

EVALUATION OF THE REDUCTION BEHAVIOR OF HEMATITIC IRON ORE UNDER BLAST FURNACE NEAR CONDITIONS

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Abstract

The operation of a blast furnace is characterized by simultaneous running chemical and physical processes. Hence, the influence of parameters like pressure, temperature and gas composition on the reduction behaviour of the iron bearing minerals cannot easily be presented in a simplified form, e.g. a reduction test with only CO as reducing agent. In the course of this work experiments on the reduction behaviour of iron ores were made with a vertical retort furnace. The mass loss due to the removal of oxygen in the iron bearing material was recorded. The morphologic changes of the microstructures before and after the reduction process were examined by means of metallographic sections of samples. The goal of this work was to evaluate the influence of both gas composition and temperature profile on reducibility and to determine optimized conditions for the operation of a blast furnace.

Keywords: reduction, iron ore, blast furnace, hematite

1. INTRODUCTION

The goal of this work was to investigate different parameters, which influence the reduction behavior of iron ores, and to determine optimized conditions for the operation of a blast furnace. Therefore experiments on the reduction behavior of iron ores were operated with a vertical retort furnace (**Fig. 1**). Hematitic lump ore was reduced by a gas mixture with varying contents of CO, CO₂ and H₂. The mass loss due to the removal of oxygen in the ferrous material was recorded to calculate the reduction degree and the reduction rate.

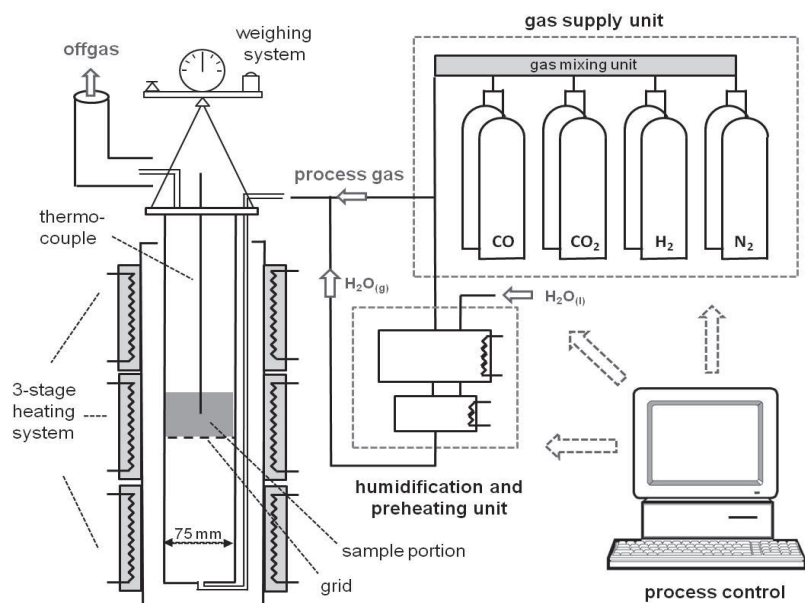


Fig. 1 Layout of the testing equipment [2]

Technical data of the retort:

- Max. Temperature: 1100 °C (possibility of varying T-profiles)
- Process gases: CO, CO₂, H₂, H₂O and N₂
- Input material: lumpy material like coke, lump ore, sinter and pellets [1]

2. DETERMINATION OF THE EXPERIMENTAL PROCEDURE AND EXEMPLARY TESTING

To define the process conditions for simulating the shaft part of a blast furnace, measured gas compositions and temperature profiles in dependence of the position within the blast furnace (hence the residence time of the burden) were taken into account. Two exemplary profiles are shown in **Fig. 2**. The parameters for the experiments were chosen as in **Fig. 3**. The experiments start with a gas oxidation degree (GOD) of 0.54 or 0.46 at 300 °C and end at GOD 0.28 or 0.10 at 950 °C, by following a continuous temperature increase and a linear change of the gas mixture. [1]

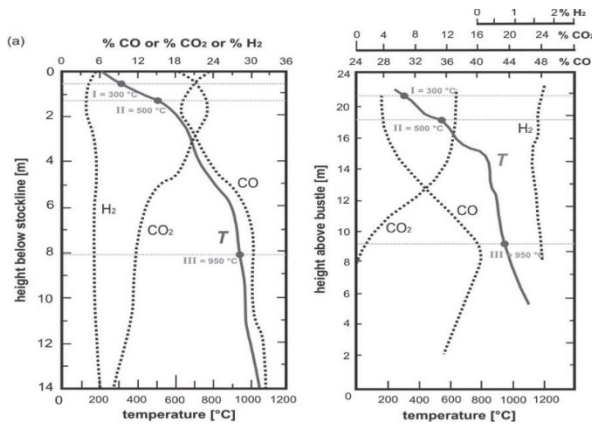


Fig. 2 Measured gas composition and temperature in a blast furnace according to [3] (left) and [4] (right)

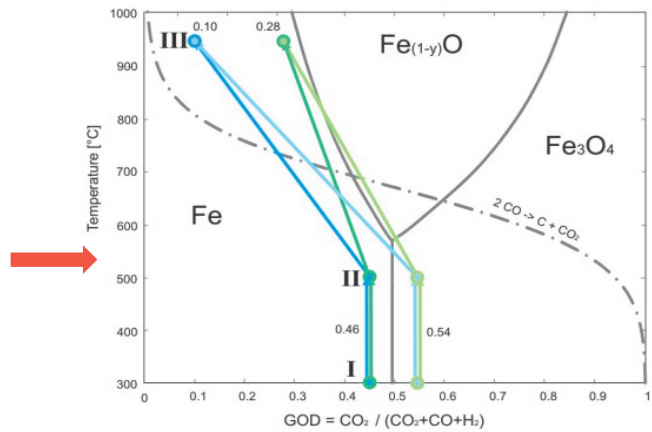


Fig. 3 Testing parameters within the Baur-Glaessner diagram [2]

Additionally, for depicting the influence of small amounts of H₂, all tests were performed either without or with 3 % H₂ in the gas mixture. The specific reduction curves of the different tests are drawn in **Fig. 4**. Microscopic morphological investigations of the raw and the reduced material confirm the results (see **Figs. 5-7**). [1]

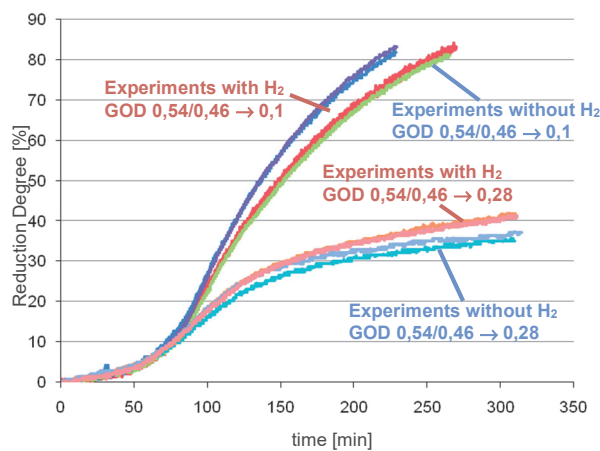


Fig. 4 Results of the tests, reduction progress (calculated from the weight loss due to oxygen release) vs. time [1]

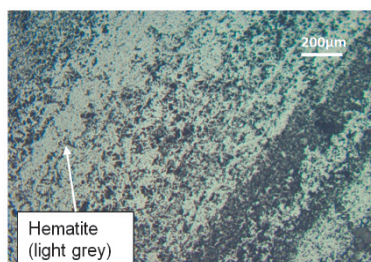


Fig. 5 Structure of the originally hematitic lump ore [1]

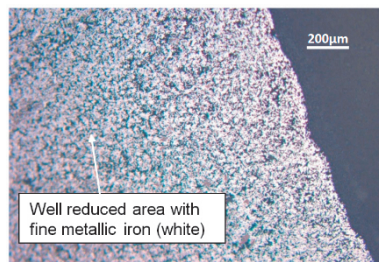


Fig. 6 Metallic iron at the edge area - GOD 0.46/0.1 [1]

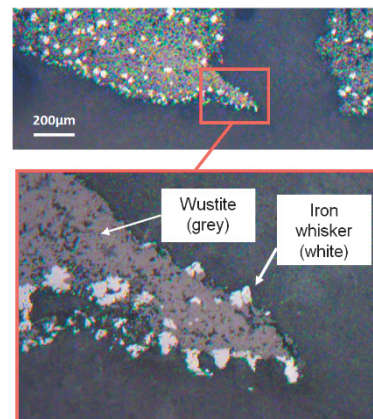


Fig. 7 Edge area with iron whiskers - GOD 0.54/0.28 [1]

CONCLUSION

The final GOD is of major importance for gaining a desired high reduction degree. At the lower reduction potential (GOD 0.28) a RD of > 40 % could never be achieved. In contrast to that, the initial GOD did hardly influence the final result. Nevertheless, the presence of 3 % of hydrogen enhanced the reduction rate in every case. The following table shows the different reduction rates at various testing conditions with a final GOD of 0.1 (Table 1).

Table 1 the different reduction rates at various testing conditions with a final GOD of 0.1.

Testing conditions	Reduction rate (dR/dt) ₄₀ [min ⁻¹]
GOD 0,46-0,10	0,53
GOD 0,46-0,10 + 3 % H ₂	0,59
GOD 0,54-0,10	0,50
GOD 0,54-0,10 + 3 % H ₂	0,65

Fig. 6 shows metallic iron (white) and some wustite (grey) after reduction at a final GOD of 0.1. On the other side iron whiskers formed, when the experiments were finished with a GOD of 0.28. Via diffusion of iron, crystals are formed preferentially at the edge area of the ore (see **Fig. 7**).

These results enable a quantitative evaluation of the kinetics and reaction mechanism of ironmaking processes. [1, 2]

ACKNOWLEDGEMENTS

This work has been performed within the K1-MET metallurgical competence center and is financially supported by the BMVIT, BMW_F, voestalpine, Siemens VAI and the provinces of Upper Austria, Styria and Tyrol.

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