K1-MET

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

Main location	Linz, Upper Austria
Other locations	Leoben, Styria
Thematic field	K1-MET has its focus on the modeling and simulation of metallurgical processes, including metallurgical raw materials and refractories with the goal of an optimal process control with respect to product quality, zero waste and the minimization of energy and raw materials.

Success story summary

Key components of metallurgical plants – New materials and technologies (Area 5, Project 1)

The Chair of Ferrous Metallurgy in Cooperation with Siemens VAI Metal Technologies has been investigating the utilization of ultra fine iron ores in smelting reduction process. An upstream agglomeration step is one solution for charging ultra fines, but crucial demands, such as reducibility and compressive strength have to be met.

Success story

Introduction and Motivation

Due to abundant supply of ultra fine iron ores there are various ambitions of developing metallurgical technologies for utilizing pellet feed (synonymously used as ultra fines). It seems that especially fluidized bed systems are appropriate for charging pellet feed. In the Geldart classification of powders, shown in Diagram 1, pellet feed is located in the area of cohesive and aeratable powders. Besides the option of direct charging, a previous agglomeration step for ultra fines is supposable. Therefore various binder concepts have been tested concerning their influence on the reduction behavior as well as mechanical properties of the agglomerates.

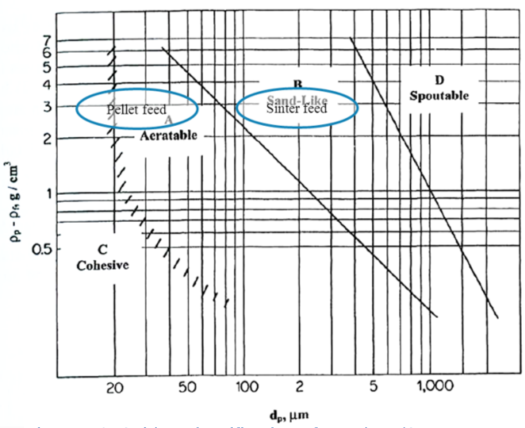

Diagram 2: Geldart classification of powders (Source: Yang W.C., Handbook of Fluidization and Fluid-Particle Systems)

Facilities and Methods

The testing procedures for the micro agglomerates with different binders and various thermal treatments were:

1. Compressive strength tests of micro pellets before and after reduction process
2. Pressure thermo gravimetric analyzer tests: the conditions of the three reduction steps are pictured in Diagram 2
3. Morphological surveys with optical microscope, scanning electron microscope, confocal laser scanning microscope and chemical composition tests
4. 160 mm fluidized bed reactor tests

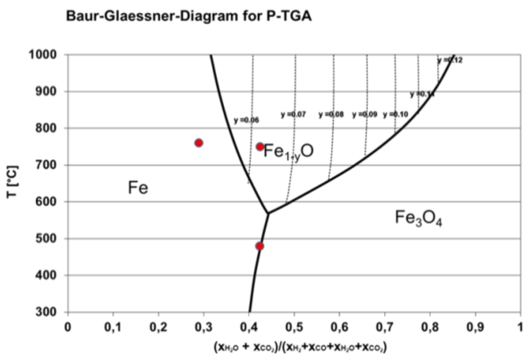

Diagram 1: Conditions of three reduction steps

Results

In the pressure thermo gravimetric analyzer the weight of the micro pellets decreased between 13.6 % (binder: bentonite) and 20.5 % (binder: lime hydrate). Micro pellets with a higher thermal treatment reduced their weight faster in the first step and reached a lower output weight at the end of the process.

Sodium silicate, which is an inorganic binder, achieved the highest compressive strength. There is a factor of 5 to 20 to micro agglomerates with other binders, depending on thermal treatment, progress of reduction process and binder content (Diagram 3). During the reduction process the compressive strength of the micro agglomerates decreased conspicuously, but their ranking concerning compressive strength remained the same. Additionally, the compressive strength of the strongest micro agglomerates was measured after every single reduction step: while usually compressive strength decreases with the reduction degree, the samples with 1.5 wt% sodium silicate have become stronger after the first reduction step. The reason for the increase of compressive strength is a hardening in consequence of thermal treatment.

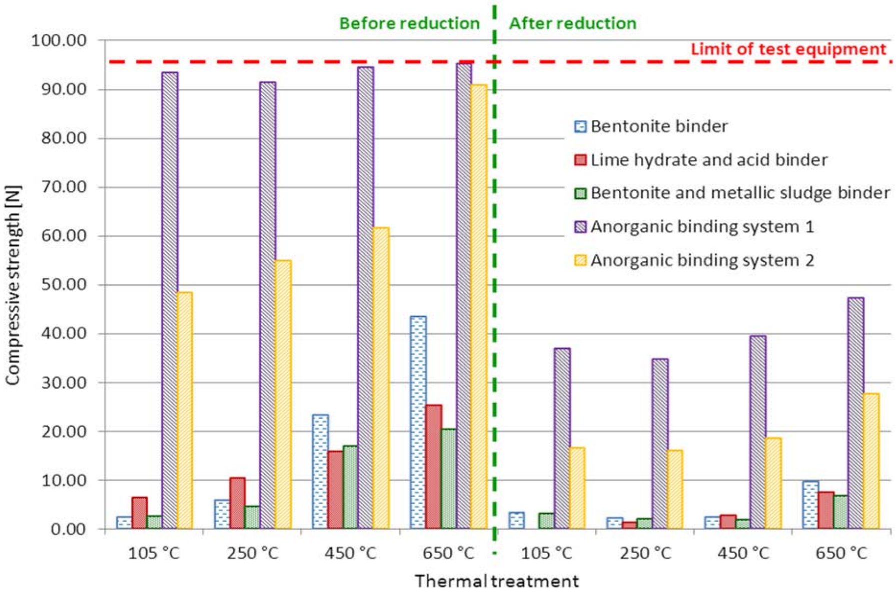

Diagram 4: Compressive strength of micro agglomerates before and after reduction tests

Finally, the micro agglomerates with the highest compressive strength have been tested in the 160 mm fluidized bed reactor. The test has been carried out with micro agglomerates between 1.0 and 4.0 mm and limonitic (sideritic) iron ore for the mass fractions smaller than 1.0 mm (Diagram 4). The amount of attrition and disintegration of the micro agglomerates was almost zero and no disintegrated pellets were found in smaller fractions after the test. The sample weight loss of 15 % corresponds well with the pressure thermo gravimetric analyzer results.

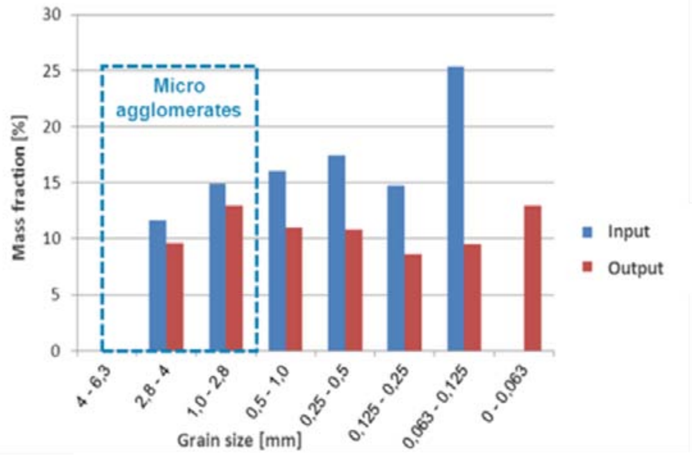

Diagram 3: Grain size distributions of input and output of fluidized bed reactor

Impact and effects

Conclusions

- Faster reduction of samples that have been treated at higher temperatures results from a reoxidization during thermal treatment.
- The reduction degree depends on the utilized binder, but not on the compressive strength.
- Compressive strength decreases after the reduction process.
- Thermal treatment of the micro agglomerates increases compressive strength of samples.
- The investigated micro agglomerates with sodium silicate binder have been appropriate for processing in a fluidized bed reactor, showing good reduction behaviour, little attrition and no disintegration.

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