Massive CO_2 Savings by use of HBI made with natural gas. Where are the loci?

By Robert Hunter,
Midrex Technologies, Inc.

1. lo·cus (lok'əs) MATH.
a. any system of points, lines, etc. which satisfies one or more given conditions
noun pl. loci lo'ci' (lo'si')

INTRODUCTION

This is the second of a series of articles discussing the consumption of HBI in blast furnaces as a means of greatly decreasing the amount of CO_2 generated by ironmaking. The prior article was published in the 3rd/4th quarter 2009 'Direct From Midrex' as "Massive Savings in CO_2 Generation by Use of HBI."

The previous article discussed the means by which generation of CO_2 is prevented, namely by employing natural gas instead of coke as the source of reductant for transforming iron oxide into metallic iron. This article will describe potential logistics for how this might be done. Specifically, iron ores are in one location, the natural gas deposits are in others, and the blast furnace customers are in yet others. How might the flow of materials occur in order to make this concept a successful and profitable enterprise?

SOURCES OF IRON ORE

The international trade in iron ore has grown dramatically over the past few decades. It is now approaching one billion tons per year. Approximately 90% of this trade is carried in ocean going vessels; the so-called seaborne trade. Of this seaborne trade, between three-fourths and four-fifths originate in Australia, Brazil, or India, with Australia and Brazil each accounting for about one-third of the total and India supplying slightly more than one-tenth. Please refer to Figures I-3 which show the iron ore producing regions of the world (brown circles), the blast furnace ironmaking regions (red dots), and the major natural gas containing basins (green fields). First, let's focus on the iron ore exporting nations of the world.

Data from the United Nations Conference on Trade and Development (UNCTAD) for the year 2008 was used. The larger circles, in Australia, Brazil and India, represent 309, 282 and 101 million tons per year, respectively. The smaller circles are for Mauritania, Peru, Chile, Venezuela and Iran. The circles shown on this map represent over 98.5% of the world's total seaborne iron ore in 2008.

It should be noted that only 1.6% of the world's direct reduced iron is made from iron ore fines, with the remainder produced from pellets and lump. This is in sharp contrast to the shipments of iron ore, which are predominately fines and only a small portion of lump and pellets. For instance, exports from Brazil in 2008 were 17% pellets and 73% fines. Exports from Australia were even more markedly non-pellet, only 0.3%, whereas fines were 69%. Clearly, if large quantities of DRI are to be produced using natural gas, not only DR plants, but also pellet plants are needed.

BLAST FURNACE HBI USER LOCATIONS

The next question is, where must the DRI be shipped for blast furnace use, thereby greatly lowering the CO_2 production of the blast furnace and indeed, greatly lowering the global CO_2 generation of the ironmaking process? Again, refer to Figure 2 which shows an approximation of the locations of the blast furnaces of the world. Information is from the World Steel Association (WSA) 2009 data that has been plotted so that each

Location of merchant supplies of iron ore

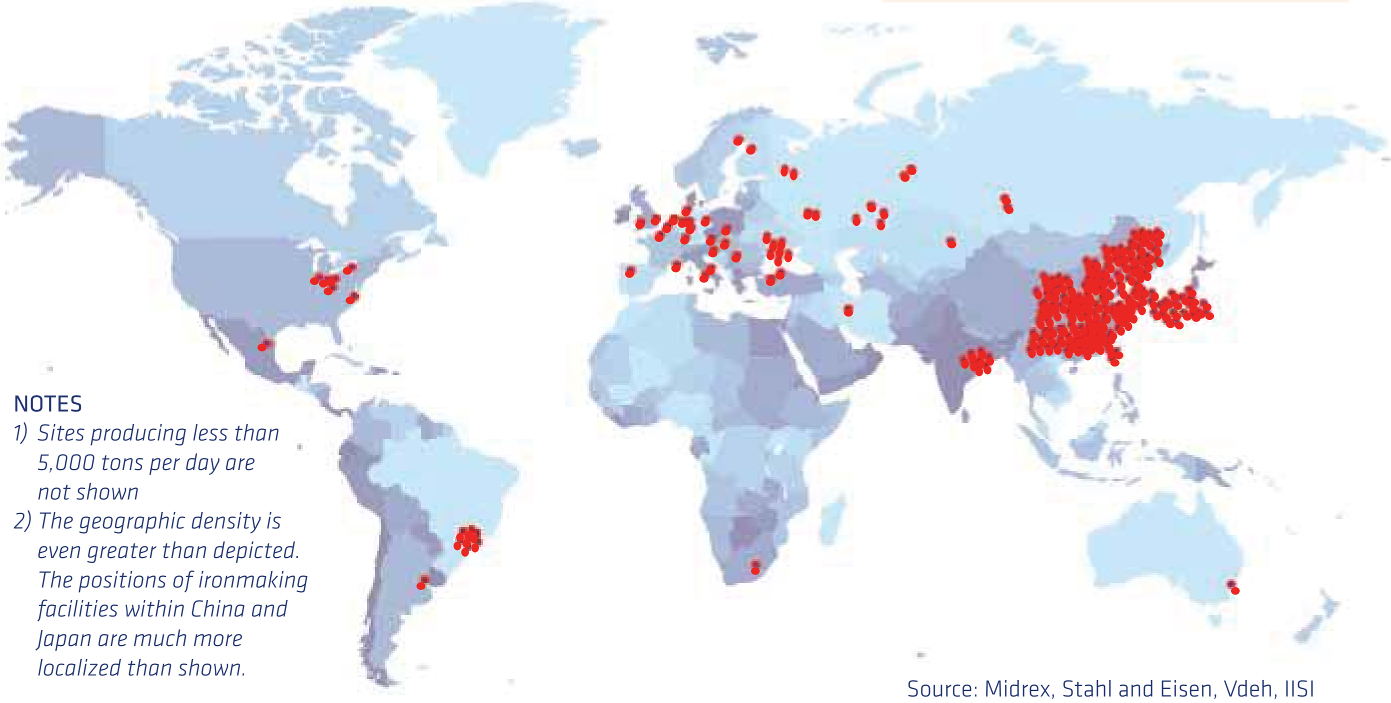
FIGURE 1

Location of world blast furnace hot metal production (in 2009)

FIGURE 2

WHERE THE IRONMAKING IS LOCATED

Each dot represents 10,000 tons/day of hot metal produced



NOTES

1) *Sites producing less than 5,000 tons per day are not shown*
2) *The geographic density is even greater than depicted. The positions of ironmaking facilities within China and Japan are much more localized than shown.*

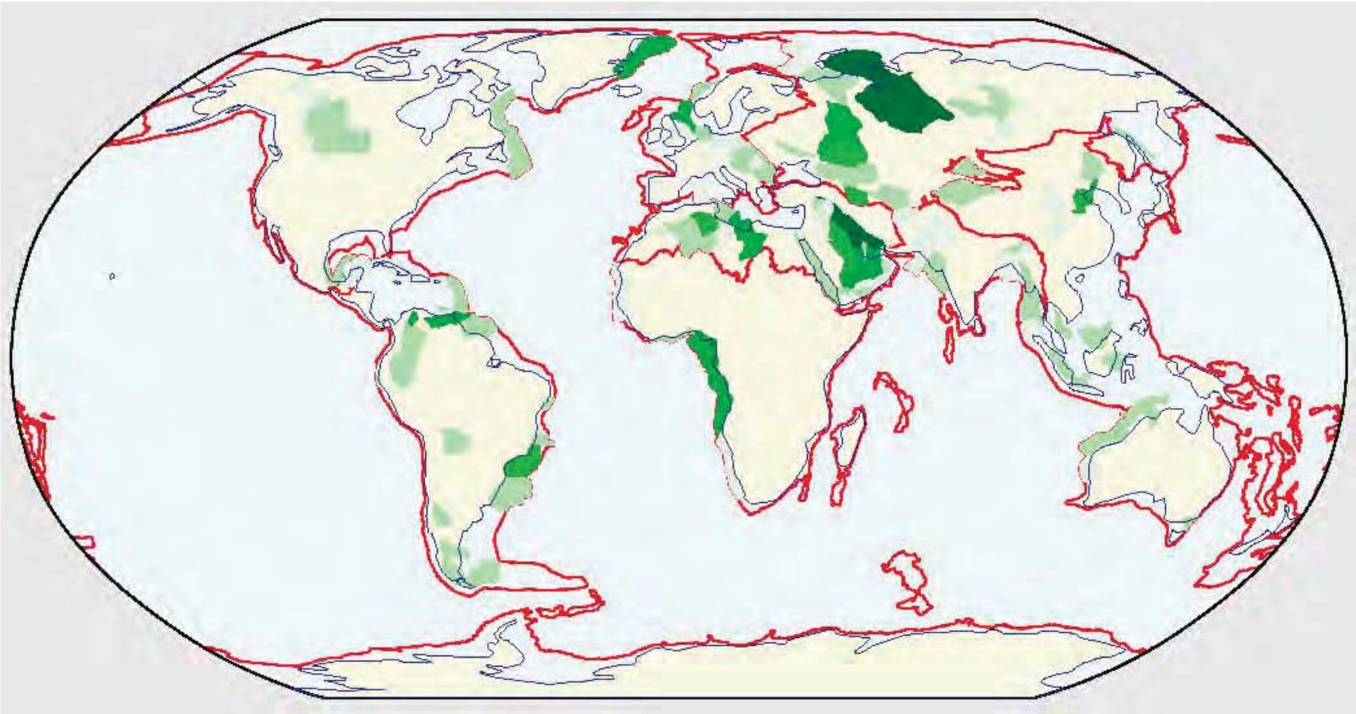
Source: Midrex, Stahl and Eisen, Vdeh, IISI

Location of natural gas

FIGURE 3

WHERE NATURAL GAS IS CONCENTRATED

Darker shaded regions show more concentrated areas of natural gas



Source: US Geological Survey

10,000 tons per day of hot metal production equals one red dot. There has been only a minor effort made to properly locate each dot within the country, so some of them might seem to be slightly out of place. Also, since everything is averaged to the nearest 10,000 tons per day, those countries producing less than half of this (5,000 tons per day) do not show. In addition, in many cases, a dot will represent two different locations within one country, each producing about 5,000 tons per day. In such a case, there has been an attempt to place the dot closer to the larger of these two sites.

One question that might be asked is, "Why choose 2009 data, rather than 2010, since 2009 was such a down year for the world steel industry?" For much of the western world in 2009, hot metal production declined to only about one-half of the norm as the financial crisis closed numerous blast furnaces. Meanwhile, the effect of the crisis on the Chinese steel industry was far less and relatively brief. The year 2009 is probably more indicative of the long-term future of ironmaking. Undeniably, for the next few years, most of the blast furnaces that were shuttered on the North Atlantic Basin will return to operation. But, as time progresses, it is almost certain the older and less efficient of these blast furnaces will again be permanently shut down. There is a long term trend of manufacturing semi-finished steels in other countries and shipping the billets and slabs to the US, Canada and Western Europe. It is expected that this trend will continue as it enjoys many economies.

The first thing that one sees when looking at the location of the blast furnaces is that the industry is utterly dominated by China and the surrounding nations. The total map represents 900 million tons of hot metal made in 2009. East Asia produced over 640 million tons, 72% of the total. India made almost 30 million tons, slightly more than 3%, so the Asian total was three-quarters of the entire world. But, most remarkably, China alone produced over 60% of the world's hot metal. Therefore, without question, in order to strongly effect the world's CO_2 generation from ironmaking, China must participate. Measures incorporated by European and North American nations may save millions of tons of CO_2, but only China can save hundreds of millions of tons.

To further stress this point, hot metal production within China was over 28 times the hot metal production of the United States. And, thus, CO_2 generation from ironmaking was over 28 times greater.

PUTTING IT ALL TOGETHER

Even a quick glance at the map shows that the great majority of the seaborne iron ore originates in the southern hemisphere, primarily Australia and Brazil, and it is consumed in the northern hemisphere, primarily China, but also Europe, North America and others. As established in the prior article on this subject, the most powerful means of lowering CO_2 generation by the steel industry is to reduce iron ore with natural gas. So the important question is, where can the iron ore meet with the natural gas for processing to iron (HBI), and then be shipped to the blast furnaces?

One point to bear in mind about natural gas is that it is inconvenient (expensive) to transport. There are only two methods of transporting large quantities of natural gas over long distances: pipelines and shipment of liquefied natural gas (LNG). Either of these methods involves billions of dollars of investment and so raise the cost of the gas substantially but LNG is the only way to move gas across open sea.

Therefore, locations where gas is readily available near the route of the ore going to the blast furnaces are needed. Let us again look at the map to see the major gas containing deposits (information and map courtesy of the US Geological Survey).

Comparing the three sets of information on the maps, iron ore deposits, blast furnace locations and natural gas deposits, reveals that there are a number of readily available sites where the ore, while in transit from mine to steelworks, can be converted at coastal locations into iron using natural gas and thereby abating the generation of massive quantities of carbon dioxide. Partially listed, these are the southern coast of Brazil, the southern Caribbean (Venezuela and Trinidad), the bite of Africa approximately from Nigeria south to Angola, north Africa from Algeria to Egypt, in the Indian Ocean along both the Arabian Sea and the Bay of Bengal, the Northwest Coast of Australia and in the Malay-Indonesian archipelago. Other locales are also possible, for instance for ores moving to Western Europe, the North Sea gas fields are convenient. And, obviously, even though landlocked, the Siberian gas fields are quite convenient to the Russo-Ukrainian ore deposits.

Clearly, many of these sites correspond to already existing HBI plants; as examples, HBI plants in Venezuela, as well as plants in Libya, western India, Russia and Malaysia. Also, it should be noted that wherever both gas and ore are at coastal locations where large modern bulk carriers can be used for transport (necessitating deep water ports), it is possible to economically implement ironmaking. This would also include the current HBI locations within the Arabian Gulf.