SUB-COMMITTEE ON CARRIAGE OF CARGOES AND CONTAINERS
10th session
Agenda item 5

CCC 10/INF.xx
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AMENDMENTS TO THE IMSBC CODE AND SUPPLEMENTS

Background to proposals for amendment to the IMSBC Code schedules for DIRECT REDUCED IRON (A) Briquettes, hot-moulded and DIRECT REDUCED IRON (B), Lumps, pellets, cold-moulded briquettes

Submitted by IIMA

SUMMARY

Executive summary:	Following discussion on this subject at CCC 9 and E&T 40, this document contains background information, aimed at facilitating consideration of the proposed amendments at CCC 10.
Strategic direction, if applicable:	7
Output:	7.13
Action to be taken:	Paragraph 14
Related documents:	CCC 9/5/15, CCC 9/14, E&T 40/3/3, E&T 40/INF.2, CCC 10/5 and CCC 10/5xx

Introduction

1 The purpose of this information document is to provide relevant context to document CCC 10/5/xx proposing amendments to the IMSBC Code schedules for Direct Reduced Iron (A) and Direct Reduced Iron (B). The proposed amendments are driven predominantly by safety considerations, safety of personnel, ships and cargoes.

Background

2 DRI (B) (direct reduced iron - DRI) and DRI (A) (hot briquetted iron, HBI, produced by compacting DRI at high temperature and pressure into briquette form) are ferrous feedstock materials for steel production, principally by the electric arc furnace (EAF) process route where they supplement the main ferrous scrap charge. DRI (A) also finds application in blast furnaces and basic oxygen furnaces.

3 In 2022, about 72% of DRI was produced by the solid state reduction of high grade iron ore in shaft furnaces by carbon monoxide and hydrogen from reformed natural gas, with

about 28% being produced in coal-fired rotary kiln furnaces, mainly in India, this product being known as sponge iron.

4 DRI reduction reactions are:

(1) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(2) $Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$

5 Product-related background information was given in the annex to E&T 40/INF.2 and can be summarized as follows:

.1 Direct reduced iron or DRI (B) is a porous iron material which, due to its highly reduced state, is very reactive and easily re-oxidized back to the oxide form in the presence of oxygen/air (reaction (1) below). This reoxidation reaction is exothermic, i.e., heat is generated, which can lead to self-heating, which in turn, if not controlled, can cause ignition and fires. The tendency to reoxidize can be loosely defined as "reactivity."

.2 In contact with water, especially salt water, DRI can oxidize with the generation of hydrogen, a combustible and explosive gas which is lighter than air (reaction (2) below). This reaction is endothermic, i.e. heat is absorbed, when water is in the liquid phase, but is exothermic if the water is in the vapour phase.

.3 The oxidation reactions for DRI are:

(1) $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

(2) $2Fe + 3H_2O \rightarrow Fe_2O_3 + 3H_2$

.4 DRI (A) was developed in response to the difficulties in shipping DRI (B) and is much safer to transport as a bulk cargo. The compaction of DRI (B) into dense briquettes reduces its porosity and thus the surface area available to oxygen and moisture, meaning that DRI (A) has much lower reactivity and tendency to reoxidize and self-heat or generate hydrogen. DRI (A) therefore does not require the rigorous safety precautions necessary for safe shipment of DRI (B), principally inerting of the cargo with a blanket of nitrogen. At the time that DRI (A) was developed as a product, it was determined through a series of practical tests that maintaining its apparent density at greater than 5,000 kg/m^3 is key to an acceptable level of reactivity and thus safe carriage.

.5 For DRI (A) cargoes, the apparent density is a good indicator of the effectiveness of the briquetting process and is a good proxy for the porosity and reactivity of the material. Apparent density can be negatively impacted by too low briquetting temperature and/or pressure, as well as by problems with the briquetting press itself. At an apparent density higher than 5,000 kg/m^3, the reactivity is considered by the iron and steel industry to be sufficiently reduced for safe shipment.

.6 Density is the mass per unit volume of a substance. Apparent density (as opposed to true density or bulk density) is weight (mass) in air per unit volume, including both the solid and void spaces <u>within</u> particles, but excluding the void spaces <u>between</u> particles. Further and more detailed information about the determination of apparent density of DRI (A) was provided in E&T 40/INF.2.

.7 Physical strength of DRI (A) is another important property relating to safe carriage of this cargo. Briquettes which have not been pressed at high enough temperature and/or pressure may exhibit less than adequate physical strength, leading to breakage and generation of small particles and fines (under 6.35 mm in size) in excess of the permitted maximum 5% by weight. In addition, breakage of inadequately pressed briquettes may also expose or liberate uncompacted pellets, in effect DRI (B) with its attendant risk of self-heating. The images in Figure 1 are from an actual shipment of what was nominally DRI (A) and clearly illustrate this issue.

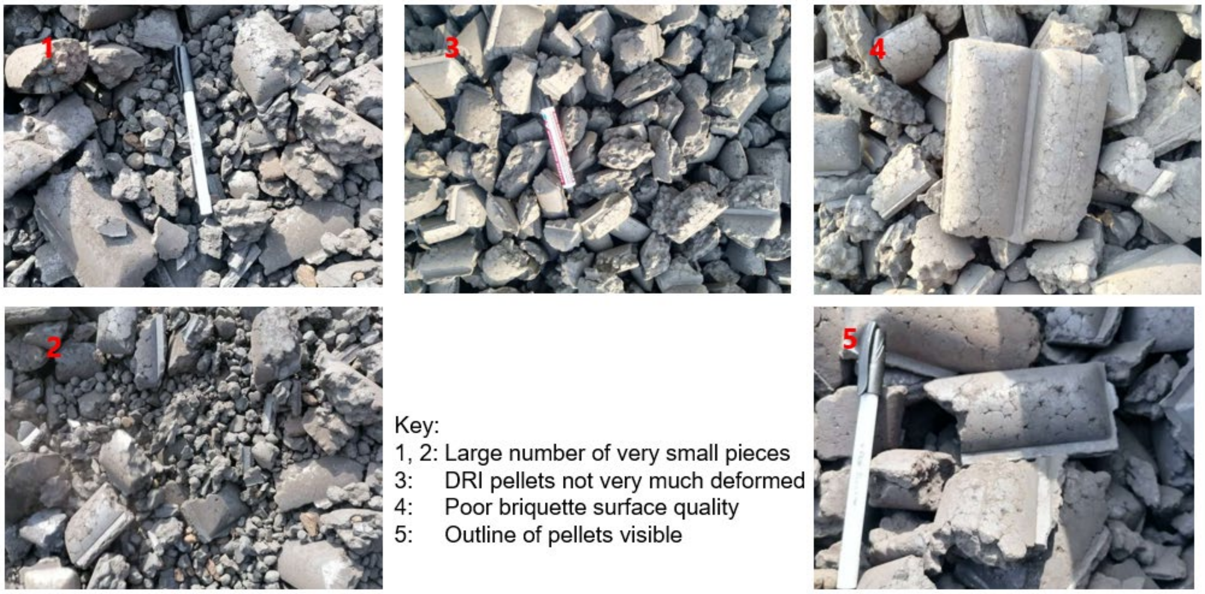

Figure 1: Example of poor quality DRI (A) briquettes

.8 Expert opinion is that material such as that shown above will continue to degrade every time it is handled and also during the ocean voyage due to the rocking action of the vessel. Thus, the quantity of both fines and loose pellets will increase considerably between ship loading and ship unloading.

.9 The shipment in question was intended for a voyage of about 7,000 nautical miles (nm), but in the end sailed only about one day to a nearby discharge port without incident. Outturn analysis showed less than 10% whole briquettes. A previous shipment actually undertook the 7,000 nm voyage and caught fire at the discharge port.

.10 The greater the proportion of broken briquettes, loose pellets and excess small particles below 6.35 mm, the greater the surface area of the cargo that is exposed to oxygen/air and or moisture and thus the greater the reactivity and propensity to self-heat and, in case of exposure to moisture, the propensity to generate hydrogen. In effect, there is a risk that the material will behave more like DRI (B) which requires much more rigorous safety precautions and measures for safe shipment, notably the requirement for shipment under a blanket of inert gas, usually nitrogen.

6 Per the World Steel Association, in 2020, on average every tonne of steel produced led to the emission of 1.891 tonnes of CO_2 into the atmosphere. In 2020, 1,860 million tonnes of steel were produced and total direct emissions from the steel sector were of the order of 2.6 billion tonnes, representing between 7% and 9% of global anthropogenic CO_2 emissions.

7 In October 2020, the International Energy Agency (IEA) released its Iron & Steel Technology Roadmap. This document analyses the impacts and trade-offs of different technology choices and policy targets for the industry to be in line with the goals of the Paris Agreement. Under the IEA's Sustainable Development Scenario, total direct emissions from the iron and steel sector must fall by more than 50% by 2050 relative to 2019 and the emissions intensity of crude steel production by 58%. This pathway foresees a progressive transition from traditional blast furnace / basic oxygen furnace technology (about 72% of crude steel production globally in 2022) to scrap-based EAF steel production (about 28% globally in 2022).

8 The perceived longer term shortage of high quality steel scrap notwithstanding, it is difficult to produce the highest grade steel products from scrap alone, due to the presence of contained metallic impurities, such as copper. DRI, being produced from iron ore, is a "clean" metallic feedstock material for EAF steel production and, as such, serves to dilute the impurities in the steel scrap charge, thus facilitating the production of high grade steels. By the same token, DRI enables the inclusion of lower grade scrap in the charge mix, thus facilitating the circular steel economy as such lower grade scrap might otherwise have to be landfilled.

9 The largest share of CO_2 emissions from steel production are from the ironmaking part of the process. Two principal solutions for reduction of CO_2 emissions from DRI production are foreseen: 100% hydrogen-based reduction and, to a lesser extent, natural gas-based reduction coupled with carbon capture, utilisation and storage (CCUS).

10 Per its Energy Technology Perspectives 2020 report, IEA projected DRI demand in 2050 under its Sustainable Development Scenario of 411 million tonnes (which compares with 2022 production of 127 million tonnes).

11 A likely development of the transition to DRI/EAF is some decoupling of iron and steel production, whereby DRI production shifts from the steel plant location to where iron ore and natural gas/hydrogen are most economically available, for example in the Middle East or Australia, with large volumes expected to be shipped to steel plants, for example in Asia.

12 Such a growth target for DRI/HBI production presents many challenges to the iron ore to steel value chain, one of the most important of which is the adequacy of supply of the high grade iron ore necessitated by the demands of EAF steel production. One solution to this problem is the use of lower grade iron ore. Use of lower grade iron ore inevitably leads to lower grade DRI/HBI which may exhibit different properties and behaviour to the currently produced material based on high grade iron ore, for example lower apparent density. Hydrogen-reduced DRI may also exhibit different properties and behaviour to the currently produced natural gas-based material. Such different properties and behaviour may have implications for safe handling and transportation.

13 A research project, designated HBI C-Flex and partially financed by a European Union authority, has been established by a number of participants along the iron ore to steel value chain to investigate the reactivity of HBI produced from lower grade iron ore and by hydrogen reduction. The ultimate goal is to facilitate safe shipment of such material and to provide the basis for any changes to maritime and other regulations that may become necessary. An overview of the HBI C-Flex project is shown in Figure 2.

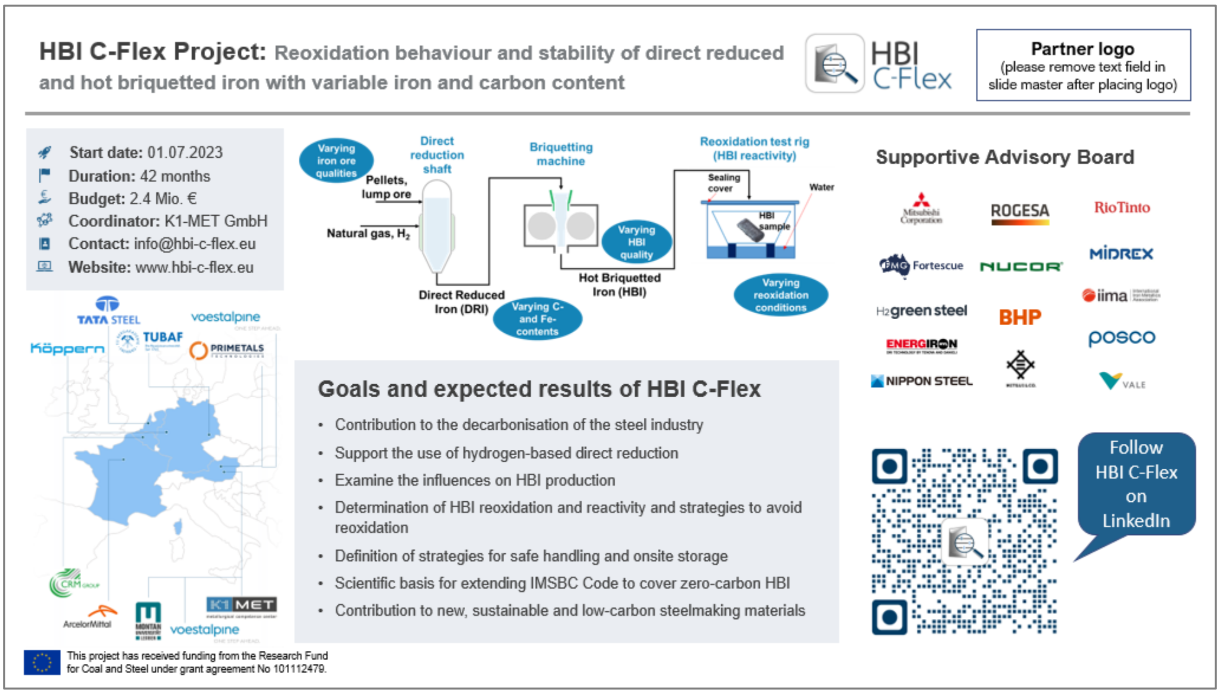

Figure 2: HBI C-Flex project overview

Action requested of the Sub-committee

14 The Sub-committee is invited to note the information provided in this document when considering CCC 10/5/xx.

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