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F.M. Kaußen, B. Friedrich

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Phase characterization and thermochemical simulation of (landfilled) bauxite residue ("red mud") in different alkaline processes optimized for aluminum recovery

Kaußen, F. M.* fkaussen@ime-aachen.de, Friedrich, B.* **bfriedrich@ime-aachen.de**

***IME Department of Process Metallurgy and Metal Recycling, RWTH Aachen University, Intzestraße 3, 52056 Aachen, Germany**

Abstract

In coherent studies three different processes of hydrometallurgical, alkaline extraction of aluminum from bauxite residue (BR) are examined and benchmarked regarding their efficiency on aluminum recovery. The employed processes include a direct second caustic pressure leaching, a caustic pressure leaching of the slag produced by reductive smelting of BR with simultaneous pig iron recovery (adapted "Pedersen-process") and leaching of BR after a sintering stage with sodium carbonate and further additives including lime and coke. In order to ensure a direct comparability, all experiments are conducted using the same homogenized BR from an old industrial landfill. After detailed characterization of the used BR using XRF chemical analysis, XRD phase analysis, SEM optical analysis and Qemscan® phase analysis/distribution, occurring phase formations during the employed processes are also calculated and predicted by FactSage® simulation software. The actual phase formation and leachability of the formed aluminum phases are verified during experiments and a special focus is set on the dissolution of silicon as major impurity in all processes. It can be shown that aluminum extraction efficiencies of 90 % are still possible but interlinked with massive silicon dissolution due to the almost complete dissolution of aluminum silicates.

Keywords: Aluminum recovery, aluminum extraction, bauxite residue, red mud, Bayer-process, Pedersen-process

1 Introduction

Based on published literature this study examines the effects of different (pre-) treatments of BR on the recovery yield of aluminum with special focus on phase formation and phase transitions occurring along the treatment. It is the first time in literature that different processes are compared based on one and the same homogenized industrial BR, in this case taken from the old "red mud" landfill in Lünen, Germany. The benchmark is set on the extraction efficiency of Bayer-process under common industrial conditions of high temperature digestion as best available technology (BAT) without special pre-treatment. The first step of improving is pushing the classical Bayer-process towards its limits by raising process temperature and concentration of sodium hydroxide solution up to 280 °C and 40 % NaOH (= 562 g/l) with and without the addition of lime, leading to the "concentrated caustic pressure leaching process". The second step allows pre-treatment and is based on the "Pedersen-process" by smelting BR with lime including a simultaneous pig iron