Success Story
COMET

K1-MET
Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development
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P4.2 Valuation and optimization of iron carriers in reduction processes
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Effect of alkali metals on lumpy iron carriers

Alkali metals like potassium and sodium are generally known as harmful elements in ironmaking processes. They affect coke and iron carrier regard to higher reactivity and lower mechanical strength. To evaluate the behaviour of industrial used raw materials a special methodology to simulate the behaviour of lumpy materials in alkali-enriched fluids was developed. Combined with reduction/tumbling tests and different analysis methods it is possible to determine the behaviour of the alkali-influenced ferrous burden material on its path through the ironmaking reactor. Furthermore, by the investigations of the petrographic structure it is possible to gain important understanding of ironmaking fundamentals.

Introduction & Scope of work

Due to the thermochemical behaviour of potassium and sodium (reduction and evaporation in high-temperature zones, oxidation and condensing in low-temperature zones), both elements usually form a circulation in shaft reactors. Furthermore, this leads to enrichment of K & Na in some regions of the furnace up to 30 times. To investigate the behaviour of ferrous burden material in these regions a special methodology was developed.

Assimilation and reduction behaviour

Based on the idea to simulate the interaction between the alkali-metal in the gas phase and the solid iron carrier, the iron carrier was impregnated with alkalis by a fluid (aqueous solution). Tab. 1 shows the success of this fluid-solid-treatment with 5-molar Na/KOH-solution. All materials show an increase in the total alkali-content depending on the structural density. Since the charged materials haven´t homogeneous structures, it was important to characterize the alkali-assimilation for each type of petrographic structure.

	K_2O [%]	Na_2O [%]
Lump ore (2 types)	+0.26/+0.87	+0.10/+1.10
Pellets (2 types)	+1.88/+1.06	+1.09/+0.92
Sinter(2 types)	+0.38/+0.87	+0.82/+1.10

Tab. 1: Increase of alkalis in the iron carriers by the alkali-treatment

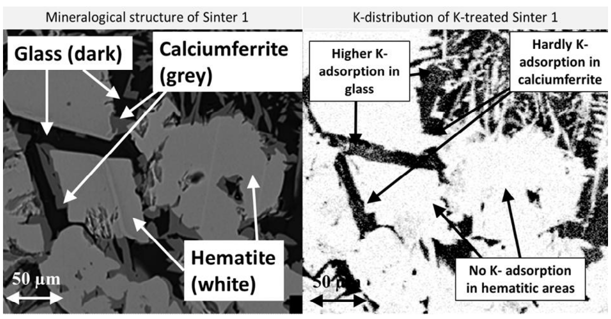

Fig. 1: Exemplary image of the morphological structure of sinter (left) and the alkali-assimilation after the K-treatment (right)

Investigations by the microprobe (see Fig.1) showed, that especially the K/Na-content of the

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glass- and gangue phases can increase significantly. After the treatment the material was charged into reduction tests (which picture the shaft of the blast furnace). Tests have been performed under standardized ISO-conditions (ISO 4695) as well as under modified, process-near conditions (BF) with various contents of CO/CO_2, H_2 and a different temperature profile (similar to the blast furnace).

Tab. 2: Increase of reducibility by the addition of alkalis (ISO-conditions)

	with K_2O [%]	with Na_2O [%]
Lump ore (2 types)	+43/+43	+0/+0
Pellets (2 types)	+90/+50	+48/+42
Sinter (2 types)	+43/+44	+2/+34

The reduction tests show various results for the different types of iron carrier and the amount of alkalis. Tab. 2 shows a summary of the increase in reducibility for the different types of burden material under ISO-conditions by the addition of alkalis. The reason therefore is a katalytic effect of the K on the nucleation of metallic iron; stable nuclei are formed earlier, which accelerates the total reduction process. Additionally to the reduction tests, tumbling tests were performed to evaluate sticking behaviour, abrasion and degradation tendency. Fig. 2 shows the abrasion tendencies of different iron carrier regards to the addition of K (black) and Na (dark grey). Especially pellets show an extraordinary correlation between chemical analysis of the glass phase and the effect of alkalis on the pellet-stability. The amount of fines after the reduction increased up to 25 % of the total mass for lump ore and pellets. The sticking tendency also increased for lump ore (+15-25 %) and pellets (+30 %). Degradation was not changed significantly for lump ore and pellets (except acid pellets with high SiO_2-content). Sinter showed no significant change in sticking- and abrasion tendency, but a big change in disintegration tendency. The sinter stability was decreased, some sinter showed only 60 % of stable particles after the reduction.

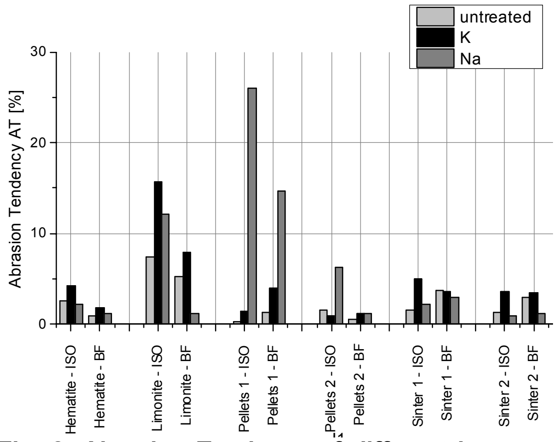

Fig. 2: Abrasion Tendency of different iron carriers during reduction (incl. influence of K & Na)

According to the process conditions (ISO-conditions & process near BF-conditions) there were similar trends for both test profiles. Under pure CO-atmosphere (ISO) the K/Na-treated material showed more changes in mechanical stability compared to the BF-tests.

Impact and effects

The investigations within this research work, combined with literature data, could provide a suitable basis for the understanding of the effects of alkalis on iron ore reduction. By choosing the right input material for K/Na-rich areas in the furnace, higher amounts of dust can be avoided and a stable furnace performance can be achieved. Further these investigations lead to a better understanding of fundamental kinetic phenomena during iron ore reduction.

Contact and information

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