Essential Readings in Light Metals: Alumina and Bauxite.
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A YEAR OF OPERATION OF THE SOLID-LIQUID CALCINATION (SLC) PROCESS

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1.0 INTRODUCTION

1.1 Organics in Bayer Liquor

The presence of organics in Bayer liquor affects to some extent all the operating steps of the process. Organics in general and in particular, the humates, reduce liquor productivity and degrade hydrate and alumina quality (1, 2, and 3). There are many processes to remove or destroy organics from the liquor (4) but none offers a complete and specific solution to each Bayer plant.

1.2 Background

The difficulties in developing a suitable organics control technology led to a jointly funded effort by Alumina Española S.A. (Spain), (now Alcoa Europe), Alcan International Ltd. (Canada), Aughinish Alumina Ltd. (Ireland) and FFE Minerals A/S (Denmark). The result is the Solid-Liquid Calcination (SLC) process, a new, advanced and user-friendly method to safely destroy organic matter and causticize Bayer liquor.

The SLC process is based on the "sintering process" (5) and consists of four steps; (i) mixing of an alumina source with Bayer liquor, (ii) drying and agglomeration of the blend, (iii) calcination and (iv) sodium aluminate (clinker) dissolution.

An intensive pilot-testing programme to select and develop the best SLC process equipment began in 1992. Most of the preliminary work was carried out in a 24 tpd integrated pilot plant built at the F.L. Smidth test centre at Dania, Denmark (5). In 1998, a nominal 120-tpd plant was commissioned at Alcoa Europe's refinery in San Ciprián, Spain (6).

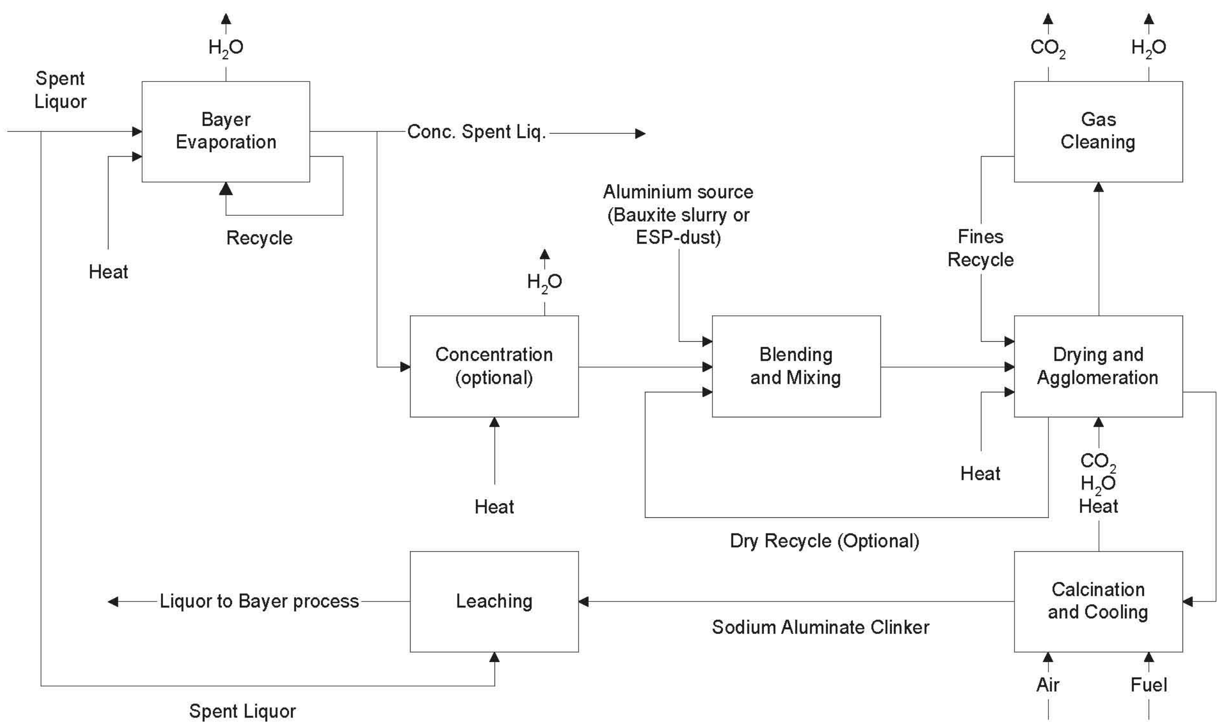

Figure 1. SLC Process Block Diagram

2.0 THE SOLID-LIQUID CALCINATION (SLC) PROCESS

The SLC process for liquor burning comprises the following unit operations:

- Evaporation to concentrate spent liquor, crystallisation and filtration to form saltcake
- Mixing of feed materials to achieve stoichiometric chemical composition ((Al+Fe)/Na = 1)
- Evaporation, drying and agglomeration of the slurry into solid particles done in the Gas Suspension Dryer (GSD)

- Calcination of the solid particles to form a sodium aluminate clinker done in the fluid bed calciner (FBC)
- Cooling of the clinker
- Gas cleaning to capture particulate matter
- Leaching of clinker to dissolve sodium aluminate and recover valuable caustic and alumina

The process block diagram in Figure 1 shows the stages of the SLC process in the 120-tpd-demonstration plant (6).

2.1 Feed Slurry Preparation

Plant liquor with a total soda concentration of 350-500 gpl measured as Na_2CO_3 is mixed with salt cake and an alumina source comprising a bauxite slurry or ESP dust to form a pumpable feed slurry. The mixing is done in an automatically controlled batch-process. The feed slurry is then pumped to the GSD via an intermediate holding tank.

2.2 Evaporation and Drying

The feed slurry is injected into the GSD through atomising spray nozzles. The GSD is operated at an inlet temperature minimising emission of volatile organic matter, and at an outlet temperature providing complete evaporation of water without scaling. The dry product is discharged from the bottom of the GSD in the form of granules or pellets.

2.3 Calcination

The dry material is calcined in a fluid-bed. The calcination unit provides sufficient residence time at 900-1000°C for complete destruction of organics and formation of sodium aluminate. Slightly higher temperatures are needed if ESP dust is used as the alumina source.

2.4 Cooling

Cooling is performed in a controlled flow grate cooler, designed for cooling the solids to about 80°C, which is desirable for leaching the clinker with plant liquor.

2.5 Gas Cleaning

Dust emerging from the calcination and cooling units flows with the hot gases into the GSD where it is re-agglomerated into the dry product. The fine fractions of the dry solid are entrained out of the GSD by the gas flow and captured in a baghouse and recycled directly into the GSD, thus reducing the overall dust emission to below environmental standards.

2.6 Leaching

The cooled sodium-aluminate clinker is discharged into the dissolution tank and recycled back into the Bayer process dissolved in plant liquor.

3.0 PERFORMANCE AND EXPERIENCE OF THE SLC DEMONSTRATION UNIT

The nominal 120-tpd clinker demonstration unit was started at San Ciprián in the autumn of 1998. Success of this unit was to be determined by achievement of the criteria set out in Table I.

After almost 10 months of operation of the plant we are now in a position to make an assessment of the performance of the plant as well as to check our design.

Table I
Criteria for Technical Success

Performance Parameter	Success Criteria	Remarks	Comments
Availability	>85% of available time	During 30 days out of first six (6) months	
Organics destruction	>95%		
Dust emission	<50mg.m^3 (dry, 11% O_2)		
TOC emission	Odour free	150 ppm at 11% O_2	
Recovery of Na & Al	R_{Na}*R_{Al}>0.85		
Capacity	1) Consuming all salt cake produced during the commissioning period 2) 80 tpd Clinker	30 days period	
Specific heat consumption	2025 kcal/kg Clinker		
Specific power consumption	170 kWh/t Clinker		

3.1 Availability

This was achieved during March –99. In general, following the commissioning of a new plant, there is a period of learning for the operations and maintenance staff when the responsibility for the plant changes over from the commissioning team to the regular staff. During this period availability of the plant normally decreases for some time before rising back to a steady level.

3.2 Organics Destruction

This has been consistently achieved. Although the organics content in the feed slurry can vary depending on the amounts of saltcake and spent liquor used in the mixture, the TOC in the final product is on average less than 0.1%.

3.3 Dust Emission

Problems with the baghouse have caused the emission levels to go over the target at times. The problems, which were mechanical in nature, have been corrected, and the baghouse is now performing better.

3.4 TOC Emission

This is linked to the performance of the calciner burners, as well as to the inlet temperature of the dryer. Recent observations suggest that it is also linked to the amount of material recycled over the dryer. An odor sensing point was installed in the stack after the filter. Since odor sensing equipment has not been found, all observations are subjective, however there does appear to be evidence that the recycled fines which coat the filter bags in the baghouse also act as a de-odorising mechanism. The indications are that the TOC emission goal can be met once better burners are installed in the calciner.

3.5 Recovery of Na and Al

This has almost been achieved. It has proved to be advantageous to slightly increase the Na/Al molar ratio in order to control formation of Na_2CO_3 As the formation of carbonate seems to be related to the combustion conditions in the fluid-bed calciner effords are currently underway to improve these.

3.6 Capacity

The goal of consuming all saltcake produced during a 30 dayperiod has been achieved. However, lack of storage facilities for the saltcake has meant, that during periods when the plant was shut down for modifications or repair, saltcake has had to be disposed of by other means. A storage facility is now being built, in order to avoid this in the future.

The goal of 80 tpd production of clinker has been achieved. Plant production is limited by the capacity of the dryer. It operates very close to design evaporation rate, but as it is necessary to use extra liquor in the feed slurry to keep it pumpable the amount of water present in the feed is larger than anticipated during design. This prevents us from reaching the design capacity of 120 tpd. During the test with ESP dust (see below) we reached 115 tpd production without any problems. This was due to the smaller amount of moisture in the feed.

In general the feed slurry has been the major source of unexpected problems, as the properties of a freshly made slurry differ significantly from those of a slurry that has been stored for some time. The slurry shows shear-thinning behaviour and this is now being utilised in a redesign of the intermediate storage tank. This should open a possibility of using ”thicker ” blends of feed components and thus an increase in clinker production rate.

3.7 Specific Heat Consumption

We have consistently achieved consumptions of less than 1500 kcal/kg of clinker produced during normal operation.

3.8 Specific Power Consumption

Less than 120 kWh/t of clinker produced has been consistently achieved during normal operation.

Both the consumption figures in the Success Criteria were ”worst case” figures. The figures realised are much closer to the design values.

4.0 TEST WITH ESP DUST

In July 1999 a test was conducted replacing bauxite slurry with ESP dust from the calciners at San Ciprián as a source of aluminium. This feed slurry had a considerably lower water content and for this reason it was possible to increase the plant production almost to the design value, while consuming saltcake far in excess of the normal production.

The test proved that ESP dust could successfully be used in the process, thus opening the way for wider application of the process. The relative ease of handling the ESP dust slurry compared to the normal feed slurry, points to investigation of slurry blends with both ESP dust and bauxite. Further tests along those lines are being considered.

5.0 OPTIMISATION

Most of the problems highlighted during the first year of operation have been mechanical. They are summarised as follows:

Bag house protection: The original system designed to protect the filter bags from excess temperatures during sudden loss of feed, (e. g. during power failures) did not work, and a definitive system which uses automatic dampers is now being installed.

Feed homogenisation: Sedimentation occurred in the feed holding tank. An agitator is being installed to increase blending in the tank.

Recycle system: The original feed system for the fines recycle failed to give the required reliability. A larger definitive system is now being installed.

Slurry feed pumps: The pumps wear fast. New materials for the internals of the pumps are being tested, and alternative types of pumps are being investigated.

6.0 FUTURE UNITS

The San Ciprián demonstration unit was deliberately designed with a large degree of flexibility so that alternative process steps could be incorporated if this became necessary. This approach has resulted in a tall, narrow building. As it turned out this extra space was not needed and future units can be designed (along the lines of the pilot plant at Dania) to be less than half the height of the existing unit.

7.0 CONCLUSION

The new SLC process has demonstrated simultaneous liquor purification and recovery of waste residues without generating odours. The advantages of the SLC technology are:

7.1 Increased Liquor Productivity

The reduced impurities level of Bayer liquor will decrease the quantity of precipitation stabilising agents and permit an increase in caustic concentration. The result will be an increase in liquor productivity, which will lead to an expansion of plant capacity, or better fuel and power efficiencies, or both.

7.2 Environmentally Sound Waste Reprocessing

The San Ciprián refinery has an evaporation-crystallisation process for liquor purification and generates so-called "salt cake" wastes. Those residues create an environmental problem, which is now being solved. The SLC process permits complete salt cake reprocessing to convert the sodium salts into sodium aluminate without generating additional residues.

7.3 Hydrate and Alumina Quality Improvement

In time, continuous operation of the SLC process is expected to lead to an improvement of hydrate colour (6), a reduction of sodium in alumina and the production of a coarser product. It is yet too early to document these effects in San Ciprián. Furthermore, it is possible to use ESP dust or fines as alumina sources, which can reduce the content of superfines in alumina.

7.4 Plant Efficiencies Improvement

Organic removal from plant liquor should reduce the viscosity of the liquor and the amount of organic soda in the liquor. Caustic consumption should be reduced by recovering soda from the salt cake. Viscosity reduction results in a small improvement in power consumption. The use of the SLC process should also permit increased mud settling rates and reduce foam formation which would lead to a reduction in flocculant and anti-foam consumption and more effective use of installed precipitator volume.

7.5 High Organic Bauxite

The SLC process permits the use of cheaper, high organic bauxites in the Bayer process. This makes it possible to reduce costs.

7.6 An international R & D project

The joint development project of the new SLC process technology between Alumina Española S.A., Alcan International Limited and FFE Minerals A/S was formed with the objective of developing and marketing the SLC process. The potential advantages and drawbacks of such an agreement can be summarised:

Table II - An International R&D Project

	Alumina Refiner	Equipment Supplier
Advantages	Fast improvement Broader know-how base Risk sharing (more R&D) Income from technology sale	Shorter time to market Broader know-how base Risk sharing (more R&D) Viable "presold" prototype Focused approach
Drawbacks	Slower decision process Assumes part of the supplier's cost Commitment to test prototype	Slower decision process Shares income with Partners

To a large extent, these points are balanced and shared between the alumina refiner and the equipment supplier, with the end result that the SLC process is now a proven process and ready for the market.

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