DIRECT FROM MIDREX

3RD QUARTER 2006

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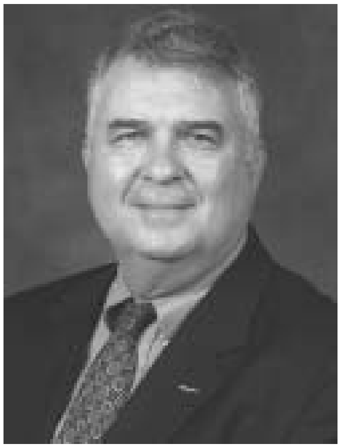
Commentary

Waste Not, Want Not



Jim McClelland
Director - Research and Development

Worldwide, there is an increasing emphasis on environmental issues, with the steel industry falling under scrutiny. To address this situation, Midrex is continuing its efforts to reduce the environmental impact of iron and steelmaking processes and to develop new solutions to environmental problems. One issue is the disposal of metal-bearing wastes, both ferrous and non-ferrous. Integrated steel facilities and mini-mills are finding it more and more difficult to dispose of wastes from iron and steelmaking processes. These wastes include iron oxide screenings, mill scale, sludges, and baghouse dust. 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 viable. Mini-mills also face problems in disposing of electric arc furnace baghouse dust, which is a listed hazardous waste in the USA. Sending these wastes off-site for disposal can entail logistical difficulties and considerable cost.

In addition, there are millions of tons of metal oxide-bearing waste materials stockpiled around the world from various mining and processing operations. Many of these facilities process ores not only containing non-ferrous elements, but also a significant amount of iron.

With the commercialization of the FASTMET® Process, there is now a cost-effective means of dealing with these wastes and recovering mineral resources. Developed by Midrex Technologies and Kobe Steel, Ltd., FASTMET uses a rotary hearth furnace to convert ferrous wastes and iron oxide fines into highly metallized DRI. Carbon contained in the wastes or added as coal or coke is used as the reductant. FASTMET provides an excellent means of recycling iron-bearing materials, thus greatly reducing the volume to be disposed of, as well as producing a cost-effective iron product. This product can be melted in an electric arc furnace, BOF, or blast furnace. In the case of EAF and BOF dust, the zinc oxide is released from the dust, concentrated, and recovered in the baghouse. This zinc oxide becomes a valuable byproduct that can be sold to a processor for production of metallic zinc. With today's metals prices, a FASTMET waste recycling plant can provide an attractive return on investment.

Midrex is now discussing FASTMET waste treatment plants with a number of potential clients. One interesting concept is to build a regional treatment facility, which would receive wastes from local steel mills, sell DRI back to the mills, and sell zinc oxide to a processor. Another possibility is to build a FASTMET Plant at a mine site to treat stockpiled mine tailings.

FASTMET is already well-proven for treating steel mill wastes, with commercial plants operating in Japan for more than six years on a scale of up to 250,000 tonnes per year. These plants have shown that FASTMET has an important, profitable role to play in treating iron-bearing waste materials, recovering valuable mineral resources, and protecting the environment.

Our near-term goal is to build a FASTMET recycling plant in the United States that demonstrates the value of the technology under North America conditions. This is a goal that appears to be close on the horizon.

MISSION STATEMENT

Midrex Technologies, Inc. will be a leader in design and integration of solids and gas processes. We will meet or exceed performance expectations, execute projects on time, enhance existing product lines, and provide value-added design, procurement, logistics and field services to our clients. We will develop new business opportunities that will challenge our employees and maintain the economic vitality of our company. Our employees are the key to our success, and we are committed to encouraging them to grow professionally and personally.

The New Iron Age
Direct Reduction's Role in the World Steel Industry

Part Three: Expanding the Envelope

By John T. Kopfle,
Director - Corporate Development
Robert L. Hunter,
Product Applications Engineer
Midrex Technologies, Inc.

Editor's note: Part Two of this three-part series reviewed the growth in DRI production through 2005 and the technological enhancements that enabled that growth to occur

A BRIGHT FUTURE

The surge in steel and DRI demand and prices that began in 2004 and has continued through the summer of 2006 has been remarkable. This boom has resulted in major capacity increases for steelmaking and direct reduction. There are now 14 MIDREX® Plants under contract that will start up from 2006-08 and another two under agreement. The combined capacity of these projects is over 17 million tons.

Yet the question remains, what about the future of the steel and direct reduction industries? Although the present strong market shows no signs of a major drop off in the near future, steel will continue to be a cyclical industry. Most industry experts, however, believe that the pricing floor will be substantially higher in the future. One positive factor is that because of the consolidation that has taken place in the worldwide steel industry, and especially in North America, it appears better poised to withstand future downturns by restraining output when prices drop. This was demonstrated during the summer and fall of 2005. From June-August, steel and metallics prices dropped significantly, but because US mills reduced production, the prices of HR coil and No. 1 Bundles increased over $100/t by October. Another factor which will increase the floor prices for iron and steel is iron ore and coal prices that have more than doubled since 2001.

Looking at future production, China is a wild card, but indications are that production there will continue to expand for a few years. In the rest of the world, production will likely grow at slightly less than GDP, probably on the order of 2-3 percent per year. China's capacity expansions will continue to be primarily via the blast furnace/basic oxygen furnace (BF/BOF) route, with growth ex-China mostly from the electric arc furnace (EAF). Using these assumptions, Midrex has developed a world EAF metallics balance to 2015, as shown in Table V on the following page. The figures for 2000 and 2005 are actuals, with those for 2010 and 2015 Midrex forecasts.

The table focuses on the EAF because 95 percent of DRI and HBI are used in that application. The data shows that because of increased EAF production worldwide, there will be continuing pressure on scrap supplies, particularly low residual material, with a scrap requirement increase of over 116 Mt from 2005-2015. This should keep prices at attractive levels for producers and result in good demand for DRI and HBI. Thus, the future looks bright for both the steel and direct reduction industries and Midrex will continue "expanding the technology envelope."

STEEL INDUSTRY NEEDS

The technological improvements Midrex has developed, as described in Part Two of this series, have enabled Midrex to provide the steel industry with cost-effective, energy efficient, flexible, and environmentally friendly direct reduction facilities. Given the positive outlook for the steel industry, Midrex is enhancing its technology development efforts and has recently formed a four-person Technology Development Group that is spearheading the work. Also, the company has invested a significant amount to refurbish and upgrade the Technical Center, including a complete minerals processing laboratory.

The first step in technology development is to determine the needs of the industry. Then, a strategy can be formulated to apply the company's expertise and skills to develop new technologies. What are the requirements for the steel industry of the future?

Following are several:

Use of fines, low grade ores, and waste materials

As mines are depleted, the ore quality diminishes. Iron content declines, fines content increases, and impurity levels rise. In addition, there are billions of tons of iron-bearing waste materials worldwide, with more generated each year. There are not a lot of viable routes for processing these materials.

Lower CAPEX

Iron and steelmaking are very capital intensive, and the cost of a multi-million ton facility can be several billion dollars. There is a continual need to find process routes that have lower CAPEX.

Fewer unit operations and more continuous processing

There are many unit operations required to turn iron ore into a steel product, each one involving capital and operating costs and operational issues. Also, there are discontinuities in many ironmaking/steelmaking routes because one process is batch while an adjacent one is continuous.

Use of low cost energy

Since the cost of iron ore is about the same in many locations, the deciding factor for an ore-based steelmaking project is often energy. The blast furnace is very efficient, but it requires high grade coal to make coke. The cost of this coal has tripled during the last four years. Use of lower-grade coals to make iron would save considerable operating cost.

Lower environmental impact

The environmental effect of primary metals production is increasing in importance since the industry is a major source of sulfur, solid wastes, and CO_2. Although there are ways to reduce those emissions, the challenge is to do so while not dramatically increasing production costs.

	2000	2005	2010	2015
Metallics requirements				
Steel production	847.7	1,129.3	1,310	1,450
EAF production	287.4	358.2	445.5	533.0
% EAF	33.9%	31.7%	34.0%	36.8%
EAF metallics required	316.1	394.0	490.1	586.3
Metallics sources				
Scrap	253.8	308.3	368.5	424.8
Captive DRI	33.6	42.2	61.5	90.0
Merchant DRI/HBI	7.6	11.0	18.1	26.5
Total DRI	41.2	53.2	79.6	116.5
(% of EAF charge)	13.0%	13.5%	16.2%	19.9%
Domestic pig iron	4.2	9.9	15	15
Merchant pig iron	14.6	17.6	20	20
Hot metal	4.0	5.0	7	10

Table V - World EAF Metallics Balance (Million metric tons except as noted)

Process	No. modules	Ironmaking Cap (Mt/y)	Notes
Blast Furnace	~450	700	
Direct Reduction	~150	55	gas-based and coal-based
Mini-BF	~150	33	
COREX	5	2.7	
FINEX	2	2.1	
HIsmelt	1	0.8	prototype
Tecnored	1	0.03	demo
World total		~800	

Table VI - Ironmaking Process Routes

A FEW WORDS ON TECHNOLOGY DEVELOPMENT

Before describing the innovations Midrex has available and is developing to meet the needs of the steel industry, it is worthwhile to make some observations based on the company's nearly 50 years of experience in ironmaking technology development.

Development of a new ironmaking process is very expensive and time consuming, taking $100 million and 20 years or more. This has been borne out many times, most recently by the wave of new process endeavors begun during the steel boom in the mid-1990s. Most of these have been abandoned and none has become an unqualified success yet. The costs expended were several billion dollars. Why is this so difficult? One reason is there are chemistry, thermodynamic, and materials constraints that are difficult to overcome and have plagued many of the efforts. An example is FeO erosion of refractory. Most of the new processes are good ideas, which have been thought of previously and would be profitable if they operated as envisioned. Unfortunately, they cannot be made to work efficiently at large scale.

Table VI shows ironmaking processes that are operating at significant scale. The blast furnace (including mini-blast furnace) and direct reduction routes predominate, even with all the efforts to develop smelting reduction processes over the last 20 or more years. The blast furnace and DR processes (primarily shaft furnace-based) continue to be so successful for three reasons: 1) the ore and energy are high quality, making processing relatively easy; 2) they are counter-current, which is the most efficient means of processing; and 3) there is a vast amount of operating experience worldwide in many situations.

Given the difficulty and expense of developing a new ironmaking process, Midrex intends to devote its technology development efforts on refining existing processes and developing new applications. One major focus is downstream processing of DRI.

MIDREX TECHNOLOGY DEVELOPMENT INITIATIVES

Following are the technology developments that Midrex has available and is working on to meet the steel industry's needs.

Use of fines, low grade ores, and waste materials

FASTMET®, FASTMELT®, ITmk® - these rotary hearth-based processes use iron ore fines as a feedstock and have the capability to process lower-grade materials as well. There are three FASTMET Plants operating in Japan, processing nearly 500,000 t/y of steelmaking waste materials. (See Figure 6) Midrex and Kobe Steel are pursuing numerous projects worldwide which use virgin iron ore fines and waste materials. The companies continue to refine RHF technologies in the areas of raw material flexibility and operational cost.

Lower CAPEX

MIDREX® Direct Reduction Process - The natural gas-based MIDREX Process has been refined over the last 40 years through technology developments and operational improvements. This has resulted in a very competitive capital cost, as low as $125/annual ton (battery limits basis). Although design improvements have played a role, the major factor in the low specific CAPEX has been the tremendous improvement in shaft furnace productivity. The productivity of the MIDREX® Shaft Furnace is the highest in the industry, with some plants achieving 14 ton/day-m^3. In addition, the annual capacity has increased by a factor of more than ten since the first modules were installed in 1969. Midrex now offers capacities of up to 2.8 Mt/y in a single shaft, the MIDREX SUPER MEGAMOD®.

Fewer unit operations and more continuous processing

Hot Discharge/Transport/EAF Charging – Most MIDREX Plants discharge cold DRI, which is generally aged and stored for several days, then reclaimed to feed the EAF. Midrex has developed a number of options to provide for hot discharge of DRI, hot transport to the meltshop, and continuous hot feeding to the EAF. This saves electricity consumption and increases meltshop productivity. For MIDREX Plants, the options are transfer vessels, a conveyor, or the HOTLINK® System. With HOTLINK, the EAF is located below the shaft furnace and DRI is continuously charged by gravity. Midrex has supplied these systems for four new projects and is continuing to refine the designs.

Figure 6 - Hirohata FASTMET Plant

FASTMELT – In the FASTMELT Process, hot DRI is charged by gravity to the EIF™ (Electric Ironmaking Furnace) or a coal-based melter, providing the same benefits as the MIDREX Plant hot charging options. The EIF is available now and the coal-based melter is under development.

KWIKSTEEL™ – This is an innovative process whereby hot DRI is melted in an RHF to produce a high quality nugget that can be melted in an EAF. This process has potential in areas with high electricity costs or a weak grid. KWIKSTEEL is now being tested at the bench scale. See KWIKSTEEL flowsheet on the following page, Figure 7.

Use of low cost energy

MIDREX Process – There are a number of areas around the world with natural gas at $3/MMBtu or less. In these locations, the MIDREX/EAF route can produce liquid steel at a cash cost as low as $160/t.

FASTMET®, FASTMELT®, ITmk® – These processes use coal, thus avoiding the need for coke. To date, only low volatile coals have been used, but Midrex and Kobe Steel are investigating the use of lower cost sources of carbon.

Coal gas/MIDREX – Coal gasification is now well developed at large scale and several processes can produce an acceptable quality syngas for use in a MIDREX® Shaft Furnace. Midrex is working with the major gasification technology providers to optimize flowsheet alternatives for the Coal gas/MIDREX Process. One possibility is the use of lower-grade coals or pet coke that are available at low cost.

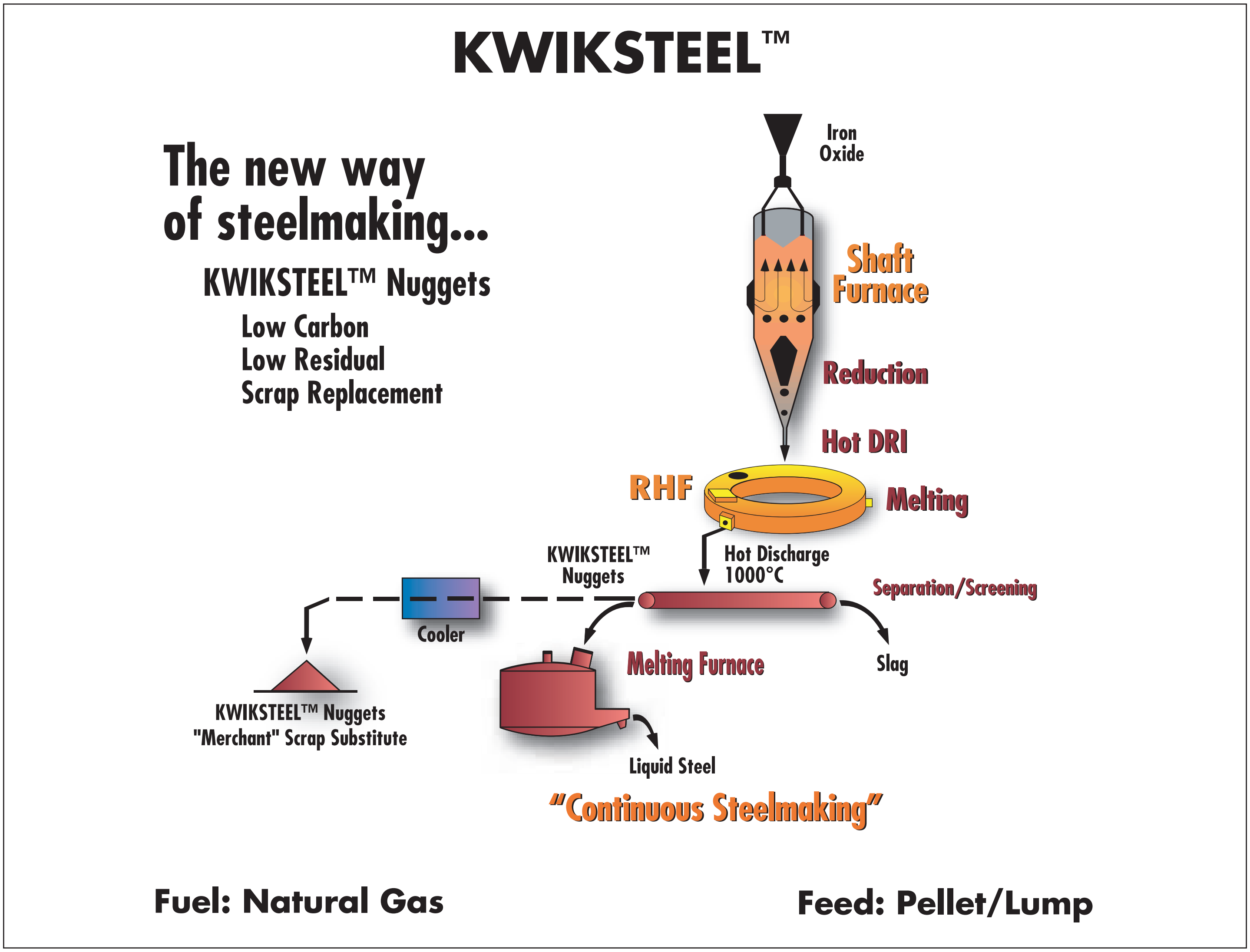


Figure 7 - KWIKSTEEL Flowsheet

Lower environmental impact

MIDREX Process – The MIDREX Process is environmentally friendly in a number of ways. Since natural gas usually has little or no sulfur, SO_2 emissions from a MIDREX Plant are generally not an issue. Also, because natural gas has less carbon per unit of energy than coal, the MIDREX/EAF steelmaking route has lower CO_2 emissions than the BF/BOF. If the electricity is generated from hydro or nuclear, CO_2 emissions are just one-third.

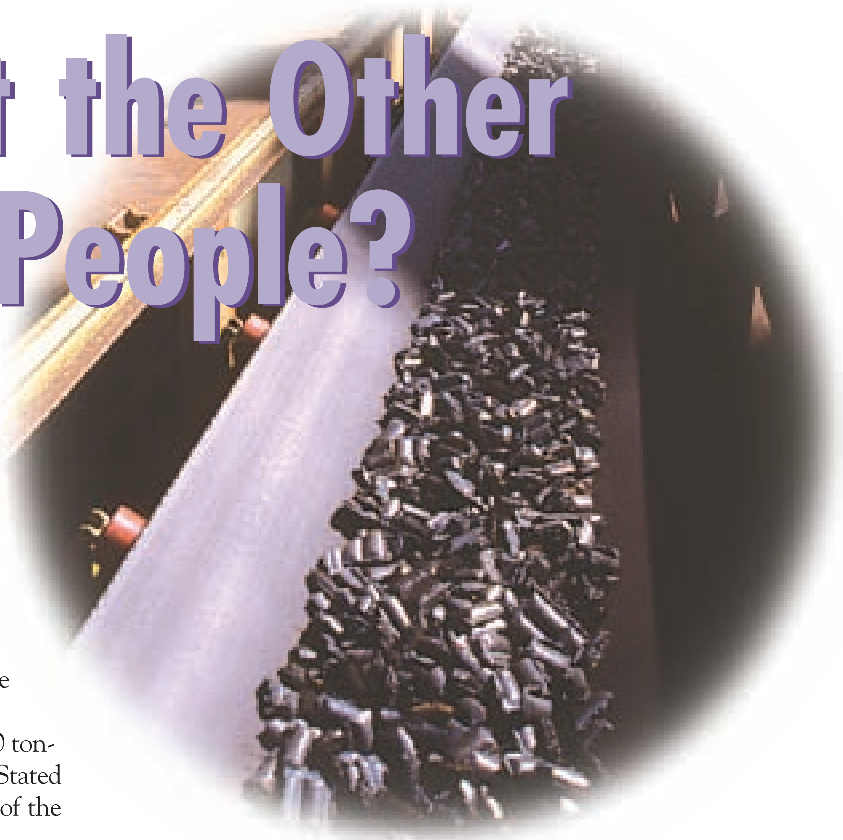
FASTMET, FASTMELT, ITmk3 – As mentioned previously, these processes can utilize waste materials as an iron source or reductant. This provides the possibility of recycling steelmaking wastes or remediating a waste pit. Midrex is doing a substantial amount of R&D for numerous clients using their feed materials.

Coal gas/MIDREX – In the process, CO_2 is removed to increase the reducing gas quality. This generates a high purity CO_2 stream that could be used for enhanced oil recovery or sequestered underground.

CONCLUSIONS

The world steel industry has made a remarkable turnaround in the last three years, with production and price levels reaching all-time highs. Although Chinese steel demand played a major role, economic growth in the rest of the world also contributed. DRI demand and production have grown almost continuously since 1970, to 56 million tons in 2005. The vast majority of DRI is used in EAFs and the rise in demand has been due to strong growth in EAF production, the movement of mini-mills into low-residual products, and metallics supply limitations. DRI production via the MIDREX Process has risen because of the favorable economics in areas with low cost natural gas, the reliability of the process, and continual technology improvements. Because of the surge in DRI demand and prices since 2004, there are now 14 MIDREX Plants and one ITmk3 Plant under contract or agreement, with a combined capacity of over 17 million tons. Midrex sees a bright future in the steel and direct reduction industries and the company has enhanced its technology development efforts. Major focus areas include hot transfer and melting of product, use of lower grade feed materials, and development of coal-based processes.

What About the Other Five Billion People?



By Robert L. Hunter,
Product Applications Engineer
Midrex Technologies, Inc.

We are all well aware of the Chinese steel industry's remarkable growth, as well as the nearly endless litany of superlatives used to describe that growth. Two such superlatives related to ironmaking that continue to surprise some are:

1. China now produces more than 10 times as much iron as the United States.
2. For the first six months of 2006, China added a new 10,000 ton-per-day blast furnace (or its equivalent) every 12 days! Stated another way, China added as much capacity as all of that of the US within a period of less than four months this year!

Figure 1 - Map of the World's Current Ironmaking

Each dot shown in Figure 1 on the world map represents 10,000 tons-per-day of ironmaking capacity and shows how dominant China has become. Clearly, East Asia has by far the greatest share of world ironmaking. In fact, throughout China, Japan, and South Korea, it was difficult to locate and note all the dots on the capacity map because there was not enough space! (Please note that in many cases, a dot may represent more than one blast furnace, thus locations are approximate.)

The news has been full of China's extraordinary achievements. But, what about the other five billion people on earth? Have they built any new iron and steel works?

Yes, they have. An investigation of new ironmaking capacity outside China shows that, on average, about seven million tons-per-year is added. This investigation spanned a 15 year period, from 1994 through 2008, inclusive. The seven million ton-per-year average seems small when compared to the volume of new capacity that China has been building; nonetheless, it is significant. Many of the new mills displaced old capacity that underwent closure, and are in different locations. In other words, the world's ironmaking has been migrating to new areas. As would be expected, these new locations have easy access to either iron ore or energy used for iron reduction.

In general, ironmaking has been slowly waning in the United States for over three decades, and to a lesser extent in Western Europe. Meanwhile, it has grown in South America (Brazil and Venezuela), India, and the Middle East.

A remarkable aspect of this growth is the extent of direct reduction. We frequently think of direct reduction as comprising a small portion of total ironmaking production; less than 10 percent of the world's iron is produced via direct reduction. But when viewed from the aspect of new capacity, direct reduction is at least as large as the blast furnace industry outside of China.

From the beginning of 1994 until the present, we were able to identify 77 million tons-per-year of new capacity that was commissioned outside China. Of that, 45 percent, or 35 million tons per year, consisted of direct reduction plants. Looking forward, based on currently contracted and expected capacity, direct reduction will play an even greater role. At present, there are 25 million tons-per-year of direct reduction capacity under construction or agreement that is scheduled to begin operation by December 31, 2008. This number compares to nine million tons of blast furnace capacity that has been announced. Thus, for the period 1994-2008, direct reduction will account for over 50 percent of new ironmaking capacity outside China. See pie chart in Figure 2 below.

Direct reduction is no longer just a niche market. For "the other five billion people," it has become the leading means of building new ironmaking capacity.

Credits: IISI, VOEh, Stahl und Eisen, Midrex files

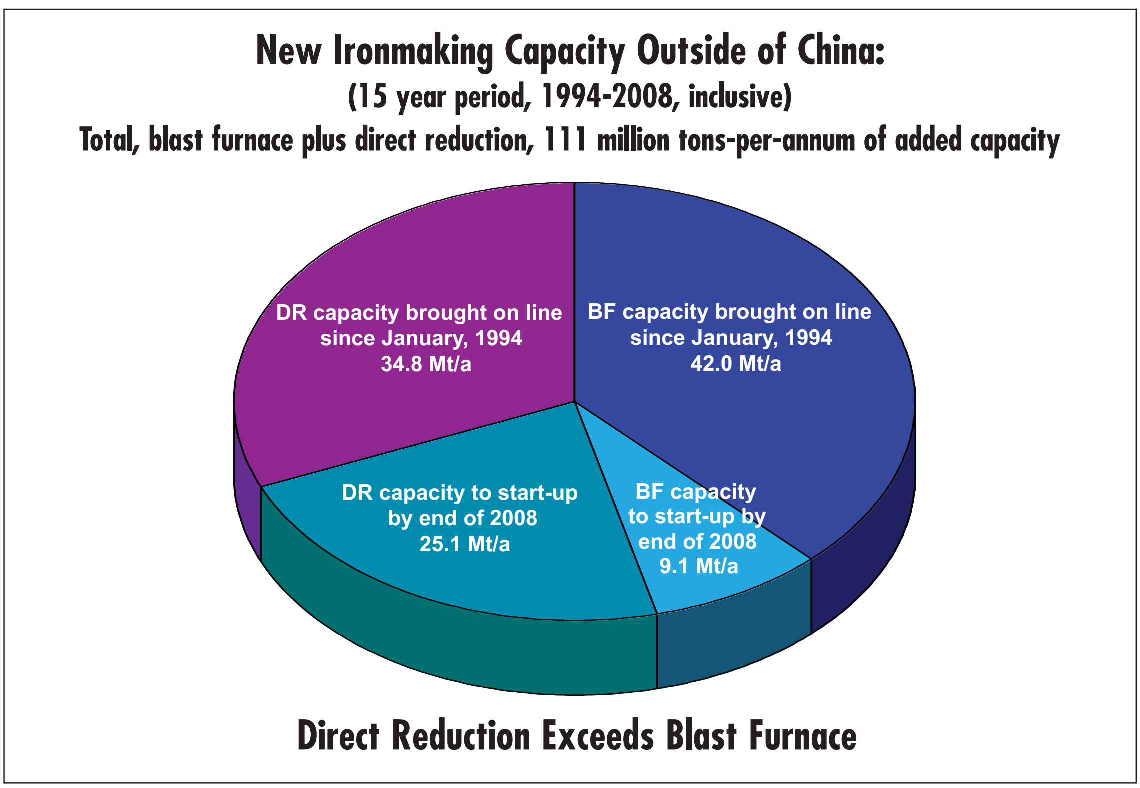


Figure 2 - New Ironmaking Capacity

Midrex News & Views

Stephen Montague
Vice President – Commercial and Technology

Montague Promoted to Commercial Vice President

Midrex Technologies, Inc. recently announced the promotion of Stephen Montague to Vice President – Commercial and Technology.

Montague has been a long term fixture within Midrex. Before joining the company as a fulltime employee in 1989, he worked for Midrex as a co-op student during the summers of 1987 and 1988.

Throughout his extensive history with Midrex, Montague has served in a number of positions, including Designer, Mechanical Engineer, Field Operations Manager, Product Manager, Director of Engineering, and Director of Technology Development.

He was responsible for the successful commissioning/start-up of the first MEGAMOD® CDRI plant at Ispat Industries, Ltd. (IIL) in 1994-95. This included almost one year of service in India to oversee the project. Montague was also in charge of the successful commissioning/start-up and training at IMEXSA (now Mittal Steel Lazaro Cardenas), in Mexico in 1997.

In addition, Steve participated in the start-ups of OPCO (1989), Venprecar (1990), CIL III (1999), Saldanha (1999), as well as helped to develop several new technologies and patents for Midrex, such as HOTLINK®, Oxygen Injection, OXY+®, and SIMPAX®, etc.

Montague is a North Carolina native with a B.S. in Mechanical Engineering from North Carolina State University. He lives in Charlotte with his wife Angelica and their three sons, Emmanuel, Rommel, and Jonathan.

Henry P. Gaines, Jr.
Plant Sales Director

Gaines Named Plant Sales Director

Midrex Technologies, Inc. has announced the promotion of Henry P. Gaines, Jr. to the position of Plant Sales Director. Gaines will now be responsible for the sale of all new shaft furnace-based projects and plant expansions.

Since returning to Midrex, he has served in the sales department for approximately two years and was instrumental in securing the LION and Al-Tuwairqi projects. Gaines has truly been a "road warrior" when it comes to travel, bringing high energy and dedication to the Sales Group.

Gaines's familiarity with Midrex and direct reduction dates back to the early 1980s when he worked for Midrex's engineering department on plant construction.

Prior to joining Midrex, Gaines was Vice-President of Controls Southeast (USA); he also worked for Dow Chemical Company as Development Engineer.

Gaines is a licensed professional engineer and holds a B.S.M.E. from Clemson University in South Carolina.

Christopher M. Ravenscroft: Editor

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