Overview of Market for Direct Reduced Iron

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Unlike the blast furnace process, which utilizes coking coal, the direct reduction process utilizes natural gas and non-coking coal as a reductant. The worldwide production of direct reduced iron (DRI) has rapidly increased. This paper outlines the history and prospects of the market for direct reduced iron.

Direct reduction iron-making is a method for producing iron without using a blast furnace. Direct reduction iron-making was first industrialized in the 1960s, and various plants started to be built on the commercial and semi-commercial scales. Direct reduction iron-making processes roughly fall into two classes, natural gas base and coal base, depending on the reductant used. The former includes the MIDREX® process and the HYL/ENERGIRON process, while the latter includes the SL/RN process, the FASTMET® process, the FASTMELT® process and the ITmk3® process.

The production volume of direct-reduced iron has increased steadily. As shown in **Fig. 1**, between 1970 and 2008, the volume increased by a factor of more than 80 from about 800 thousand tonnes to approximately 68 million tonnes.

Kobe Steel has built many direct reduction iron-making plants over the world since the company first delivered a direct reduction iron-making plant to the Qatar Steel Company; this plant began operation in 1978, based on the MIDREX process. In 1983, MIDREX Technologies, Inc. became a wholly-owned subsidiary of Kobe Steel. Currently, about 58% of the direct reduced iron produced in the world is made by the MIDREX process (**Fig. 2**).

Direct reduction iron-making plants are much less capital intensive than blast furnace based plants and do not require coke either. Because of this, developing countries, particularly natural gas producing countries, have built direct reduction iron-making plants for their own ironworks.

As-reduced iron is known to have pores which are left after oxygen has been removed. These pores, if filled with water, for example, can cause the iron to re-oxidize, generate heat and occasionally ignite a fire. This makes the marine transport of reduced iron difficult, and ironworks must consume it in-house.

To resolve this issue, Kobe Steel introduced a technology for agglomerating the reduced iron into hot briquette iron (HBI) to prevent re-oxidation. This technology has facilitated the marine transport of reduced iron, making it an iron source for the global market.

With this background, several countries, such as Venezuela, have built direct reduction iron-making plants with HBI technology and are specializing in exporting the HBI.

As shown in **Fig. 3**, the demand for crude steel has increased rapidly since the beginning of this century, supported by strong demand in the BRIC countries.

Year	Total	Year	Total	Year	Total	Year	Total
1970	0.79	'80	7.14	'90	17.68	'00	43.78
'71	0.95	'81	7.92	'91	19.32	'01	40.32
'72	1.39	'82	7.28	'92	20.51	'02	45.08
'73	1.90	'83	7.90	'93	23.65	'03	49.45
'74	2.72	'84	9.34	'94	27.37	'04	54.60
'75	2.81	'85	11.17	'95	30.67	'05	56.99
'76	3.02	'86	12.53	'96	33.30	'06	59.79
'77	3.52	'87	13.52	'97	36.19	'07	67.22
'78	5.00	'88	14.09	'98	36.96	'08	68.45
'79	6.64	'89	15.63	'99	38.60		

Source : Midrex Technologies, Inc.

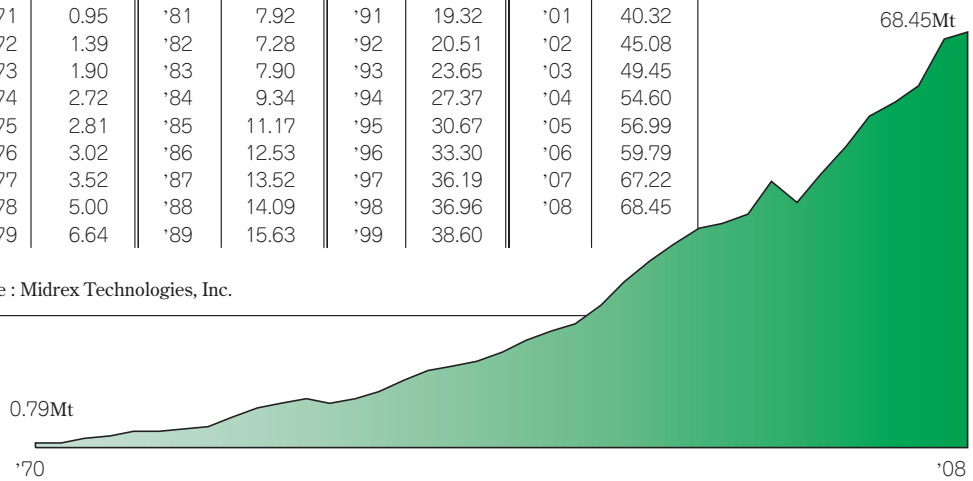


Fig. 1 World-wide direct reduced iron production by year

It remains strong, although the growth rate has slowed since the latter half of 2008 due to the financial crisis triggered by defaults on sub-prime mortgage loans in the United States.

The demand for the construction of direct reduction iron-making plants has increased in response to the increasing demand for crude steel. Many plants based on the MIDREX process were built one after another between 2005 and 2008. In addition, strengthened environmental controls promoted the use of the FASTMET process for separating constituents such as zinc from iron-making dust to produce/recycle reduced iron.

Fig. 4 shows the plants currently in operation based on the MIDREX and FASTMET processes.

The top three regions producing reduced iron are Asia/Oceania, Middle East/North Africa and Latin America. In the Asia/Oceania region, India has significantly increased its production volume in recent years. It produces reduced iron mainly by the SL/RN process using coal as a reductant. On the other hand, in the Middle East, North Africa and Latin America, regions rich in natural gas, produce reduced iron using their natural gas as a reductant (**Fig. 5**).

As the BRIC countries continue to industrialize, the global competition for natural resources has become increasingly severe. As a result, high-quality resources such as high-grade ore and coal are becoming depleted, and the leaving resources that are inferior in quality. In addition, environmental regulations such as CO_2 restrictions are becoming more stringent with global awareness of environmental protection.

Direct reduction iron-making helps to address the resource issue, as it allows the use of low grade iron ore and non-coking coal. There are high expectations for the direct reduction process for ironmaking, with its low environmental burden, including small CO_2 emissions.

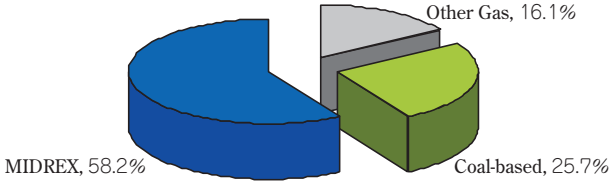


Fig. 2 World-wide direct reduced iron production process in 2008

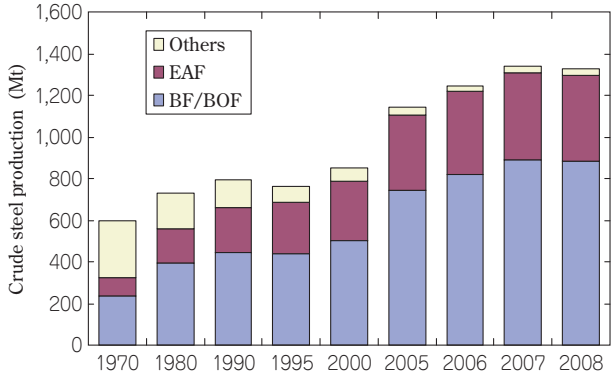


Fig. 3 World-wide crude steel production

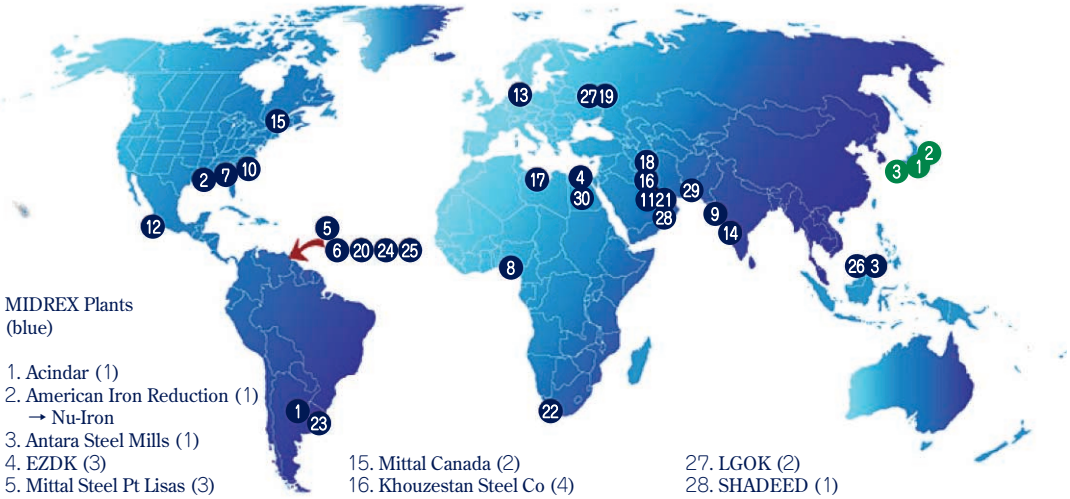
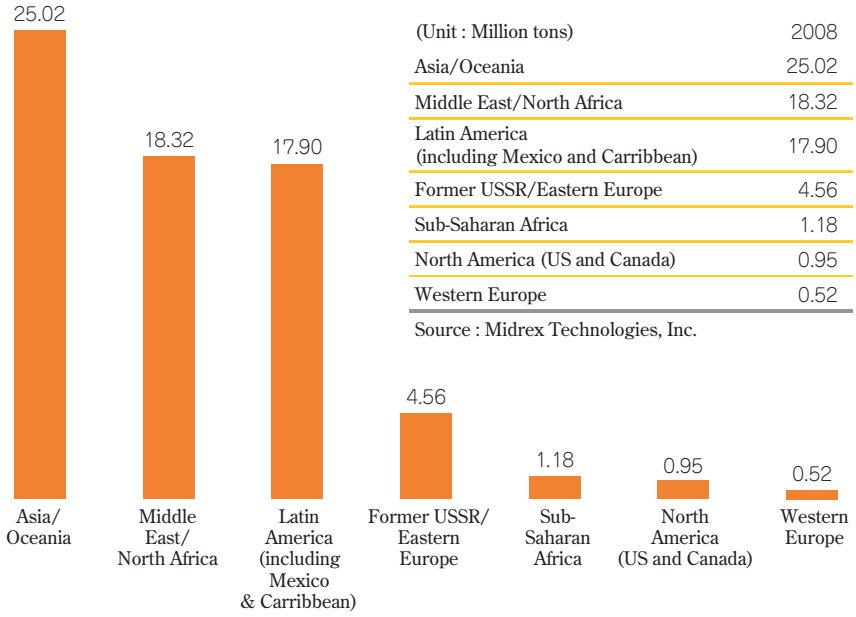


Fig. 4 MIDREX/FASTMET plant in the world



(Unit : Million tons)	2008
Asia/Oceania	25.02
Middle East/North Africa	18.32
Latin America (including Mexico and Carribbean)	17.90
Former USSR/Eastern Europe	4.56
Sub-Saharan Africa	1.18
North America (US and Canada)	0.95
Western Europe	0.52

Source : Midrex Technologies, Inc.

Fig. 5 World-wide direct reduced iron production by region in 2008

Year	DRI	HBI	Year	DRI	HBI	Year	DRI	HBI
1970	0.004	—	'85	0.71	0.61	'00	4.54	5.02
'71	0.04	—	'86	0.89	0.73	'01	2.83	6.58
'72	0.08	—	'87	0.85	0.77	'02	4.85	6.45
'73	0.13	—	'88	1.48	0.83	'03	4.63	7.63
'74	0.26	—	'89	1.27	0.94	'04	4.26	6.82
'75	0.34	—	'90	1.46	1.71	'05	6.76	7.12
'76	0.37	—	'91	1.29	2.67	'06	7.81	6.75
'77	0.32	—	'92	1.45	2.71	'07	10.82	6.24
'78	0.28	0.11	'93	1.45	3.56	'08	8.01	5.99
'79	0.66	0.12	'94	2.44	3.93			
'80	0.81	0.25	'95	3.69	3.98			
'81	0.83	0.25	'96	3.58	3.20			
'82	0.80	0.18	'97	3.99	3.51			
'83	0.59	0.36	'98	4.24	3.00			
'84	0.83	0.39	'99	4.01	4.41			

Source : Midrex Technologies, Inc.

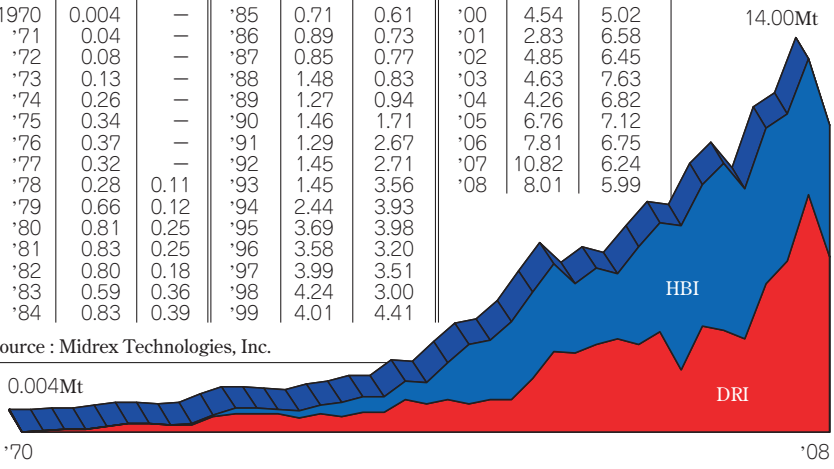


Fig. 6 World-wide direct reduced iron shipment by year

Even in advanced countries such as the USA, the demand for reduced iron as an alternative source of clean iron is increasing and the volume of reduced iron shipment is also on the rise (**Fig. 6**). Steelmaking in electric arc furnaces (EAFs) has been expanding (**Fig. 7**), and this factor too will increase the demand for reduced iron.

Plants based on the FASTMET, FASTMELT and ITmk3 processes use coal as a reductant. They are more flexible in their site location than the plants based on the MIDREX process, which requires natural gas. Thus, the demand for FASTMET, FASTMELT and ITmk3 plants is expected to grow, as well as the demand for the MIDREX plants.

The Kobe Steel group owns various promising direct reduction processes for iron-making and will continue to contribute to iron and steel production world-wide.

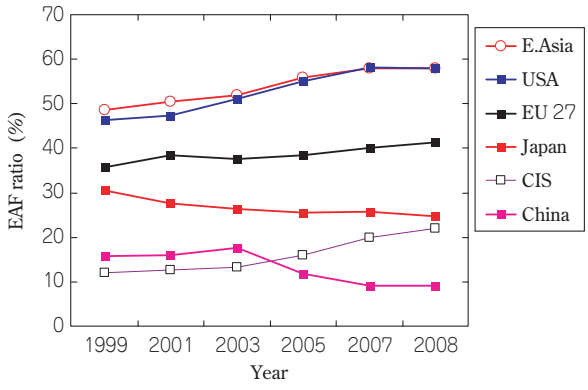


Fig. 7 EAF ratio of crude steel production