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Iron Metallics Association

OBMS & CARBON NEUTRAL STEELMAKING

Whitepaper 1: Ferrous Metallics for Steelmaking

OBMs & CARBON NEUTRAL STEELMAKING

Paper 1 Ferrous Metallics for Steelmaking

Ore-based metallics: enablers of reduced CO_2 emissions by the steel industry and the circular economy for steel

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Overview

With the recent acceleration in interest, strategic thinking, and commitment towards decarbonisation, we as a key component of the steelmaking value chain need to play our part in this endeavour. To be effective in tackling the challenges and opportunities we face, the merchant ore-based metallics sector has begun exploring its role in the pathway to creation of a carbon-neutral steelmaking industry. The current findings are contained in the first edition of a series of whitepapers on this topic,

Introduction to the whitepapers

The whitepapers aim to foster discussion and ignite collaboration with stakeholders in the merchant ore-based metallics value chain including academia and public policy makers. We believe that the foundation to successful decarbonization is knowledge sharing and awareness raising on the challenges and opportunities inherent in this process, garnering deeper understanding and fostering potential solutions but most importantly ensuring sustainable outcomes.

Many companies in our value chain from iron ore miners to steelmakers have already published their thinking and strategy for decarbonization and there will be more to come. The purpose of our whitepaper is to examine these, identify common elements and issues and to catalyse thinking and advocacy for action. We recognise this is an evolving space and therefore plan to continually monitor and regularly update the whitepaper as a living document.

IIMA OBM & Carbon Neutral Steelmaking whitepapers

- **Whitepaper 1** – Ferrous Metallics for Steelmaking
- **Whitepaper 2** – An Assessment of Future Challenges for Electric Arc Furnace Steelmaking
- **Whitepaper 3** – Hydrogen-based DRI Production and Use
- **Whitepaper 4** – Blast Furnace/Basic Oxygen Furnace Steelmaking and Alternative Iron Smelting Technologies

Abstract

This paper begins with an overview of ferrous metallics for steelmaking, covering first steel scrap and then ore-based metallics (OBMs) comprising pig iron and the various forms of direct reduced iron. The role of OBMs as scrap supplements rather than scrap substitutes in electric arc furnace (EAF) steelmaking is explained, i.e., as virgin metallics with their extremely low levels of metallic impurities, OBMs dilute the metallic impurities in recycled scrap, thus on the one hand enabling production of high value steel products via the EAF and on the other hand facilitating the use of lower grade scrap which might otherwise not be usable, in effect, enhancing steel's circular economy. With EAF steelmaking being an essential part of the roadmap to carbon-neutrality, the use of OBMs to dilute out impurities in the feedstock facilitates the production of higher quality steel products with EAF technology, OBMs enable realisation of lower CO_2 emissions from EAF steelmaking in comparison with traditional integrated steelmaking via the blast furnace and basic oxygen converter.

1 Introduction: What are ferrous metallics for steelmaking?

1.1 The two types of ferrous metallics

Ferrous metallics is a generic term for metallic iron feedstock materials used in the production of iron, steel and ferrous castings. They can be divided into two types:

Iron and steel scrap

Iron and steel scrap, or ferrous scrap, comes from the steel manufacturing process itself (home scrap), from OEMs manufacturing products made from steel, e.g. automotive (prompt scrap) as well as many consumer products like automobiles and household appliances to industrial structures and equipment such as buildings, railroads, trains, bridges, ships, and farming equipment (obsolete scrap).

Steel scrap use in crude steel production in the major countries and regions reported by BIR amounted to 491 million tonnes in 2019 with global cross border trade just over 100 million tonnes. World use in 2019 was estimated at 630 million tonnes.[1]

Ferrous scrap is the main ferrous feedstock for electric arc furnace (EAF) steelmaking, but is also used in blast furnaces and basic oxygen converters. It is also the principal feedstock for iron and steel foundries.

Ferrous scrap comes in a variety of grades, categorised according to steel type, origin, processing methods, size, impurities, etc. Whilst there are no globally

[1] Data from BIR "worldsteel recycling in figures 2015 – 2019"

applicable steel scrap standards, there is a variety of national/regional specifications, e.g. in the USA and the EU.

From the EAF steelmaking perspective, a key parameter of scrap quality is the content of residual metallic impurities such as copper, tin, zinc, etc. The tolerance for such impurities depends upon the grade of steel being produced, the most demanding being flat products such as automotive sheet, the least demanding being long products such as rebars (See Figure 1 below).

Ore-based metallics (OBMs)

Pig iron

Hot briquetted iron (HBI)

Direct reduced iron (DRI)

OBMs as the IIMA graphic above depicts are pig iron, hot briquetted iron (HBI) and direct reduced iron (DRI). HBI is a form of DRI that has been briquetted at high temperature to form a dense, less reactive material that was developed to overcome the hazards in handling and transporting the more reactive DRI.

From a quality perspective, what differentiates OBMs from ferrous scrap is that they are virgin, not recycled materials, manufactured by the reduction of iron ore, in a blast furnace in the case of pig iron, and in a direct reduction furnace for DRI and HBI. As such they have a well-defined and controlled specification and, most importantly, minimal metallic impurities.

Whereas most blast furnace (BF) iron, or hot metal, is consumed in the liquid state within the steel works, a certain volume is cast into ingots and solidified to form (cold) pig iron. There is a significant market for so-called merchant pig iron, sold either by dedicated merchant producers with no downstream steel production, or by integrated steel producers with BF iron that is surplus to the requirements of their own steel plants.

DRI and HBI are manufactured in the solid state. The great majority of DRI is consumed within integrated mini-mills, where the DRI is fed directly to adjacent

EAFs, either as cold or hot DRI. A limited volume of DRI is traded internationally. HBI is the principal merchant form of direct reduced iron and is traded globally.

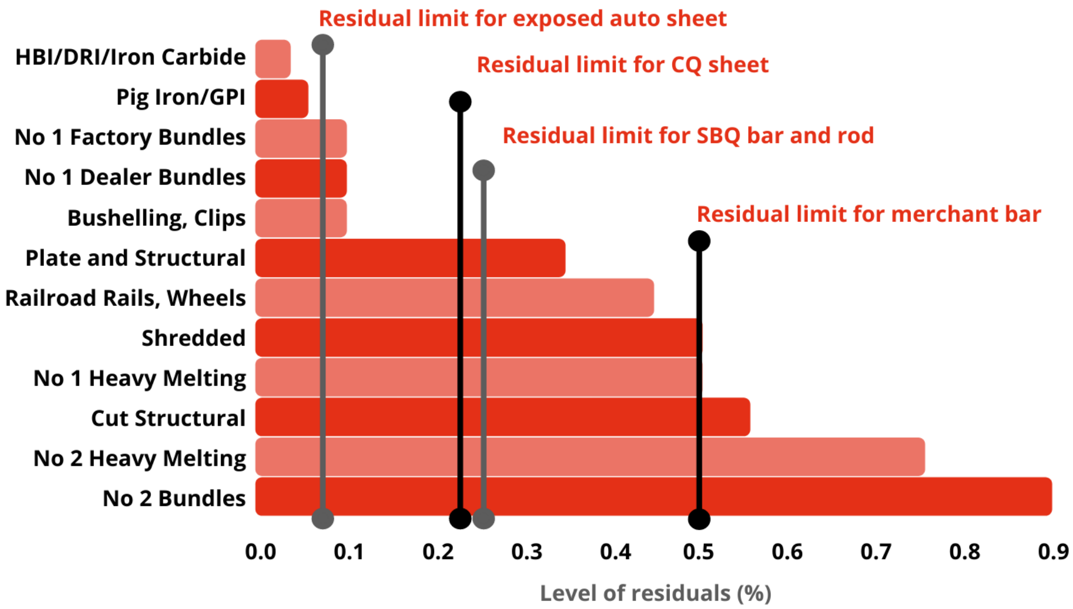
Cross border trade in OBMs is very much less than in ferrous scrap: in 2019, about 102 million tonnes scrap, 12-13 million tonnes of pig iron and about 9 million tonnes HBI/DRI were traded internationally.

1.2 OBMs are scrap supplements, not scrap substitutes

The traditional vernacular of the industry was that OBMs were considered as "scrap substitutes" or "alternative irons" – old habits die hard and such terms can still be heard. In reality, OBMs are "scrap supplements" because their primary role is to dilute the residual metallic and other impurities present in scrap, thus enabling the steel specifications to be met, or enabling greater use of lower quality grades of scrap, or a combination of both.

Figure 1 below illustrates the tolerance for residual metallic impurities in OBMs and various grades of ferrous scrap.

FIGURE 1: TOLERANCE OF RESIDUALS IN SCRAP



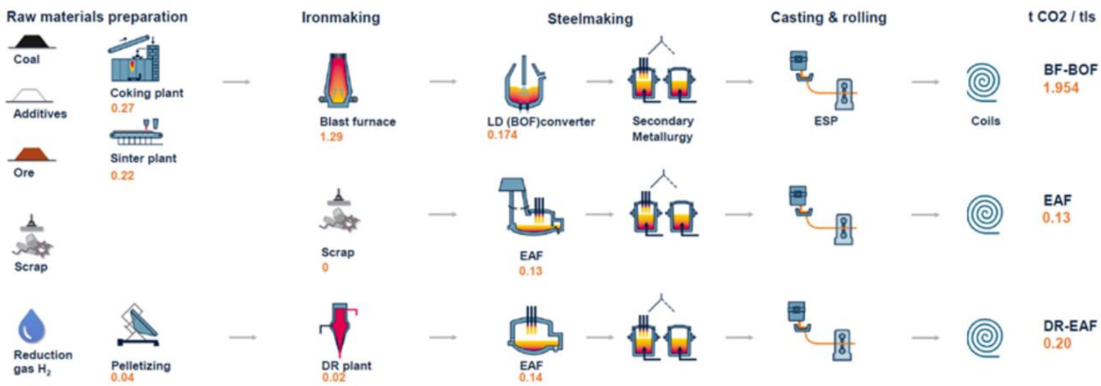
1.3 OBMs: enablers for reduction of CO_2 emissions and the circular economy

Much has been written about the pathways to carbon-neural steelmaking over the coming decades. There is no universal wisdom, but what is not in dispute is that there will be a gradual transition from the iron ore-based integrated BF/BOF route to the scrap-based EAF route. For example, in its Energy Technology Perspectives

2020 report[2], the International Energy Agency (IEA) foresees EAF steel production increasing from 29% in 2019 to 53% by 2070 under its Stated Policies Scenario and to 74% by 2070 under its Sustainable Development Scenario. Another prediction, by World Steel Dynamics, foresees BF/BOF steel production declining by 256 million tonnes to 753 million tonnes by 2050 and EAF production increasing by 218 million tonnes to 758 million tonnes by 2050. Figure 2 below illustrates the CO_2 emissions for the various steelmaking process routes.

FIGURE 2: RELATIVE CO2 EMISSIONS FROM STEELMAKING ROUTES (SOURCE PRIMETALS PRESENTATION)

CO_2 emissions of main steel production routes



CO_2 emissions in tons per ton of liquid crude steel considering OECD EU-28, emission factor of 80 grams CO_2/kWh (Target 2050) and BAT, utilization of BF top gas and LD gas in power plant, scope 3 emissions for raw materials and credits considered.

A key success factor for such scenarios is the availability of ferrous scrap, not only in quantitative terms, but also qualitatively so that the required grades of high-quality steel products can be produced via the EAF route. As Figure 3 below illustrates, whilst global scrap availability is expected to continue to grow rapidly out to 2050, much of this growth comprises lower quality, obsolete scrap as infrastructure and buildings reach the end of their useful lives, especially in the developed economies. Growth of the higher quality home and prompt scrap is rather flat as steel production and manufacturing industry become more efficient and generate less waste.

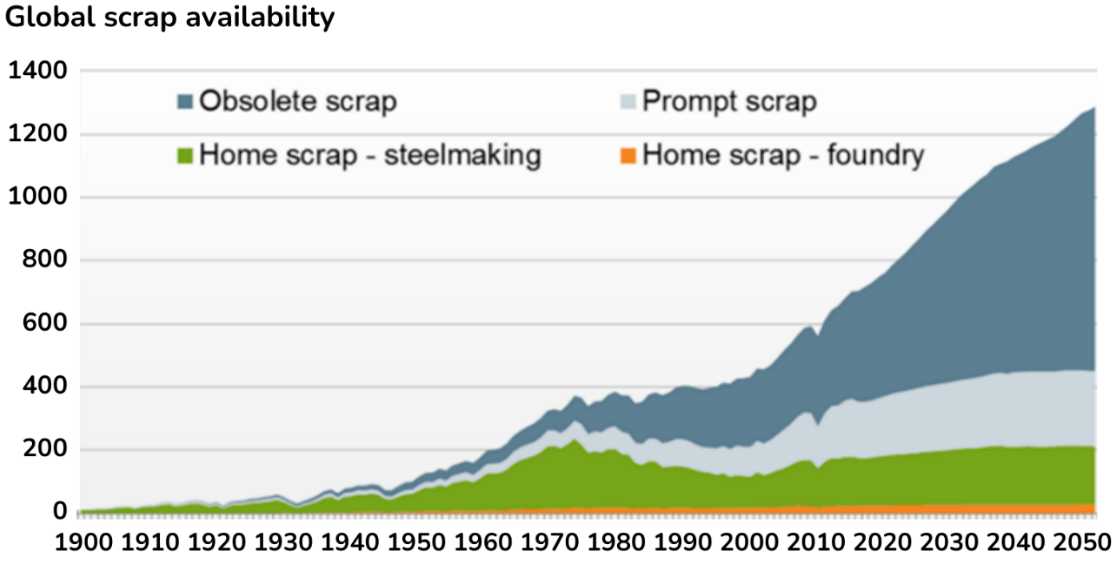
Per Figure 1 above, obsolete scrap with its typical copper content of about 0.3% will not be useable on its own for production of high-grade steels such as

[2] Report downloadable from IEA website

automotive sheet and SBQ bar and rod. Of course, manufacturing industry and scrap processors can contribute to the solution of this problem:

- designing products with recycling in mind
- investing in technology for removal of residual metallic impurities from scrap
- more careful grading of scrap shipments to avoid contaminating low residual with high residual grades

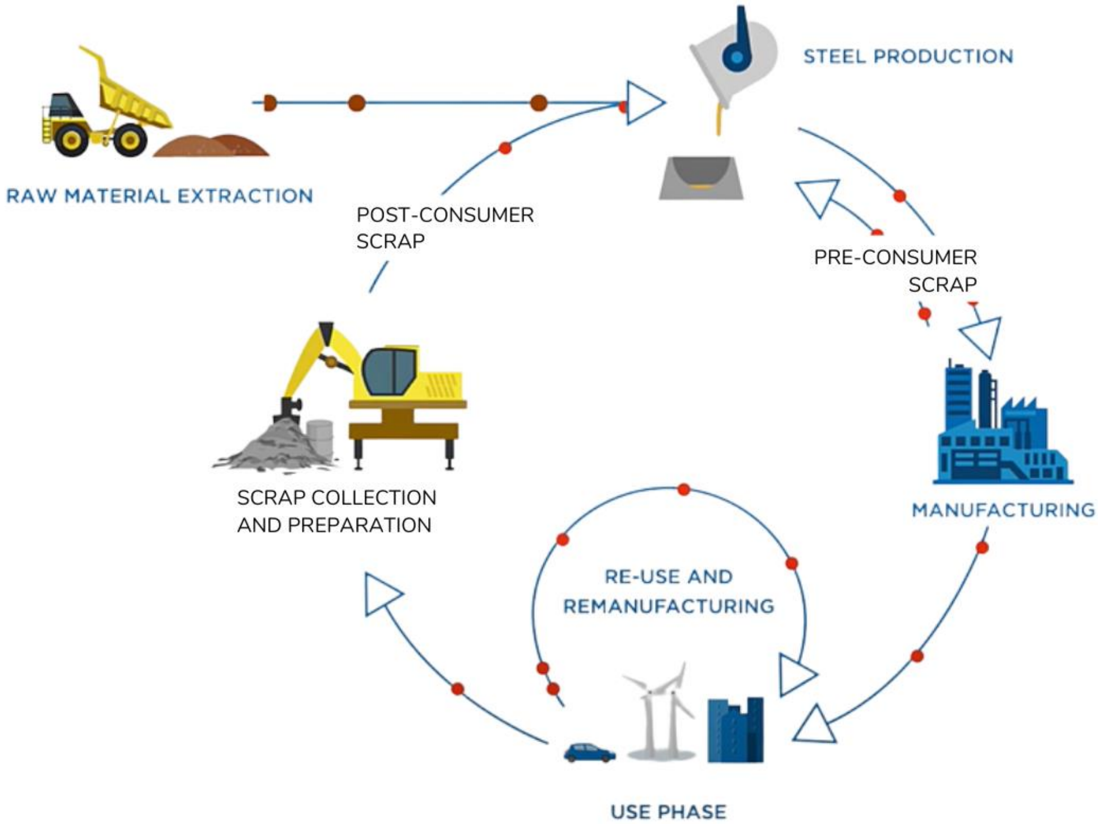
FIGURE 3: GLOBAL SCRAP AVAILABILITY, MT (SOURCE WORLDSTEEL)



In the meantime, the enabling role of OBMs as diluents of scrap residuals is crucial if the shift from BF/BOF to EAF steelmaking - and thereby the reduction in CO_2 emissions by the steel industry - is to be achieved.

Steel is the most recycled material in the world, indeed more steel is recycled than all other recyclable materials combined - 630 million tonnes in 2019[1]. Steel is 100% recyclable and its unique properties mean it can be recycled infinitely without loss of properties or performance. Figure 4 illustrates the circular economy of steel.

FIGURE 4: THE CIRCULAR ECONOMY OF STEEL (SOURCE EUROFER)



The increasing share of obsolete scrap in global scrap supply, coupled with the likelihood of increasing metallic residuals provide OBMs with a second enabling role, this time as enabler of longer-term circularity in the steel economy: without dilution of the residual impurities of obsolete scrap, there is a danger that the cost of utilising it in certain applications would be too high, leading to landfilling rather than recycling.

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