

Chemical state mapping of iron in heterogeneous reduction of iron-ore sinters

Masao KIMURA^{1,2}, Yasuo TAKEICHI^{1,2}, Reiko MURAO³¹Photon Factory, Institute of Materials Structure Science, High Energy Accelerator Research Organization, 1-1 Oho, Tsukuba, 305-0801, Japan²Department of Materials Structure Science, School of High Energy Accelerator Science, SOKENDAI (The Graduate University for Advanced Studies), 1-1 Oho, Tsukuba, 305-0801, Japan³Advanced Technology Research Laboratories, Nippon Steel & Sumitomo Metal Co., Chiba 293-8511, Japan

1 Introduction

Iron-ore sinters constitute the major component of the iron-bearing burden in the blast furnace in most countries in the Asia-Pacific region. Iron-ore sinters are formed by liquid-sintering at $T > 1500\text{K}$, and are composed of iron oxide phase (mainly $\alpha\text{-Fe}_2\text{O}_3$ and partially Fe_3O_4) and calcium-ferrites (CFs)[1]. In industrial process, it is required to optimize the speed of reduction and to minimize the degradation due to mechanical strength during reduction. Therefore it is of great importance to understand where the reduction starts and how it progresses among sinters. We tried to reveal the reduction process in terms of iron chemical state changes (Fe^{III} , Fe^{II} , and Fe^0).

2 Experiment

Macroscopic chemical mapping in 2D was carried out based on X-ray absorption measurements obtained by scanning the specimen (Fig. 1).

The sinter was embedded in resin and sliced into specimens with a thickness of 20–30 μm . X-ray absorption near-edge structure (XANES) spectra were measured using ion chambers before and after absorption by the specimen. The XANES spectrum at each point is assumed to be expressed as the linear combination of those of $\text{Fe}^{\text{II}}\text{O}$ and $\text{Fe}^{\text{III}}_2\text{O}_3$ and the ratios were determined by least squares fitting. X-ray fluorescence was also measured using a silicon drift detector (SDD) in order to determine the chemical composition of iron and calcium. Experiments were carried out at the synchrotron undulator beamline BL-15A1 of the Photon Factory, IMSS, KEK in Japan [2].

3 Results and Discussion

Figure 2 shows the results of iron chemical state mapping in 2D and compositional mapping of iron ore sinter before and after reduction. Before the reduction, most areas show a chemical state of Fe^{III} (red) and $\text{Fe}^{\text{III}}+\text{Fe}^{\text{II}}$ (pink) corresponding to $\alpha\text{-Fe}_2\text{O}_3$ and Fe_3O_4 , respectively. Some areas with a high calcium concentration show a chemical state between Fe^{III} and Fe^{II} (white) corresponding to CFs.

Areas with a low calcium concentration changed to Fe^{III} (a typical areas is shown by a blue arrow in Fig. 2), while areas with a high calcium concentration remained

as Fe^{III} (red; shown by a red arrows in Fig. 3) or between Fe^{III} and Fe^{II} (white) [3].

It was observed that reduction was more likely to proceed in areas with low calcium concentration, which can be explained by experimental results using powder specimens of individual phases that iron oxides are more easily reduced than calcium ferrites [2]. The heterogeneous reduction is easily expected to cause crack formation and deteriorates the mechanical strength of the sinter. The relationship is now being studied.

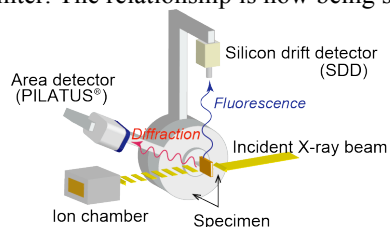


Fig. 1 Schematic diagram of the experimental setup for chemical mapping at BL-15A1 in PF

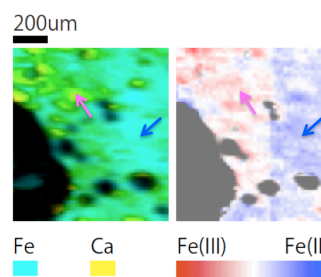


Fig. 2 Results of iron chemical state mapping (right) and compositional mapping (left) of iron ore sinter after reduction.

Acknowledgement

Part of this work carried out by MK and YT was supported by the Cross-Ministerial Strategic Innovation Promotion Program (SIP SM⁴I, units D66) operated by the Cabinet Office of Japan.

References

- [1] S. N. Ahsan et al. *Ironmaking and Steelmaking* **10**, 54 (1983).
- [2] M. Kimura et al., *J. Phys.: Conf. Ser.* **712**, 012077 (2016).
- [3] M. Kimura et al., *J. Phys.: Conf. Ser.* **849**, 012015 (2017).

* masao.kimura@kek.jp