Investigation of the reoxidation behaviour of hot briquetted iron (HBI) samples produced on a laboratory scale

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The increased production of direct reduced iron (DRI) in recent years, particularly in the form of metallized DRI pellets and hot briquetted iron (HBI), is a promising development in global ferrous metallurgy. The aim of this study is to understand and describe the fundamental mechanism of HBI reoxidation for the safety of future handling and transport logistics.

Introduction and motivation

The expected increased of direct reduction processes implies the necessity of using iron ores with lower quality (with iron content ranging from 60 to 65 wt.%) that are currently used for the blast furnace (BF) process, since high-grade pellets will not be available in sufficient quantities to cover the global demand. Unlike in the BF process, gangue cannot be partially separated as slag during direct reduction. Instead, it is transferred to subsequent processes, influencing the quality of the final steel product. However, clean steel breakthrough technologies could make zero-carbon steelmaking possible by 2030 [1, 2]. The potential and use of DRI resulting from DR processes using low-grade ores must be examined, while also considering H_2 as a future reductant. To investigate the reoxidation behavior of different HBI qualities, the three-step process (see Fig. 1) was designed using existing equipment at AMMR and CRM (reduction step), at TU BAF (hot briquetting step), and the storage system developed at TU Leoben to realize defined conditions (for the reoxidation studies).

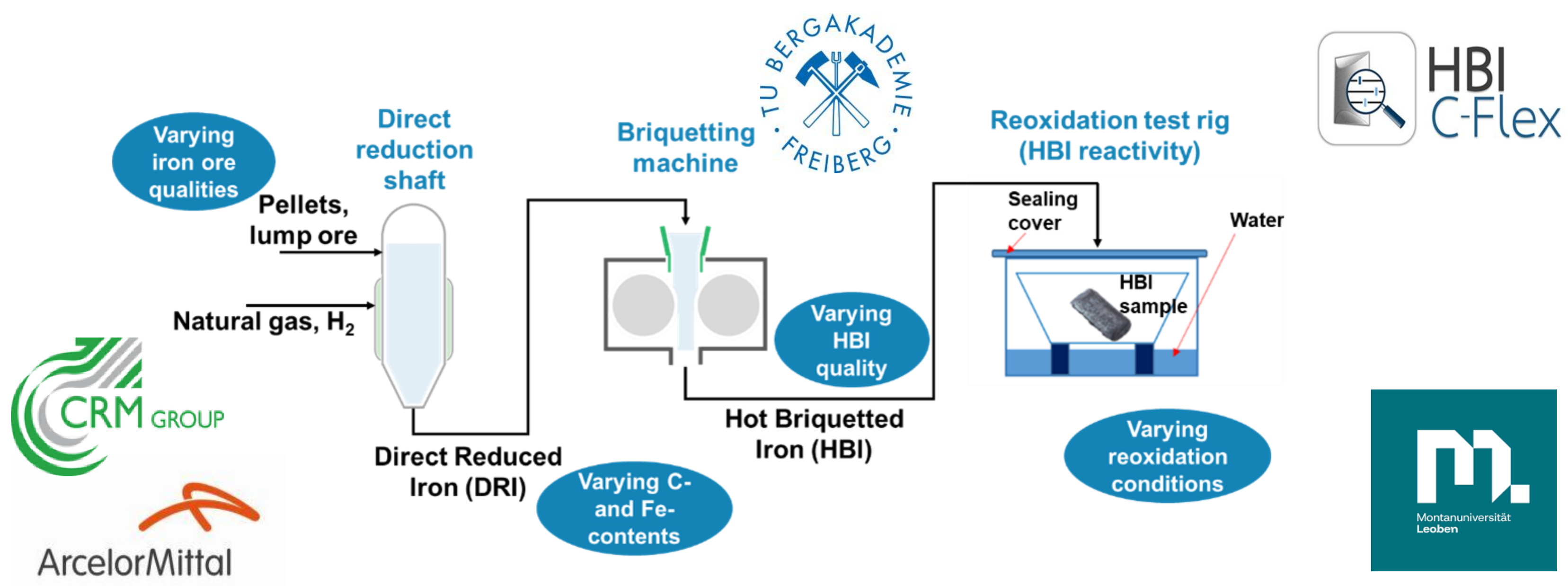

Fig. 1: The lab-scale HBI production and reoxidation comprises the steps: 1.) reduction, 2.) briquetting and, 3.) reoxidation.

Experimental setup

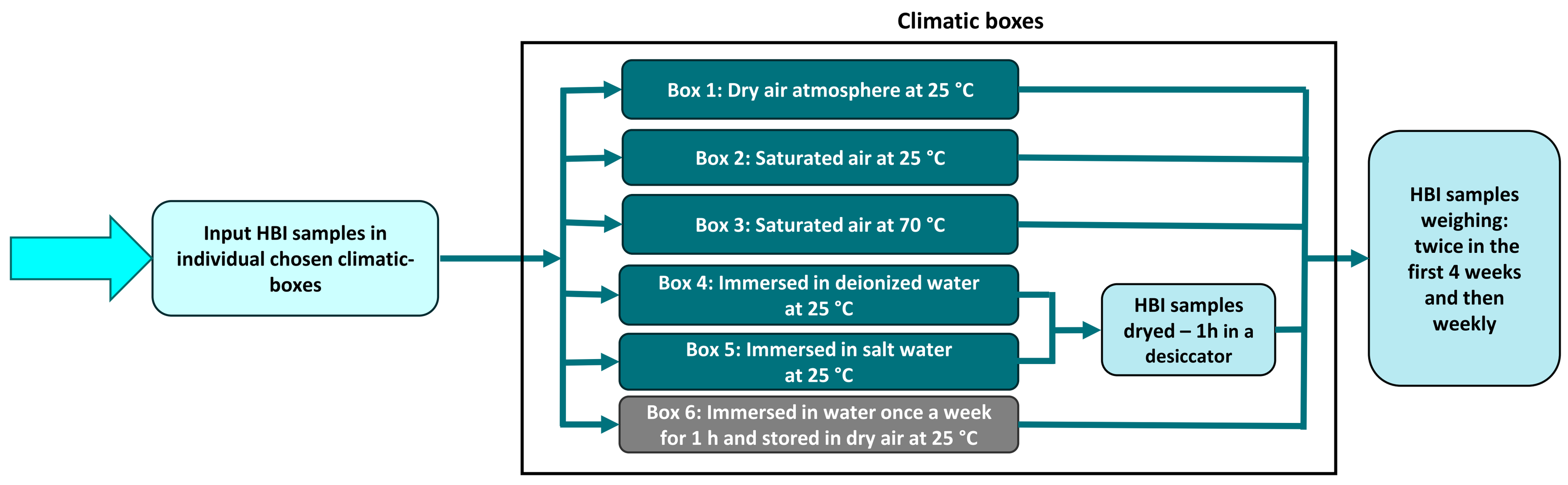

Fig. 2: Schematical illustration of the reoxidation tests with HBI samples.

The reduction tests carried out in CRM's HUGE reactor under defined reduction conditions aim to produce sufficient quantities of DRI-Pellets for the briquetting trials. In the preliminary stages of hot briquetting DRI pellets, TU BAF developed a methodology for briquetting trials in inert atmosphere under consultation of TU Leoben. Different briquetting conditions were set according to the relevant industrial environment to validate HBI. Each test examined the effect of briquetting parameters, such as compression pressure and temperature, on the apparent density of the HBI in relation to the material parameters.

To examine the reoxidation (ReOx) behaviour of the HBI-samples, an experimental plan was developed as follows. The ReOx behaviour of the HBI-samples is investigated under six different storage conditions for a period of 12 weeks, whereby the mass increase during the storage period and further analysis of the reoxidized samples are used to assess the tendency of reoxidation. To realize the defined storage conditions, the samples are placed in opened and sealed boxes, which in turn are stored in climate chambers to ensure a defined conditions are intended to reflect possible extreme cases during the storage and transport of industrial HBI (see Fig.2).

Results & conclusion

The first reduction test with DR grade pellets was aimed at generating sufficient quantities of H_2-DRI for the briquetting trials. In the first trial, HBI samples were produced at a compression temperature of 900 °C and a pressure of 300 Mpa to achieve an apparent density of 5 g/cm³. Tab. 1 shows the results of the mass balance of the dried samples before and after the ReOx tests.

The conditions in Box 5 lead to the highest mass gain, followed by Box 2 and Box 6.

This first results show that the different conditions in the six boxes have an influence on the mass gain and thus on the reoxidation of the HBI samples. With the help of further analyses, the tendency of reoxidation is examined in detail and used to interpret the mass gains.

Table 1: Reoxidation conditions and mass gain of 10 HBI samples with a mass of ca. 1.5 kg in total in each box after a storage period of 12 weeks.

Box	Atmosphere [-]	Temperature [°C]	Mass increase [%]
1	Dry air atmosphere	25	0.014
2	Saturated air	25	0.914
3	Saturated air	70	0.269
4	Immersed in deionized water	25	0.367
5	Immersed in salt water	25	1.269
6	Immersed in water once a week for 1 h and stored in dry air	25	0.897

References

[1]. European Commission (EC): The Green Deal, COM (2019) 640 final, 2019.

[2]. EC: 'Fit for 55' - delivering EU's 2030 climate target on way to climate neutrality, COM (2021) 550, 2021.

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HBI C-Flex

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