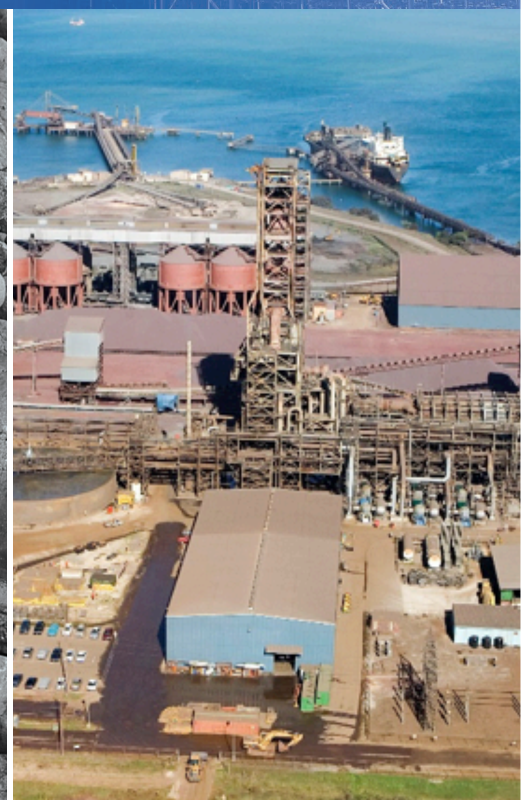
DIRECT FROM MIDREX

1ST QUARTER 2017



INSIDE THIS ISSUE

COMMENTARY

JULIUS CAESAR HAD NOTHING ON **ROBERT HUNTER**

By Frank Griscom

EDITOR'S NOTE:

*I guess that it inevitably happens... after 40-plus years, long-time Midrex product marketing authority, salesman, and guru, **Robert Hunter** has officially retired from Midrex. For those that know Robert either personally or by reputation, he is "Mr. HBI" - an expert on the subject (and various others) whose career has paralleled the development of the merchant DRI market. We wish him glad tidings and happiness in his next adventure and graciously leave the door open for him in the future to grace us with his knowledge, perspective and weirdly entertaining factoids.*

Happy Retirement Robert!

In 47 BC, Julius Caesar is purported to have announced in a letter to the Roman Senate, "Veni, vidi, veci" ... I came, I saw, I conquered. Looking back over the last 40+ years, Robert Hunter could very well have made the same pronouncement.

Robert began his career at Midrex in 1974, after graduating from the University of North Carolina - Chapel Hill in 1973, with a Bachelor of Science degree in physics. At the time, Midrex was still in a formative stage following purchase of the patent rights for the **MIDREX® Direct Reduction Process** by Willy Korf. Plant contracts were already underway as the company was being formed in Charlotte. People key to the technology were relocating from Toledo, OH, while additional staff was being recruited locally.

"The circumstances called for a quick ramp up with a steep learning curve," Robert recalls. "It was no time or place for the faint-hearted."

Robert joined Midrex as a project documentation clerk responsible for assuring that the teams at the project sites had the latest versions of engineering drawings. He soon was given the task of analyzing the raw data of daily operations from the growing number of **MIDREX® Plants**, and he played a key role in preparing for and conducting the first Operations Seminar for **MIDREX® Process Licensees** in 1976.

In 1978, Robert added monitoring iron ore developments relative to direct reduction to his repertoire. His scientific education, analytical talent and inquisitive nature served him well and he became an acknowledged industry expert on the subject. He continued to hone his presenting skills during the annual Midrex Operations Seminar, at which he did double-duty as the meeting host.

Kobe Steel Ltd. of Japan acquired the assets of Midrex in 1983, as part of a plan to expand its iron unit plant building business (KSL was already a provider of iron ore pelletizing plants and had been involved through Mitsui & Co. Ltd. in Qatar Steel, which included a **MIDREX® Plant**). Shortly after start-up of the first **MIDREX® Hot Briquetted Iron Plant** in 1984 on Labuan Island, Malaysia, KSL began planning the renovation and reactivation of the Minorca High Iron Briquette (HIB) Plant in Puerto Ordaz, Venezuela and asked Midrex to assist in developing the market for hot briquetted iron (HBI).

Marcus Davies, then President of Midrex, had seen Robert in action at the Operations Seminar and approached him about becoming involved in HBI marketing for OPCO, which would become the name of the Minorca facility when it was restarted by KSL with **MIDREX®** technology in 1990. Robert was assigned to develop sufficient interest among prospective customers to secure letters of interest, which were required to secure World Bank financing for the project.

OPCO HBI PLANT

For the next 16 years, Robert visited every EAF-based steel mill making high quality, low residual steel in the US and Canada, most in Mexico and many in Europe, India and Asia on behalf of OPCO and COMSIGUA, another **MIDREX® HBI Plant** in eastern Venezuela involving KSL. He became a frequent visitor to the Port of New Orleans Gonzales operation, which received and transshipped HBI from Venezuela.

As HBI became an established product and an industry association was founded to further its commercial development, the Hot Briquetted Iron Association (HBIA), Robert became available for mainline Midrex marketing assignments. He quickly emerged as a popular speaker on the iron and steel industry conference circuit: highly respected for his insights and information on a broad range of iron-related topics and renowned for his showmanship and storytelling.

"My 'breakthrough' as a public speaker came in 2004 with a presentation on the value of iron. I took people back to Mesopotamia, when iron was much more valuable than gold or silver and various parts of the king's anatomy were the basis of measurements." Then he adds with a smile, "I became known in Europe for making my stage entry to music chosen for the subject ... usually a popular recording with personal accompaniment."

It's fair to say that when you ask a long-tenured steel industry consultant or media person who personifies Midrex the answer will be Robert Hunter. Throughout his 40-year career at Midrex, Robert has cultivated many skills, adding something from each stop along the way. If anyone can say "been there, done that", it's Robert.

But if you ask Robert what he considers his greatest accomplishment, he will tell you it's his family. He and Gaye, whom he met while in college and married in 1973, have raised three successful sons who still reside in the Charlotte area.

"I couldn't have done the things at Midrex for all these years without the support and encouragement of my family. It is such a blessing to have them all close by, especially now that I am retiring."

Robert Hunter is one of those rare people who is respected and loved by everyone he meets. He always has a smile on his face and a story in mind. He is constantly looking for more to learn and experience so he can share it with anyone who will listen ... and for that reason, he will never really retire. We can't let him because who could take his place?

Best wishes, Robert, and thanks for being a colleague, friend, and inspiration.

MIDREX PROVIDES SULB OPERATIONAL FLEXIBILITY

Teams with Kobe Steel to Solve Spikes in Natural Gas H_2S Content

By TODD AMES
Director – Sales, Midrex Technologies

INTRODUCTION

When Foulath of Bahrain and Yamato Kogyo Company Ltd. of Japan decided to have Kobe Steel Ltd. supply a 1.5 million ton/year **MIDREX® Direct Reduction Plant** for their joint venture steel project, Bahrain United Steel Company (SULB), they knew the plant would need a system to handle the hydrogen sulfide (H_2S) in the natural gas they would receive. H_2S content in the local natural gas at the time of the plant contract in 2010 ranged from about 350 to a maximum of 600 ppmv.

Feed gas to the reformer in the **MIDREX® Direct Reduction Process** needs to contain 2-5 ppmv of H_2S – less than 2 ppmv may cause the catalyst to deposit carbon in the reformer tubes and reduce tube life; more than 5 ppmv may decrease catalyst activity and have a negative effect on reformer capacity. Therefore, due to the inherent natural gas quality in Bahrain, a LO-CAT® (a registered trademark of Merichem Company of Houston, Texas, USA) H_2S Treatment System was included in the **MIDREX® Plant** design.

LO-CAT® SYSTEM FOR H_2S REMOVAL

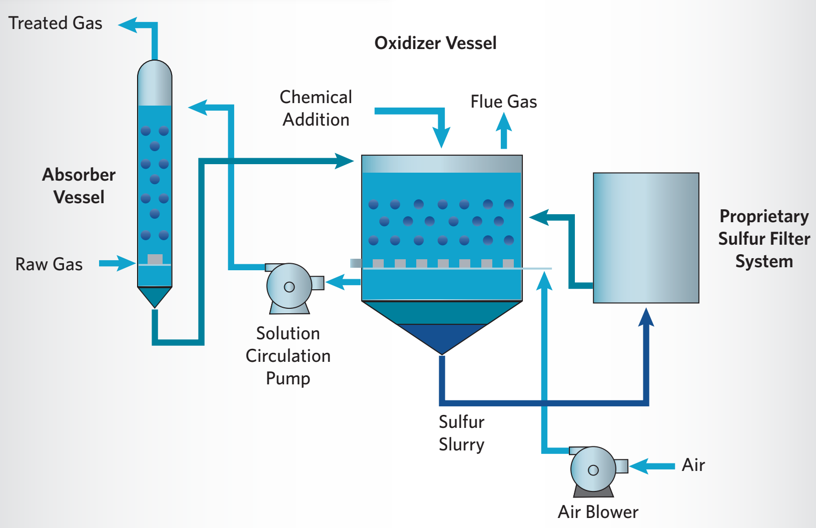


FIGURE 1 *Diagram of the LO-CAT® System for H_2S Removal*

LO-CAT® is a patented, wet scrubbing, liquid chemical reduction-oxidation system that uses a chelated iron solution to convert H_2S to safe, stable elemental sulfur. It does not use any toxic chemicals and does not produce any hazardous waste byproducts. The SULB system was designed to treat natural gas having H_2S content of up to 600 ppmv by reducing the H_2S to 5 ppmv or less. A diagram of the LO-CAT System is shown in ***Figure 1***.

Shortly after successful completion of the Plant Acceptance Test in February 2013, SULB brought to the attention of Kobe Steel Ltd. (KSL), the turnkey supplier of the **MIDREX® Plant**, that the H_2S level in the natural gas being supplied was averaging 650 ppmv and had spiked as high as 900 ppmv. SULB requested KSL to provide a solution for handling H_2S levels of up to 1000 ppmv.

SULFATREAT MEDIA & SYSTEM

KSL asked Midrex to determine the most effective technology for treating natural gas containing up to 1000 ppmv of H_2S and design a system that would complement the LO-CAT System already installed and operating at the SULB site. The solution was SulfaTreat (a product of Mi-Swaco of Chesterfield, Missouri, USA), a non-hazardous granular material that can be used in a variety of configurations to remove H_2S from natural gas streams through batch-processing treatment.

During the H_2S removal process, gas flows through the consistently sized and shaped Sulfa Treat media, which is packed into a vertical pressure vessel where it chemically reacts with the H_2S to form a stable, safe byproduct. The life of the SulfaTreat media depends on the amount of H_2S that passes through the bed of the pressure vessel. This economically matches the need for H_2S removal with variations in system flow conditions and outlet specifications, regardless of the total volume or other common components of the gas.

In the SulfaTreat system, iron oxide and the H_2S in the gas stream combine in an electrochemical reaction to produce primarily iron pyrite (FeS_2) and water (H_2O). The reaction involves the transport of electrons promoted by the moisture layer on the SulfaTreat media, similar to a corrosion process. Water saturation is necessary for the SulfaTreat media to be effective. A lack of moisture will slow down the removal process.

To best accommodate the routine replacement of SulfaTreat media, the system is arranged in a lead-lag bed arrangement; i.e., in series ***(Figure 2)***.

DUAL VESSEL LEAD-LAG SOLID SCAVENGER SYSTEM

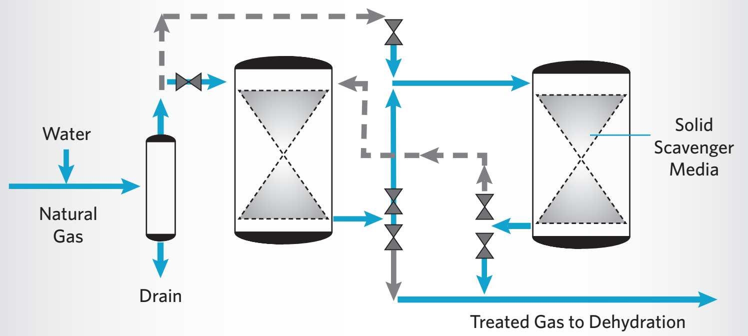


FIGURE 2 *Diagram of the SulfaTreat Lead-Lag System for H_2S Removal*

When the sulfur removal capacity of the lead bed is exhausted, it is isolated and the lag bed remains in service while the media is replaced in the lead bed. After the media is replaced, both beds can be brought on-line and the lag bed becomes the lead bed, and the cycle is repeated.

DESIGN CASES

The concentration of H_2S in the natural gas supplied to SULB is usually within the performance limit of the LO-CAT System. Therefore, Midrex prepared four cases when designing the integration of the SulfaTreat System into the SULB plant. Data for the cases are shown in ***Table 1*** and a system diagram can be seen in ***Figure 4***.

Case A is a series operation. It assumes the approximate natural gas flow to the DR plant to be 64,400 Nm^3/h and ensures a maximum of 657 ppmv of H_2S is delivered to the existing LO-CAT System, which has previously demonstrated the ability to operate acceptably at this inlet H_2S level. This amounts to 1.43 metric tons of sulfur removed per day from the load on LO-CAT. The natural gas pressure conditions at the inlet of LO-CAT are similar to the current operating conditions (approximately 17 barg +/- 0.5 bar).

Case B also is a series operation and assumes a minimum flow rate of natural gas to the SulfaTreat System while the LO-CAT System is in operation.

Case C is neither a series nor a parallel operation case. Similar to Case B, it assumes a minimum flow rate of natural gas to the SulfaTreat System, but the LO-CAT System is offline in Case C. In this case, the natural gas to the DR Plant is used to fire the auxiliary burners only.

Case D is a parallel operation case. It assumes that the LO-CAT System is limited in the flow rate of natural gas that it can receive at its inlet. For this case, a new bypass line around LO-CAT was required.

ASSURING SUSTAINABLE OPERATION

SULB owns and operates a “combination plant,” the latest plant design from Midrex. A combo plant, as it is known, includes a hot discharge **MIDREX® Shaft Furnace** that is configured for simultaneous discharge of cold DRI (CDRI) and hot DRI (HDRI). The plant is equipped with one of several hot transport systems available from Midrex to retain the sensible heat in the HDRI while it is transported to the melt shop ***(Figure 3)***.

The 1.5 million ton per year combo plant was started up in January 2013 producing CDRI to feed the SULB steel mill. In mid-August 2013, the HDRI transport system to deliver HDRI to the steel shop was commissioned.

The SULB steel works is located in Hidd Industrial Area, adjacent to a two-plant 12 million t/y pelletizing operation owned by Gulf Industrial Investment Company (GIIC). Oxide pellets used in the DRI plant are purchased from the GIIC facility, both plants being supplied turnkey by KSL. Plant 1 was started up in 1984, with a design capacity of 4 million t/y and was upgraded in-house to 5 million t/y in 2007. Plant 2 began commercial operation in early 2010, with a design capacity of 6 million y/y and is capable of producing 7 million t/y.

Natural gas for the SULB works is supplied by Bahrain Petroleum Company (BAPCO). This is associated petroleum gas (APG), or associated gas, which is found with deposits of petroleum, either dissolved in the oil or as a free gas above the oil in the reservoir. APG typically was released as a waste product by the petroleum extraction industry until the advent of direct reduction technology, which transforms it into useful process gas.

Case	Maximum H_2S in natural gas, ppmv	NG flow to SulfaTreat System, Nm^3/h	NG flow to LO-CAT System, Nm^3/h	Approximate NG flow to DR Plant, Nm^3/h	Predicted SulfaTreat System bed life, days
A	1000	Maximum 22,200	64,412	64,400	29
B	600	Maximum 3,200	64,315	64,315	312
C	1000	Maximum 3,200	0	3,200	186
D	600	Maximum 22,200	Maximum 42,100	64,400	48

TABLE I *- Four design Cases for SulfaTreat System at Sulb*

FIGURE 3 *Hot DRI transport conveyor from the MIDREX® Shaft Furnace to the melt shop*

As SULB found out, the chemical composition of APG can fluctuate, especially the H_2S content, which can have a detrimental effect on the operation of a DRI plant reformer. Now that the SulfaTreat system has been installed to complement the LO-CAT System ***(see Figure 4)***, SULB has the flexibility to operate in the most cost-effective way regardless of the H_2S level coming from BAPCO in the APG.

CASE	A	B	C	D	E	F	G
A	64,300 Nm^3/h @1,000 ppmv H_2S	22,200 Nm^3/h	42,100 Nm^3/h	22,312 Nm^3/h @10 ppmv H_2S	64,412 Nm^3/h @657 ppmv H_2S	0	0
B	64,300 Nm^3/h @600 ppmv H_2S	3,200 Nm^3/h	61,100 Nm^3/h	3,215 Nm^3/h @10 ppmv H_2S	64,315 Nm^3/h @570 ppmv H_2S	0	0
C	3,200 Nm^3/h @1,000 ppmv H_2S	3,200 Nm^3/h	0 Nm^3/h	3,215 Nm^3/h @10 ppmv H_2S	0	3.215 Nm^3/h @10 ppmv	0
D	64,300 Nm^3/h @600 ppmv H_2S	22,200 Nm^3/h	42,100 Nm^3/h	0	42,100 Nm^3/h	0	22,312 Nm^3/h @10 ppmv

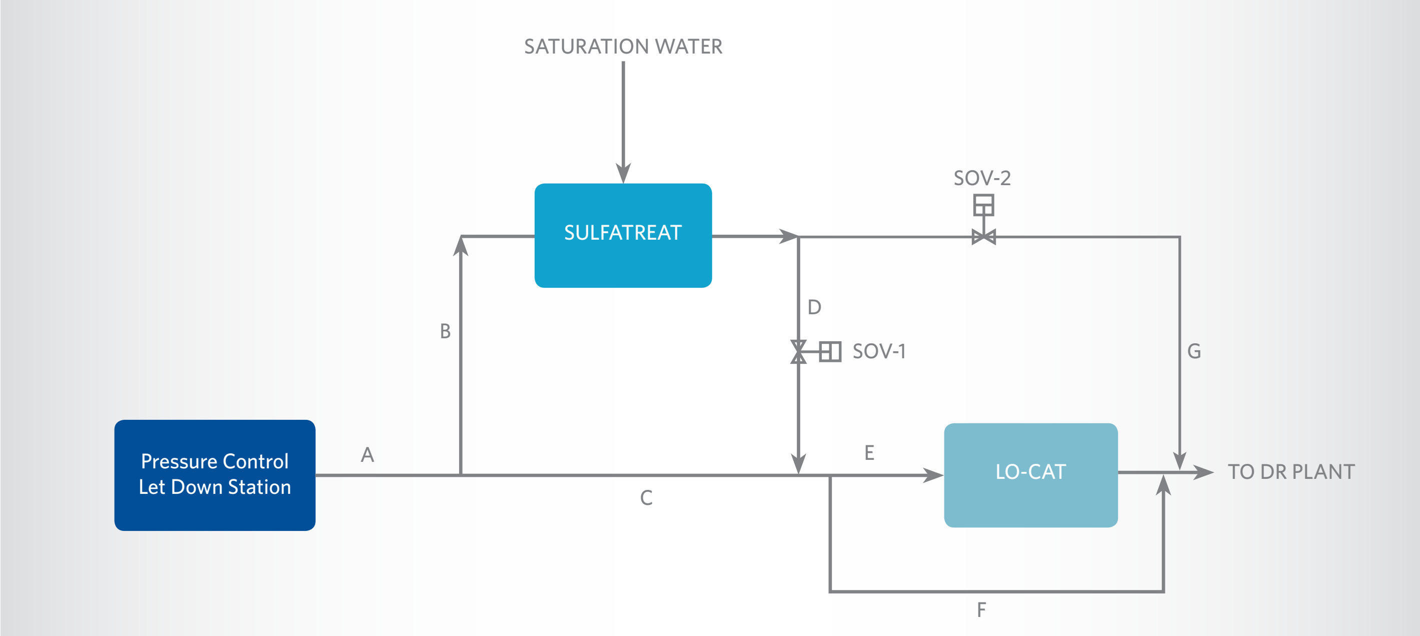


FIGURE 4 *Diagram of Parallel Installation of SulfaTreat and LO-CAT Systems*

MIDREX GLOBAL SOLUTIONS

How well a plant is maintained and serviced is instrumental in determining its performance, reliability, and longevity. The larger the capital investment, the more important the selection of an aftermarket services provider becomes.

Midrex Global Solutions (MGS), as its name represents, does more than provide spare parts and materials. It takes a broad, in-depth approach to the needs of Midrex customers and develops comprehensive solutions based on the knowledge, expertise and experience of Midrex and its family of Process Licensees.

MGS is the latest in the natural progression of customer service functions that has evolved as the number of **MIDREX® Plants** has increased globally. For the first 20 years, Midrex primarily provided technical advice and managed the transfer of technology. In 1990, Professional Services International (PSI) was established as a subsidiary of Midrex to provide procurement and logistics services to KSL, the parent company of Midrex, as well as to supply spare parts to **MIDREX® Process Licensees.** The decision was made in 2004 to integrate PSI into Midrex, and Midrex Solutions was formed soon thereafter (later renamed Midrex Global Solutions).

Within a **MIDREX® Plant**, MGS is capable of servicing a wide range of production and maintenance operations. These activities include designing engineered solutions, managing maintenance, repair and operation (MRO) programs, sourcing and procuring spare parts and materials, and providing field services. The successful SulfaTreat project for SULB is an excellent example of the capabilities of MGS. ■

ADVANCING PERFORMANCE OF NU-IRON'S MIDREX® DRI PLANT

By Curtis Moore and Gary Levanduski, ***Nu-Iron Unlimited***
Eric Weisenhorn, ***Midrex Technologies, Inc.***

EDITOR'S NOTE:
This article has been adapted from a paper given at the 2016 AISTech Conference.

INTRODUCTION

In September 2004, Nucor acquired the physical assets of American Iron Reduction, a 1.2 million ton per year cold DRI (CDRI) plant utilizing MIDREX® Direct Reduction Technology. Nucor relocated the plant to Point Lisas, Trinidad in 2005, from it's original location in Louisiana, USA. In the process, it increased the plant's capacity to 1.6 million metric tons per year. The new plant, Nu-Iron Unlimited, commenced DRI production on December 30, 2006. The company is the largest shipper of CDRI in the world and has produced more than 12 million tons of cold DRI since start-up, which has been successfully shipped to and melted in Nucor Steel mills in the USA.

Looking to push technology and performance even further, Nu-Iron established a Direct Reduction Engineering and Technology (DRET) group in coordination with Midrex Technologies, Inc. Nu-Iron is a wholly owned, full subsidiary of Nucor Steel, the most diversified steelmaker and the largest recycler of steel and steel products in the United States. This article will present and describe the measures thus far employed to enhance the operation, reliability and productivity of the plant including both maintenance practices and equipment development.

BACKGROUND

During the 1990s, rising scrap prices forced USA mini-mills to look for alternate sources of feedstock. An attractive option was domestic natural gas-based direct reduction because of low natural gas prices, from $1.50-2.00 per million Btu at the wellhead. GS Industries, then the parent company of Georgetown Steel Corporation, and Birmingham Steel partnered to develop a new **MIDREX® Direct Reduction Plant**. The concept was to produce ore-based metallic DRI in Louisiana, which would be shipped to their mini-mills in the Southeast and Midwest USA. Excess product would be sold to others.

The plant was known as American Iron Reduction (AIR) and was located in Convent, Louisiana, on the Mississippi River between New Orleans and Baton Rouge. This location had several advantages including: inexpensive natural gas, rail connections, and river access to receive Brazilian iron ore and ship out DRI. The plant, shown in ***Figure 1***, included a 6.65 meter diameter

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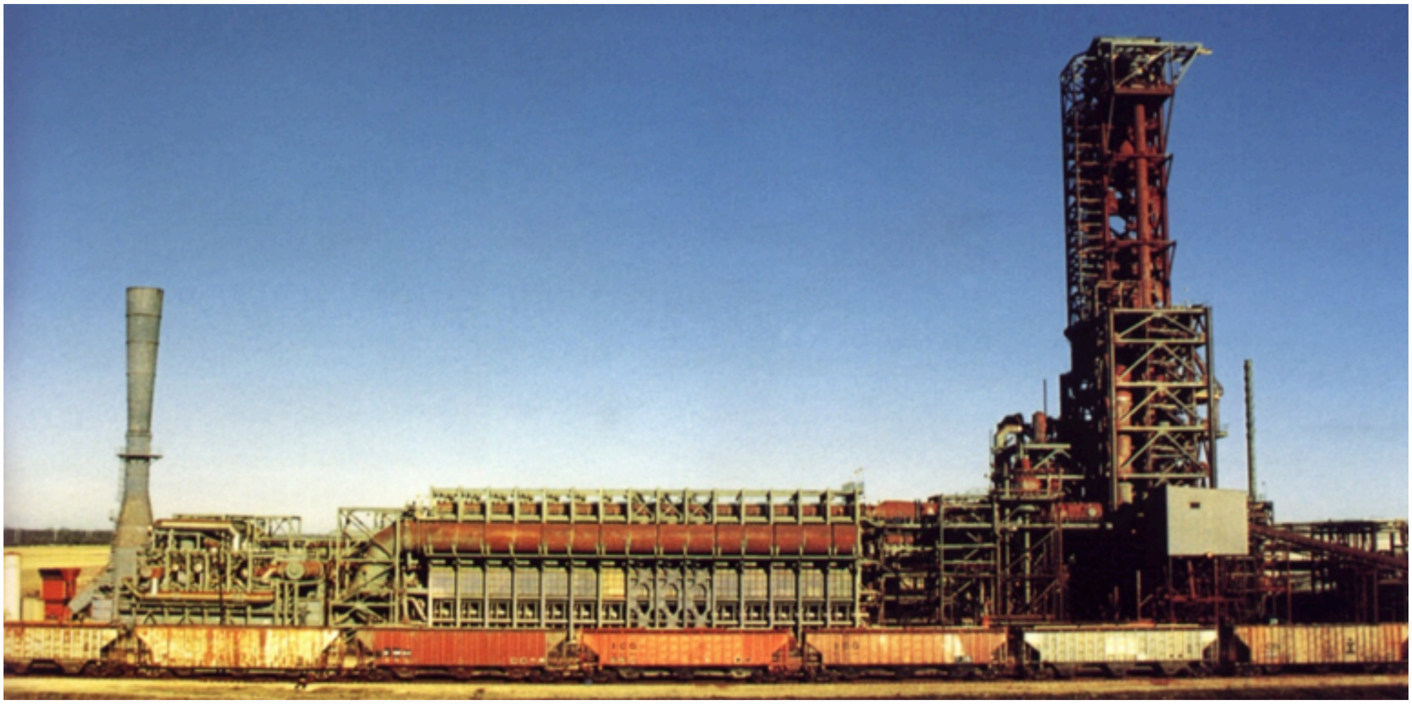
FIGURE 1 *American Iron Reduction - Convent, Louisiana, USA*

MIDREX® Shaft Furnace, a 15-bay **MIDREX® Reformer** and was the first **MIDREX® Plant** to incorporate a vertical furnace feed conveyor. AIR was started up in January 1998, and passed the performance test within one month of first product. Production rates of up to 180 ton/hour were achieved, with metallization levels as high as 96% and carbon content of 1.8%. Unfortunately, the USA steel market turned down in 1998, reducing demand for DRI and AIR did not operate continuously. By the second half of 2000, rising natural gas prices forced the owners to close the plant permanently. It produced a total of 1.65 million tons of DRI from start-up until its closure in September 2000.

After performing its due diligence, Nucor determined that it would be feasible to dismantle the AIR Plant and relocate it to Trinidad, which could provide a competitive supply of natural gas and favorable logistics for receiving iron ore and shipping DRI to Nucor's melt shops in the United States. Such a move was not unprecedented, as relocation of **MIDREX® Plants** had been done twice before. The former Norddeutsche Ferrowerke GmbH (NFW) plant in Germany was moved to India in 1990, and the British Steel Modules in Scotland were relocated to Mobile, Alabama in 1997. In September 2004, Nucor purchased the idled AIR Plant and began dismantling it. In April 2005, Nucor signed a contract with Midrex Technologies, Inc. for upgrading the plant's capacity by 400,000 tons per year. A site was identified at the Point Lisas Industrial Estate in Trinidad.

Nucor registered the company, Nu-Iron Unlimited, under the laws of Trinidad and Tobago. Several obstacles were overcome by Nucor's construction and engineering group to safely and efficiently dismantle and transport the plant on 13 ocean barges down the Mississippi River, across the Gulf of Mexico and Caribbean Sea to its final destination at Point Lisas, Trinidad, with the last barge diverting slightly to avoid Hurricane Katrina. Simultaneously, Nucor worked closely with Midrex to expand the plant's capacity by adding reforming capability and gas compressor capacity, which increased the


FIGURE 2 *Nu-Iron Unlimited- Pt. Lisas, Trinidad & Tobago*

nameplate rating to 1.6 million tons per year. The completed facility is shown in ***Figure 2***, with the shaft furnace in the center of the photo, the DRI storage bins just to the left and the receiving and shipping docks just to the right of the furnace tower.

Production began on December 30, 2006, and the first cargo was shipped to Mobile, Alabama, on January 21, 2007. With no steelmaking capability at its site in Trinidad, Nu-Iron ships all DRI produced to four ports in the USA: Charleston, South Carolina; Mobile, Alabama; New Orleans, Louisiana and Morehead City, North Carolina. After discharge, the product is transported via barges to receiving mills based in: Berkeley County, South Carolina; Tuscaloosa, Alabama; Decatur, Alabama; Memphis, Tennessee; Hickman, Arkansas and Hertford County, North Carolina.

CREATION OF DRET TEAM-ADVANCING PLANT PERFORMANCE

As a key part of Nucor's ore-based metallics (OBM) strategy, the Nu-Iron facility is one of the world's most advanced DRI operations. It is based on flexibility, inclusion and performance. Adhering to the Nucor quality principles, Nu-Iron boasts world class DRI product quality while maintaining a safe and productive work environment. Typical DRI product is greater than 96% metallization (amount of reduced Fe content) with carbon content of 2.8% or higher. The plant also features exemplary safety standards, with a DART of 0.0. DART is a safety metric that stands for "days away, restricted or transferred." Nu-Iron's DART is well below the national industry average of 1.67.

With the latest and most productive DRI technology in use at the Point Lisas site, Nu-Iron sought to push the DRI technology and plant performance even further. To see where they could go, Nu-Iron began benchmarking their operations and comparing themselves to various other **MIDREX® DRI** facilities. Through their discovery phase, they determined that there was room for improvement.

The company had goals of setting new standards and breaking internal and external records. With a vision set, the next item was to create a team empowered to make changes. As embodied in Nucor basic philosophy, Nu-Iron embraced the idea of "... succeeding by working together."

To achieve this end, in 2014, Nu-Iron established a Direct Reduction Engineering and Technology (DRET) team. Its primary focus was to keep the plant running at optimum performance, improve product quality and minimize downtime.

The DRET team brought together about a dozen professionals from all the engineering disciplines at the plant site. Members of DRET include process engineering, E&I, mechanical engineering, a refractory specialist, a control systems engineer, senior technicians and specialists. It also includes a mechanical engineer from Midrex Technologies, Inc., who functions as an onsite **MIDREX® Technology** liaison. The group takes a broad view towards various aspects of plant operation in order to define realistic and achievable goals. Once defined, the group systematically outlines and implements procedures and strategies to attack the challenges. The DRET team sought best operational practices and procedures throughout the industry. Using this inclusive approach, they did not limit themselves and embraced practices from the blast furnace industry, as well as from other **MIDREX® DRI** plants.

The DRET team is responsible for major shutdown planning, creating and maintaining a 5-year "living document" for plant maintenance and operations, conducting root cause analysis investigations and developing equipment preventive maintenance procedures, as well as implementing the Management of Change process. DRET is a hands-on team, not administrative, which is one of the reasons it is so effective. With the proper vision and team established, Nu-Iron embarked on ways to improve operation through minimizing unscheduled downtime. They adopted available thermography and vibration analysis technologies to enhance their preventive maintenance programs.

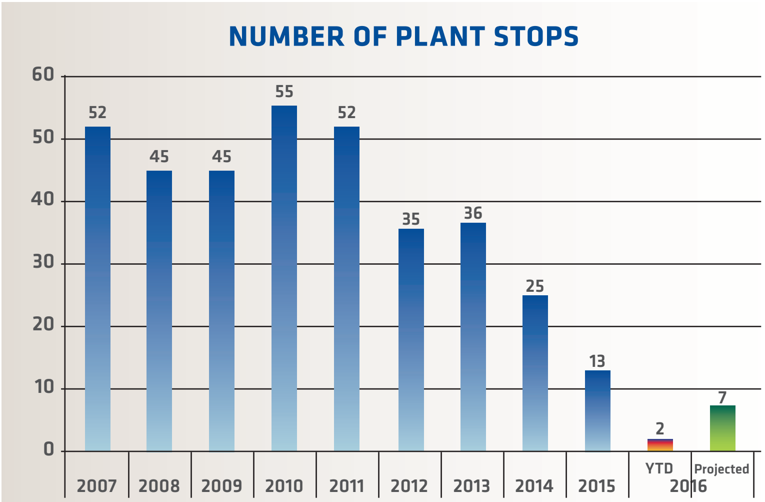

FIGURE 3 *Unscheduled number of plant stops*

Where possible the plant increases automation and focuses on frequent monitoring of key equipment and process streams. Thermography and oil and vibration analysis are used to effectively monitor the health of vital equipment, to reduce wear, predict maintenance needs and limit the number of unscheduled plant stops ***(Figure 3)***.

A key to maximizing plant performance very simply is to maintain stable operations and minimize plant stops wherever possible. A plant stop can result from any interruption in the operation of the plant and subsequent production. A stop can be the result of an equipment trip from a voltage dip or a component failure, a lost interlock, operator error, even poorly designed control logic. A stop also occurs when plant operations are intentionally halted for planned maintenance.

Two examples of adopting blast furnace best practices include the use of laser analyzers and blast furnace refractory systems. The DRET group pursued the use of laser analyzer technology over mass spectrometers for on-line gas analysis and control of the DRI making operation. The laser analyzer technology was recognized as a blast furnace best practice and readily adopted by Nu-Iron as a cost effective alternative to mass spectrometry. DRET also successfully incorporated blast furnace refractory practices such as shotcrete and pouring castable refractory in critical areas throughout the refractory system. The effectiveness of the DRET group can be illustrated in the drop of mechanical and process stoppages, as seen in ***Figure 4***.

Since start-up of the plant, Nu-Iron has focused on product quality while ramping up operation. ***Figure 5*** shows both the increase in tons of CDRI produced, as well as the number of hours the plant operated during the period. Through adoption of new procedures and monitoring, Nu-Iron has made considerable strides over past years and is confident that current 2016 operations will exceed 2015 results.

As previously stated, Nu-Iron produces high quality DRI. The plant produces a premium, highly metallized product (greater than 96% metallization/reduced Fe content) with carbon content of 2.8% or higher. Nu-Iron operations focuses on metallization over carbon in production of this product, meaning they favor the production of a higher metallized product over maximizing carbon content. The product specs exceed the standards of many other operating DRI facilities. In fact, any DRI produced with met lower than 96% is considered remet by Nu-Iron's internal standards. Note that remet does not have an industry standard definition for met percentage of metallization; however, typically anything under 89% is generally considered remet, and thus Nu-Iron's remet would be considered as acceptable product by most plants throughout the world.

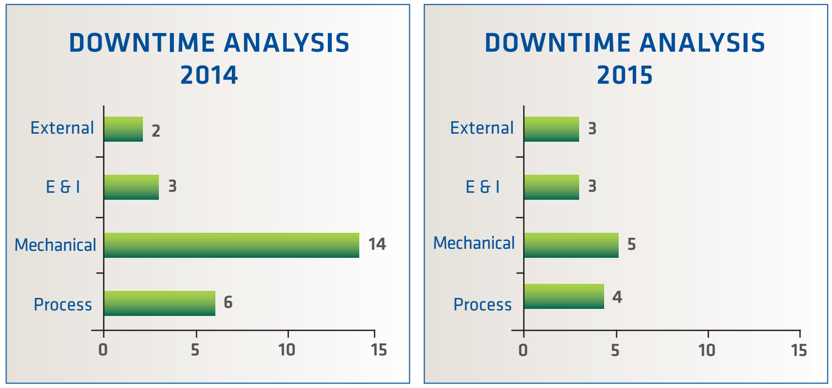

FIGURE 4 *Downtime Analysis*

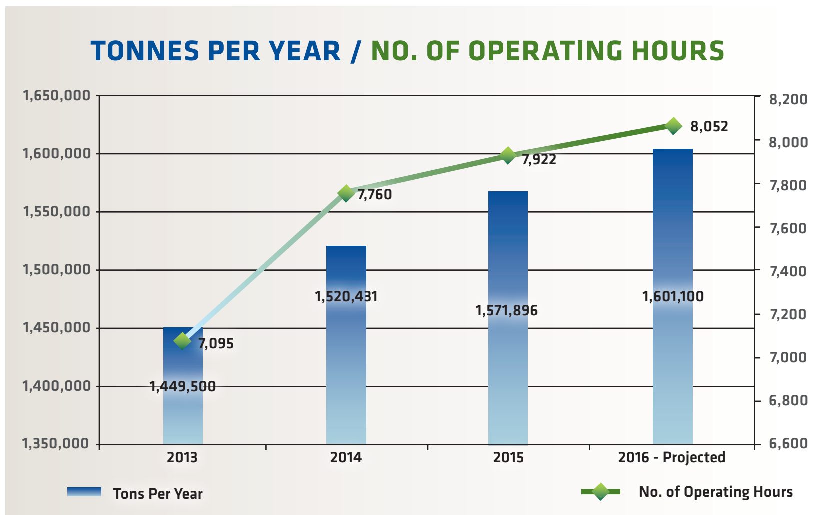

FIGURE 5 *DRI tons produced & number of operating hours*

Remet is material processed through the furnace that does not meet the individual quality requirements of the producing plant. Production of remet can occur during process condition upsets. Remet is also generated when starting up and shutting down plant operations. Typically, remet is reprocessed through the furnace to meet metallization and/or carbon content requirements and is not a loss of material, but it does impact overall plant production and efficiency. Considering that remet is generated for every plant stop, the desire to operate without interruption is intensified.

To produce such high quality product consistently would typically cause one of two effects. The plant would tradeoff general productivity (ton/hour) for product quality and/or reject more DRI produced as remet. Through DRET implemented initiatives, Nu-Iron has been able to continue to ramp up production while simultaneously lowering the amount of DRI products being produced with metallization under 96% ***(Figure 6)***.

ADDITIONAL DRET INITIATIVES

Beyond core DRI plant operation and production of DRI product, the DRET group pursues additional initiatives keeping with core Nucor philosophies. These include the addition of a belt filter press, a newly developed DRI polisher and cold briquetter to improve yield, efficiencies and environmental quality in addition to plant profitability. The belt filter press allows Nu-Iron to reclaim water that would normally be lost in evaporation from sludge ponds. This advancement grew out of necessity as the seasonally high precipitation of Trinidad did not lend itself to typical industry best practices of using sludge ponds to dry out clarifier slurry. The solution currently implemented reclaims water for process use, as well as eliminates the need for settling ponds.

Nu-Iron also developed and constructed a DRI polisher of their own design – a cylindrical tumbler that effectively peens the surface of the DRI pellets resulting in a significant reduction in the amount of dust and fines generated through subsequent handling and improving recognized yield. In addition, the plant is now employing a DRI fines cold briquetting system to reclaim DRI fines and safely ship materials to the USA. These technology implementations minimize yield loss by reclaiming more of the iron content, and also represent environmental advances to plant operation keeping with Nucor's environmental vision.

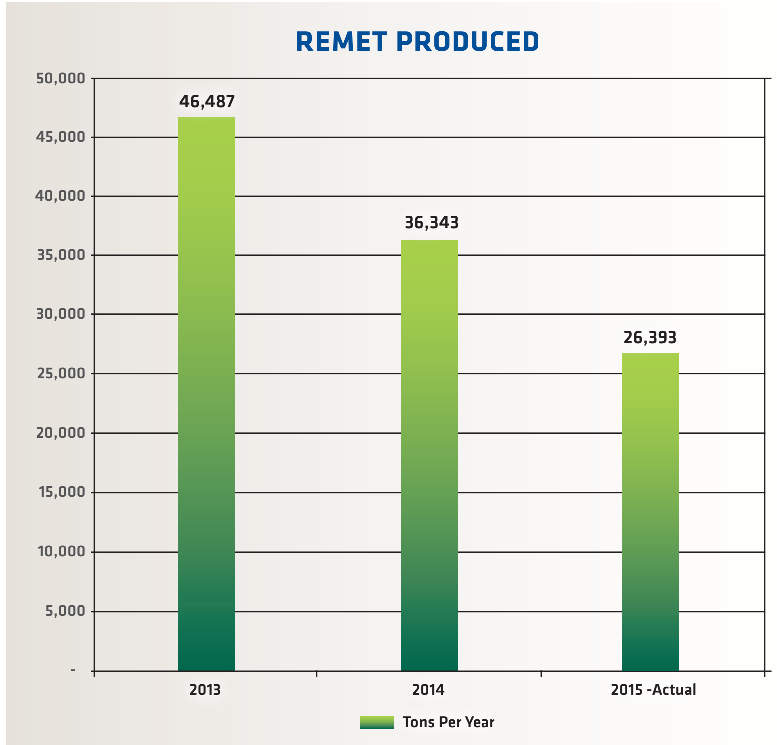

FIGURE 6 *DRI produced as remet*

SUMMARY

The Nucor culture inspires high performance and results driven operations that embody safety and teamwork. The DRET group embodies core Nucor values and spirit to do better, looking to push technology and performance further while creating a safe and prosperous work environment. The DRET group, by working together various internal team members and including Midrex Technologies, Inc. into the fold has established new goals and set new standards for direct reduction ironmaking. Improved systems and procedures can produce desired availability, product specs and productivity; however, the right culture, the Nucor way, is one that will take us beyond. ■

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