Essential Readings in Light Metals: Alumina and Bauxite.
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6. PRODUCT HYDRATE FILTRATION AND ALUMINA PRODUCTION BY CALCINATION

The papers selected for this section reflect the historical development and changes in product hydrate filtration, calcination, and dust emission control technology.

Product hydrate filtration has been performed using mainly horizontal pan filters since 1953. The design of the horizontal pan filters utilizes the gravity force and vacuum suction as driving forces for the filtration process. Though no major technology changes have taken place over the years, the mechanical design has been constantly improved, and the size of the filtration area, and thus capacity, has grown more than sevenfold.

The production of alumina by calcination of product hydrate removes irreversibly the crystal water and had been carried out until 1970 almost exclusively in rotary kilns. The exception being the 300–900 tpd stationary fluid flash calciners developed and started by Alcoa in the years 1960 to 1970 for production of sandy smelter grade alumina (SGA). With the advent of the first oil crisis, only stationary calciners were thereafter installed for production of sandy SGA with exception of the first 500 tpd circulating fluid bed calciner at Vereinigte Aluminium Werke at Lüenen, Germany producing floury SGA.

The modification of rotary kilns and change to stationary calciners, of various design and brand name(s), for production of sandy SGA, was strongly driven by the oil crisis and lower capital investment. Subject to the moisture content of the hydrate feed, the typical specific heat consumption of rotary kilns producing sandy SGA at about 4,000–4,200 MJ/ton alumina, was reduced by 25–30% to 2,800–3,200 MJ/ton alumina, when replaced with stationary calciners. Even lower thermal energy consumption is predicted for the new pressure calcination process piloted by Alcoa.

Traditionally, product hydrate filtration has been integrated with calcination in the same building, but introduction of the 2,300 and 4,500 tpd size stationary gas suspension calciners, at Yarwun and Queensland Alumina in Australia, has shown that a decoupling is indeed feasible with both product hydrate filtration and calcination operation being controlled from the remote central control room.

Electrostatic precipitators were exclusively used for control of the particulate emission from the rotary kilns and stationary calciners until 2004, when Queensland Alumina, Australia, replaced its rotary kilns with stationary calciners. These units became the first stationary calciners to be equipped with baghouse or fabric filters only, with the ability to maintain control of the dust emission in situations where the alumina refinery experiences a power failure.

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THE WORLD'S LARGEST HYDRATE PAN FILTER: ENGINEERING IMPROVEMENTS AND EXPERIENCES

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Abstract

FLSmidth Dorr-Oliver Eimco GmbH (FLS) and Aluminium Oxid Stade GmbH (AOS) present the latest engineering highlights and details of the operation of the world's largest hydrate pan filter at AOS. The various features of the pan filter with a filtration area of 71m² have resulted in AOS's decision to use FLS technology for product filtration.

A track record is provided that deals with experiences of the filter operations. This covers the major process features and the operating procedures which have been developed to maximize the availability and performance of the filtration system. Comments are made concerning a comparison with the operation of hydrate drum filters used before the commissioning of the 71m² pan filter. The production of high quality hydrate is discussed in relation to filtration parameters and optimization measures which have been practiced since the startup of the filter.

Introduction

The alumina plant AOS is located in Stade/Germany on the river Elbe in the vicinity of Hamburg. The plant started operation in 1973 with a designed production capacity of 600,000 t/a alumina. Since 1973, production capacity at AOS has continuously increased and 1,033,000 t/a of alumina were produced in 2007.

Until 2005 product filtration was carried out with two identical drum filters. Because of the steadily increasing production output (2005: 923,000 t/a alumina) these filters reached their performance limit. That means each shutdown of one of the filters led to several operational problems. Therefore a new filter had to be found, which was able to provide the same capacity as the two drum filters together.

AOS decided to install a pan filter constructed by FLS. This pan filter started operation in February 2006.

Figure 1. AOS pan filter, discharge scroll

After an optimization period the filter capacity increased further on. This additional filtration capacity has made an important contribution to the increase in AOS production which stands at more than 1,000,000 t/a of alumina.

Initial Situation

Since the start of operations at AOS in 1973 the product filtration had been carried out using two vacuum drum filter units. After every 7.5 hours of operation the filters had to be stopped for half an hour for caustic filter cloth cleaning. Thus, for three hours per day half of the hydrate produced had to be pumped back to the precipitation.

Because of the production increase each year, the drum filters reached their designed capacity (Table I). For example in 2005 production reached 923,000 t/a alumina which led to a working load of the drum filters of 95 %.

Table I. Design Data of the Drum Filters	
Manufacturer	Dorr Oliver Eimco GmbH
Filter Area	80 m² per filter
Specific Capacity	1,200 kg/(m²*h) dry hydrate
Capacity	96 t/h dry hydrate
Density of the Slurry	1,320 g/l
Water Ratio (wash water/capacity)	0.80 m³/t dry hydrate
Steam (5 bar)	2.0 t/h
Filter Cake Thickness	50 mm

In brief, to ensure a secure product filtration an additional filter device was needed.

FLS Pan Filter

As already mentioned the new filter device needed to have a capacity that was equivalent to that of both drum filters together. In addition a higher flexibility concerning operational parameters was required particularly concerning the density of the slurry and a lower wash water consumption.

The pan filter of FLS meets the requirements (Table II).

Table II. Design Data of the Pan Filter	
Manufacturer	FLSmidth Dorr Oliver Eimco
Filter Area	71 m²
Specific Capacity	2,584 kg/(m²*h) dry hydrate
Capacity	183.5 t/h dry hydrate
Density of the Slurry	1,350 g/l
Water Ratio (wash water/capacity)	0.40 m³/t dry hydrate
Particle Size Distribution	4.0 % < 45 µm 2.8 % < 30 µm 1.2 % < 10 µm

Filter Design

In Figure 2 a schematic of the AOS pan filter is provided based on the filter design supplied by FLS. The main components of the 71m² pan filter design supplied to AOS are:

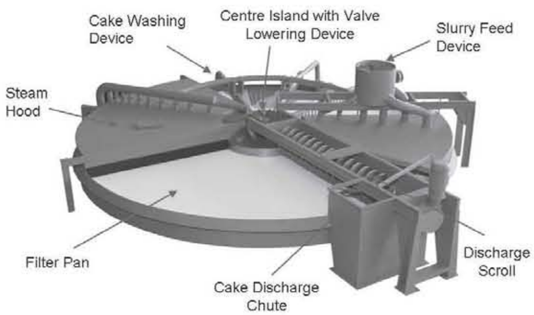

Figure 2. Schematic of AOS pan filter

- Filter pan with a diameter of 9.76 m divided into 24 cells and a sloped bottom for a discharge through the centre island of the filter.
- Variable speed pan drive allowing for operation of the filter pan in the range from 0.3 – 2.0 rpm driven by a 22 kW motor.
- Adjustable slurry feed system for equal distribution of the incoming feed over the entire pan radius comprising a feed vessel with six adjustable feed chutes designed for a maximum feed flow of approximately 500 m³/h.
- Cake wash pipes (2 pieces) for filter cake washing in counter current mode.
- Steam hood for improved reduction of the cake moisture by saturated low pressure steam.
- Cake discharge scroll with a diameter of 750 mm driven by a 30 kW motor.
- Filter control valve divided into three sections for individual collection of mother filtrate, strong filtrate and weak filtrate. The distribution of the individual zones is widely flexible, allowing adjustment of the individual size of each process zone in accordance to the product requirements.
- Valve lifting device for lowering/lifting of the valve during inspection and maintenance.
- Vapor hood covering the complete filter with steel roof and removable rubber curtains.

Figure 3 provides an insight view of the manufacturing of the largest filter pan for dewatering of hydrate. The pan has been shipped in two halves which have been welded together at the final spot by FLS.

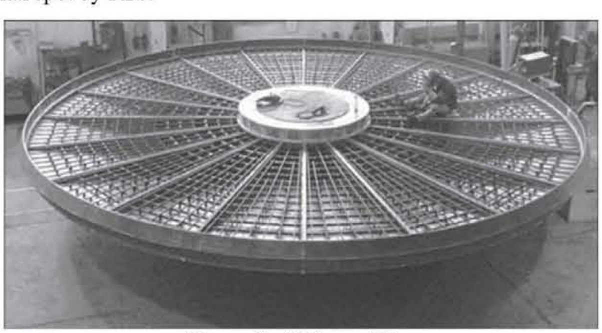

Figure 3. AOS pan filter

Highlights Of The FLS Pan Filter Technology

The actual FLS pan filter technology installed at AOS represents the largest pan filter size supplied by any manufacturer for hydrate filtration. The filter design is a result of more then 50 years of unique process experience with pan filters installed for hydrate filtration. As a result FLS meanwhile has supplied worldwide – only for product hydrate filtration - more then 210 pan filters with a total filtration area of 7,700 m².

Beside the size of the filter the highlights of the state-of the art pan filter technology installed at AOS are:

- New valve design resulting in minimum pressure losses allowing for very high filtration capacities combined with very low cake moistures.
- Optimized filter valve design with adjustable filtration zone sizes for sharp separation of mother liquor and wash filtrates - a major feature for achieving good washing results at low wash water consumption.
- Filter operation with controlled heel cake layer thickness allowing for operation at the optimum heel cake layer thickness.
- Large diameter and hard faced discharge scroll designed to discharge up to 250 t/h hydrate.
- Extra thick wear plate allowing for long term operation.
- Few moving parts and all steel heavy duty design well suitable for a reliable operation at minimum maintenance requirement.
- Limited instrumentation and control devices required for remote operation of the unit.

In Figure 4 a top view of the AOS pan filter is illustrated. The five operation zones on the pan filter as well as major filter components are shown. In addition the various liquid feeding zones (slurry, weak filtrate and wash water) are outlined.

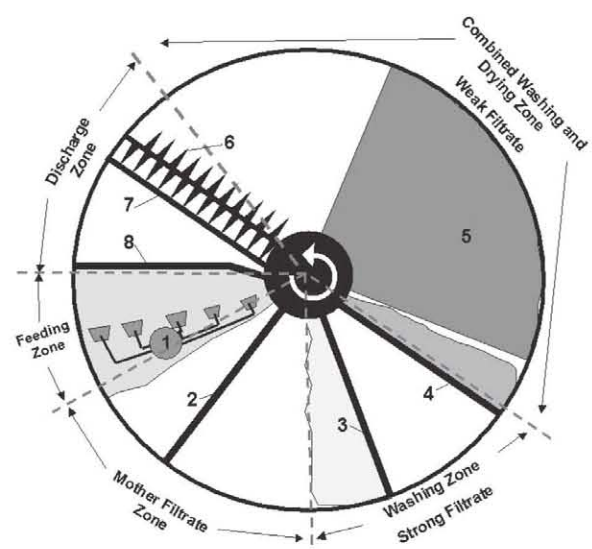

Figure 4. AOS pan filter, top view

Experiences

According to AOS specification the moisture of hydrate must be between 5 – 9 %. Another important aim for AOS is to achieve a soluble Na_2O-concentration in the hydrate of less then 0.01%. To ensure these targets, two parameters are of major importance.

<u>Steam Hood</u>
Normally the pan filter is able to reduce the moisture without using any steam. Only in special cases is an addition of oversaturated steam (5 bar) needed.

In Figure 6 the optional usage of steam in the pan filter is shown in the course of two month. The grey graph shows the moisture of hydrate and the black one the specific steam demand.

The diagram shows one of the great advantages of the pan filter, the possibility of saving energy due to the optional usage of steam. Normally AOS adds the steam, when the moisture of the hydrate is higher then approximately 7.5 %.

In the drum filters a permanent steam addition was necessary to achieve approximately 7.5 % moisture of the hydrate.

AOS reduced the total requirement of steam to the product filtration from 37,600 t/a (2005: annual production 923,000 t alumina) to 14,350 t/a (2007: annual production 1,033,000 t alumina).

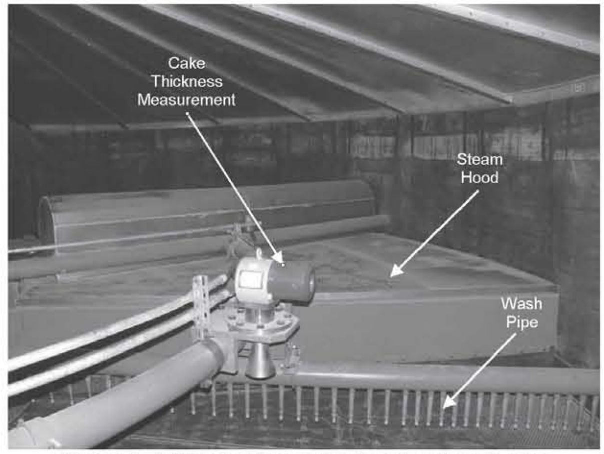

Figure 5. AOS pan filter, steam hood and wash pipe

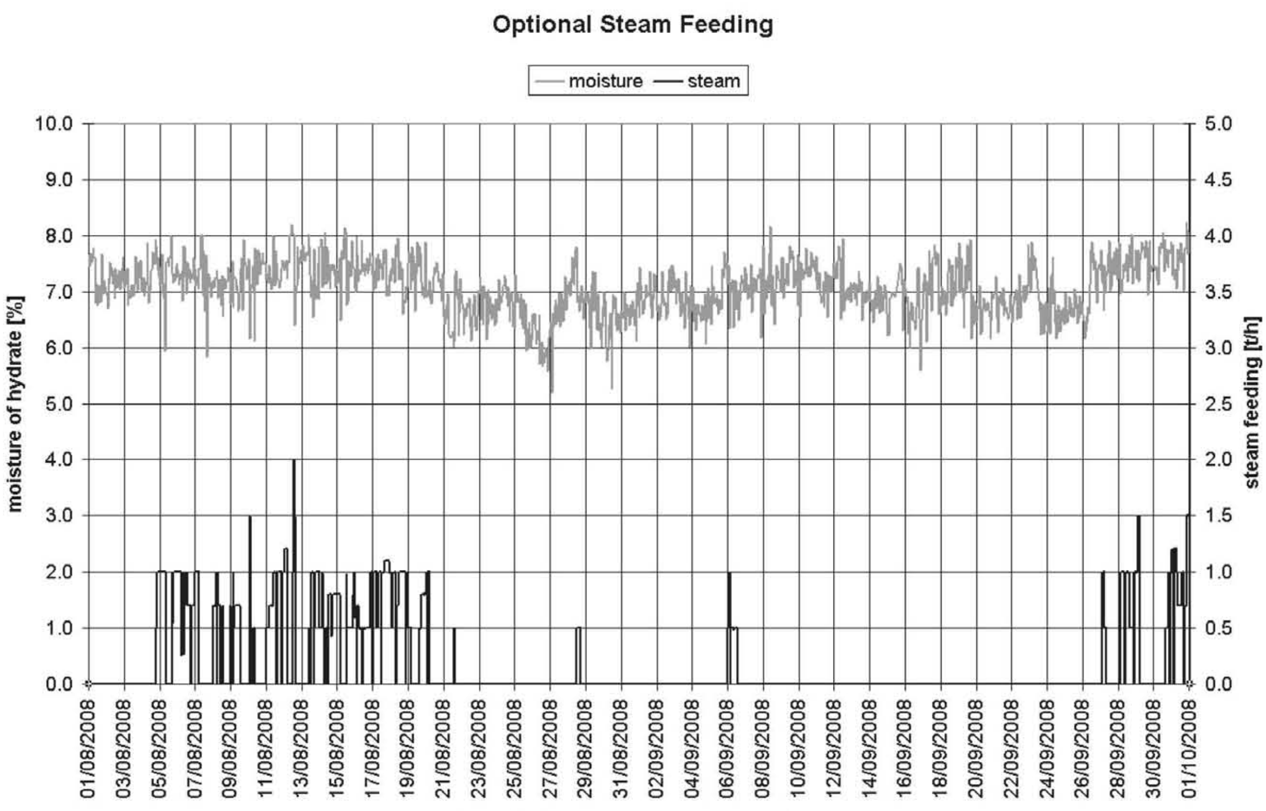

Figure 6. Optional steam usage over time

Filtrate Separation
Another advantage of the pan filter compared to the drum filters is an excellent separation of the different types of filtrate to obtain a two-stage washing mode with a low wash water consumption. The weak filtrate of the combined washing and drying zone (Figure 4) can be used as wash water in the first washing zone. Experiences show that the specific wash water demand per ton hydrate of the pan filter is much lower than on the drum filters.
The separation of the filtrates in the pan filter contributes remarkably to the product quality.

AOS normally operates the pan filter with a water ratio of 0.6 m^3/t to ensure a soluble Na2O-conzentration of 0.00 % in the hydrate.

Density Of The Slurry
During the pan filter optimization process the density of the slurry was carefully increased. Due to the now lower amount of slurry on the filter it was possible to reduce the volumetric flow of the mother filtrate (Figure 4).

Figure 7. AOS pan filter, slurry feeding

The benefit of a higher density is a better separation of the filtrate (Due to the lower amount of the slurry less liquor is carried on the surface of the hydrate from one zone to the next).

Standard Parameters Of Operation
The following Table III shows the parameters of operation that resulted from the optimization phase.

Table III. Standard Parameters of Operation of the Pan Filter at AOS

Specific Capacity	2,960 kg/(m^2*h) dry hydrate
Capacity	210 t/h
Density of the Slurry	1,520 g/l
Water Ratio (wash water/capacity)	0.60
Soluble Na_2O-conzentration in the Hydrate	0.00 %
Steam (5bar)	optional, max. 2.0 t/h
Rotational Speed	0.33 - 0.45 rpm
Filter Cake Thickness	100 mm
Particle Size Distribution	3.8 % < 45 µm 2.6 % < 30 µm 1.5 % < 10 µm

Filter Cloth

Filter Cloth Testing
Together with FLS the application of an interwoven double layer type of filter cloth has been developed in order to replace the traditional clothing method using a filter cloth fixed on top of a support cloth. Filter cloths of two cloth suppliers with increasing air permeability have been tested on the filter in operation.
In the beginning the lifetime of such a combined cloth was 1500 working hours in average. Recently trials performed with similar combined cloths from different manufacturers resulted in an increase up to 2600 working hours.
The monofilament filter cloth made of polypropylene provides good mechanical and process features and a filtrate solids content of approximately 2 g/l. The filter cloth is suitable for being fixed on filter segments by caulking-ropes fixed into omega-notches.

Filter Cloth Cleaning

For the pan filter AOS distinguished between three different washing cycles. Two of them have to be carried out every day and the third one only every five days.

- First Washing Cycle

  The washing process is operated every three hours. The volumetric flow of the slurry on the pan filter is reduced to 100 m³/h. The rotational speed is decreased to a minimum. For eight minutes the pan filter is cleaned with 40 m³/h of wash water, which is fed with a nozzle bar. These nozzles are located between the slurry weir (Figure 4; item 8) and the feeding zone.

- Second Washing Cycle

  The washing process is operated once a day. The volumetric flow of the slurry is stopped for ten minutes. The rotational speed is decreased to a minimum. For ten minutes the pan filter is cleaned with 40 m³/h of wash water.

  Figure 8 describes the first and second washing cycle during the course of 24 hours. The rotational speed of the pan filter is pictured in black, the volumetric flow of the slurry to the pan filter in grey.

- Third Washing Cycle

  The caustic cleaning of the filter cloth is carried out every five days. The pan filter is taken out of operation for 3 - 4 hours, while the entire hydrate filtration is done by the drum filters. First of all the whole cake is discharged by scroll. Afterwards the rotational speed is decreased to a minimum. In the next step 150 m³/h of hot caustic liquor (90°C) is poured onto the filter cloth. The liquor is sucked through the filter cloth and dissolves hydrate crystals adhering to the cloth.

Conclusions

AOS is very satisfied with the FLS pan filter technology. It helps to make our production more secure and flexible, to increase the quality of the AOS hydrate, to save energy (steam) and to reduce the wash water demand – not to mention that it helped AOS to exceed the 1,000,000 t/a alumina.

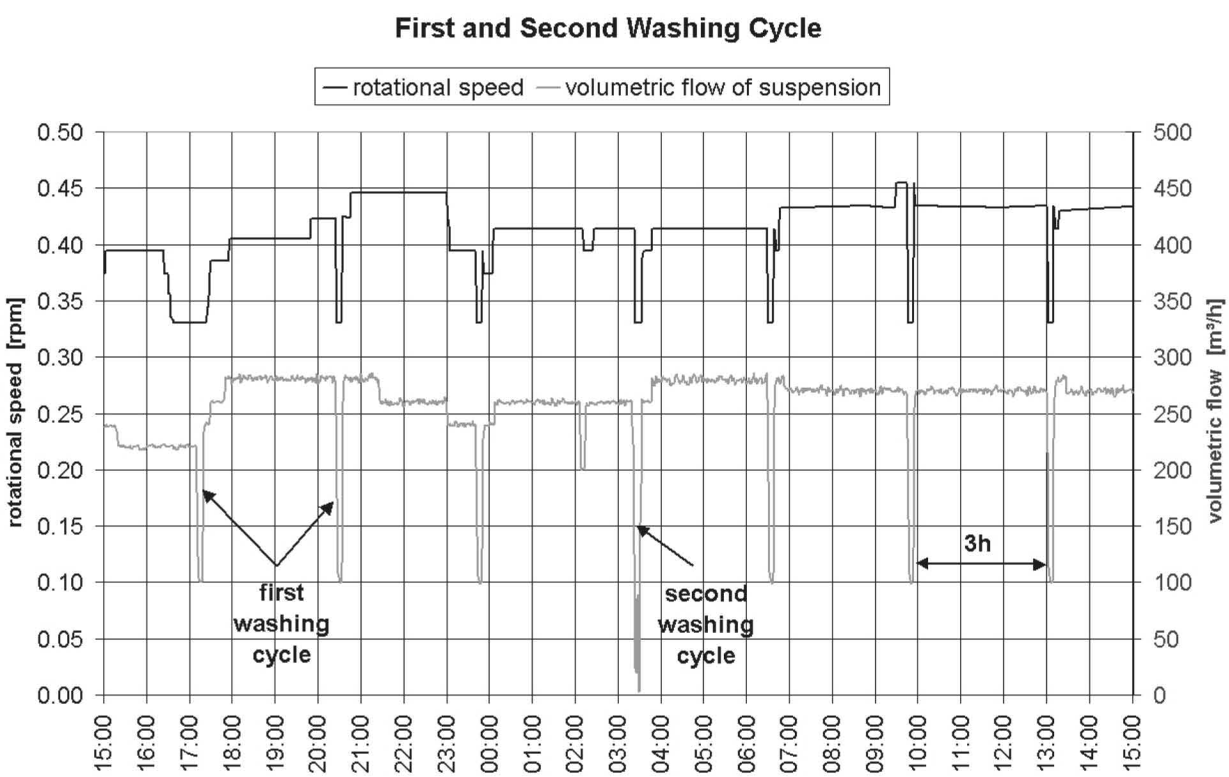

Figure 8. AOS, pan filter, washing cycle