Value in use of ore-based metallics

The International Iron Metallics Association has developed a value-in-use model for ore-based metallics. Jeremy Jones and Chris Barrington explain its principles and purpose

For many years, pig iron, direct reduced iron and hot-briquetted iron – so-called ore-based metallics – were categorised as 'scrap substitutes' or 'alternative iron units' and often still are.

One of the principal objectives of the International Iron Metallics Association (IIMA), which represents those involved in merchant ore-based metallics industry, is to promote recognition of the true value-in-use of ore-based metallics relative to steel scrap as well as the fact that they should not be regarded just as scrap substitutes, but rather as scrap supplements, because they have a value which is greater than that of their intrinsic iron content.

To explain this point, IIMA has, in co-operation with Continuous Improvement Experts (CIX), developed a relatively simple value-in-use model which allows a quick comparison of EAF feedstock materials on a head-to-head basis, using a standard set of evaluation parameters that can be applied across all types of EAF ferrous metallics and thereby indicate the most cost-effective selection of charge materials in terms of value-in-use.

Ore-based metallics benefits

The benefits of using ore-based metallics are many. Pig iron, direct reduced iron (DRI) and hot briquetted iron (HBI) are produced by the reduction of iron ore in blast furnaces and direct reduction plants, respectively. Pig iron is also a co-product of the smelting of titanium-bearing minerals such as ilmenite.

They have a predictable and consistent chemical analysis and have a very low content of residual metallic impurities that makes them ideal for blending down and diluting the impurities in steel scrap in EAF steelmaking. This has two benefits: production of higher specification steel than can be produced in the EAF from scrap alone (*see chart*), or the possibility to utilise more lower-quality, and thus lower cost, scrap grades in the charge.

Other benefits include the chemical energy contributed by contained carbon in ore-based metallics (typically 3.5-4.5% in pig iron, 1.0-4.5% in DRI and 0.5-1.6% in HBI), which promotes faster melting and higher productivity. Their consistent shape and form enables efficient materials handling and DRI and HBI can be continuously charged to the furnace.

High material bulk density can reduce the number of bucket charges and allows for increased use of lower cost, less-dense materials, also reducing storage space. Their lower melting point reduces electrode consumption, while their ability to act as a nitrogen scavenger reduces nitrogen content in steel. Ore-based metallics also contribute to a better foaming slag.


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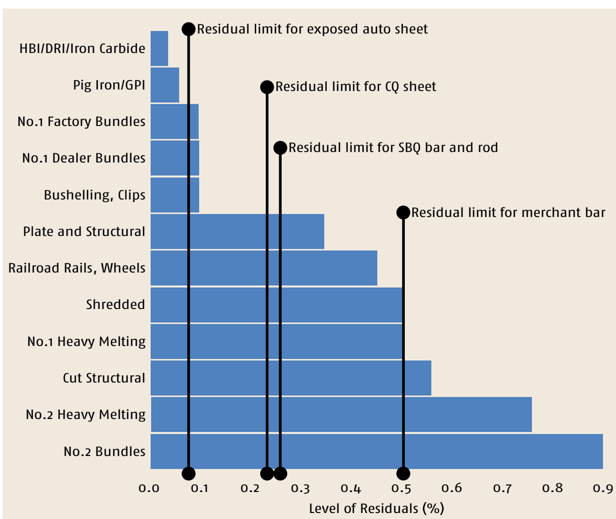
The use of ore-based metallics is valuable to dilute impurities in EAF steelmaking to the appropriate levels for each type of steel produced



Source: Orinoco Iron

Value in use

The headline price of ferrous feedstock materials, such as Metal Bulletin's iron ore/scrap prices, fundamentally reflects their iron content, but the impact of those materials on the steel products to be made and the process used to produce them is complex. Value-in-use as applied to steelmaking raw materials is a methodology that attempts to capture that impact, both positive and negative.

EAF charge and operating practices clearly vary from one steel plant to another, depending on a number of factors, not least of which is the available scrap supply (its volume, quality and price), so there is no "one size fits all" solution to selection of charge materials. Of course, the common goal is to minimise steel production cost, commensurate with required steel product specifications and operational constraints.

Traditional EAF feedstock cost models in effect considered all iron units to be equal and thus equated pig iron and other ore-based metallics with steel scrap, generally basing value-in-use on iron yield only. Such models did not take into account such variables as the impact of residual metallic and other impurities, process parameters, environmental factors (components that generate waste, propensity to generate EAF dust etc.) and other important scrap characteristics, all of which can have a significant impact on the true cost of steel production.

Modern EAF feedstock optimisation models do take such variables into account, based on process data such as real-time slag analysis, and thus recognise and quantify the true and relative value-in-use of the feedstock materials modelled.

Residual impurities

Residual impurities are an essential consideration for charge material selection, especially for more sophisticated steels such as flat products for the automotive market. In terms of residual impurities, IIMA's model (*www.metallics.org/viu-model.html*) so far takes into account only the copper content, or rather the lack thereof in ore-based metallics, since copper is one of the more important residual impurities in steel scrap.

Values for copper as an impurity were derived from an analysis of the prices of various grades of scrap (HMS No. 1, HMS No. 2, No. 1 Shredded, No. 2 Shredded, No.1 bushelling, No.1 Dealer Bundles and Plate & Structural), using ISRI specifications as the basis for the copper content and factoring in appropriate yield factors.

Different scrap types were considered head-to-head in an attempt to allocate the difference in scrap pricing to the difference in copper content. This analysis, based on scrap pricing over a 10-year period (2002-2011), indicated that a value in the range of $1-2 per tonne per 0.01% Cu would be a reasonable basis for value-in-use purposes, depending on the scrap types considered. In order to validate this comparison, higher cost, lower-copper-content grades of scrap were compared with a blend of pig iron or HBI and lower-value, high-copper-content scrap grades.

Additional value of ore-based metallics

Scrap grade	Cu content %	Additional value of OBM $/t
No. 1 Dealer Bundles	0.1	20
Bushelling	0.08	16
No. 1 HMS	0.3	60
No. 2 HMS	0.5	100
No. 1 Shredded	0.17	34
No. 2 Shredded	0.25	50
Plate & Structural	0.15	30

OBM Cu content typically 0.002% (depends largely on source iron ore)

Source: IIMA

The calculated benefit of the near-zero copper content of pig iron and HBI relative to the various grades of scrap, based on this analysis and a $2 value per tonne per 0.01% Cu, ranged from $16 to $100 per tonne of ore-based metallic (*see table*).

Process parameters

The process parameters that are impacted by charge material characteristics include productivity and yield, electricity and energy consumption, electrode consumption (which has become a very important consideration recently), slag generation rate, and flux and alloy consumption.

Charge materials have a multitude of characteristics. For example, tramp materials, such as dirt, affect productivity and yield – the lower their content, the higher is the yield and the lower the volume of charge material required.

The higher the total iron content of the charge, the higher is the yield. The lower the content of metallic iron, the higher is the consumption of electricity and reductant required to recover the iron units. Iron can be recovered from iron oxides, but at the cost of higher consumption of energy and reductant.

The content of carbon in the charge material contributes energy and reductant and thus reduces the requirement for injected carbon. Carbon contained within charge materials enables better control of carbon additions.

The content of silicon in the charge material can also provide energy when oxidised, but then adds to the slag volume and thus impacts yield and energy consumption. Moisture content represents a yield loss and thus higher energy consumption.

The content of fine materials, some of which will be lost to the off-gas system, also impacts yield, while the content of gangue material (for example, silica and alumina), will impact slag volume and thus yield and energy consumption.

And, not least, the bulk density of charge materials can impact productivity: the higher the bulk density, the fewer is the number of bucket charges

IIMA's model

IIMA's model takes into account: differences in metallic iron content; carbon content and its effect on charge carbon; gangue content and its effect on flux requirements to maintain a given basicity; overall metallic yield (taking into account slag losses); recovery factor for iron oxide; fines losses in pig iron, DRI and HBI; moisture content and its impact on energy requirements; and copper content.

From an economic standpoint, IIMA's model aggregates the costs and benefits for each feedstock material. It can compare the equivalent costs on a head-to-head basis or calculate the break-even price of one material against another and thus if its price is higher or lower relative to the reference material from a value-in-use perspective.

As material specifications and prices change – frequently where prices are concerned – it makes sense to run the model at each decision point. Value-in-use, of course, is just one consideration among many in raw material selection and purchasing decisions.

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