OPTIMIZE SALT REMOVAL IN ALUMINA WASHING

Keywords: filtration, alumina, HPC

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Internship period: 8 Feb – 24 Jun, 2016

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FINAL Report
Acknowledgments

Process Development department in Amsterdam of Albemarle Catalyst supported this work. I want to thank Anatolie Motelica, my company’s supervisor who continuously supported me in carrying out this research. I also want to thank Johan Krop and Claudia Germano, my university’s supervisors, for the encouragement and time taken to evaluate my work.

Summary

Washing of boehmite cake is one of the crucial steps in catalyst production process. Understanding and quantification the influence of washing conditions, on purity of washed cake is of high importance. This allows finding the optimal washing conditions for existing processes and optimal design of new ones. In this report, the focus is on developing a correlation that predicts the amount of adsorbed ions (Na⁺ and SO₄²⁻) on boehmite, under certain washing conditions. The proposed correlation is developed based on theoretical insights and its parameters are determined from several sets of washing experiments. To show the applicability of the correlation, a simple Continuous Stirred Tank Washing model is developed. The calculated trends, for example, influence of slurry pH on the amount and type of adsorbed ion is well captured by the proposed correlation.

Conclusions

- A new model that correlates the amount ions (Na⁺ and SO₄²⁻) adsorbed on alumina boehmite is developed. The main model feature is that it can be employed to calculate the adsorbed amount of ions for various washing conditions (slurry pH, amount of washing water and wash water temperature).
- To fit the model parameters many washing experiments have been done. The reproducibility of the experiments is not always satisfactory. The measured data that we did not trust were eliminated from model parameter fit. The main source of errors is the required multistep handling of the cake and mother liquor to prepare the samples for XRF measurements, as the XRF equipment is not calibrated to measure concentrations in the domain required for our experiment. Aging of the slurry taken from the plant also contributes to difficulties in getting reproducible measurements. Several rules for XRF sample preparation are identified, and employed to mitigate the source of errors.
- The applicability of salt adsorption correlation is shown in modeling a Continuous Stirred Tank Washing process. The predicted trends, and the amount of adsorbed salts on boehmite, upon variation of slurry pH, amount of wash water, temperature and the amount of solids percentage in the cake left on the filter after filtration is as expected.

Recommendations

- Improve the measurement method or experiment strategy for the salts content in the washed cake and mother liquor to get a good reproducibility of the measurements.
- Extend the salts adsorption model for slurries which containing silica.
- It observed that the slurry properties slightly changes after two weeks based on the solid content test. Thus, the experiment must be done directly after get the slurry from the plant.
- Developing a plug flow washing model based on continuous stirred tank washing model and compares the results with the practical experiments.
Table of Content

Acknowledgments ........................................................................................................ 2
Summary ..................................................................................................................... 2
Conclusions ............................................................................................................... 2
Recommendations ..................................................................................................... 2
List of abbreviations .................................................................................................. 4
List of notations ......................................................................................................... 4
1. Introduction ............................................................................................................. 5
2. Objective ............................................................................................................... 5
  2.1 General .............................................................................................................. 5
  2.2 Specific ............................................................................................................. 5
3. Research question .................................................................................................. 5
4. Sources of the errors ............................................................................................ 6
5. Literature review ................................................................................................... 7
  5.1 Alumina: Precipitation process ........................................................................ 7
  5.2 Cake washing methods in general ..................................................................... 7
  5.3 Salts washing methods ...................................................................................... 8
6. Theoretical background .......................................................................................... 9
  6.1 Alumina’s washing process .............................................................................. 9
  6.2 Maximum adsorption sites on pseudo-boehmite .............................................. 10
  6.3 Sulfate and sodium adsorption model ............................................................... 11
  6.4 Linearization of the adsorption model ............................................................. 13
7. Experimental methods ........................................................................................... 14
  7.1 Work flow of the experiment ......................................................................... 14
  7.2 Purpose of using the pure powder .................................................................. 15
  7.3 Source of possible errors ................................................................................. 15
8. Result and discussion ............................................................................................. 17
  8.1 Slurry .................................................................................................................. 17
9. References .............................................................................................................. 18
List of abbreviations

SO₄ - Sulfate ion
Na - Sodium ion
HPC - Hydro Processing Catalyst
Al₅₁₆ - Aluminum Sulfate
Natal - Sodium Aluminate
WG - Water Glass (Na₂SiO₃)
WW - Wash Water
ML - Mother Liquor
CSTR - Continuous Stirred Tank Reactor
CSTW - Continuous Stirred Tank Washing
PP - Pure Powder
H-water - Deionized water
XRF - X-Ray Fluorescence

List of notations

Sₚₚ - Solid content in the pure powder (%w)
Sₓ - Solid content in the cake after 2ⁿᵈ filtration (%w)
S₁ₓ - Solid content in liquid after 1ˢᵗ filtration (%w)
S₁π - Solid content in cake after 1ˢᵗ filtration (%w)
Wₙₐ₂₀,ₚₚ - Na₂O content in the pure powder (%w)
Wₙₐ,ₚₚ - Na content in the pure powder (%w)
Wₙₐ₂₀,ₚₚ - SO₂ content in the pure powder (%w)
mₚₚ - Mass of the pure powder (g)
mₚ - Mass of the cakes of pure powder (g)
m_Cₗₚ - Mass of the cakes after 2ⁿᵈ filtration (g)
m_Cₗₚ - Mass of solid in the cake after 2ⁿᵈ filtration (g)
m_Cₗ - Mass of solid in the cake after 2ⁿᵈ filtration (g)
m_Cₘₚ - Mass of dry solid in the cake (%w)
m_Cₘₚ - Mass of dry solid in the cake after 2ⁿᵈ filtration (g)
m_Cₗₚ - Mass of dry solid in liquid after 2ⁿᵈ filtration (g)
m_Cₗₚ - Mass of dry solid in liquid after 2ⁿᵈ filtration (g)
M_Na - Molecular weight of Na (g/mole)
Mₙ₂о₉ - Molecular weight of Na₂O (g/mole)
m_H₂O - Mass of the slurry used in experiment (g)
Wₙ₂₀,ₚₚ - Na₂O content in the cakes (%w)
Wₙₐ,ₚₚ - Na content in the cakes (%w)
Wₙₐ₂₀,ₚₚ - SO₂ content in the cakes (%w)
Wₙₐ₂₀,ₚₚ - Na₂O content in the cakes with PP (%w)
Wₙₐ₂₀,ₚₚ - SO₂ content in the cakes with PP (%w)
Wₙₐ₂₀,ₚₚ - SO₂ content in the cakes with PP (%w)
Wₙₐ₂₀,ₚₚ - Na content in the cakes with PP (%w)
m_Na - Mass of Na in the cakes (g)
m_Na₂o₃ₚₚ - Mass of SO₄ in the cakes (g)
w_S - Weight fraction of solids (include salts) in the slurry (%w)
Wₙ₂₀,ₚₚ - Na₂O content in the slurry (%w)
Wₙₐ₂₀,ₚₚ - SO₂ content in the slurry (%w)
Wₙₐ₂₀,ₚₚ - Na content in the slurry (%w)
Dₚₚ - Water density at 2⁵°C (g/L)
Vₚₚ - Volume liquid in the cake (g/L)
m_Naₚₚ - Mass of Na adsorbed on boehmite (g)
m_SO₂ₚₚ - Mass of SO₂ adsorbed on boehmite (g)
m_Naₚₚ - Mass of Na adsorbed on liquid phase (g)
m_SO₂ₚₚ - Mass of SO₂ adsorbed on liquid phase (g)
m_p - Mass of boehmite (g)
m_HNO₃ - Mass HNO₃ added in the liquid (g)
m_t - Total mass of the cakes (g)
r_Wₙ₂₀,ₚₚ - Na₂O content in the liquid (%w)
Wₙₐ₂₀,ₚₚ - Na content in the liquid (%w)
Wₙₐ₂₀,ₚₚ - SO₂ content in the liquid (%w)
Wₙₐ₂₀,ₚₚ - Na₂O content in liquid phase with PP (%w)
Wₙₐ₂₀,ₚₚ - SO₂ content in liquid phase with PP (%w)
Cₙₐ₂₀,ₚₚ - Concentration Na in liquid phase (g/L)
Cₙₐ₂₀,ₚₚ - Concentration SO₂ in liquid phase (g/L)
LOIₚₚ - Loss on ignition cake at 120°C (%w)
ρₛ₁ₕᵤₑᵦ - Density of the slurry (kg/m³)
cₙₐ₂₀,ₚₚ - Concentration Na in the slurry (g/L)
cₙₐ₂₀,ₚₚ - Concentration SO₂ in the slurry (g/L)
cₙₐ₂₀,ₚₚ - Density of H-water at 50°C (kg/m³)
ρ_HNO₃ - Density of HNO₃ at 50°C (kg/m³)
HNO₃_sol - Solution content of HNO₃ (%w)
pHₑᵦ - The pH set point
pHₘₑₓ - The pH mixture of the slurry and H-water
m_H₂O - Mass of H-water added (g)
m_Cₗₚ - Mass of cake from 1ˢᵗ filtration (g)
m_Cₗₚ - Mass of liquid from 1ˢᵗ filtration (g)
m_Cₗₚ - Mass of cake from 1ˢᵗ filtration (g)
m_Cₗₚ - Mass of dry solid in the cake after 1ˢᵗ filtration (g)
m_Cₗₚ - Mass of dry solid in the cake after 1ˢᵗ filtration (g)
m_Cₗₚ - Mass of cake used to analyze (g)
m_pₚₚ - Mass of the pure powder used to analyze (g)
m_pₚₚ - Mass of the liquid used to analyze (g)
r_Lₚₚ - Density of liquid (kg/m³)

*The list of abbreviations and notations is used for reading the report and the attachments.