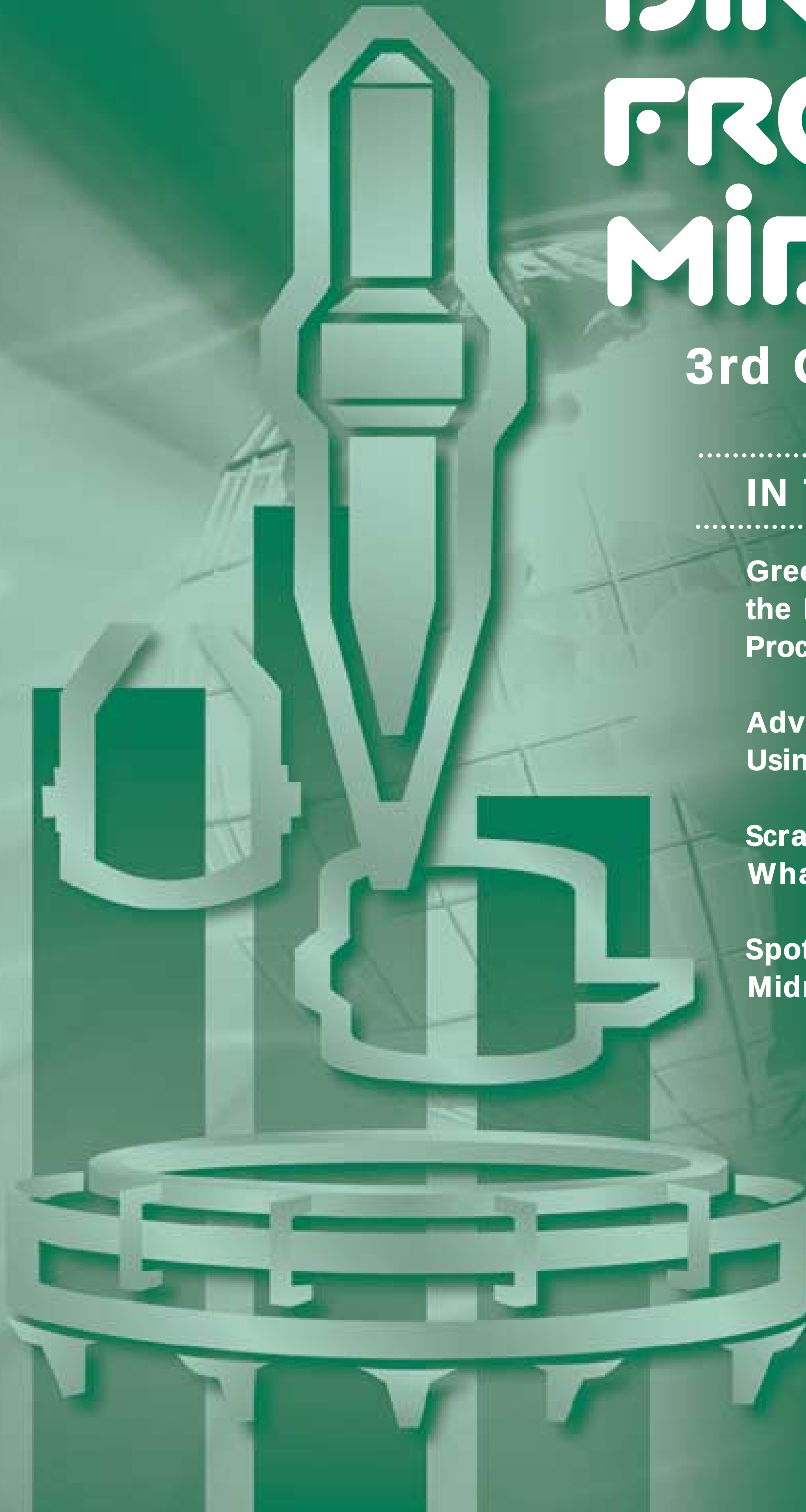
DIRECT FROM MIDREX

3rd Quarter 2001



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3rd Quarter 2001

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Printed in U.S.A.

Commentary

Environmental Progress

Dan Sanford
Vice President of Operations

Worldwide there is an increasing emphasis on environmental issues. Today's environmental focus is on avoiding pollution rather than controlling and treating it, with a goal of zero emissions and waste.

For the iron and steel industry, emissions from integrated steel mills, especially sinter plants and coke ovens, are of particular concern.

Reducing energy use goes hand in hand with environmental benefits because it automatically leads to lower emissions. In fact, in the US it now takes 45 percent less energy to produce a ton of steel than it did in 1975.

As a member of the global community, Midrex, along with our parent company Kobe Steel, recognizes the importance of the environment and the limits to natural resources. Through the years we have been proactive in improving environmental performance in our iron and steelmaking processes by energy conservation and recycling.

MIDREX® Direct Reduction Plants are designed to minimize air, water and noise pollution, and emission levels meet all applicable World Bank standards.

The MIDREX® Process is the most energy efficient of all commercially available direct reduction processes, with a natural gas consumption of 2.25 net Gcal per ton of DRI and an electricity consumption of 95 KWh per ton of DRI. New MIDREX Plants can be engineered with four stages of heat recovery. Typically, plants are designed for zero discharge of recycled reducing gas, thus maximizing energy efficiency and minimizing emissions. Process water is also recycled.

In the past decade, we have gone even further to aid the environment through technological innovation with the commercialization of FASTMET for waste recycling. Also, steel shops can reduce their energy consumption and their carbon emissions by charging "blast furnace grade" DRI/HBI such as from MIDREX Plants.

In this *Direct From Midrex*, we feature "Green Steelmaking with the MIDREX® and FASTMET® Processes" (page 3). We compare carbon emissions from various ironmaking/steelmaking routes including the blast furnace/BOF, the MIDREX Direct Reduction Process, the FASTMET Process and the EAF, describing how the use of direct reduction processes can lower greenhouse gas emissions.

Midrex will continue to further reduce the environmental impact of direct reduction-based steelmaking and of processes outside iron and steel through our business development efforts. We are applying proven techologies and expertise to other industries to develop new business opportunities while improving their environmental friendliness.

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.

GREEN STEELMAKING with the MIDREX® and FASTMET® Processes

By: Dr. Sara Hornby Anderson, John T. Kopfle and Gary E. Metius
Midrex Technologies, Inc.

Masahiro Shimizu
Kobe Steel, Ltd.

This paper was originally presented at COM 2001 (Conference of Metallurgists) and Electrochemists 2001 August 26-29, 2001, Toronto, Canada

Introduction

This article compares carbon emissions from various ironmaking/steelmaking routes, including the blast furnace, the BOF, the MIDREX® Direct Reduction Process, the FASTMET® Process, and the EAF, and describes how use of direct reduction processes can lower greenhouse gas emissions.

Use of steel mill wastes as feedstock to the FASTMET and FASTMELT® Processes may also lower greenhouse gas emissions. This data and that for other realistic EAF charge mixes will be featured in the next *Direct From Midrex*. New MIDREX® Technologies will further improve the environmental benefits of direct reduction. From a global perspective, production of steel in gas-rich countries using the MIDREX Process can be an environmentally friendly approach: emissions trading is a possibility.

The generation of greenhouse gases and the choice of production methods for primary metals are invariably linked. Although efficient operation of metals production facilities does decrease the generation of greenhouse gases, to significantly reduce the emissions requires an understanding of how and where the production of the greenhouse gases originates.

To identify the options available for achieving a measurable reduction in CO_2 (carbon emissions), it was necessary to assemble an overview of the typical levels of carbon emissions generated in the various stages in the production of steel. Specifically, this paper provides an evaluation of carbon emissions and energy consumption in steel production, from the receipt of basic raw materials to the tapping of a ladle of liquid steel. The information assembled includes blast furnace/BOF operations with the primary focus falling on exploring options available with alternative iron/EAF operations.

Energy Use And Carbon Emissions

Background

Conventional technology based on blast furnace/basic oxygen furnace operations has been the backbone of steel production. The pre-eminence of these operations is being challenged by steel mills using electric arc furnaces which charge significant quantities of scrap with varying amounts of Alternative Iron (AI), primarily pig iron and DRI/HBI.

The advances achieved in EAF operations and casting technology as well as the development of new alternative iron sources offer greater flexibility and competitiveness to steelmakers than was available 10 years ago. This flexibility results in a wider selection of raw materials, increased energy efficiency, and a reduction of greenhouse emissions over the conventional steelmaking techniques.

Production Processes

The following sections briefly describe the production processes which were considered in this comparison. This non-exhaustive list of possible ironmaking/steelmaking techniques demonstrates characteristics typical of each respective option. The processes and conditions were chosen to represent “real world” examples. Table I shows the conditions for the eight cases considered and Figure 1 summarizes the energy consumption and carbon emissions (per tonne of liquid steel). In this paper all reference to tons are equivalent to metric tons (1,000 kgs). *[Ed. Note: Details of these calculations can be obtained from the Information Center section of www.midrex.com.]*

The scope of the processing incorporated into each of the production methods begins with the receipt of charge materials (iron ore and scrap), reductants (coal, natural gas, etc.), and energy (coal, natural gas and electricity) and ends with the tapping of a ladle of liquid steel (0.04 percent carbon and 1620°C) prior to any ladle furnace processing.

Blast Furnace / BOF

The blast furnace information included was based on two independent sources, the first covering the average of eight BF/BOF operations in Japan summarized by Shimizu et al.[1], and the second covering the average of four BF operations in the

Table I – Conditions for Steelmaking Alternatives

BF / BOF PRODUCTION CONDITIONS

Operation	Sequence Step	Conditions
BF-BOF	Pelletizing	• Oil-fueled induration, fluxed or acid pellet, 64% total iron pellet
	Sinter	• Coal-fueled sintering, fluxed sinter, 56% total iron
	Blast Furnace	• Coke + coal injection + oil / nat.gas add. + oxygen enrichment, 4.0% carbon, 0.5% silicon, 1500°C
	BOF	• 80% HM, 20% scrap, 0.04% carbon, 1620°C

DRI / EAF PRODUCTION CONDITIONS

Operation	Sequence Step	Conditions
DRI-EAF	Pelletizing	• Natural gas-fueled induration, DR pellet, 67% total iron
	Direct Reduction	• Natural gas-based, shaft furnace, 2.5% carbon
	EAF	• 80% DRI, 20% scrap, carbon injection, 20 Nm^3 / t oxygen, 0.04% carbon, 1620°C

HBI / EAF PRODUCTION CONDITIONS

Operation	Sequence Step	Conditions
HBI-EAF	Pelletizing	• Natural gas-fueled induration, DR pellet, 67% total iron
	Direct Reduction	• Natural gas-based, shaft furnace, hot briquetting, 1.5% carbon
	EAF	• 30% HBI, 70% scrap, carbon injection, 20 Nm^3 / t oxygen, 0.04% carbon, 1620°C

PI / EAF PRODUCTION CONDITIONS

Operation	Sequence Step	Conditions
Pig Iron-EAF	Pelletizing	• Oil-fueled induration, acid pellet, 64% total iron pellet
	Sinter	• Coal-fueled sintering, fluxed sinter, 56% total iron
	Blast Furnace	• Coke + coal injection + oil / nat.gas add. + oxygen enrichment, 4.0% carbon, 0.5% silicon
	EAF	• 30% PI, 70% scrap, carbon injection, 20 Nm^3 / t oxygen, 0.04% carbon, 1620°C

USA, reported in *Iron & Steelmaker*[2]. The BF/BOF information from Japan was used as the basis for the overall integrated energy balance covering coking, pelletizing, sintering and BOF steelmaking. The BF operations from the USA were the basis for specific consumptions in the BF operations area.

Direct Reduction / EAF

The direct reduction information, using natural gas-based DRI, was gathered from material presented at the Midrex HBI/DRI Melting Seminar[3], and data provided for the Midrex 2000 Operations Report[4], covering information gathered on an annual basis from each of the operating plants.

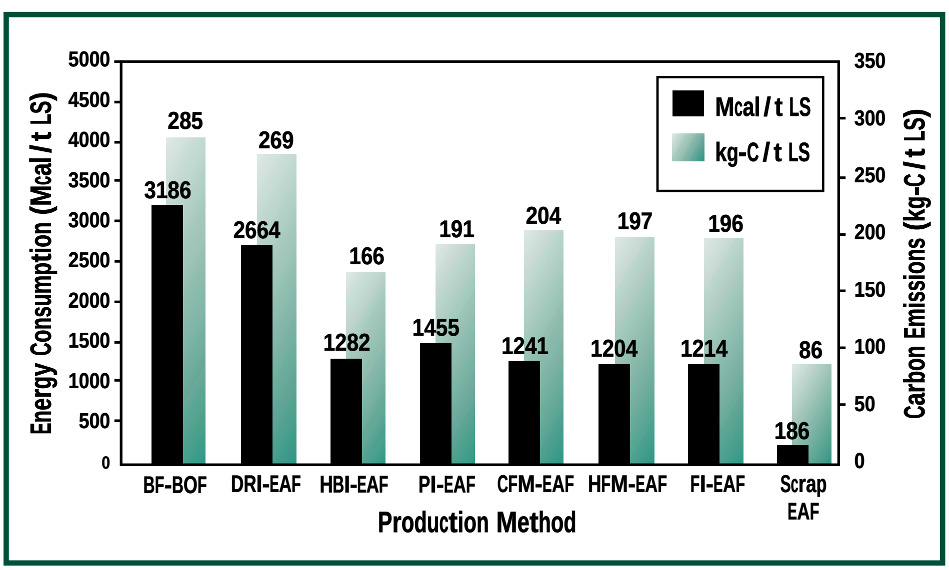

Figure 1 Total Carbon and Energy Emissions

Hot Briquetted Iron / EAF

The hot briquetting information, using natural gas-based HBI, was gathered from material presented at the Midrex HBI/DRI Melting Seminar[3], and data provided for the Midrex 2000 Operations Report[4].

Pig Iron / EAF

The pig iron information was based upon communications with steelmakers using high percentages of pig iron by Hornby-Anderson[3, 5] and the second covering the average of four BF operations in the USA, reported in *Iron & Steelmaker*[2].

FASTMET / EAF

The FASTMET information was based upon a summary of work presented by Hoffman[6]. The raw materials are assumed to be cold briquetted (CBQ) in this study case.

Hot FASTMET / EAF

The hot FASTMET information was based upon a summary of work presented by Hoffman[6] and private communications with McClelland[7]. This case differs from the previous case in that this FASTMET product is transferred hot to the EAF.

Table I – Conditions for Steelmaking Alternatives (continued)

FASTMET / EAF PRODUCTION CONDITIONS

Operation	Sequence Step	Conditions
Cold FASTMET-EAF	Cold Briquetting	• Coal reductant, organic binders, iron ore concentrate
	Direct Reduction	• Natural gas-fueled, rotary hearth furnace, hot briquetting, 2.5% carbon
	EAF	• 30% HBI, 70% scrap, carbon injection, 20 Nm^3 / t oxygen, 0.04% carbon, 1620°C

HOT FASTMET / EAF PRODUCTION CONDITIONS

Operation	Sequence Step	Conditions
Hot FASTMET-EAF	Hot Briquetting	• Coal reductant, organic binders (iron ore concentrate)
	Direct Reduction	• Natural gas-fueled, rotary hearth furnace, 2.5% carbon, hot transfer at 500°C
	EAF	• 30% HDRI, 70% scrap, carbon injection, 20 Nm^3 / t oxygen, 0.04% carbon, 1620°C

FASTIRON / EAF PRODUCTION CONDITIONS

Operation	Sequence Step	Conditions
FASTIRON-EAF	Cold Briquetting	• Coal reductant, organic binders (iron ore concentrate)
	Direct Reduction	• Natural gas-fueled, rotary hearth furnace, 1000°C
	EIF™	• AC furnace, 4.5% carbon, 1500°C
	EAF	• 30% HM, 70% scrap, carbon injection, 20 Nm^3 / t oxygen, 0.04% carbon, 1620°C

SCRAP / EAF PRODUCTION CONDITIONS

Operation	Sequence Step	Conditions
Scrap / EAF	EAF	• 100% scrap, carbon injection, 20 Nm^3 / t oxygen, 0.04% carbon, 1620°C

FASTIRON® / EAF

The FASTIRON information was based upon a summary of work presented by Hoffman[6]. The production of FASTIRON, a liquid hot metal product, uses the FASTMET rotary hearth direct reduction technology and close links the hearth with an EIF™, electric ironmaking furnace, to produce the hot metal and thereby reduce the slag compounds going to the EAF.

Scrap / EAF

The scrap information was based upon discussions with steelmakers Hornby-Anderson[3, 5]. The information is being primarily presented to show the background scrap results, which were used in nearly all of the case comparisons.

Energy And Emissions Results

Figure 1 summarizes the results of the total energy and carbon emissions evaluation for the production methods indicated. The total energy and carbon emissions are given in Mcal/t of liquid steel and kg-C/t liquid steel, respectively. *[Ed. Note: The kg-C/t denotes the carbon contained in the CO_2.]*

The results of the study indicate that:

- To minimize energy consumption and carbon emissions, use the maximum amount of scrap possible.
- Since many steel products cannot be made with a 100 percent scrap feed, a portion of alternative iron is needed to meet quality requirements.
- The type of AI used does not have a major impact on energy consumption or carbon emissions; however, DRI and HBI have lower energy consumption and carbon emissions than pig iron.
- For a 100 percent iron ore-based steelmaking facility, the MIDREX Process provides lower energy consumption and carbon emissions than the BF/BOF technology.

FASTMET and FASTIRON offer advantages in raw material flexibility with minimal increase in carbon emissions and lower energy consumption overall. The cases considered here utilized an iron ore concentrate only, but these processes can easily consume the waste oxide streams of a steelmaker along with the concentrate in producing their respective products. *[Ed. Note: More data will be forthcoming in the next Direct From Midrex.]*

For an ore-based ironmaking/steelmaking process, the MIDREX Process has lower energy consumption and carbon emissions versus the blast furnace/BOF because of its efficiency and the use of natural gas. Production of steel using the MIDREX Process/EAF route in natural gas rich countries can lower overall energy use and carbon emissions. A possibility would be for industrialized countries to "buy" emissions credits from natural gas rich countries.

Acknowledgements

The authors would like to acknowledge the kind support of Midrex Technologies, Inc., Kobe Steel, MIDREX Process Licensees and contributing steelmakers for providing their operating data for the continued improvement in steelmaking operations.

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Advanced Gas Analysis Using Mass Spectrometers

By: Jim Helle
Manager-Midrex Solutions™

The single-point analyzers traditionally used for gas analysis in MIDREX® Plants are limited to a single gas component (i.e., H_2S, CO, CO_2, CH_4, or O_2). In the latest generation designs, Midrex has installed on-line mass spectrometers, which provide much more information than a single-point analyzer.

Single-point analyzers display the concentration of the gas component that it is calibrated for and this is used for single-loop control and/or to provide a record of the data. To obtain any additional information on a particular gas stream, a sample of gas must be taken to the lab for Orsat or gas chromatograph (GC) analysis to identify the different components in the gas stream.

A mass spectrometer analyzes the whole gas stream and displays the complete gas composition, typically 8–10 components. This provides on-line data to the control room and allows for changes to be made to the process much quicker than having the lab provide the information. The lab may still run Orsat or GC analyses periodically, mainly to verify the data from the mass spectrometer.

Running gas analyses in the lab is a time-consuming process. The different gas samples must be taken in the field, then the separate analyses are run and the data for each stream is recorded. The lab then passes this information on to the control room. It is not uncommon for the control room to receive data that is 2-3 hours old.

On-line mass spectrometer gas analysis incorporated into the Distributed Control System (DCS) allows for more advanced control loops. One example would be the benefits of knowing the real-time reformed gas analysis. With the information from the reformed gas stream, the H_2/CO ratio could be measured directly. This could allow a plant to operate closer to the minimum H_2/CO ratio, as the H_2/CO ratio would be controlled directly rather than by the calculated percentage of water in the process gas or by process gas temperature.

A mass spectrometer incorporates a sampling system that allows it to monitor several gas streams. The sampling system will step through up to 64 different sampling points. The more points that are sampled the longer it takes to get updated data on any one stream. The combination of a good sampling sequencer and a mass spectrometer can analyze 30 different points in about eight minutes.

Mass spectrometers have been used to replace the redundant analyzers in MIDREX Plants (typically seal gas O_2, reformed gas CO_2, reformed gas CH_4 and bustle gas CH_4). Where redundant analyzers are required, one existing single point analyzer can be maintained, using the mass spectrometer as the redundant analyzer.

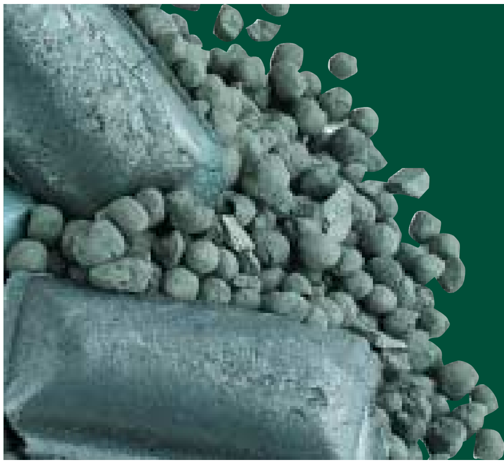
Mass spectrometers are now part of the standard MIDREX Plant design.

The advantages include faster gas analyses, increased process data, possibility of more advanced control loops and foundation for Level 2 control, reducing the number of analyzers in the plant and more efficient use of reductants.

A complete mass spectrometer system with 16-point calibration panel and local computer costs $170,000 – $220,000 and can be installed while the plant is operating. Each existing sample stream requires a tap/isolation valve to be provided on the sample conditioning panel. For any additional sample streams a new sample conditioning panel may be required.

Midrex has designed many advanced control features for MIDREX Plants (Level 1.5); for more information see 1st Quarter 2000 *Direct From Midrex* (downloadable from www.midrex.com). Midrex is also designing a Level 2 Control System that will further optimize plant operations by predicting metallization and carbon on-line.

On-line gas analysis of the components in the various gas streams, by a device such as a mass spectrometer, is needed to fully utilize the features of these Advanced Control packages. For example, valuable catalyst protection and reformer performance information can be obtained using data from an on-line mass spectrometer [such as the feed gas molar ratios, (H_2 + CO) produced per tube, reformer heat duty (Gcal/h/tube), reformer normalized DP, etc.].



MARKET ANALYSIS

Scrap, DRI, and Pig Iron: WHAT'S NEXT?

By: John Kopfle
Director - Marketing and Planning
Midrex Technologies, Inc.

As late as the 1980s, virtually all EAFs ran on a 100 percent scrap charge. For the year 2000, the percentage of alternative iron (direct reduced iron, hot briquetted iron, merchant pig iron and hot metal) fed to the EAF in North America was more than 18 percent, and worldwide over 20 percent. DRI alone comprised about 9 percent of the charge mix in North America, 13 percent globally.

Given record world steel production and the widespread demand and usage of alternative iron, the downturn in steel and metallics prices from mid 2000 was unexpected. Although prices have recovered somewhat, they are well below profitable levels.

The 2000 downturn was disturbing for two reasons: 1) world steel production and metallics demand were at all-time highs, 2) the downturn occurred barely two years since the last deep one — normal steel cycles are 5–8 years trough-to-trough.

From 1995–2000, North American (US and Canada) EAF production increased 17 million tons (Mt) and world output grew 47 Mt, yet steel and metallics prices dropped $50–$100/t.

Does this portend a change in the relationship between steel production and prices and in steel cycles? What is the future for alternative iron?

Metallics Sources: 2001–2010

Clearly, mini-mill growth will continue as steel demand increases and blast furnaces are closed. Total EAF metallics demand will increase significantly to 2010. What will be the sources of the required feedstock? Midrex has forecasted metallics requirements for North America and the world out to 2010.

North America

Imported scrap will likely stay at present levels. The dollar is not expected to strengthen further, and there are economic and logistical restrictions on increasing scrap imports. Also, the former USSR economies must eventually reform, which will reduce their need to export scrap at unrealistically low prices.

Domestic scrap, under this scenario, requires a 21 Mt increase in generation. This is a large increase, nearly four times the rise from 1995–2000. Also, scrap quality is an issue.

Captive DRI production will increase with the growth of coal-based technologies such as FASTMET®. There will probably be no more gas-based plants built in North America, and little merchant production. However, there should be a sizable jump in HBI imports from Venezuela and Trinidad with their low production costs and favorable locations. DRI and HBI will continue to be an essential part of the North American EAF charge mix.

Midrex forecasts that North American pig iron imports will decrease over time. Although Brazilian charcoal pig iron is touted as an environmentally friendly material, the reality is different. Today, only about 30 percent of the trees harvested are replanted, whereas the govern-

ment mandate is 70 percent. The working conditions at the charcoal ovens are not good and would not be tolerated in an industrialized country. In a true capitalist economy, the cost of producing and shipping pig iron would not allow steelmakers in Russia and the Ukraine to export to North America or Asia at a profit. It is being done now to earn foreign exchange but will not persist indefinitely.

Hot metal use in EAFs is expected to grow dramatically over the next few years because of the EAF productivity benefits. Many new technologies are being developed. These include FASTMELT™, which employs a rotary hearth furnace producing DRI that is melted, then charged to an EAF.

World

A world EAF metallics balance is shown in Table I. Gas-based captive DRI production will increase in areas with low cost natural gas and coal-based production will be employed elsewhere to supply the growing EAF requirements. Technologies such as HOTLINK™ will be employed to closely couple the DR plant and steel mill and utilize the DRI sensible heat. HBI trade will grow substantially as plants started up in the late 1990s reach full capacity.

Merchant pig iron trade will likely be flat from 2000–2010. Brazil, Russia, Ukraine, and China will continue to be sizable exporters because of their raw material cost structures and unique economics. Other countries such as Japan and India will jump in and out of the market, selling pig iron when steel demand drops. However, the merchant pig iron business is very difficult and is not generally profitable throughout the steel cycle.

Regarding hot metal use in EAFs, the same scenario applies worldwide as in North America, and it is expected to grow dramatically over the next few years because of the EAF cost and productivity benefits.

Despite environmental pressures, scrap generation in the industrialized world continues to grow, and the developing countries will produce more as well as their economies mature. Scrap exports from the former USSR will decline at some point, but this may not occur for many years.

	1995	1999	2000	2005	2010
Metallics requirements					
Steel production	752	788	844	850	900
% EAF	33	33	34	37	42
EAF production	248	263	282	315	378
EAF metallics required	273	290	310	346	416
Metallics sources					
Scrap	227	230	245	264	315
Captive DRI	21	29	31	41	52
Merchant DRI	8	8	10	16	19
Total DRI	29	37	41	57	71
Merchant pig iron	17	20	20	20	20
Hot metal	0	3	4	5	10

Table I World EAF Metallics Balance (Mt)

Implications

The reason for rock-bottom metallics prices while steel demand and production reached record levels appears to be excess metallics supply. Given the large number of metallics sources, the many countries involved, and the uncertainties of the real world, at times there is oversupply and undersupply, as with any market. Special problems are posed by metallics from the former USSR and pig iron from Brazil whose prices may not reflect the true cost of production.

The drop in world steel prices is also due to excess supply. The estimates vary, but there is 200–300 Mt of excess steelmaking capacity in the world. Although almost all observers agree there should be major rationalization, this is difficult to do because of political, labor, pension and healthcare liability factors.

Another factor resulting in the downturn in metallics and steel prices has been the strong dollar. From 1995–2000, the dollar appreciated 40 percent versus the currencies of the US' major trading partners. Since most steel and metallics trade is denominated in dollars, a strong dollar tends to depress prices.

What does the future hold? Assuming the world's economies continue growing at a moderate pace and steel demand does also, EAF production will comprise the bulk of the increase in steel output. This 2–3 percent per year EAF production increase will necessitate an increase in metallics supply, some of which will be provided by DRI/HBI. Midrex forecasts a world DRI production increase of about 3 Mt/y for the period 2001–2010.

The consensus opinion is that 1–2 years will be required for the present low metallics prices to recover substantially. Thus, a new wave of interest in DR plants should occur in 2–4 years; i.e., the 2003–2005 time frame. Despite all the talk about the "new economy", we can expect that business and steel cycles will continue.

Midrex Solutions™ Offers Steel Plant Training

Midrex Solutions has announced that it will now provide steel operations training courses and custom seminars for groups and companies. Drawing upon Midrex's wealth of technical knowledge and experience, Midrex Solutions is able to provide steel training that focuses on operator understanding, process optimization, cost reduction and yield improvement. These can range from one-day programs to two-week, hands-on seminars and educational sessions on topics relevant to MIDREX® Plants and Mini-mills.

For more information regarding *Midrex Solutions Training Programs*, please contact:

Jim Helle, Manager, Midrex Solutions
direct line: (704) 378-3393
fax: (704) 373-1611
e-mail: solutions@midrex.com

Current training includes:

- Complete DRI Plant operations
- EAF optimization
- Steel mill industrial gas usage
- HBI / DRI use and optimization
- Melting seminars
- Custom programs

Around the World: Midrex at SEAISI

Highlights from the 30th Anniversary SEAISI Conference held earlier this year in Singapore.

Midrex Announces Donald Beggs Scholarship Winners

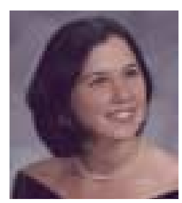
Midrex Technologies, Inc. is pleased to announce the 2001 winners of the Donald Beggs Scholarship. This award is named for Donald Beggs, who conceived the idea for MIDREX® Direct Reduction Process in the early 1960s.

The $3,000 academic 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. This year's named recipients are Victoria Elliot and Susan Metius.

Daughter of Antonio Elliot, Manager of Technical Services at Midrex, Ms. Elliot is a sophomore at the University of North Carolina – Chapel Hill. She is majoring in biology with a minor in chemistry and also volunteers at the university's student health clinic.

Victoria Elliot

Ms. Metius, a junior at the University of North Carolina at Wilmington, is also majoring in biology, with a minor in Spanish. Ms. Metius is the daughter of Gary Metius, Manager-New Technology at Midrex and plans to study next summer in Ecuador to further build upon her Spanish minor.



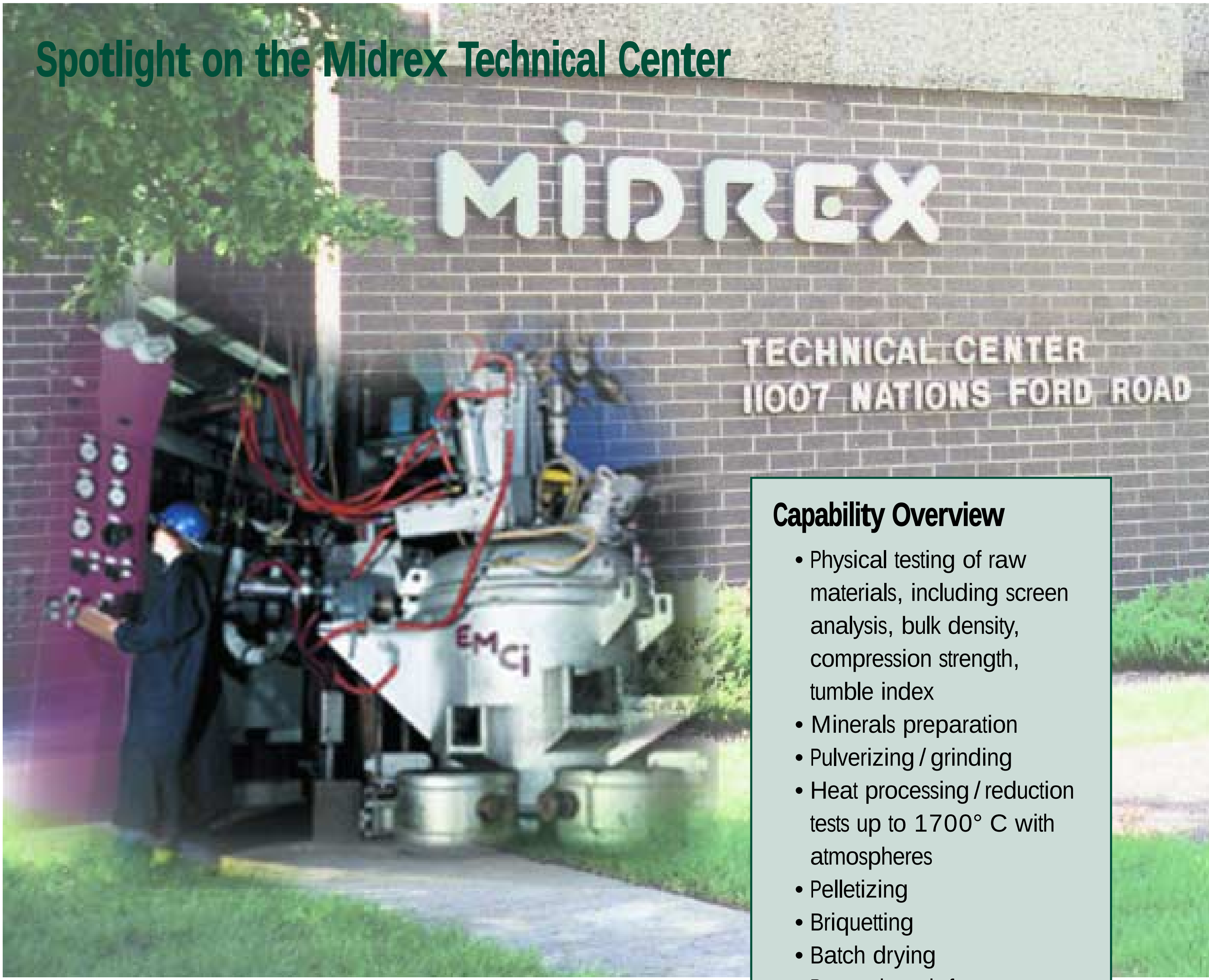
Susan Metius

Midrex congratulates this year's winners and wish them luck with their continuing academics and future careers.

Upcoming Events

Midrex will present the latest paper on FASTMET® at the International Conference on DR and Direct Smelting – Jamshedpur, India, October 5–6. Midrex will have a booth at the ILAFA Expo – Lima, Peru October 21–24 and at the 59th Electric Furnace Conference November 11–14 – Phoenix, Arizona. For more information visit www.midrex.com.

Spotlight on the Midrex Technical Center



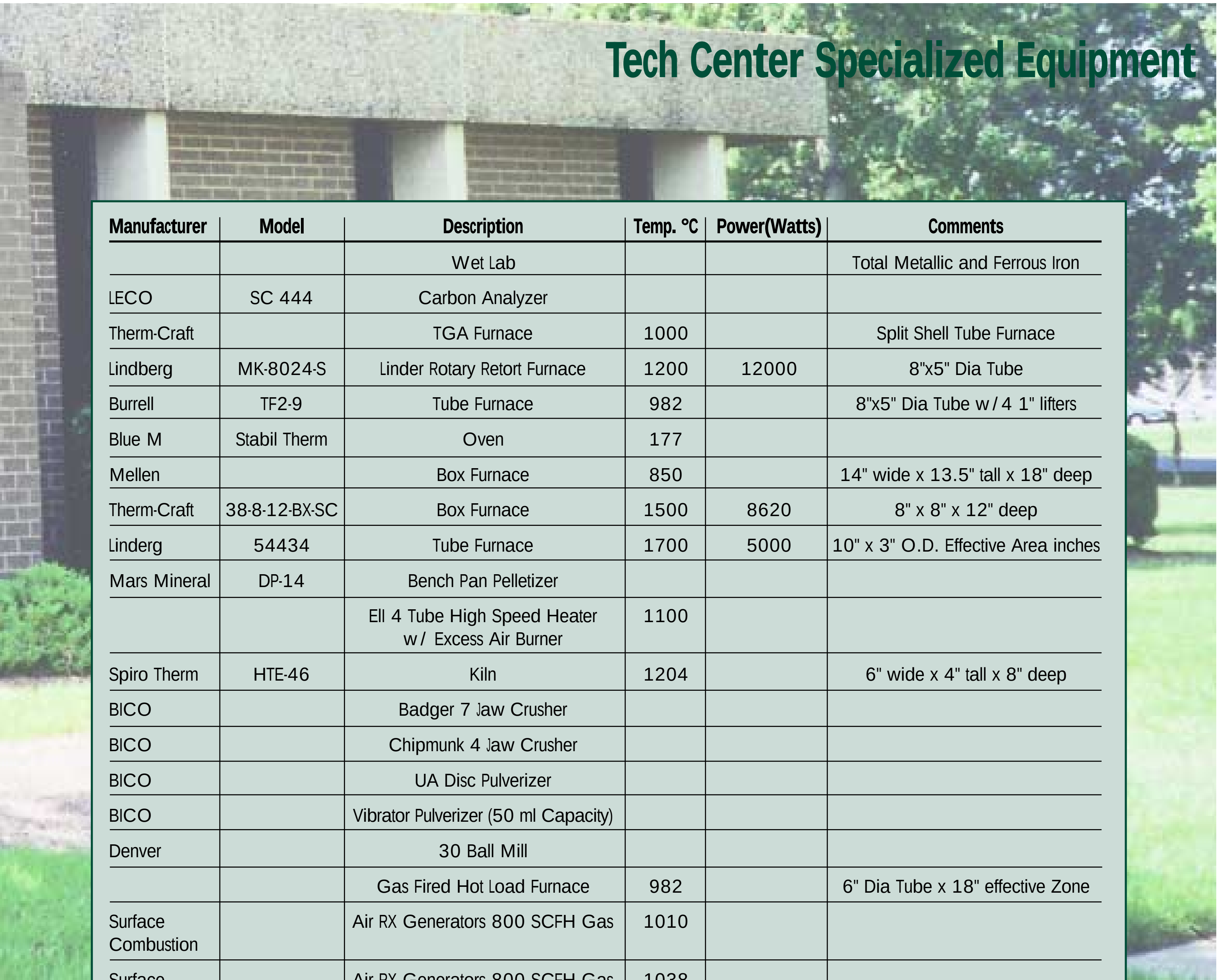
Capability Overview

- Physical testing of raw materials, including screen analysis, bulk density, compression strength, tumble index
- Minerals preparation
- Pulverizing / grinding
- Heat processing / reduction tests up to 1700° C with atmospheres
- Pelletizing
- Briquetting
- Batch drying
- Rotary hearth furnace 1500° C 150 Kg / hr
- Electric ironmaking furnace single phase, 250 KVA

The Midrex Technical Center is an invaluable resource for testing, research, analysis and development. Located in Pineville, North Carolina, near Midrex's corporate headquarters in Charlotte, North Carolina, the Midrex Technical Center contains a variety of equipment for preparing, processing and analyzing raw materials, reductants and energy sources.

The Midrex Technical Center is used for Midrex Technology development projects and several of the MIDREX® Process enhancements have been tested and refined at the center. It is also available on a contract basis.

The Tech Center also has extensive capabilities for testwork on the FASTMET® and FASTMELT® Processes. In early 1992, Midrex constructed and operated a nominal 350 pounds per hour FASTMET pilot plant which contained a pelletizing and screening system, pellet drying system, a nine-foot diameter RHF reduction furnace and an offgas treatment system. More than 100 campaigns were run at the pilot plant from 1992-1994. An electric ironmaking furnace (EIF™) has been added for testing the FASTMELT Process.



Tech Center Specialized Equipment

Manufacturer	Model	Description	Temp. °C	Power(Watts)	Comments
		Wet Lab			Total Metallic and Ferrous Iron
LECO	SC 444	Carbon Analyzer			
Therm-Craft		TGA Furnace	1000		Split Shell Tube Furnace
Lindberg	MK-8024-S	Linder Rotary Retort Furnace	1200	12000	8"x5" Dia Tube
Burrell	TF2-9	Tube Furnace	982		8"x5" Dia Tube w/4 1" lifters
Blue M	Stabil Therm	Oven	177		
Mellen		Box Furnace	850		14" wide x 13.5" tall x 18" deep
Therm-Craft	38-8-12-BX-SC	Box Furnace	1500	8620	8" x 8" x 12" deep
Linderg	54434	Tube Furnace	1700	5000	10" x 3" O.D. Effective Area inches
Mars Mineral	DP-14	Bench Pan Pelletizer			
		Ell 4 Tube High Speed Heater w/ Excess Air Burner	1100		
Spiro Therm	HTE-46	Kiln	1204		6" wide x 4" tall x 8" deep
BICO		Badger 7 Jaw Crusher			
BICO		Chipmunk 4 Jaw Crusher			
BICO		UA Disc Pulverizer			
BICO		Vibrator Pulverizer (50 ml Capacity)			
Denver		30 Ball Mill			
		Gas Fired Hot Load Furnace	982		6" Dia Tube x 18" effective Zone
Surface Combustion		Air RX Generators 800 SCFH Gas	1010		
Surface Combustion		Air RX Generators 800 SCFH Gas	1038		
		High Convection Dryer w/ 825 SCFM Blower	760		2' x 2' Drying Area
Simpson		60 kg Mixer-Muller			
Simpson		20 kg Mixer-Muller			
Komarek	B-250-1	Briquetter			5,12, and 20cc Dies
Mars Mineral	D2OHD	24 Drum Pan Pelletizer			
LECO	GDS-400 A	Glow Discharge Spectrometer			
Comten Industries		Automatic Driver Compression Tester			
Carver		Hydraulic Press w/ 6.5 Ram Stroke			
MTI	P200H	Gas Chromatograph			

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