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HBI: Thirty Years Old and Still Growing

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Hot briquetting of direct reduced iron (DRI) has been practiced on an industrial scale for 30 years and is now the preferred method of preparing DRI for storage and transport.

Beginning with the start-up of the FIOR de Venezuela plant in late 1976 in Puerto Ordaz, Venezuela, hot briquetting has been proven technically and commercially over the years. *(See Note #1 on page 6)* The FIOR plant operated three briquetting machines supplied by Maschinenfabrik Köppern GmbH & Co. KG and was capable of producing about 400,000 metric tons per year (t/y). It and the second hot briquetted iron (HBI) plant (Thyssen Purofer plant in Ahwaz, Iran), which are no longer in operation *(see Note #2 on page 6)*, introduced a product form that is now produced by 14 other direct reduction plants worldwide. In 2005, these plants produced well over 10 million metric tons (Mt) of HBI. An additional four MIDREX® Direct Reduction Plants representing 5.94 million tons per year total capacity are under construction. These plants will produce HBI as all or a portion of their output. By the beginning of 2007, Köppern will have supplied more than 100 presses for HBI worldwide.

This article will review the 30-year history of hot briquetting - why it is done and what are the relevant issues today.

Why Hot Briquetting?

As the DRI industry experienced its early growth in the 1970s, numerous steel works around the world were curious about its uses and how they might apply it in their own practices. Shipments of DRI went to many locales, and quite a number of papers were published describing the use of this "new" form of iron. *(See Note #3 on page 6)* But one aspect of DRI's nature quickly became evident: under specific circumstances, it was possible for the heat of oxidation from wet, rusting DRI to accumulate, and if these circumstances were prolonged, the temperature of the iron could continue to rise to the point of combustion. In some cases, the DRI softened and agglomerated into a cluster.

During the first few years of use, DRI was so popular that Midrex reported that merchant shipment accounted for approximately 10 percent of the total output of MIDREX Plants, although none of the plants had been built for merchant supply. However, there were some incidents in which cargoes of DRI overheated while involved in deep water transport. In some cases, it is possible for hydrogen to be produced in the ship holds, creating a flammable gas mixture. Because of these incidents, by 1982 shipments of DRI had declined significantly. Cargo insurance rates for ocean transport rose to the point that the cost of insurance essentially was prohibitive to shipment.

Midrex investigated a number of potential techniques for passivating DRI to make it safer to ship, including one that is being marketed by others today. All of these investigations led to dead ends except one promising method where DRI is briquetted at a temperature of 650-700° C to make a product known as hot briquetted iron (HBI). The briquettes are pillow-shaped, with typical dimensions 30 mm X 50 mm X 100 mm. Briquetting closes up the pores of the DRI and greatly reduces the surface area available for reoxidation. It increases the density of the product by a factor of two.

Early tests by Midrex of HBI product showed that it was approximately 100 times more resistant to oxidation (dry conditions tests) than DRI passivated by the means routinely practiced at that time. In addition, Midrex found that the heat created by oxidation was more easily conducted through the briquettes; therefore, the heat would not collect within the bulk stack of iron. The result of these two mechanisms – far lower oxidation rates and much better conduction of heat out of the stack of iron - prevents the overheating and combustion of the reduced iron product. Figure 1 shows the typical reactivity of various forms of dry DRI. Note that the y-axis is logarithmic, emphasizing the extremely low reactivity of HBI.

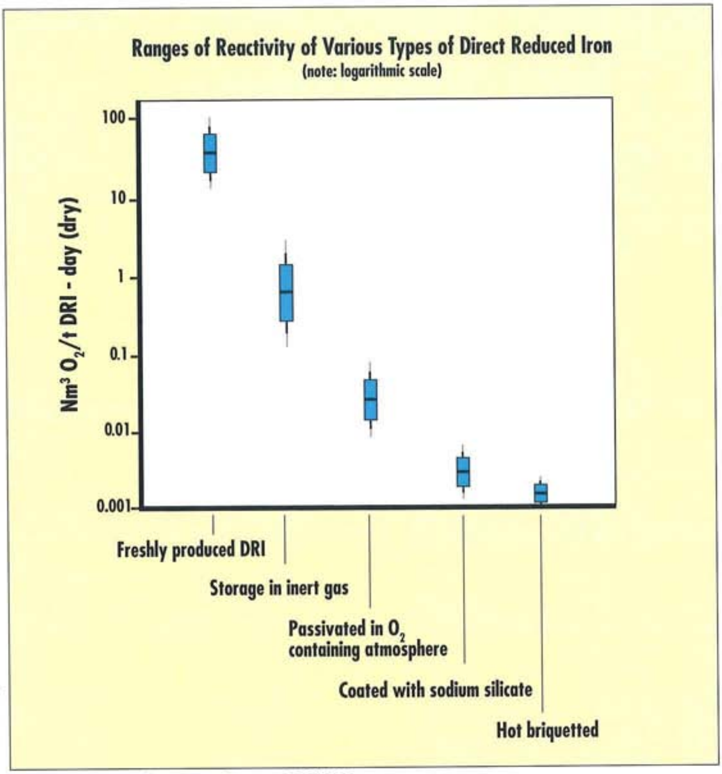

Figure 1 - Ranges of reactivity of various DRI/HBIs

Today, nearly 14 million tons of DRI is shipped annually

Also in the early 1980s, Midrex was in the preliminary design phase of the Sabah Gas Industries (SGI) direct reduced iron plant in Malaysia (now know as Antara Steel). Because SGI was to be a dedicated merchant facility, it was decided that HBI technology, based on machines designed and supplied by Köppern, should be included in the plant. After start-up, SGI shipped 100 percent of its output without any incident.

The HBI concept proved to be remarkably successful, as evidenced by the large number of plants built since SGI and as noted in the second paragraph of this article. The growth of HBI allowed direct reduced iron to be shipped anywhere in the world with much less strenuous precautions required to ensure product and vessel safety. With this improvement, the percentage of MIDREX® Iron shipped relative to the amount produced rose to twice its former level, representing approximately 20 percent of total production by MIDREX Plants.

IMO Guidelines, Passivation and Insurance

In 1982, an international effort by the iron and steel industry, shippers, insurance companies, and the International Maritime Organization (IMO) resulted in a set of guidelines for safe shipping and handling of DRI and of the newer product, HBI. These were incorporated into the Code of Safe Practice for Solid Bulk Cargoes, commonly known as the BC Code. This code is issued by the IMO with the following advice, "The BC Code is recommended to Governments for adoption for use as the basis for national regulations ..." As such, it has become the foundation for the laws relevant to transporting bulk cargoes, which are written by most sovereign nations.

Due to the much lower reactivity and higher thermal conductivity of HBI, the code is considerably less restrictive for transporting HBI. One of the more stringent requirements placed on DRI (but not needed for HBI) is a requirement for, "Maintenance throughout the voyage of cargo spaces under an inert atmosphere containing less than 5% oxygen; or that the DRI has been manufactured or treated with an oxidation- and corrosion-inhibiting process which has been proved, to the satisfaction of the competent authority, to provide effective protection against dangerous reaction with seawater or air under shipping conditions." *(See Notes #4 and #5 on page 6)*

Perhaps equally important is that the insurance companies do not recognize any practice for passivating DRI as being effective. Specifically, the Protection and Indemnity (P&I) Clubs, which provide insurance underwriting for oceangoing cargoes, have reinforced their stated positions that DRI must be inerted. Quoting from a circular recently released (August 2006) by Skuld, one of the P&I clubs, "The Association therefore continues to believe that the only proven method of carrying the low density product DRI (B) (that is, un-briquetted DRI) safely is by maintaining the cargo holds in an inert atmosphere ..."

Benefits of HBI - The Rest of the Story

As more and more MIDREX HBI plants have begun operation since 1984, the wealth of true operating knowledge and experience has validated HBI as the best technical and most economical solution for merchant DRI. This is evidenced by the recent wave of new plants and the acceptance of HBI as an alternate iron commodity to the steelmaking industry.

An innovative technology born from the need to safely transport DRI now provides HBI plants and steelmakers alike many other benefits including:

- High density HBI generally produces less fines than pellet or lump DRI and thus the yield to finished steel can be higher.
- An HBI plant has the ability to recycle fines to the briquette machines, thereby increasing productivity and adding value to the typically low value or zero value fines at DRI plants.
- HBI can be stored outside without special precautions so the end user (the steel mill) does not require special storage/inerting facilities.
- HBI can be moved using typical scrap handling equipment and easily batch charged to the EAF.
- HBI can be continually charged to the EAF with specially designed systems.

World DRI Shipments (Mt)

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

Source: Midrex Technologies, Inc.

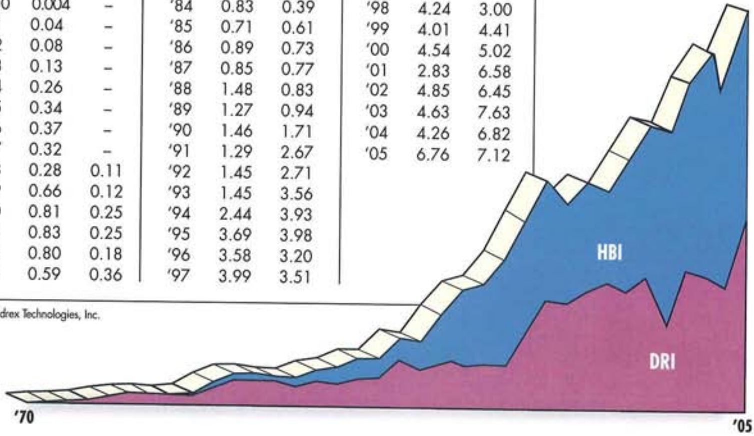

Figure 2 - HBI and DRI shipped year-by-year

Success of HBI

Over the past 30 years, massive quantities of HBI have been shipped to almost all corners of the globe, as shown in Figure 2 on the previous page. To date, shipments of HBI are believed to total more than 400 billion tons-kilometers. That is enough to ship the Great Pyramid at Giza around the world and then more than halfway around again!

Based on the success of HBI technology to date, more HBI plants are being built. A number of the direct reduction plants currently under construction include HBI capability, even though the plants are intended to make DRI for melting by an adjacent EAF. The ability to produce HBI will allow those facilities the flexibility to ship HBI during periods when the output of the direct reduction plant exceeds the needs of the meltshop, and to store the HBI easily and without the need for silos or other buildings when the steel works is down for maintenance..

The HBI industry continues to grow steadily. By 2010, it is expected that HBI shipments will exceed 10 million t/y. Hot briquetting has proven itself to be a crucial advancement, greatly facilitating the use of merchant DRI.

For more information, see the Hot Briquetted Iron Association Website: www.hbia.org

Acknowledgement

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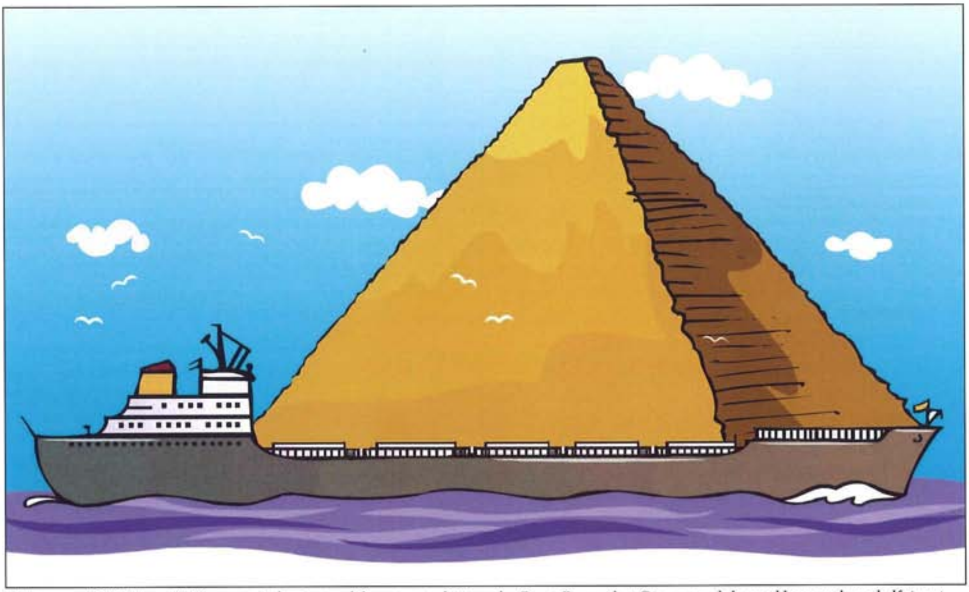

Shipments of HBI since 1976 are equivalent in ton-kilometers to shipping the Great Pyramid at Giza around the world one and one-half times!

Note #1. *There was an earlier attempt to produce HBI, the High Iron Briquette project, sponsored by US Steel in Venezuela, but it was not successful.*

Note #2. *Siderurgica Venezolano, the owners of the FIOR de Venezuela plant, are currently working to restart the plant.*

Note #3. *Midrex has some of these papers on file in its library. If you are interested, please contact* info@midrex.com.

Note #4. *The BC Code may be purchased from the IMO at .....* https://www2.imo.org/b2c_imo/b2c/init.do. *The sections about DRI and HBI are on pages 107-111.*

Note #5. *The "competent authority" is defined by the BC Code as, "A competent person recognized by the national Administration of the country of shipment." This person is also charged to "certify to the ship's master that the DRI, at the time of loading, is suitable for shipment."*

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