

Recovery of impurities from secondary alumina by acid leaching

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Abstract



Gas scrubbing in aluminium primary production effectively forms a closed loop leaving the produced metal and the bath as the main sink for impurities. To avoid this negative impact on metal quality and negative influence on current efficiency due to redox reactions in the bath, it is desirable to create another sink for impurities. Several attempts have been made to strip a size fraction of the secondary alumina where the impurity loading is high. Mapping of impurity distribution in secondary alumina has, however, shown that impurities have different distributions, thus complicating the selection of a particle cut-off size setting. A high cut-off value would remove a significant amount of the secondary alumina. Fluorides residing in the finer fractions would also be lost. Another strategy is to remove impurities from the stripped alumina by acid leaching. Different acids have been evaluated with respect to their leaching efficiency for the impurities of highest negative impact. It has been found, using excess acid, that leaching efficiencies as high as 90 % can be obtained. In order to minimize the acid consumption in leaching, a quasi-cascade leaching process has been evaluated. By recycling acid in several steps, a more cost-efficient recovery process is obtainable. The economic potential of the recovered impurities is also discussed.

Keywords: Secondary alumina; impurities; stripping; acid leaching.

1 Introduction

Modern dry scrubbers are very efficient in capturing dust particles in the off-gas; returning the particles to the cell and leaving the impurity bleed to the metal and surplus bath. From previous work it has been shown that the finer fraction of the secondary alumina from the off gas dry scrubber in aluminium plants are enriched in impurities [1, 2, 3]. For some impurities, an accumulation is also observed in the bath causing loss in current efficiency. Hence, removing these impurities may improve both the metal quality and contribute to better current efficiency.

The main sources of impurities are alumina and anode coke. Raising concerns about degrading purity of traditional anode coke qualities and the introduction of non-traditional anode cokes, with higher levels of impurities to cover the anode coke demand, may make impurity removal even more attractive in the future [4].

Based on investigations of the impurity distribution in secondary alumina, it is found that removing the finer fraction of the secondary alumina potentially removes more than 50 % of many of the impurities [1]. Since the impurities represent only part of this fine fraction a significant amount of valuable materials is also lost, especially alumina and fluorides. To reduce loss of valuable materials, stripping may be run in campaigns or stripped alumina can be subject to recovery processes. Some methods have been proposed [5, 6], however, not many methods have been subject to comprehensive studies. In addition to studies on secondary alumina, the composition of dust in the off gas before the scrubber has been investigated [2, 3]. Hence, it may also be possible to reduce the amount of impurities by treating the pot off-gas before the dry scrubber.

Regardless of method, disposal of waste materials should be reduced to a minimum and a strategy for recovering all materials is beneficial from an environmental point of view. Typical impurities in secondary alumina are Fe, Mn, Si, Ti, Zn, Ga, Be, alkali and alkaline earth elements, such as Li and Mg. Some reported effects of impurities are listed in Table 1.

Both iron and phosphorous are reported to negatively impact the current efficiency [7]. Sturm and Wedde [1] found that the distribution between P in the bath and the tapped metal was about 10/1. In their investigation they found that the impurity stripping could reduce P from about 150 ppm down to 40 ppm in the bath. Removing particles below 45 μm would remove more than 70 % of the impurities.

Table 1. Effects of impurities introduced to the electrolytic bath in aluminium production.

Element	Main source	Main effect
Phosphorous	Alumina	Decrease current efficiency (increase metal corrosion and brittleness)
Sulfur	Anode	May affect current efficiency
Gallium	Alumina	Reduce corrosion resistance and lower mechanical properties of metal
Beryllium	Alumina	Health concern in pot rooms
Heavy metals, Ni, Fe, V, Ti, Zn	Anode	Negative effect on metal purity. May effect current efficiency
Silicon	Alumina	Negative effect on some metal grades
Sodium	Alumina	Increase cryolite ratio, causing surplus bath
Calcium	Alumina	Reduce alumina solubility, increases bath density

Characterization and analysis of pot gas dust and secondary alumina from a Norwegian aluminium plant has been reported previously [2]. In addition, some introductory acid leaching tests was reported [8]. The present paper report on the results from more extensive laboratory experiments for recovering materials in the finer fractions of secondary alumina. Since hydrometallurgical processes usually allow separation of a broad range of elements, it may be an attractive route for purification of secondary alumina and recovery of valuables from the impurity stream.

2 Experimental

2.1 Classification of secondary alumina

A pilot scale classifier was used to separate the fines from secondary alumina. The secondary alumina was mixed with air and fed to the classifier through a vertical pipe positioned at the bottom of the classifier,

Figure 1. The classifying takes place by forced vortex action in the classifying chamber. The coarse material is discharged through the bottom outlet at a flow rate of 70 m^3/h . The finer fractions are separated from the air in a cyclone and collected. The filtered air, after passing through the fan, is exhausted to the atmosphere. The secondary air inlet is used to detach fine particles adhered to the surface of coarse particles by impaction. Two fractions with 50 % of the particles finer than $D_{50} = 10 \mu\text{m}$ and $D_{50} = 20 \mu\text{m}$ were aimed at in two separate runs.

The particle distribution in the secondary alumina and the classified fractions was determined using a Malvern Mastersizer 2000 after dispersing the particles in distilled water.

alumina fines, it is also seen that Ca, after an initial increase tends to flatten out or even decrease. This is most likely due to the low solubility of CaSO₄. For the other less soluble elements it may be seen that Pb and Mg is the two elements with the most pronounced decrease in the leach solution from step to step. It is anticipated that the increase in fluoride content may be the cause for this observation.

The slow dissolution rate of the nickel is presently not known since the compounds of nickel are not determined. Usually, nickel oxides dissolve quite fast in hydrochloric acid [9], but it may be slowed down due to divalent iron (Fe²⁺).

As the residue after centrifuging was dried without further washing, some of the impurities in the residue are due to the remaining leaching solution. This has not been corrected for in the present calculations, but on average about 15 % of the solution remained with the residue. The error is of course largest for the elements with highest leaching efficiency.

Currently, the results have not been subject to thermodynamic modelling, however, the present investigation is useful as a base for determining the most significant elements that may affect a leaching process and to determine which elements should be included in a thermodynamic model. A more comprehensive and thermodynamic based approach is a subject to later studies.

5 Conclusion

Acid leaching of secondary alumina fines shows that many of the impurity elements are dissolved, resulting in a residue with much lower impurity content than in the original sample. The results also show that the loading of the solution in most cases has not reached saturation, in spite of the total amount of added secondary alumina fines in kilograms to leach solution in litres reached 1:1. Proper treatment of the leachate will make it possible to recover many of the impurities. Among the most important impurities, nickel seems to behave slightly different from most other elements, probably due to slow dissolution kinetics in the studied system.

6 References

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