two MIDREX modules currently boast a decade long safety record of Zero Lost Time Accidents. As Figure 2 illustrates, Qatar Steel has also enjoyed record levels of DRI production during this decade of safety excellence.

**FIGURE 2**

**Qatar Steel DRI Modules Excellence in Safety Performance – Zero LTA in Last 10 Years**

Clearly, the overall efficiency and productivity of any manufacturing facility can be directly linked to the performance of the company’s safety program. A proven safe working environment allows the crewmember to focus on performance goals and keeps the most experienced employees clocking in year after year.

**DECREASING DIRECT AND INDIRECT COSTS**

The average direct cost of a single lost time injury in the United States is about $38,000. As was briefly discussed in part one of this series, the direct costs of an LTA are just the beginning of the financial strain on the company. The indirect costs of an LTA will generally exceed the direct costs by a ratio of 4 to 1 or higher. So for a single LTA, the total expenditure by the company to cover all associated costs is likely to be $190,000.00 or more. (6)

**EXAMPLES OF LTA DIRECT COSTS**

- Worker’s compensation premiums
- Case management
- Medical costs for surgery, medicine and rehabilitation

**EXAMPLES OF LTA INDIRECT COSTS**

- Loss of production
- Administrative costs
- Overtime pay required
- Costs of new hire
- Negative media attention
- Legal fees
- Increase in worker’s comp costs
- Reputation loss
- Lower employee morale
The direct and indirect costs for a single LTA are extremely high, but the true expense cannot be fully appreciated until we examine the total revenue that is needed to recover the costs of a single LTA.

**SALES NEEDED TO RECOVER FROM A SINGLE LTA**

Using the total LTA cost figure of $190,000.00, the total sales needed to recover from a Single LTA would be:

- If typical profits are 10%: $1,900,000.00
- If typical profits are 5%: $3,800,000.00

No matter where the profit margins fall, the costs of an LTA far exceed the investment needed to establish and maintain a successful safety program at your facility. Prevention of just one LTA not only reduces total operating costs by an average of $190,000; it helps to ensure that the hard fought efforts of your sales team are used to bolster the bottom line. Of course, the true operating costs savings that are afforded by a 100% effective safety program will never be completely realized in monetary gains.

The manufacturing facility necessitated by heavy industry is, by its very nature, a hazardous environment. An investment in the establishment and improvement of an effective safety program prevents financial losses for the company each year. A company that works proactively to ensure that each and every worker, on every single shift, will return home safe helps to ensure that the workforce feels safe and is seen as a valued part of the company.

**CONCLUSION**

As we have examined the impacts of the worksite safety program on employee morale, production totals, and operating costs, it is obvious that safe operations contribute to the bottom line. Eliminating all risk is not always possible, but a proper safety program can provide not only a safer working environment, but a more prosperous one as well. Excellence in health and safety performance leads to improved productivity and lower costs, because less time is needed to deal with worker injury, accident investigations and legal proceedings. In the modern industrial environment, a company that is not actively investing in the ongoing improvement of its employee safety program is sacrificing profit each year from its balance sheet. It is also disregarding the health and well-being of its employees, which places the entire corporation at risk. The more effective a plant safety program is, the more time there is to focus on the goals and profitability of the company.

**REFERENCES**


The world's direct reduction industry grew again in 2013, setting yet another new record with 75.2 million tons produced, according to data compiled by Midrex and audited by World Steel Dynamics. This was 2.8% above 2012's numbers - quite remarkable considering the economic forces that have affected the industry. In terms of technology, MIDREX® Plants once again led the production of all DRI products, with 63% of the market.

The DRI industry has grown in eight of the past ten years. Output in 2013 was more than 85% greater than in 2001. Factors that placed a drag on growth in the preceding years have continued but were overshadowed by the demand for DRI products.

The primary region of industry growth was the Middle East/North Africa (MENA), which grew by 5 million tons over 2012 numbers. The Kingdom of Bahrain joined the group of DRI-producing nations and Iran once again underwent major growth, primarily via the ramp-up of several recently commissioned modules. Saudi Arabia and the United Arab Emirates set new records for national DRI production. Oman increased tonnage as their industry continues to rebuild from the civil war. Together, MENA made 32.4 million tons of DRI, 55% of the world's total production of natural gas fueled DRI.

Additional growth was also seen in Russia, which had a new national record production of 5.3 million tons. Two key producing countries, India and Venezuela, saw significant declines in production.

India fell to 17.8 million tons, down from the all-time high of 23.4 million tons in 2010. The main detractors were the same that have been seen in the past few years, including: lower availability of domestic iron ore, licensing related to environmental requirements and extremely high prices of natural gas. Since 2010, natural gas based DRI production in India is down by more than half.

Venezuela continued to struggle with DRI production - now down to less than one-third of its maximum production in 2005, the decline spurred by a shortage of iron oxide pellets to feed the DR plants but fueled by a lack of funds for maintenance throughout the supply chain and infrastructure.

Despite these restraints, demand has steadily grown as the world economy continues to slowly recover from the financial crisis of 2008-2009. Approximately 16 million tons per year of DRI capacity are currently under construction. A conservative view of the situation is that some of the plants/projects are in locations where it will be difficult to maintain schedules as planned with economic and political factors in...
these areas possibly slowing completion. Midrex forecasts that those plants currently under construction will come on stream over the next 3 years.

Total DRI production in the USA is expected to be at least 10 million tons per year by 2020. Shale gas exploration in the USA and Canada has led to lower natural gas pricing in North America - encouraging the building of new DR capacity. Nearly half of this increased production capacity has already been built or is in the construction phase. North America will most likely see 2-3 more facilities by end of this decade.

Midrex believes that there will be increases of five million tons per year and more over the next decade.

In areas without access to low cost natural gas, other technologies are being explored and implemented. Already in progress for India are plants using syngas produced from coal instead of natural gas for DRI production. Two of these facilities are expected to be commissioned in 2014. In addition, at least one plant is exploring supplementing its natural gas supply with coke oven gas (COG) to maximize existing resources and lessen dependency on natural gas.

For more complete information on the 2013 DRI Production, please visit www.midrex.com to download the 2013 World Direct Reduction Statistics.

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**MIDREX News & Views**

**Bringing DRI to China and Far East:**

*Midrex signs exclusive Marketing Agreement with Synthesis Energy Systems and its subsidiary for Clean Coal Gasification-based Direct Reduced Iron Facilities*

_Synthesis Energy Systems, Inc. (SES)_ recently announced that its wholly owned subsidiary, SES Technologies, LLC; Shanghai-based Jiangsu Tianwo-SES Clean Energy Technologies Ltd. (T-SEC); and Midrex have entered into an exclusive agreement for the joint marketing of MXCOL® coal gasification-based DRI facilities in China. These facilities will combine the premiere SES Gasification Technology with the MIDREX® Direct Reduction Process to convert iron ore into DRI from syngas generated from low quality coals.

Midrex and SES will work together to develop and implement the marketing and commercialization strategy, with the intention of securing the product offering’s first customers, initially in China. Additionally, T-SEC will supply the gasification equipment and licensing of the SES Gasification Technology to any of SES-Midrex DRI projects in its region, which includes China, Indonesia, Malaysia, Mongolia, the Philippines and Vietnam.

“New DRI production technologies such as MXCOL® represent the future of cleaner high quality ironmaking,” said James D. McClaskey, President and CEO of Midrex. “Jointly with SES, we look forward to providing new technology that will meet evolving environmental needs to make top-grade DRI products for regional steelmakers by best utilizing local energy resources and raw materials.” “We are very pleased to be strategically aligned with the worldwide leader in DRI steel in this important SES market vertical,” said Robert Rigdon, SES
(Bringing DRI to China and Far East: cont’d.)

president and CEO. “We believe this is a very timely collaboration with Midrex because of the shifting needs in China for cleaner, economical solutions for steel making.”

New coal gasification-based DRI plants are intended to support China’s growth in an eco-friendly way as China moves away from high polluting and inefficient blast furnaces to new, cleaner technologies for the fabrication of iron product for steel manufacturing. China is the largest producer of steel in the world and currently has no DRI-based plants. The Chinese central government is encouraging the replacement of outdated facilities with new, more efficient ironmaking technology.

Contact: Midrex
General E-mail: info@midrex.com
Phone: (704) 373-1600
2725 Water Ridge Parkway
Charlotte, NC 28217 USA

General Press/Media Inquiries
Christopher M. Ravenscroft
cravenscroft@midrex.com
Phone: (704) 378-3380

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