Use of DRI in EAF’s

Gregory L. Dressel
Dressel Technologies
Pawleys Island, SC, USA

Part I: Qualities and Storage of Direct Reduced Iron

Introduction

Most EAF based melt shops have been designed for 100 % scrap based melting. In the near future, the use of Direct Reduced Iron (DRI) is expected to grow as a scrap substitute. Evaluating, handling and melting DRI requires a different operating philosophy as opposed to 100 % scrap based melting.

Scrap density in many parts of the world ranges from 0.20 to 0.50 t/m^3[*]. In many new installations this leads to 4 or 5-bucket scrap charges to an EAF. Use of purchased continuously fed DRI eliminates the multiple charges and reduces tap to tap times. Many low residual products require the use of a scrap substitute such as DRI.

DRI should not be considered a direct substitute for scrap. But by applying a little bit of knowledge, the proper use of DRI can be defined for any plant. Often this knowledge can be the difference between a profit and a loss. This series will present a practical approach to the use of DRI in electric arc furnaces.

DRI Quality

DRI can be produced as pellets, briquettes, lumps and fines. Most commercially supplied DRI is sold as pellets or briquettes. Some fines or lump material may be mixed in with the pellets or briquettes. The color can range from gray to almost black. DRI that has been stored in the open will develop a rusty surface.

Commonly the term DRI is used to refer to pellets while HBI (Hot Briquetted Iron) refers to the briquette form. Fines less than 4-mm size usually are produced during the production of pellets and briquettes. The fines can be

[*] Note: All tons are metric

gregdressel@dresseltech.com

screened out of the product for cold pressing, direct injection into an EAF or sale to a secondary user such as a concrete plant.

Cold Briquetted Iron is made from reduced iron fines combined with a small amount of lime and sodium silicate which is then cold pressed into a briquette.

DRI and HBI sizes and density depend on the supplier and amount of handling. Table 1 illustrates the range of physical properties.

Table 1: Sizes and Densities of DRI and HBI

	Size (mm)	Apparent Density(gm/cm^3)	Bulk Density (gm/cm^3)
DRI Pellets	4 to 18	3.4 to 3.6	1.6 to 1.9
HBI	Less than 100 by 50 by 25 mm	5.0 to 5.5	3.4 to 3.8

A low apparent density will lead to poor yields, increased slag FeO content and higher energy consumption. For effective melting, the pellets or briquettes must penetrate the slag layer.

Non-foaming EAF slag density ranges from 2.6 to 3.5 tons/m^3 depending on FeO content and other compositional factors. If the apparent density of the DRI or HBI is less than the slag density, it will float on top of the slag. Gravity fed fines may be sucked directly into the baghouse.

Storage costs and charging times can be influenced by bulk density. The higher the bulk density the less the charging time and storage area required.

The chemical composition of the DRI or HBI determines such important factors as yield, slag weight, energy consumption, carbon and raw material feeding rates, and oxygen usage.

DRI pellets and to a much lesser extent HBI are subject to oxidation.

By knowing the approximate chemical composition of the DRI or HBI at the time of use, the steelmaker can fine-tune the melting process. Table II illustrates typical compositions of DRI and HBI at the time of production.

Table II: DRI and HBI Compositions[1, 2]

	DRI and HBI
Fe Total	89.2 to 94 %
Fe Metallic	79 to 89 %
Metallization	83 to 95 %
Carbon	0.30 to 4.0 %
P	0.005 to 0.09 %
S	0.001 to 0.03 %
SiO2	1 to 5 %
Al2O3	0.5 to 3 %
CaO	0.1 to 2.0 %
MgO	0.1 to 1.0 %
Residuals	Trace

Metallization is usually expressed as a percentage: Fe Metallic/Fe Total x 100. For example, a DRI pellet that has 86 % Fe Metallic and 92 % Fe Total would have 93 % Metallization.

Although a steelmaker may know the metallization it is still very important to know the percentage of 'FeO' contained in the DRI or HBI. This is calculated by the following formula: (Fe Total - Fe Metallic) x 72/56 = FeO. Furthermore, one can calculate the amount of oxygen in the iron: FeO x 16/72 = O wt percent.

Carbon is contained in the DRI or HBI. If carbon is maintained at a 0.75 ratio to the oxygen in the FeO, the carbon will form CO in a stoichiometric balance.

Equivalent carbon content is the percentage difference between carbon contained in the DRI and the carbon needed to reduce the oxygen in the FeO. If it is negative, then the steelmaker must add carbon to the bath to reduce the FeO in the DRI. If it is positive, then the steelmaker may need to blow oxygen to remove the excess carbon from the steel bath.

Generally, a positive equivalent carbon leads to a reduction in electrical energy consumption with the blowing of oxygen while a negative equivalent carbon can cause bath decarburization. In most plants where bulk oxygen is available, a positive equivalent carbon is desired.

The carbon content of the DRI or HBI is dependent on the suppliers' process parameters. The FeO content is likewise affected by the supplier's process parameters but shipping, storage techniques and shelf time can also affect the value.

Adjustment of the DRI or HBI manufacturing process will affect costs and productivity so the supplier and customer must come to both a technical and economic agreement regarding the carbon and FeO or metallization content of the pellets or briquettes.

Steelmaker with DRI or HBI in raw material inventory should check chemistry when the material is received and thereafter on a monthly basis. Gangue content must be measured and reported since this affects slag composition and energy consumption. Even though the total iron, carbon and gangue quantities will not change, the material can continue to oxidize during storage.

Storage of DRI

DRI as it is produced is very reactive to free water and oxygen. Pellets and briquettes are always passivated and cooled before being shipped on the seas, rails or highways.

DRI pellets can be subject to a high degree of reoxidation. Self-ignition can occur if there is a natural air draft through the pile, the pellets buried inside are wet and the volume of material is large enough to insulate against heat losses.

Fires result when dry DRI pellets are placed on top of wet material. The best way to stop a DRI fire is to spread out the hot material with a bulldozer to a height of ½ meter. A second method is to bury the pile under sand or slag.

In the situation of a fire inside a storage silo, the pile of DRI can be flooded with extremely large amounts of water.[3] If the water is not sufficient to flood the burning pile of DRI, hydrogen gas will evolve; therefore, all unnecessary personnel should be evacuated from the area surrounding the fire.

HBI has a much more dense structure and lower surface area to volume ratio as compared to pellets. HBI on the surface of a storage pile will have a 70 % lower metallization loss as compared to DRI pellets over the same time period.[4] At 0.6 m below the surface, the metallization loss for either DRI or HBI becomes negligible.

Upon receipt at the steelmaking plant, the DRI or HBI should be kept dry. This can be as simple as spreading a tarp on top of the material or as complex as building a storage silo connected to a continuous feeding conveyor.

The storage pile should minimize the surface area to volume ratio. While the HBI is substantially less reactive than DRI pellets it should still be kept dry since it can contains lump or fines which will oxidize.

The storage area should have a level bottom with good drainage. Due to the possibility of oxygen depletion in confined spaces, personnel should always check the atmosphere before entering a storage silo containing DRI or HBI. Minimal handling should be done to prevent the production of more fines.

References:

1. “Typical Applications of Midrex Iron,” Midrex Corporation Advertisement, 1993.
2. R.D. Morales, et. al.,“The Slag Foaming Practice in EAF and Its Influence on the Steelmaking Shop Productivity,” ISIJ International, Vol. 35 (1995) No. 9, pg. 1057.
3. Robert L. Hunter, “Handling and Shipping of DRI/HBI,” http://www.midrex.com/shiphand.htm,1997.
4. Stevenson and Smailer, ed., Direct Reduced Iron, Iron and Steel Society, 1980, pg. 101.

Biographical Information

Gregory L. Dressel, P.Engr. is a metallurgist working in private practice. Mr. Dressel provides consulting services to suppliers and steelmakers in starting up new equipment or improving existing operations. He consults on raw material selection, operator training, melting practices, ladle refining, continuous casting and quality engineering. He can be contacted by E-Mail: gregdressel@dresseltech.com or phone and fax at +1 843 237-8337.

gregdressel@dresseltech.com