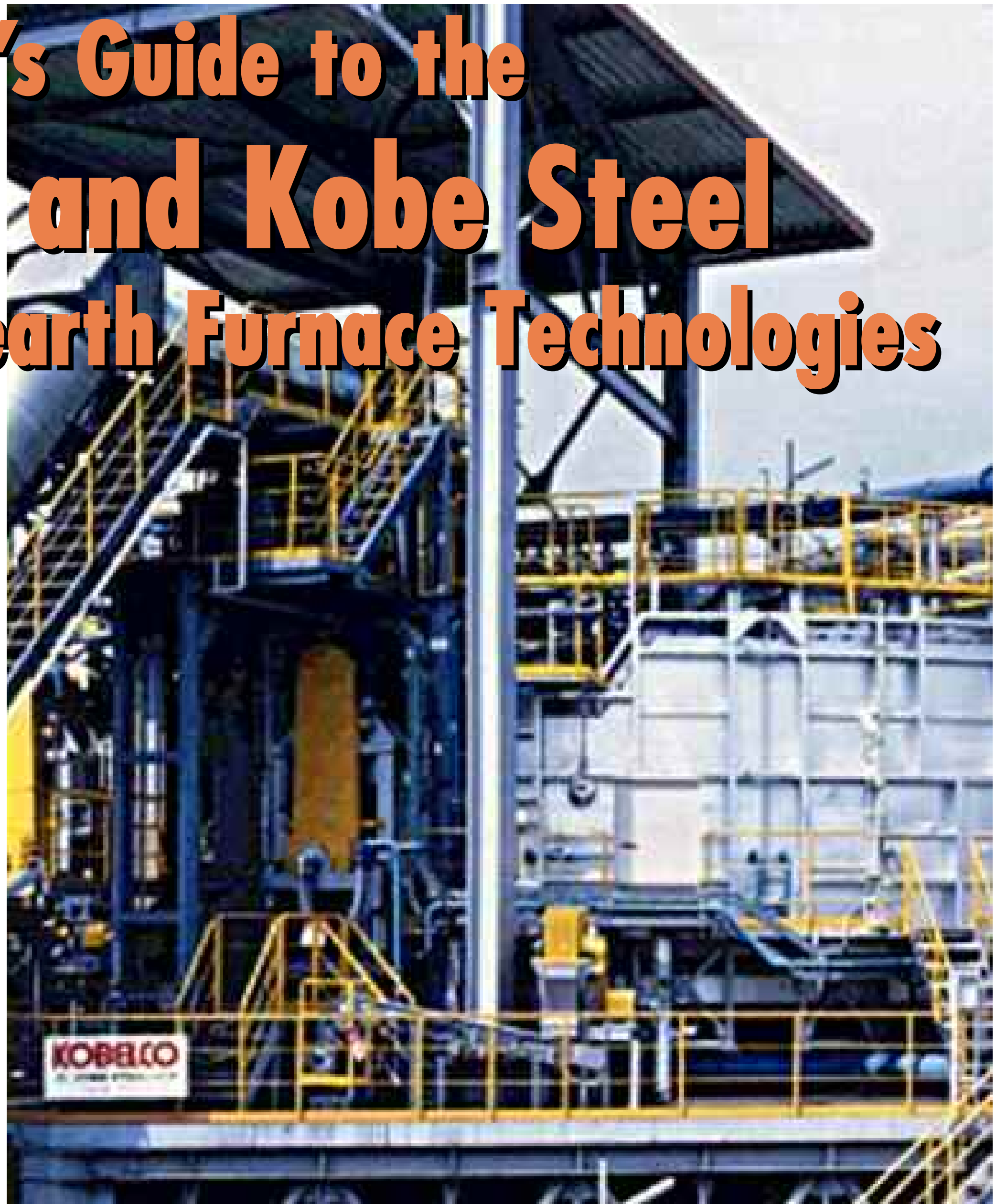
A Layman's Guide to the Midrex and Kobe Steel Rotary Hearth Furnace Technologies



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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 article in the RHF series takes a quick look at the commercially-proven FASTMET® Process, the FASTMELT® Process 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 layman's guide is written to dispel misconceptions in the industry and to show how Midrex and Kobe Steel have evolved three primary technologies from the basic RHF concept to meet specific client needs.

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 high-temperature metal recovery. Unfortunately, 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 three 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 stationary high temperature, circular tunnel kiln. The feed to the RHF consists of 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 that 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 six to 12 minutes, depending on the reactivity of the feed mixture and target product quality.

Table I shows the characteristics of each of the technologies.

	FASTMET®	**FASTMELT®**	**ITmk3®**
Iron Oxide Type	Iron ore concentrate or iron bearing wastes from integrated- or mini-mill; e.g. mill scale or BOF, BF or EAF dust		Iron ore concentrate
Internal Reductant	Pulverized coal (non-coking) or other solid carbon		
Fuel	Internal reductant plus natural gas		
Agglomerate Type	Briquettes or Pellets		Pellets
Plant Location	At or near integrated steel mill or mini-mill or stand alone for EAFD	At integrated steel mill to feed BOF or at mini-mill to feed EAF	Near iron ore concentrate source
Melter	No	Yes, includes electric ironmaking furnace (EIF®) specially designed to melt FASTMET DRI into FASTIRON	No, but iron nuggets each melt within the RHF allowing immiscible liquid iron and slag to separate
Product	Hot or cold DRI or HBI Zinc Oxide	Iron as liquid hot metal or solid pigs or granules	Iron nuggets
Byproduct	None	Slag	Slag recovered after magnetically recovering nuggets
Product Use	Iron source feed to BOF, EAF or BF	Hot liquid or hot or cold iron feed to EAF or BOF	Premium iron feed to EAF or BOF
Product Quality	82% Fe (contains gangue)	96 - 98% Fe (gangue removed as slag)	96 - 97% Fe (slag removed from iron nuggets after cooling with magnetic separation)
Capacity	150,000 to 1,000,000 tpa with excellent economies of scale at 500,000 tpa. A 1,000,000 tpa plant would consist of two 500,000 tpa modules. Specialty plants can be built between 20,000 and 150,000 tpa.		

Table I - Characteristics of FASTMET®, FASTMELT® and ITmk3® Technologies

MIDREX/KOBE STEEL TECHNOLOGIES

FASTMET

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 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 offgas energy credits, as all fuel energy is consumed within the FASTMET rotary hearth furnace (100 percent post combustion). See Figure 1.

Purpose/Market

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 also is a need to recover wastes that are stored on site. Some integrated facilities have millions of tons 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 (EAFD), which is a listed hazardous waste in the USA and elsewhere around the world. 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.

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 such issues 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.

FASTMELT

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®. See Figure 2.

Purpose/Market

The FASTMELT Process is an attractive option for many applications. Highly metallized and high temperature FASTMET DRI is fed directly to 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

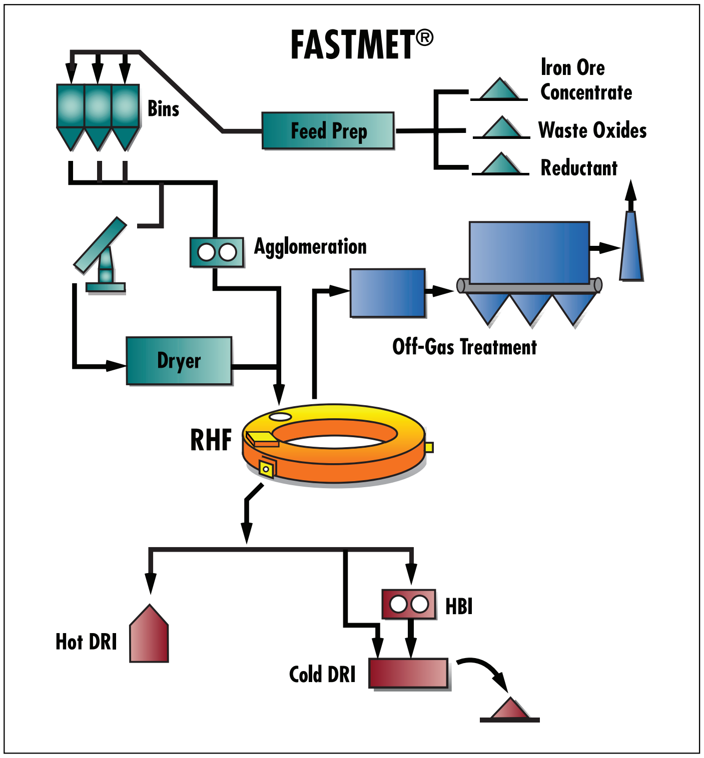

Figure 1

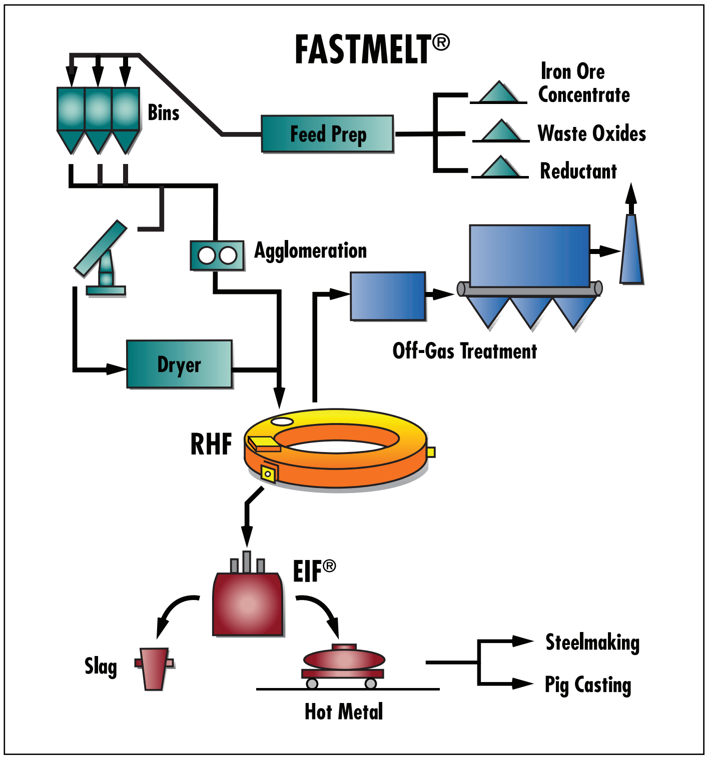

Figure 2

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 offgas 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 merchant iron plant can convert poor quality iron ores and non-coking coals into quality pig iron products.

Kakogawa FASTMET® Plant

ITmk3

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 into proven technology as shown by the demonstration plant at Cleveland-Cliffs' North Shore Mining Company located in Silver Bay, Minnesota, USA.

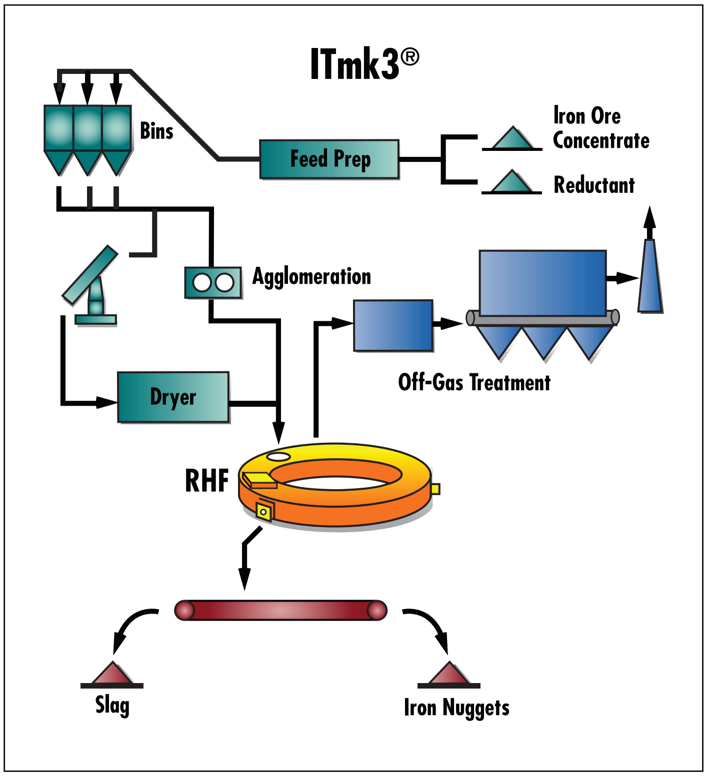

Figure 3

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. See Figure 3.

ITmk3® Nuggets

CONCLUSION

Subtle differences in detail separate these distinct rotary hearth furnace technologies available from Midrex and Kobe Steel. Knowledge of these details and how and when to apply them 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.