K1-MET

Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development

Hauptstandort	Linz, OÖ
weitere Standorte	Leoben, Stmk
Thematische Schwerpunkte	K1-MET has its focus on the modeling and simulation of metallurgical processes, including metallurgical raw materials and refractoriness with the goal of an optimal process control with respect to product quality, zero was and the minimization of energy and raw materials.

Success Story Short Version

Characterization of the reducibility / disintegration of lumpy iron carriers (Area IV, Project 4.2)

Within this project different lumpy iron carriers namely lump ores, pellets and sinters as feed material for blast furnace-, direct- and smelting reduction iron making route are investigated for their applicability in each process. Therefore beside the characterization of the named materials regarding their reducibility and mechanical properties in conventional reduction lab testing facilities at the Chair of Metallurgy, the material will be characterized in terms of morphology with microscopic investigations at the Chair of Geology and Economic Geology at the Montanuniversitaet Leoben.

Success Story Long Version

Objectives:

Within this investigation lumpy iron carriers namely lump ores, pellets and sinters as feed material for blast furnace and direct and smelting reduction iron making routes will be investigated for their applicability under different prevailing process conditions. Coinstantaneous to the characterization of the named materials regarding their reducibility and mechanical properties in conventional reduction lab testing facilities the materials have been characterized in terms of morphology with microscopic investigations.

For all raw materials provided from the industrial partners the testing procedures can be summarized as follows:

- Reducibility testing according to standardized testing procedures at first and with conditions close to industrial scale process conditions in the next steps in a reduction lab testing facility
- Morphological investigation of the material prior and after the reduction process by light microscopic analysis of polished sections
- Testing of the mechanical behaviour prior and after reduction in a rotating tumbling drum
- Implementing the results into “VisuMet”, an automated image analysing software

The investigation started with testing different lump iron ores since their morphological structure is less divers. With increasing contents of slag and glass phases within pellets and sinters respectively, the interpretation of the results is getting more complex and the implementation into “VisuMet” is getting more sophisticated.

Consequently with a better understanding of the coherency of raw material characteristics and behaviour under industrial scale ironmaking conditions a more selective and purposive assortment of lumpy iron carriers for optimization of existing processes in terms of both, economical and environmental aspects should be realized in the future.

Start up of the lab facility and results of the first testing series according to ISO 4695:

After the start up of the vertical reduction retort lab facility different raw materials have been tested according to the ISO 4695 standardized testing conditions. The weight loss of the iron oxide containing material related to the oxygen extraction due to the H_2 and CO containing gas is recorded during the whole testing procedure. An example of the interpretation methodology according to the recorded weight loss is shown in the left picture in Figure 1. The diagram on the right hand side shows the time depending reduction progress and the corresponding rate of reduction of different iron ore brands is shown. It can be seen that all the limontic ores are well reducible and reach the desired degree of reduction (80%) within 100 minutes of reduction time whereas hematitic and magnetitic ores need much longer time. Also noteworthy is the accelerated reduction rate in the first 20 minutes of reduction for limonitic ore in contrast to the rather constant reduction rate of hematite and magnetite.

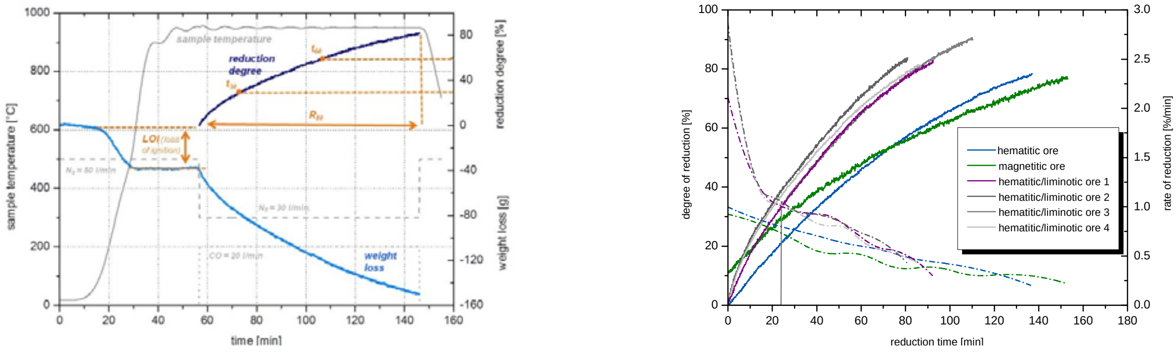

Figure 1: Principle methodology of interpreting the facility data (left) and resulting reduction curves of different iron ore brands (right)

Results of experiments with conditions close to industrial scale conditions:

By adapting the testing conditions in terms of heating rate, testing temperature, gas composition and amount the following findings concerning lump ore can be pointed out:

- The sequence of the reduction progress of limonitic ore > hematitic ore > magnetitic ore is independent of the testing conditions.
- The addition of small amounts of H_2 to the reducing gas enhances the reduction progress in each testing procedure and each type of ore. In Figure 2 the influence of adding 3 and 6% H_2 to the gas can be seen for conditions close to the blast furnace process (hematitic ore).
- An increase of H_2 content to 25% with contemporaneous decrease of reduction temperature to 800 °C leads to different effects. Whereas limonitc and hematitic ore are reduced faster compared to the conditions shown in Figure 2, the magnetitic ore could not reach a reduction degree > 60 %.

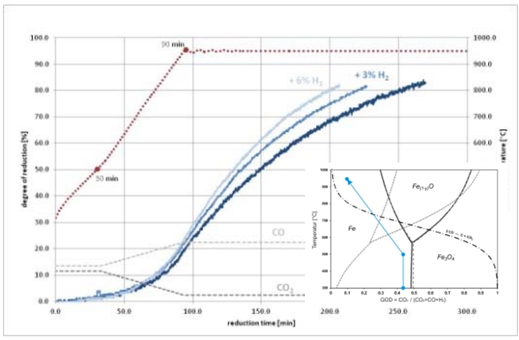

Figure 2: Influence of H_2-addition to the reducing gas on the reduction progress of hematitic ore according to blast furnace conditions

Morphological investigation of different pellet brands prior and after reduction:

As an example of the morphological investigation prior and after the reduction light microscopic pictures of two different pellet brands are shown in Figure 3. In comparison to the fine grained structure of the Robe River raw material, CVRD pellets have a coarser structure and less porosity and therefore are assumed to be less reducible. After the reduction process (reduction curves on the left side of Figure 3) it can be seen that it is not that way, most probably due to very fine distributed slag phase surrounding every single hematite grain within the Robe River pellets.

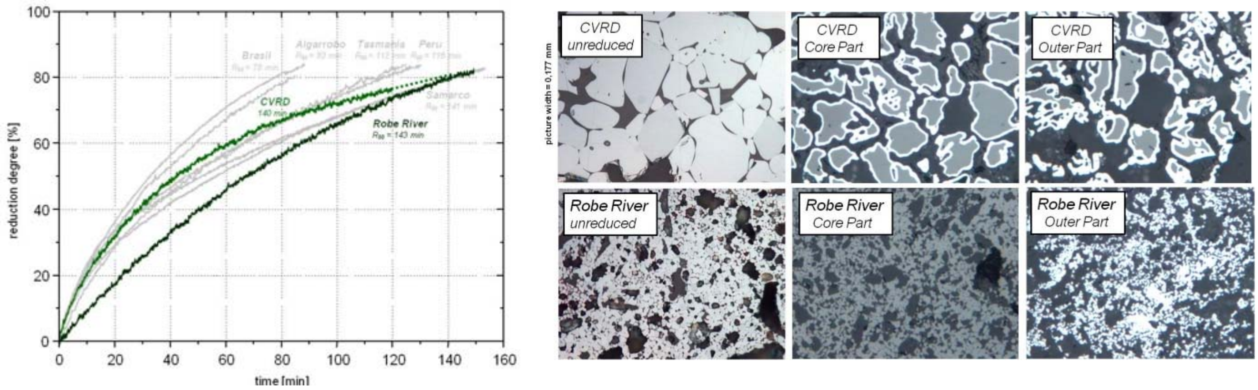

Figure 3: Reduction progress curves of different pellet grades (left) and light microscopic pictures of selected regions of pellets (right)

These facts indicate that especially the lack of knowledge concerning the effects of amount and distribution of glass/slag phases and pore distribution respectively, on the reduction properties complicates a reliable characterization with the automated image analysing software without conventional reducibility testing.

Contact:	Chair of Metallurgy, Montanuniversitaet Leoben, eisen@unileoben.ac.at +43 3842 402 2201, http://www.metallurgy.ac.at