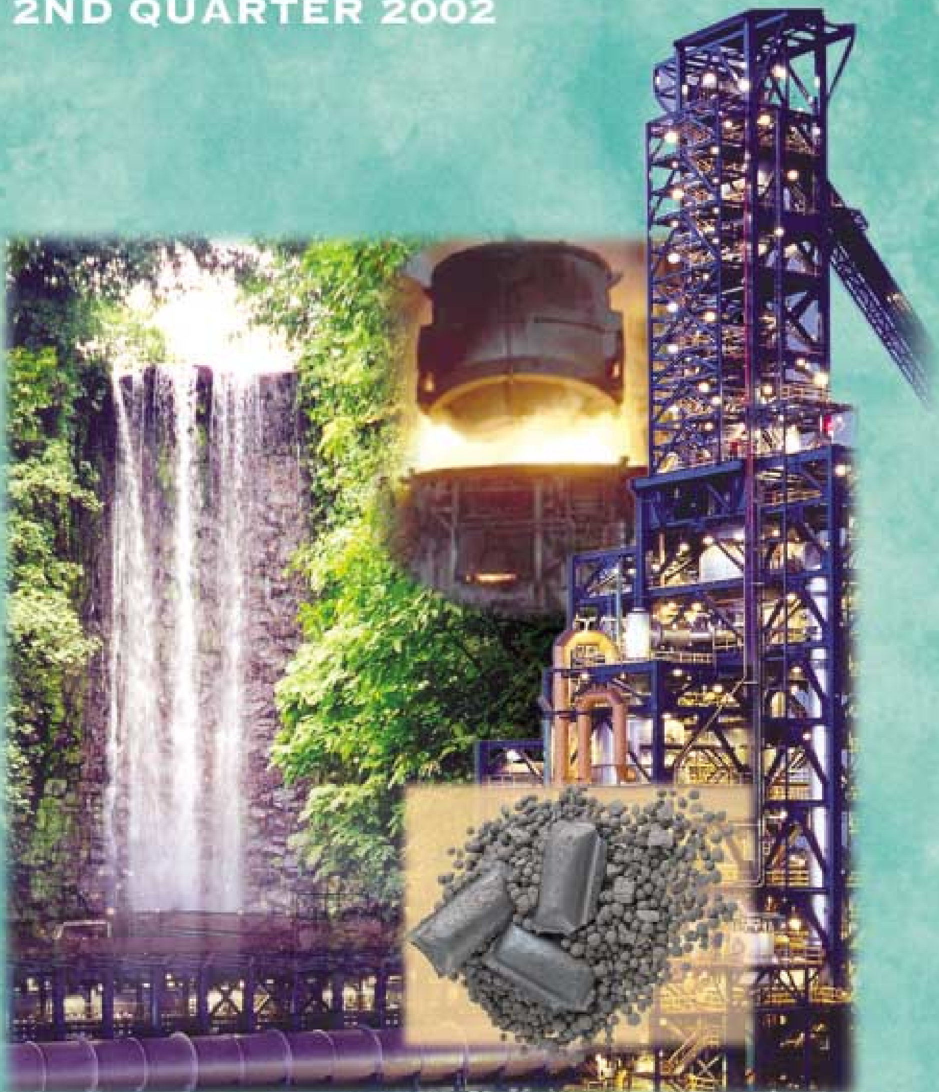
DIRECT FROM MIDREX

2ND QUARTER 2002



Not All RHFs Are Created Equal – A Rotary Hearth Furnace Primer

Proven Commercial Success in RHF Technology

Successful Iron Nuggets Production at ITmk3® Pilot Plant

Construction of Mesabi Nugget Plant to Begin

Techint, Kobe Steel and Midrex Reach Worldwide Agreement

Midrex Certified to New ISO 9001-2000 Standard

MIDREX® Solutions Signs Additional Contracts

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Commentary

All RHFs are not created equal…

“The devil is in the details…”

From recent industry events and talk surrounding them, it appears that there is much interest and confusion over the concept of rotary hearth furnace (RHF) technologies and its application to direct reduction. RHF technology is clean and green and cost effective. In addition, RHF technology is proven... but all RHF technologies used for direct reduction are not alike.

On a quick examination they might appear very similar, but it is the details in the engineering and actual application that can be miles apart. The same can be said of EAFs or continuous casters, or even gas-based shaft furnaces used for direct reduction.

Added to this is a tremendous industry buzz over ITmk3®, Kobe Steel’s revolutionary new ironmaking process (The paper that Kobe Steel’s Dr. Kobayashi presented at the Spring ISS conference to a standing room only audience begins on page 10).

True, ITmk3 is an exciting and revolutionary ironmaking process, but it is not the answer for everyone and every application. Midrex and Kobe Steel offer several different types of reduction/melting processes using RHF technology for specific industries and markets. Although revolutionary, ITmk3 has its specific niche and audience as a merchant product. The arrival of ITmk3 has renewed interest in RHF and has revealed that there is not a full understanding in the steel industry.

There are several RHF technologies in the marketplace. Midrex/Kobe has a proven RHF technology foundation – FASTMET® and several processes based on it specifically designed for different industry requirements from bag house waste dust recycling to producing continuous feed charge materials for steelmaking. Midrex understands the technology because direct reduction has been our business focus for more than three decades.

Like the others, the FASTMET RHF ironmaking concept uses a refractory hearth rotating beneath a high temperature, circular tunnel kiln to process composite agglomerates. The success lies, however, in the experience and know-how of Midrex and Kobe Steel. With two demonstration units and two FASTMET plants in commercial operation for iron-bearing waste recovery in Japan, the Midrex/Kobe RHF concept is not only proven, it is also commercially successful (see story on page 9). This can not be said of any other current RHF technology supplier in the industry.

Robert Klawonn
Vice President - Sales

To address this issue, *Direct From Midrex* is launching a multi-part series on rotary hearth furnace technologies available from Midrex and Kobe Steel and how each fits for each particular situation and application. The first article of this series is an overall primer examining the commercially proven FASTMET and FASTMELT® Processes, the new FASTEEL™ and FASTOx™ steelmaking processes, as well as the ITmk3 Process.

Why should Midrex want to differentiate these processes? Because the market is showing signs of recovery and with that comes serious thought of how to make steel operation functions more efficient and cost effective. These Midrex/Kobe RHF-based technologies present the answer for many steelmakers. So we are making the information simple and clear to help the industry decide for itself on new technologies for the future.

“The devil is in the details…” Midrex has invested more than a decade of its time and resources to learn the details and to explore the technology behind rotary hearth direct reduction. With this knowledge base, we are eager to share this information to help the industry make sound environmental and economic decisions.

Robert Klawonn
Vice President - Sales

MISSION STATEMENT

Midrex Technologies, Inc. will be a leader in design and integration of solids and gas processes and will supply to our clients superior quality services that provide value. We will meet or exceed performance expectations, execute projects on time, enhance existing product lines, and develop or acquire new technologies. Our employees are the key to our success, and we are committed to encouraging them to grow professionally and personally.

Not All RHFs Are Created Equal

A Rotary Hearth Furnace Primer

By Jim McCelland
Manager, Technical Sales
Midrex Technologies, Inc.

(Editor's note: This article is the first in a series on rotary hearth furnace (RHF) technologies available from Midrex and Kobe Steel. These articles will examine how the various RHF-based technologies fit each particular situation and application. This first in the series takes a quick look at the commercially proven FASTMET® Process; the FASTMELT® Process; the new FASTEEL™ Process, which is a combination of FASTMELT and Techint's CONSTEEL® Process; the FASTOx™ Process, a new integrated steelmaking process combining FASTMELT and basic oxygen steelmaking; and the breakthrough ITmk3® Process. In further issues, each technology will be featured individually in greater detail.)

All rotary hearth furnace-based direct reduction technologies are not alike. This primer is written to dispel misconceptions in the industry and to show how Midrex and Kobe Steel have evolved five separate technologies from the basic RHF concept to meet specific client needs.

ROTARY HEARTH TECHNOLOGY

Rotary hearth furnaces are not a new technology. For decades, they have been successfully used in a variety of industrial applications including heat treating, calcification of petroleum coke, waste treatment, and non-ferrous hi-temperature metal recovery. No, the problem with the use of RHF technology for the direct reduction of iron-bearing materials is not with the RHF itself. It's with the way it is being applied... the process technology...

The answer is process engineering. If the RHF is correctly integrated into the global process and direct reduction technology is applied correctly, the result is an energy efficient, environmentally friendly, economic system for producing quality alternative iron.

The coal-based direct reduction concept utilizing the RHF is a simple one; however, commercial implementation of the concept has not been easily achieved. Midrex and Kobe Steel have proven the concept with continuous commercial-scale operation of two RHF direct reduction plants utilizing FASTMET technology.

For those unfamiliar with the RHF concept, the rotary hearth furnace consists of a flat, refractory hearth rotating inside a high temperature, circular tunnel kiln. The feed to the RHF consists of a composite agglomerate made from a mixture of iron oxides and a carbon source such as coal, coke fines, charcoal, or other carbon-bearing solid. The feed agglomerates are placed on the hearth evenly, one to two layers thick.

Burners located above the hearth provide heat required to raise the feed agglomerates to reduction temperature and start the process. The burners are fired with natural gas, fuel oil, waste oil, or pulverized coal. Most of the heat required for maintaining the process is supplied by combustion of volatiles, which are liberated from the heated reductant, and combustion of carbon monoxide, which is produced by the reaction of carbon reducing metallic oxides.

The agglomerates are fed and discharged continuously and stay on the hearth for only one revolution, typically 6 to 12 minutes, depending on the reactivity of the feed mixture and target product quality.

HISTORY

FASTMET is a coal-based iron oxide reduction process and a descendant of the Heat-Fast Process, originally developed in 1965 as a joint venture between Midland Ross Corporation (the predecessor of Midrex), National Steel Corporation, and Hanna Mining Company. In the original Heat-Fast Process, a RHF was used to process dried, carbon-containing magnetite pellets. The process was successfully demonstrated at the Cooley Pilot Plant facility in Minnesota, where 50-70 percent metallized DRI was produced at rates of ~1.7 t DRI /hr. However, full-scale development of the Heat-Fast Process was not continued because of the simultaneous development of the natural gas-based MIDREX® Direct Reduction Process, which offered a higher metallized product, and due to the very low-cost natural gas available at that time.

In the early 1990s, Midrex renewed its interest in a coal- or solid carbon-based reduction process using a RHF. Studies confirmed that the economics for a RHF-based process were attractive. The decision was made to proceed with process development, with the intent of commercializing the technology. Building upon the Heat-Fast work done in the 1960s, Midrex made improvements to the technology resulting in higher productivity, better product quality, greater process flexibility, and increased process efficiency. Due to the short time period required for reduction and the high metallization levels achieved, the process was named FASTMET.

In early 1992, Midrex decided to construct and operate a nominal 160 kg/hour, FASTMET pilot plant located at the Midrex Technical Center in Pineville, NC. The pilot facility contains a pelletizing and screening system, pellet drying system, briquetting system, a nine-foot diameter RHF reduction furnace, and an offgas treatment system. Over 100 campaigns were run at the pilot plant from 1992 to 1994.

Based on the success of the pilot plant operation, Midrex and its parent company, Kobe Steel Limited, (KSL), made the decision in 1995 to build a 2.5 tonne per hour FASTMET demonstration plant at Kobe Steel's Kakogawa Steel Works in Kakogawa, Japan. The plant has feed material storage areas, storage bins, a coal pulverizing system, a raw material mixer, a 3-meter pelletizing disk, a roller screen, a green pellet dryer, an 8.5-meter diameter RHF, hot briquetting system, a water treatment system, and an offgas cleaning system.

As a result of the successful operation of the FASTMET Demonstration Plant, two commercial FASTMET Plants are now in operation, converting steel mill wastes into valuable mineral resources. All of the Midrex/KSL coal-based reduction technologies are derived from the FASTMET Process, yet each is specifically designed for different markets and uses.

MIDREX / KOBE STEEL TECHNOLOGIES

FASTMET

The Process / Technology

FASTMET uses a rotary hearth furnace to convert steel mill wastes and iron oxide fines to highly metallized DRI. Carbon contained in the wastes or added as coal, charcoal, or coke is used as the reductant. Combustion of volatiles from the reductant and carbon

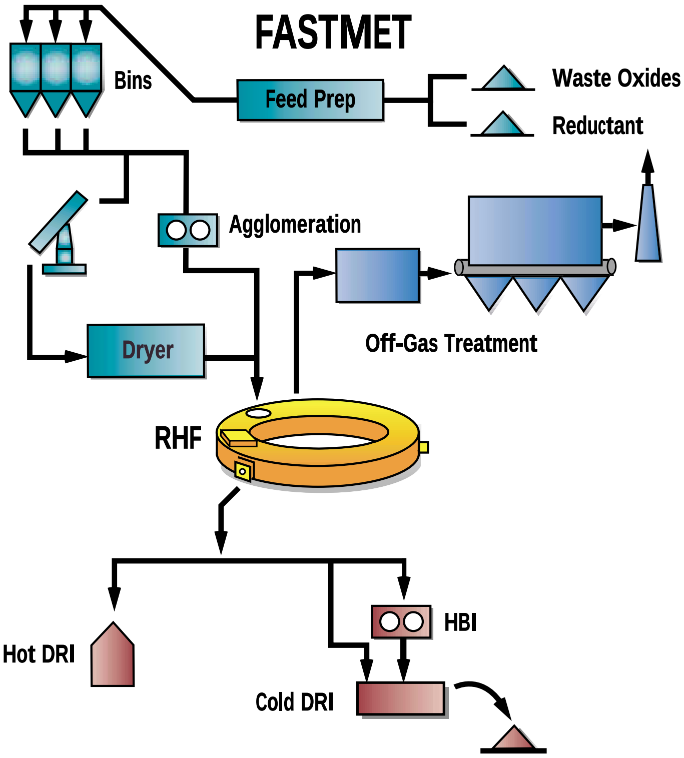


Figure 1 - FASTMET Process Flow Diagram

monoxide from the iron reduction supplies the primary energy to the RHF for the reduction reactions. The FASTMET Process is extremely energy efficient, unlike other new coal-based ironmaking processes that require off-gas energy credits, as all fuel energy is consumed within the FASTMET rotary hearth furnace (100 percent post combustion).

Purpose / Market

FASTMET is primarily a cost-effective iron oxide waste processing solution to convert steel mill wastes such as blast furnace dusts and sludges, BOF dust, and EAF baghouse dust, into useable mineral resources. This technology is especially desirable now because of issues such as disposal of iron bearing waste, closure of on-site landfills, recovery of valuable iron units, controlling steelmaking raw material costs, and conservation of capital.

Many integrated steelmakers in North America, Europe, and Asia, who have been stockpiling wastes on-site for many years, are finding that option no longer available. Sending these wastes off-site for disposal can entail logistical difficulties and considerable cost. In many cases, there is also a need to recover the tonnes of wastes that are stored on-site. Some integrated facilities have millions of tonnes of valuable minerals resources landfilled as waste. FASTMET provides an excellent means to deal with these materials by recycling them, thus greatly reducing the volume to be disposed of and producing a cost-effective iron product.

Mini-mills also face problems in disposing of electric arc furnace baghouse dust, which is a listed hazardous waste in the USA. FASTMET provides an economical means for processing this material. It produces a metallized iron product that can be recycled to the EAF and a saleable crude zinc oxide dust.

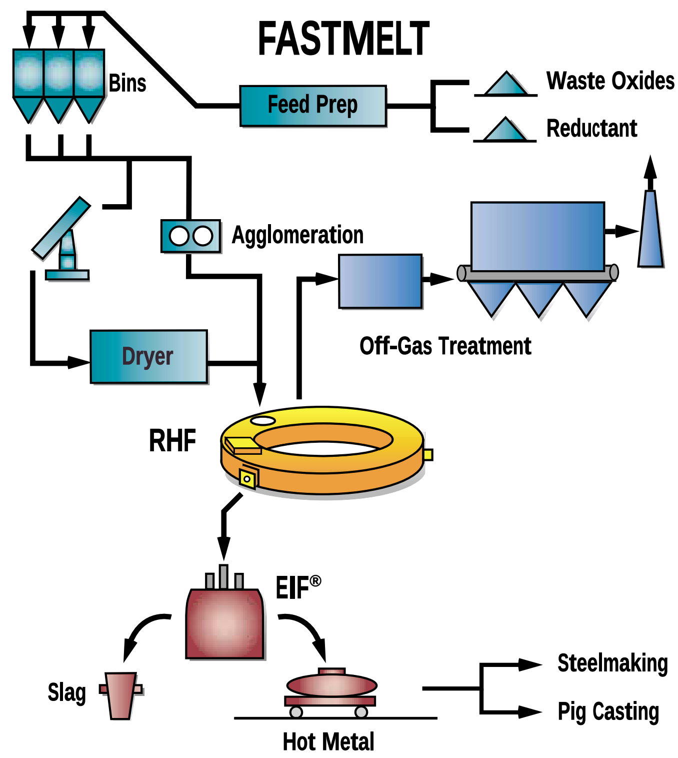


Figure 2 - FASTMELT Process Flow Diagram

FASTMELT

The Process / Technology

FASTMELT also uses a rotary hearth furnace but adds an electric iron melting furnace to take the FASTMET Process one more step. In the FASTMELT Process, hot DRI produced via the FASTMET Process is fed to a specially-designed melter, the Electric Ironmaking Furnace (EIF®), for production of a high quality hot metal known as FASTIRON®.

Purpose / Market

The FASTMELT Process is an attractive option for many applications. Highly metallized and high temperature FASTMET DRI is fed directly in a proprietary melter (EIF) to produce blast furnace-grade hot metal. By controlling the FASTMET DRI chemistry, FASTIRON can be tailored to precisely match the desired hot metal chemistry for further processing in a basic oxygen furnace (BOF) or electric arc furnace (EAF). Molten FASTIRON also can be cast into pigs or granulated for sale or later use.

Steelmakers face continuing problems and often high costs in operating, permitting, and repairing blast furnaces, coke ovens, and sinter plants. FASTMELT can enable integrated mills to produce sufficient hot metal while shutting down some or all of these facilities. Because the RHF and EIF operating units are designed for high efficiency and minimal export heating value, the process operating costs do not require any off-gas energy credits to be competitive, which also minimizes the overall capital expenditure.

FASTMELT can be used to economically convert low-grade iron ores and wastes into high quality pig iron without extensive beneficiation or conventional pelletizing. The FASTMELT Process produces pig iron with the lowest energy consumption and least green house gases of any coal-based ironmaking process.

FASTMELT can replace or augment blast furnace ironmaking with lower operating cost and greater flexibility in feed selection. A FASTMELT Process merchant iron plant can convert poor quality iron ores and non-coking coals into quality pig iron products.

FASTEEL

The Process / Technology

FASTEEL is the result of a collaboration between Midrex/Kobe Steel and Techint Technologies, merging the hot metal producing benefits of FASTMELT with the continuous scrap feeding and preheating of CONSTEEL to produce high quality steel. These processes working together provide a new method of steelmaking that offers significant environmental improvements, higher quality product, lower capital cost, and less expensive operation than traditional methods of production.

Purpose / Market

FASTEEL provides both economical and environmental benefits for current and potential steelmakers. FASTEEL offers an alternative to future shutdowns of blast furnaces, coke ovens, and sinter plants. It is more environmentally friendly because there is a reduction in the overall emissions of the steel mill, and iron units are recovered from waste oxides. Economic benefits include cost reduction of raw materials, elimination of need for BF pellets and coke, reduction of energy required for liquid steel, and reduction of waste through recovery of iron

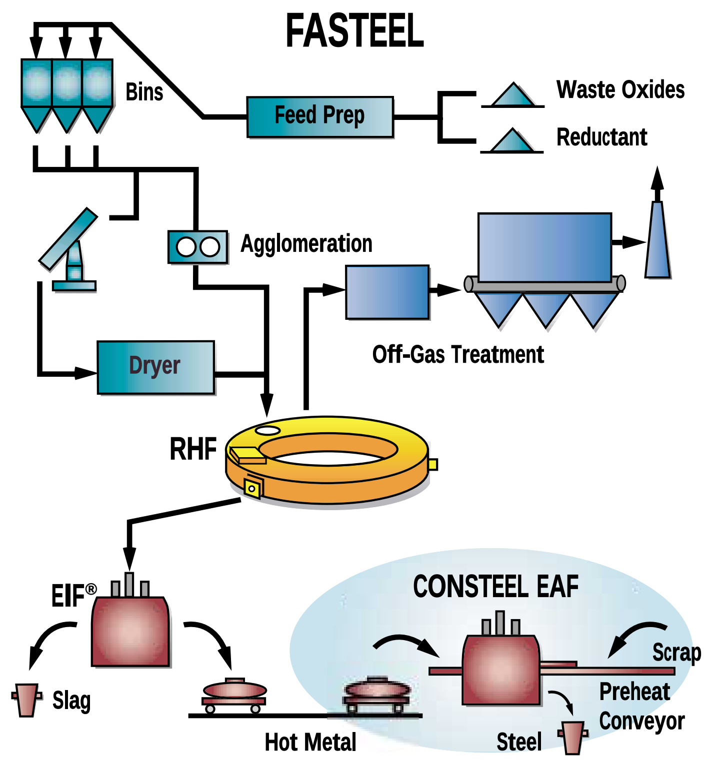


Figure 3 - FASTEEL Process Flow Diagram

units from waste oxides. Higher quality grades of steel can be produced than with scrap alone, and at more economical costs. Furthermore, FASTEEL combines 1/3 hot metal from FASTMELT with 2/3 preheated scrap from CONSTEEL to produce as much as 2.4 million tonnes of liquid steel from only one EAF. Projected FASTEEL capital cost is in the range of $125/tonne liquid steel.

FASTOx

The Process / Technology

FASTOx is a new integrated steelmaking process combining FASTMELT Ironmaking with Basic Oxygen Steelmaking. Conventional blast furnace pelletizing, sintering, and cokemaking are eliminated. Significant reductions in ironmaking energy consumption and green house gas emissions are realized compared to other ironmaking processes.

Purpose / Market

The FASTOx Process provides a new integrated method of high quality steelmaking for areas without economic scrap supplies, or clients with pre-existing BOF equipment. The FASTOx Process can use locally available iron ore fines and non coking coals, coke fines, or charcoal. Sufficient waste heat can be made available to allow for self-sufficient cogeneration of electrical power. FASTOx may be applied for either carbon steel or stainless steel production. FASTOx modules range in capacity from less than 200,000 tpy to more than 500,000 tpy of liquid steel production, and even higher with multiple FASMELT units feeding a single BOF.

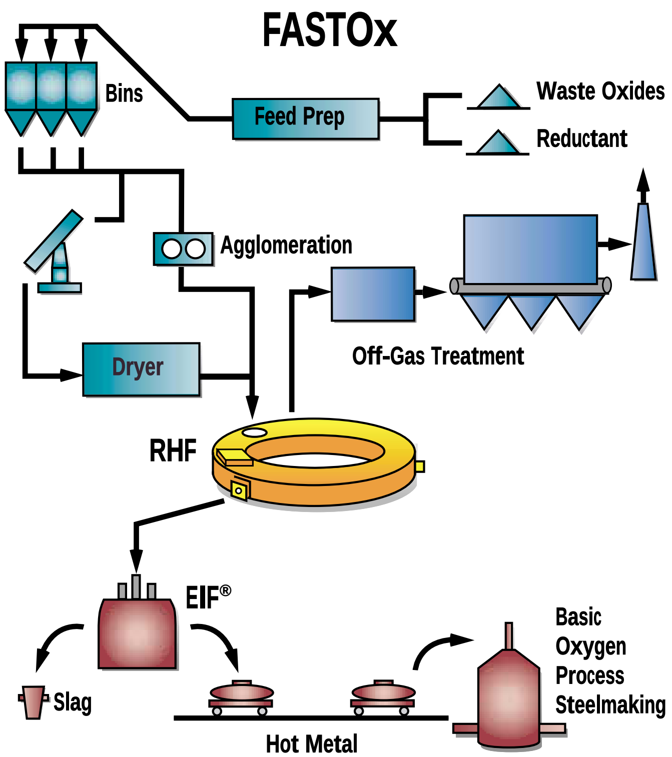


Figure 4 - FASTOx Process Flow Diagram

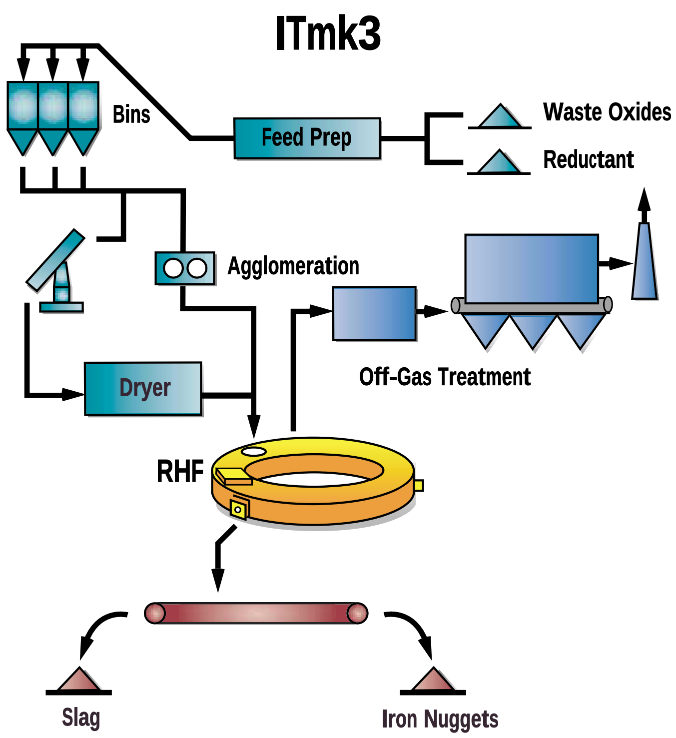


Figure 5 - ITmk3 Process Flow Diagram

ITmk3

The Process / Technology

ITmk3 represents the next generation of modern ironmaking technology, processing iron ore fines into almost pure pig iron nuggets in only ten minutes. The result is a conveniently sized, slag-free material ideally suited for further processing by conventional technologies into high quality steel products and foundry iron castings. ITmk3 Process development has passed from the pilot stage to a demonstration plant now under construction at Cleveland Cliff's North Shore Mining Company located in Silver Bay, Minnesota, USA.

Purpose / Market

The ITmk3 Process is the ideal vehicle for iron ore mining companies to supply pig iron grade nuggets directly to the EAF steelmaking industry. ITmk3 nuggets are a metallurgically-clean, dust-free source of alternative iron for high quality EAF steelmaking. ITmk3 nuggets are not prone to reoxidation and do not require special handling during shipment. Because of their convenient form, they can be continuously fed for higher productivity and lower liquid steel cost.

CONCLUSION

Subtle differences in detail separate these distinct rotary hearth technologies available from Midrex and Kobe Steel. Knowledge of this detail and how and when to apply it is the result of many years of ironmaking experience and process development. Proof of the benefit of this experience lies in the commercial success demonstrated by the FASTMET Plants at Hirohata and Kakogawa.

Proven Commercial Success in RHF Technology

By Kojiro Fuji, Hidetoshi Tanaka, and Takeshi Maki - Kobe Steel, Ltd.

FASTMET® is the direct RHF technology base for FASTMELT®, ITmk3®, FASTEEL™ and FASTOx™. FASTMELT adds to the FASTMET Process an Electric Ironmaking Furnace (EIF®) to produce hot metal or pig iron. In FASTEEL and FASTOx, hot metal is utilized to make steel. ITmk3 also functions under the same basic RHF principles for operation but adds a melting step to remove gangue and produce a pig iron nugget. (see feature story on page 3 for applications of each technology). ITmk3 has been proven at the pilot plant level; and a demonstration plant construction is underway at the Mesabi Nugget Project in Minnesota in the USA.

Hirohata

Beginning in 1990, Midrex developed the FASTMET Process to establish coal-based direct reduction technology, including construction of the FASTMET Pilot Plant in 1992. In 1995, Midrex and Kobe Steel built the Kakogawa Demonstration Plant (KDP) to demonstrate commercial FASTMET operation. Through KDP operation, the FASTMET Process demonstrated that highly metallized iron could be continuously produced at high productivity. The FASTMET Process was proved to be a suitable process for new ironmaking applications, utilizing coal as a reductant.

Hirohata FASTMET

The first FASTMET commercial facility was sold to Nippon Steel Corporation in early 1999, and is located at the Hirohata Works in Himeji, Hyogo Prefecture, Japan. The first DRI from the plant was produced on March 21, 2000. Total time from contract signing to plant start-up was 14 months. The plant processes 190,000 tonnes per year of steelmaking waste materials into 90 plus percent metallized hot DRI to be charged to the meltshop.

Dust pellets received are dried in the pellet dryer. After drying, they are fed to the RHF (21.5m in outer diameter). Within a single rotation of the hearth, oxides in the pellets are reduced. Iron contained in the hot DRI is recycled to the adjacent melt shop. Zinc and lead oxides in the dust pellets are reduced, vaporized, and collected from the flue gas in a bag filter for sale as crude zinc oxide.

The treatment rate has been kept at a high level through long time operation with excellent plant availability since its start-up. From the time continuous operation started in April 2000, plant availability has been maintained at a high level. A high metallization degree of 91.9 percent and a high dezincification degree of 94 percent has been achieved at a hearth productivity of 100 kg-DRI/m^2h.

The typical zinc content in the flue gas dust is 63.4 percent (78.9 percent as ZnO). These by-products are a valuable zinc refinery material source.

Kakogawa FASTMET

The second commercial plant for steel mill waste processing began operation at Kobe Steel's Kakogawa Works in April 2001, utilizing KDP with some modification for commercial operation as Kakogawa FASTMET Dust Reduction Plant. In this plant, "high zinc and chloride content recycled dusts" from Kobe Steel's Kakogawa steel works, which are difficult to treat with conventional processes, are processed. Furthermore, waste oil is successfully used as a fuel for the RHF to reduce the operating cost. This facility processes 16,000 tonne/y of waste in its RHF. More than 11,000 tonne/y of DRI is discharged from RHF and fed to BOF.1,400 tonne/y of crude ZnO is collected from the RHF off gas in a bag filter and sold to the zinc refinery company.

Kakagowa

Successful Iron Nuggets Production at ITmk3® Pilot Plant

By Osamu Tsuge, Shoichi Kikuchi, Koji Tokuda, Shuzo Ito, Isao Kobayashi and Akira Uragami, Kobe Steel, Ltd., Osaka, Japan

This article was adapted from the well-received paper presented at the 2002 ISS Conference held in Nashville, Tennessee, USA, and focuses on the new revolutionary ITmk3® ironmaking process. This article examines how ITmk3 has progressed to the demonstation plant stage by the success of the pilot plant tests at Kakogawa Works, Japan. High quality iron nuggets were produced directly from fine ore and coal, providing operation technology during the 21 days continuous operation recorded.

Introduction

The new innovative ITmk3® ironmaking process produces iron nuggets within the rotary hearth furnace directly from fine ore and coal using carbon composite iron ore agglomerates. The key feature of the process is the clear separation of metal and slag with a rapid reaction rate at a relatively low operation temperature. This ability suggests a great potential for ITmk3 to supply melt shops with a pure iron source as a scrap substitute, while also empowering mining sites to export a pure iron to steelmakers as a competitive value-added product.

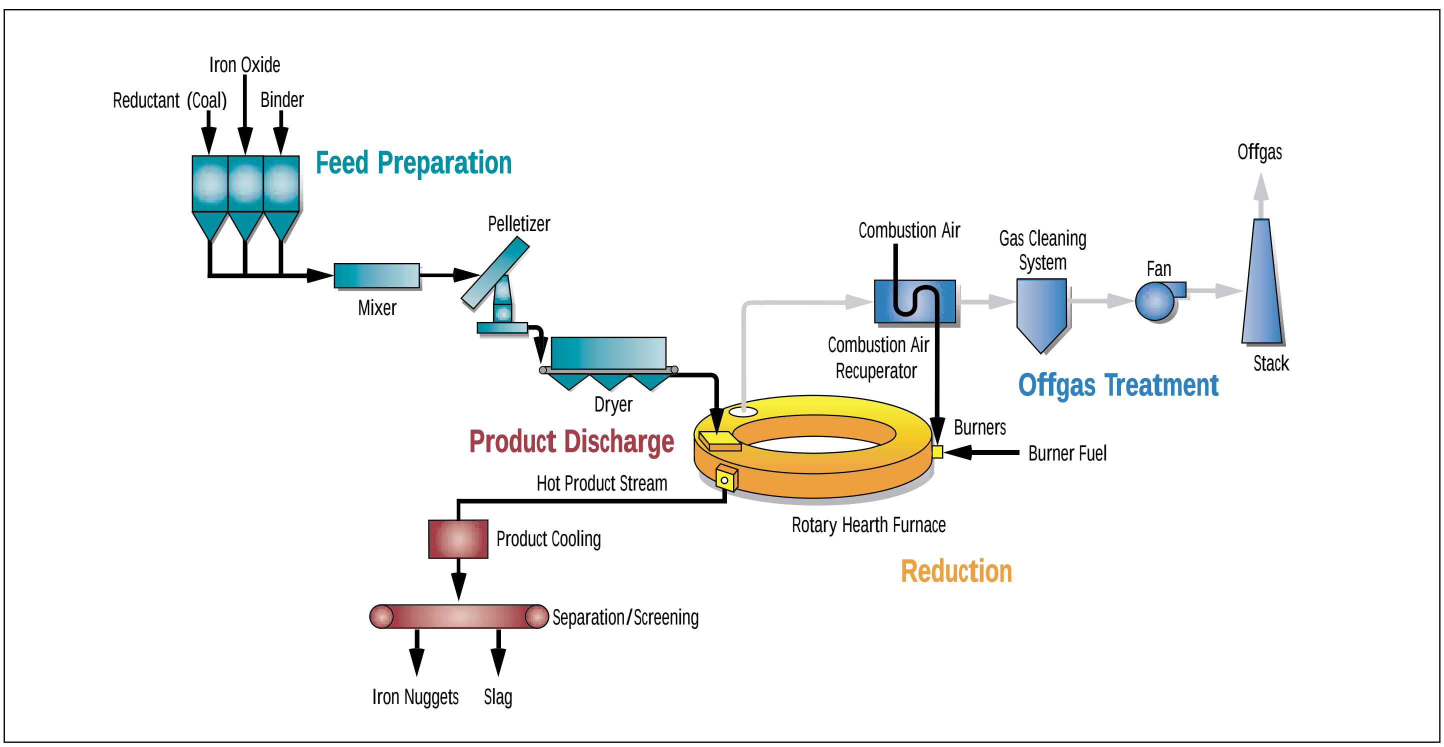


Figure 1 - ITmk3 Process Flow

Reactor	Rotary Hearth Furnace
Hearth Center Diameter	3.2 m
Effective Width	0.8 m
Design Capacity	350 kg / hr

Table 1 - Main Features of ITmk3 Kakogawa Pilot Plant

Ore	Total Fe	FeO	CaO	SiO_2	Al_2O_3	MgO
A	69.20	30.56	0.45	1.81	0.51	0.45
B	67.86	0.07	0.10	1.56	0.61	0.12
C	66.77	1.10	0.17	1.40	0.35	0.03

Table 2 - Chemical Compositions of Raw Materials (wt %)

Coal	Fixed C	VM	Ash	S
D	69.39	21.25	9.63	0.334
E	71.50	19.90	8.60	0.53
F	72.04	18.09	9.65	0.219

Table 3 - Proximate Analysis of Reductant Coal

To confirm process concept and to industrialize the technology for scale-up, a pilot plant was constructed at Kakogawa Works of Kobe Steel, Ltd. The pilot plant was operational in nine months, and 21 days of continuous operation was achieved with production of high quality iron nuggets. A process demonstration plant is now under construction at Cleveland Cliffs' NorthShore Mine pellet plant in Silver Bay, Minnesota, USA.

Pilot Plant Design Concept

The furnace configuration was designed based on the reduction/melting behavior of the laboratory tests and optimized by the evaluation of the atmospheric gas flow using the CFD (computer fluid dynamics) model.

Figure 2 - ITmk3 Plant at Kakagowa Works

Pilot plant operation was planned to optimize operating conditions, as well as to test the flexibility of raw material feed, check design database, and obtain operational data for commercial plant feasibility study.

The process flow of ITmk3 is shown in Figure 1. The system is composed of agglomeration (pelletizing), drying, reduction/melting furnace, product treatment, and off gas system. The ITmk3 reduction/melting rotary hearth furnace was newly designed and constructed. Other systems from the FASTMET demonstration plant were modified for use. The main features are listed in Table 1. An overview of the plant is shown in Figure 2.

Pilot Plant Operation

The raw materials, which were tested in the pilot plant, are shown in Tables 2 and 3. The fine ore for pellet feed was used without pre-treatment. In this operation, carbon composite pellets using hematite and magnetite concentrates were produced by the disk pelletizer. Medium volatile coals from US and Canada were used as the reductant coal, as these were easily available in the Kakogawa Works. The coal was pulverized using existing equipment from the FASTMET demo plant.

In the feed zone (see Figure 3), soot was generated by devolatilization of volatile matter included in the reductant coal. This soot is effectively used as the fuel within the rotary hearth furnace. In the reduction zone, the pellets were heated and the solid state reduction progressed calmly under the controlled temperature, so not to melt the pellets. Additional combustion air

Feed Zone Reduction Zone Melting Zone

Figure 3 - Inside View of the Rotary Hearth Furnace

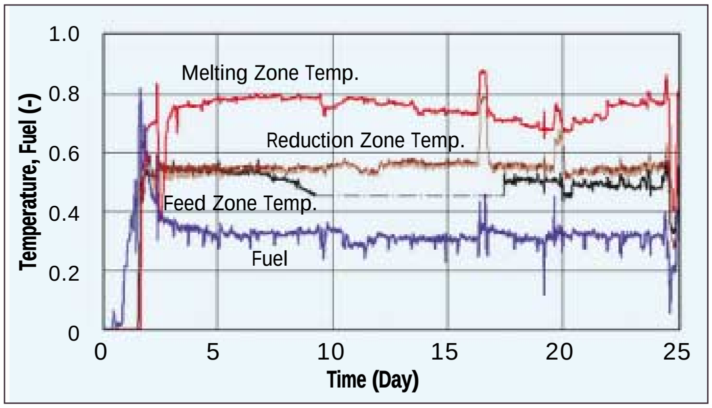


Figure 4 - Change of Furnace Temperature and Fuel Consumption

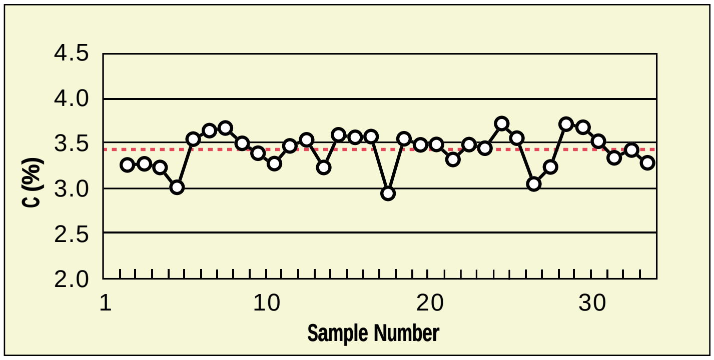


Figure 5 - Change of Carbon Content

was utilized to combust evolved carbon monoxide (CO) gas to achieve 100 percent secondary combustion. In the melting zone, the pellets were rapidly melted down and iron was separated from slag. The volume of one iron nugget decreased to less than 1/8 of the original volume by the reduction and coalescence to the iron nuggets; therefore, the diameter became less than 1/2 of the original composite pellet.

In the third campaign, long-term operation was pursued keeping operating conditions constant using the same raw materials. The transitional changes of furnace temperature and fuel consumption were plotted (Figure 4). These process variables were converted to dimensionless values of 0 to 1.0 using the representative characteristic value because many thermocouples were installed to supervise furnace behavior. It is noted that the process operation was smooth and stable after the start up and produced iron nuggets continuously during the 21 days. In this operation, small troubles were met. One was the failure of thermocouples in the feed zone, another was the mechanical failure of the material transfer line.

Figure 5 shows the change of the carbon content in the product nuggets. These data were taken every 4 hours in the third campaign. The carbon content remained in the range of 3.42 +/- 0.3 percent except for three samples, which suggests iron nuggets could be produced with stable quality.

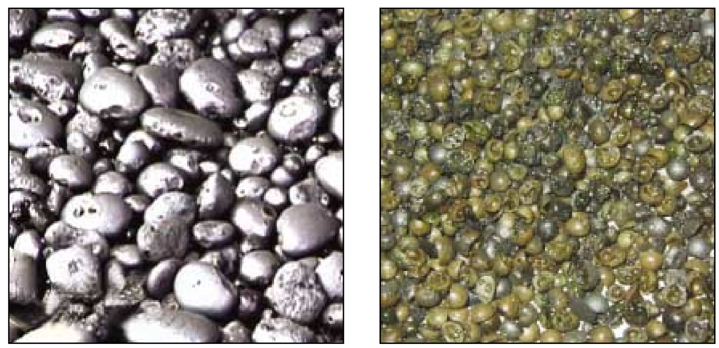
Product Iron Nuggets

The product nuggets are shown in Figure 6, together with slag particles. The iron nuggets and slag were discharged from ITmk3 furnace and collected in product cans. Metal and slag were cleanly separated in the furnace, forming nuggets. The metal and slag nuggets were easily magnetically separated after discharge. The iron nuggets were pebble shape by the coalescence, and the slag was also recovered in particulate or granular shape, as pictured in Figure 6. It is noted that the slag is separated and coagulated into small particles in the furnace.

C	2.5 - 4.3%
Si	0.2%
Mn	0.1%
P	0.06%
S	0.015 - 0.05%
Metallic Fe	Balance

Table 4 - Chemical Composition of Iron Nuggets

Figure 7 shows an example of the size distribution of iron nuggets, which were taken in the 21 days continuous operation. The iron nuggets have the density of 7.4 to 7.6 g/cm^3. The nugget high density is an advantage to the meltshop, as the nuggets are used as pure iron for scrap substitute.



Iron Nuggets **Slag**

Figure 6 - Product Nuggets and Slag Particles

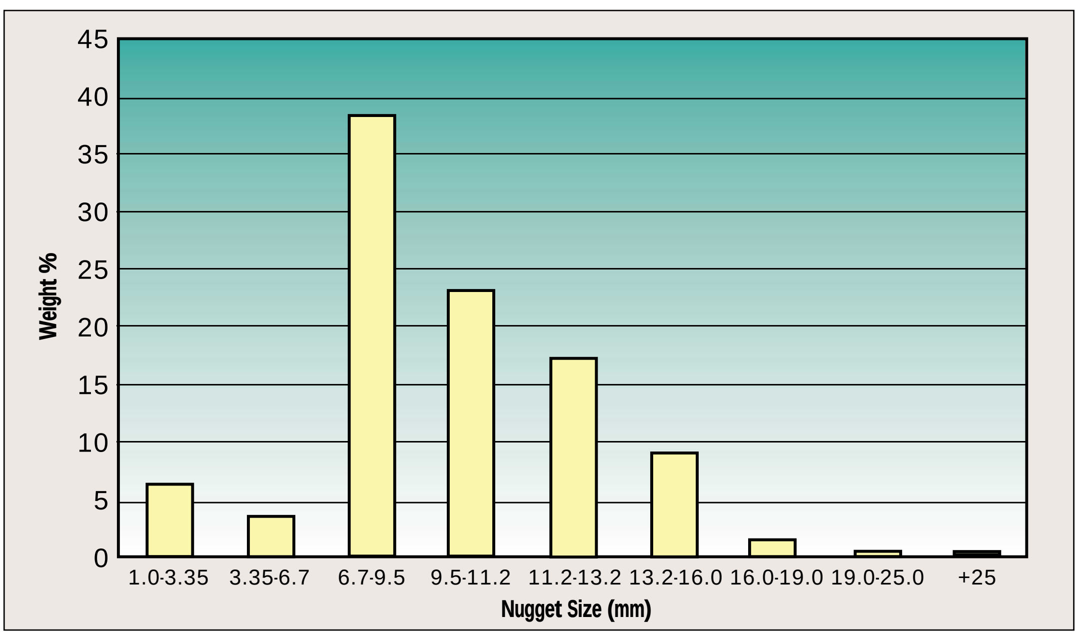


Figure 7 - Nuggets Size Distribution

The iron chemistry is listed in Table 4. The iron content is very high, same as pig iron, with essentially no gangue element included in the nugget. Carbon content is flexible in the range of 2.5 to 4.3 percent. As shown in Figure 5, when operating conditions and the mixing condition of raw materials is fixed, the carbon content is constant. In Figure 8, carbon content of pilot plant product was compared with that of laboratory tests by changing the mixing condition during the second campaign. This shows a good correlation in spite of the different atmospheric conditions of reduction/melting reaction. The former is the burner firing condition and the latter is nitrogen. This relation suggests a good possibility to control the carbon content in the product iron nuggets.

Silicon content is fairly low because the ITmk3 process is operated at a lower temperature than other hot metal production processes. Phosphorous content depends on the chemical composition of iron ore; that is, almost all phosphorous is reduced and retained in the nuggets. Sulfur content in the nugget, as expected, is influenced by the sulfur percent in the reductant coal. In the pilot plant trials, sulfur content less than 0.05 percent was achieved. Laboratory tests recorded sulfur percent <0.015, suggesting that there is a possibility to decrease sulfur content even further.

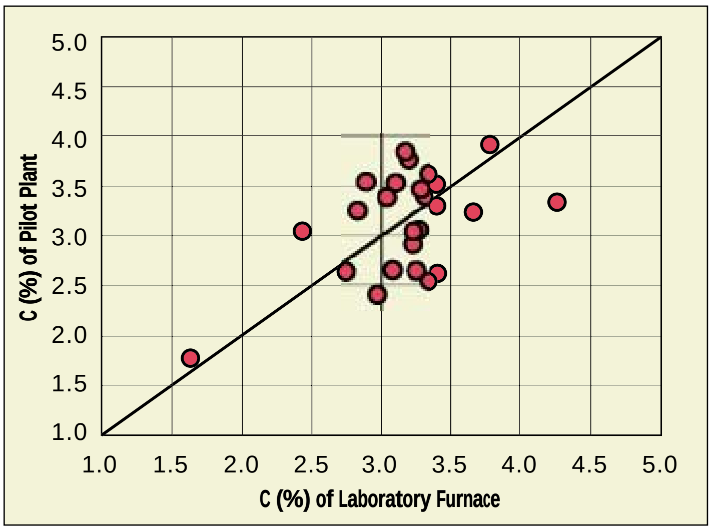


Figure 8 - Comparison of C% between Pilot Plant and Laboratory Furnace Tests

Heat Balance

The heat balance data were taken in detail during the 21 days of stable operation. Typically, a small pilot plant has a larger heat loss than a larger one; however, by evaluating the heat transfer parameters, the heat balance of the industrial scale plant was estimated and is shown in Figure 9. In this figure, the balance is calculated based on the sensible heat. The latent heat of off gas is zero due to the perfect combustion of CO. The main input heat is supplied by combustion of coal volatiles and generated CO. Additional heat is supplied by burner fuel and preheated air. In the output heat, there are two major sources; one is the reduction/melting heat, which is thermodynamically required, and the other is the sensible heat of off gas. A part of the off gas sensible heat is recovered and recycled to the heat input; however, further effective use of the sensible heat is the important subject for the next stage of ITmk3 Process.

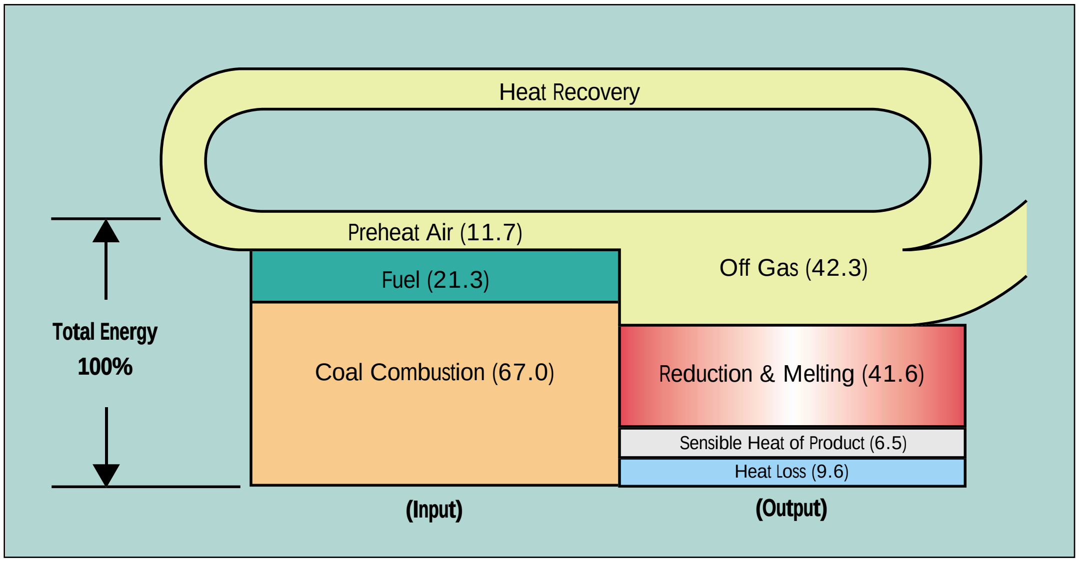


Figure 9 - Relative Heat Balance of ITmk3™ Process

Summary

The ITmk3 Process, an innovative ironmaking process capable of direct production of iron nuggets from iron ore fines and coal, has progressed to the realization of a demonstration plan through pilot plant operation. The rotary hearth furnace reduction/melting reactor was designed and the pilot plant constructed at Kakogawa Works, Kobe Steel, Ltd., Japan. The process concept and the design base were confirmed through the three campaigns of pilot plant trials, achieving 21 days of continuous operation and production of high quality iron nuggets. Through these pilot plant trials operation parameters were optimized and the design database was updated for the next scale up to demonstration plant scale.

The ITmk3 Demonstration Plant is now under construction at Cleveland Cliffs' NorthShore Mines Pellet Plant in Silver Bay, Minnesota, USA.

Construction of Mesabi Nugget Plant Underway

ITmk3® Process to be Demonstrated in Minnesota

Kobe Steel, Ltd. has signed a final agreement with Mesabi Nugget, LLC for the construction and operation of an ITmk3® demonstration plant in northeastern Minnesota (USA). With financing and equity participation in the project now completed, engineering and construction of the demonstration plant has begun.

Engineering and project planning has begun at Midrex Technologies, Inc. with construction scheduled to begin in August. After the plant is completed in March 2003, plans call for the facility to be operated for one year.

Midrex in cooperation with Kobe Steel, Ltd., its parent company and developer of the new process known as ITmk3, will engineer, design, and supply proprietary equipment and participate in field testing for the project in Silver Bay, Minnesota. This project is intended to further develop the ITmk3 Process at a scaled-up level in anticipation of commercial operation.

The ITmk3 Process is a new ironmaking technology that, in a rotary hearth furnace, turns iron ore fines and pulverized coal into iron nuggets of the same quality as blast furnace pig iron. Energy efficient and environmentally friendly, the ITmk3 Process emits 20 percent less carbon dioxide than blast furnace operations. Reduction, melting and slag removal takes only about 10 minutes. In addition, capital investment is projected at roughly half the cost of conventional ironmaking technologies. Iron nuggets could also provide an attractive mineral processing alternative for mining companies.

The 25,000-ton-per-year demonstration plant will be built at the Northshore Mining taconite plant in Silver Bay owned by Cleveland-Cliffs Inc. The project is funded by Kobe Steel and other equity investors, as well as loans from the Minnesota Minerals 21st Century Fund and Minnesota's Iron Range Resources and Rehabilitation Agency.

Kobe Steel and its subsidiary Midrex Technologies, Inc. began research on the ITmk3 Process in 1996. A pilot plant with a production capacity of 3,000 metric tons per year was built at Kobe Steel's Kakogawa Works. Test operations carried out between October 1999 and December 2000 successfully produced iron nuggets under continuous operation.

Techint, Kobe Steel and Midrex Reach Worldwide Agreement on New Iron and Steelmaking Technologies

Kobe Steel, Techint and Midrex have signed an agreement that creates a strategic alliance for the marketing and supply of FASTMET®, FASTMELT®, and FASTEEL™ projects worldwide.

Under the agreement Techint will supply the rotary hearth furnaces and melting/smelting equipment, which are integral parts of the FASTMET and FASTMELT Processes. "This agreement means that we can focus our attention on providing the most effective equipment design for each plant configuration," said Gianluigi Nova, CEO of Techint Technologies. "It will also allow us to approach our customers as a team, working together to provide the best solution possible in each market segment".

The agreement also covers cooperation for the marketing of the FASTEEL Process, which combines the FASTMELT Process with Techint's CONSTEEL, system for continuous scrap feeding and preheating.

"The FASTMET, FASTMELT and FASTEEL Processes will become increasingly popular as mills look to better ways of producing liquid steel," said Steve Okushima, Group Executive Vice President of Kobe Steel. "Techint is a leading supplier of melting and smelting equipment, and they have built more rotary hearth furnaces than any other supplier, so we feel very confident in their ability to deliver quality equipment for these processes."

In October 2001 Techint acquired the assets of EMCI from Midrex Technologies to further enhance the capabilities of the Techint meltshop division. In April 2002, Techint received a contract from Midrex to build the rotary hearth furnace that will be a part of the Mesabi Nugget demonstration plant for Kobe Steel's ITmk3® technology for producing blast furnace-grade pig iron in a form that can be continuously fed to the EAF.

Midrex Certified to New ISO 9001-2000 Standard

Midrex Technologies, Inc. and its sister company PSI have passed their upgrade audit with Underwriter Laboratories (UL) to be certified to the new standard, ISO 9001-2000.

In addition to the new certification, PSI has also successfully expanded its scope to include MRO [Maintenance, Repair and Operations supply] purchasing and Technical Staffing Services.

ISO 9001-2000 is an international standard for Quality Management Systems used to assess a company's ability to meet customer and applicable regulatory requirements and thereby address customer satisfaction. It is now the only standard in the ISO 9000 family against which third-party certification can be carried.

The new scope of registration for Midrex Enterprises, Inc, which includes both Midrex Technologies, Inc. and Professional Services International, reads:

"The provision of contracted engineering, technical staffing services, and equipment packages for industrial plants. The procurement of the original plant equipment for these engineered plants and the supply of replacement parts."

What this means is that any service provided by Midrex Technologies or PSI will be executed under our Quality Management System to the requirements of ISO 9001-2000. This includes engineering, project management, procurement, field services, technology studies, etc. for both our traditional direct reduction business, but also for any new business client in energy, environmental, or other industries.

Midrex Solutions® Signs Additional Contracts

Midrex Solutions® has recently received several new contracts for small capital projects that include engineering for expansions, custom equipment design, and productivity improvements. The new contracts add to the more than 20 small projects the group has contracted since its inception in January 2001.

Midrex Solutions was launched to assist existing MIDREX® Direct Reduction Plants to enhance their performance and to execute small capital projects involving engineered improvements. The work executed to-date has included engineering services, process training, equipment/material supply, and technical field services. As the direct reduction market improves, Midrex Solutions expects to continue its success and work with an increasing number of MIDREX Plants.

MIDREX solutions®

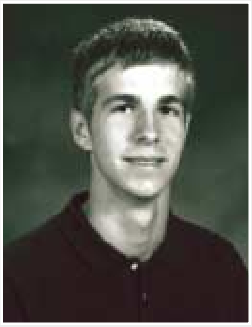
The group has received a favorable response from the marketplace and has prepared more than 75 proposals for engineered plant solutions and technical assistance.

Midrex Announces Donald Beggs Scholarship Recipients

Midrex is pleased to announce Patrick Elliot and Susan Metius as the 2002 recipients of the Donald Beggs Scholarship Program.

Named for Donald Beggs, who conceived the idea for the MIDREX® Direct Reduction Process in the early 1960s, this scholarship is awarded to college-age sons and daughters of Midrex employees and is meant to acknowledge and reward the hard work and academics of these students.

Susan Metius



Patrick Elliot

Patrick Elliot is the son of Antonio Elliot, Manager of Technical Services at Midrex. He is currently in his last year in high school, and will attend the University of North Carolina at Chapel Hill next school year in the Honors program, working towards a degree in Biology and Chemistry. Patrick was goalkeeper on his high school soccer team, which won the state of North Carolina 2A high school championship this past year.

Ms. Metius is the daughter of Gary Metius, Manager-New Technology Programs at Midrex. Susan is a junior at the University of North Carolina at Wilmington, majoring in biology. She plans to work in the medical and public health field after graduation. She is very active in UNCW's Panhellenic Affairs Council and has received student leadership awards the last two years for her activities. She also spends every other weekend working as a nurse's aid in the emergency room of the Cape Fear Memorial Hospital in Wilmington, North Carolina, USA.

Congratulations to Patrick and Susan, and thank you to all applicants who participated in this year's program.

Midrex Takes Steps Towards Diversification

Midrex Technologies, Inc. took a significant step in its diversification effort during May with the signing of business development agreements with Industrial Recovery Systems Inc. (IR Systems) and ClearStack Combustion Corporation. Over the next several months, Midrex will determine the feasibility of long-term business relationships with both companies.

IR Systems

IR Systems is a four-year old, Charlotte, NC-based environmental services company that specializes in the decontamination of soils, sludges, tank bottoms, and process wastes. They are the developer and owner of the patented Matrix Constituent Separator (MCS) system, a low temperature thermal desorber (LTTD) technology that is currently in commercial use in refineries, manufacturing facilities, and central waste treatment sites in various parts of the world, including the USA.

Midrex and and its sister company, Professional Services International Inc. (PSI), will assist IR Systems in conducting a major remediation project for the US Government. The work includes preparing an engineering package for the MCS and arranging the fabrication and shipping of multiple MCS units to the site. Additionally, Midrex and PSI are helping IR Systems with testing, marketing, and project development.

The MCS system is a static tray, batch process that heats the contaminated material with infrared radiation and draws hot air through it under vacuum. The vacuum reduces the boiling points of the contaminants, causing a phase change from liquid or solid to vapors. The vapors are transported out of the treatment chamber and condensed into liquid in the air emission control system.

The MCS system is an ideal remediation solution for limited access, restricted space, and/or high visibility sites. It is modular, portable, emits no dust during operation, and is economically feasible for small or large projects. The MCS system is effective for treatment of soils impacted with hazardous substances, petroleum products including fuels, volatile and semi-volatile compounds, chlorinated solvents, and other environmentally regulated chemicals.

IR Systems has won numerous awards for the MCS technology including the Malaysian Government Hibiscus Award and the Governor's Award from the North Carolina Society of Professional Engineers.

ClearStack Combustion Corporation

ClearStack, located in Springfield, IL, specializes in technologies for lowering NOx and sulfur emissions in coal-fired boilers. ClearStack's main product is the Ashworth Combustor™, a slagging coal gasifier that incorporates a three-stage combustion technique. This technique reduces three major air pollutants of coal combustion: NOx, SO_2, and particulate. The Ashworth Combustor provides an economical means for reducing NOx and sulfur emissions to meet the new, more stringent regulations. It enables utilities to burn higher sulfur coals and continue operating intermediate-sized coal-fired plants.

A demonstration-scale Ashworth Combustor has been installed at the Illinois Department of Human Services Lincoln Development Center in Lincoln, Illinois, USA. The plant will be started up in late June, and ClearStack is now approaching clients for the first commercial installation.

The agreement calls for Midrex to support ClearStack at the Lincoln Demo Plant, with project development, and in technology management, as part of a due diligence effort. The ultimate goal is for Midrex to be ClearStack's technology manager, responsible for enhancing and protecting the technology, and ensuring it is properly applied for each project.

Several other new business opportunities in the environmental and energy fields are currently under evaluation.

For additional information or to inquire about specific services, please contact either John Kopfle (jkopfle@midrex.com) or Frank Griscom (fgriscom@midrex.com).

Midrex Calendar of Events

**Sept 29th – Oct 2nd – AISE Annual Conference – Nashville, TN
Midrex will present and co-author a total of three papers – FASTMET®, Impact of Charge Materials at Georgetown Steel Corp., and Not All RHF Technology Is Created Equal.**

October 20-23 – ILAFA EXPO, 2002 – Cancun, Mexico

November 10-13 – 59th Electric Furnace Conference – Midrex will present the following papers – Using Oxygen to Make Reducing Gas in the MIDREX® DR Process, Influence of AIS Chemisrty on EAF Steelmaking Economics, Not All Rotary Hearth Furnaces Are Created Equal, and FASTMET® - Proven Process for Steelmill Waste Recovery

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