PLANT EXPERIENCE WITH REPLACEMENT OF A THREE STEP DRUM FILTER PLANT BY A ONE STEP PAN FILTER AT AL-HYDRATE PRODUCT FILTRATION

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Abstract

In the last decade BOKELA has introduced a new generation of rotary pan filters with new and innovative design. Plant experience with operating pan filters at several Al-refineries verify that the filtration and washing of Al-hydrate product with this new pan filter generation is performed with improved filter capacity, improved product quality and reduced operation and maintenance cost.

Now, the first pan filter equipped with FrameTrak - a new method of filter cloth attachment to rotary drum and pan filters – has started operation replacing a 3-step drum filter plant in an alumina refinery. Operation results show that product filtration is now performed with significantly improved results such as 50% reduced wash condensate consumption with simultaneously reduced Na_2O-content (no more peaks) and with reduced filter cake moisture.

Operation results and design characteristics of this modern pan filter, which is the first pan filter world-wide that is equipped with FrameTrak, are presented and it is reported on first plant experience with this new method of filter cloth attachment that replaces the traditional caulking method or bolt down clamping methods.

1. Introduction

One of the last process steps of the alumina production is the deliquoring and washing of the product hydrate. It is the aim of this filtration step to remove the liquor and thus the caustic which is a contaminant for the valuable product: the Al-hydrate. This step is necessary for achieving a clean hydrate which is the condition for a good product quality.

Different methods exist for filtration of Al-hydrate product and following combinations are used in alumina refineries:

- three drum filters in series for a three-step filtration
- disc filter and drum filter for a two-step process
- disc filter and pan filter for a two-step filtration
- pan filter for a one-step filtration

Among these possibilities of Al-hydrate deliquoring and washing the last two process designs, i.e. disc filter with pan filter for a two-step filtration and pan filter for a one-step filtration, represent the latest state-of-the-art because they are most cost-effective. The advantages of these two methods of product filtration and washing, however, strongly depend on the technology used. In order to get all the benefits of these processes modern filtration equipment by advanced design with high capacity and low maintenance level is required.

2. Former plant design with three drum filters

With the old plant design of the Al-refinery the filtration and washing of the Al-hydrate product was carried out on three rotary vacuum drum filters in series(fig 1). Each of the filters has 20 m^2 filter area and the filter medium is held in place by omega profiles, caulking and wire winding. The slurry with a solids concentration of 700 –800 g/l, a mean particle size of x_{50} = 70 µm (15% - 25 % < 44 µm) and a caustic content of $c_{caustic}$ = 150 g/l was fed to the first filter. The discharged filter cake of the first and second drum filter were re-slurried with condensate and then filtered and washed again on the respective next filter i.e.on the second and third filter. The filter cake of the third drum filter was discharged with a moisture content of 8-10 wt-% and a caustic content of 0.04 wt-%.

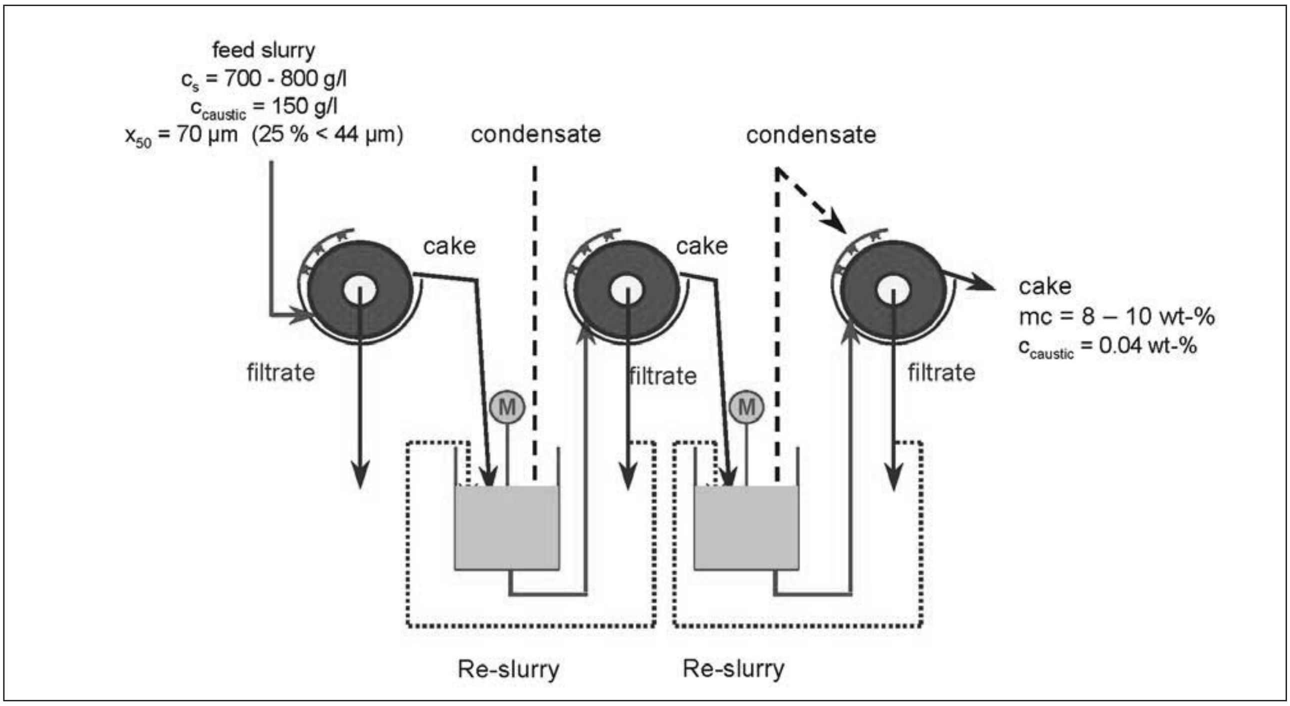

Figure 1: Old plant design and process data of Al-hydrate filtration with three drum filters in series

3. New plant design with one-step filtration on a modern pan filter

3.1 Reasons for replacement of the drum filters

Compared to three-step hydrate product filtration with the drum filters one-step filtration on a modern pan filter requires less space demand due to smaller foot print and leads to process simplification and improved handling, less operation cost and improved product purity. Replacement of the drum filters by a modern pan filter was therefore decided in order to realize the Al refinery's new targets with respect to improved plant and filter operation, cost reduction and improved product purity for generating higher sales prices and to allow entry to new markets.

3.2 Design of the new pan filter

The new pan filter has a diameter of 7.6 m, a filter area of 43 m^2 and consists of 24 filter cells of Quick Drainage cell design with a planar base and a flat bottom with a slope towards the filter centre to ensure a faster flow of the filtrates out of the filter cells. Main data are shown in table 1.

Figure 2 shows a schematic flow sheet of the two step counter-current cake wash and the steaming of the Al-hydrate product on the new pan filter.

During one filter rotation, each filter cell passes the cake formation zone, the first was zone, the second wash zone, the cake steaming zone, the dewatering zone, the cake discharge and the heel removal zone (see fig 3). The control head in the pan centre divides the filtrates of the cake formation zone (mother liquor), of the filtrate of the 1st wash zone and the filtrate of the 2nd wash, steaming and dewatering zone and feeds them to the respective three receiver vessels where the liquid is separated from air. For optimal operation each cell should be completely empty before passing on to a following wash zone, in order to avoid dragging of caustic to clean wash areas/filtrates.

When filter cake formation is finished the filter cell enters the first wash zone and the filter cake is washed with the filtrate coming from the second wash zone, cake steaming and dewatering zone. In the following (in direction of pan rotation) second wash zone the pre-washed filter cake is washed with fresh condensate and then heated and washed with condensing steam in the following steam zone. When leaving the steam cabin the filter cake is demoisture by air and discharged via the discharge scroll. The remaining heel which can not be removed by the scroll is then removed by the heel removal system using compressed air and filtrate from the 1st wash zone as described below in 3.2.7.

Table 1: Main machine data of the new pan filter (BOKELA pan filter M-type)

Feature	Data
Pan diameter	7.6 m
Filter area	43 m^2
No. of filter cells (Quick Drainage design)	24
Filter speed: range of operation /max	0.2 – 1.2 rpm/ 2 rpm
Slurry feed	forced distribution for homogeneous cake thickness
Cake wash and cake steaming	2-step counter-current wash and steam zone (1st wash with filtrate, 2nd wash with condensate 3rd wash with steam)
Cake discharge	Discharge scroll
Heel removal	2-step removal via air blow back followed by re-slurrying with pressurized wash filtrate
Filter cloth attaching system	FrameTrak
Operation mode	Fully automatic operation

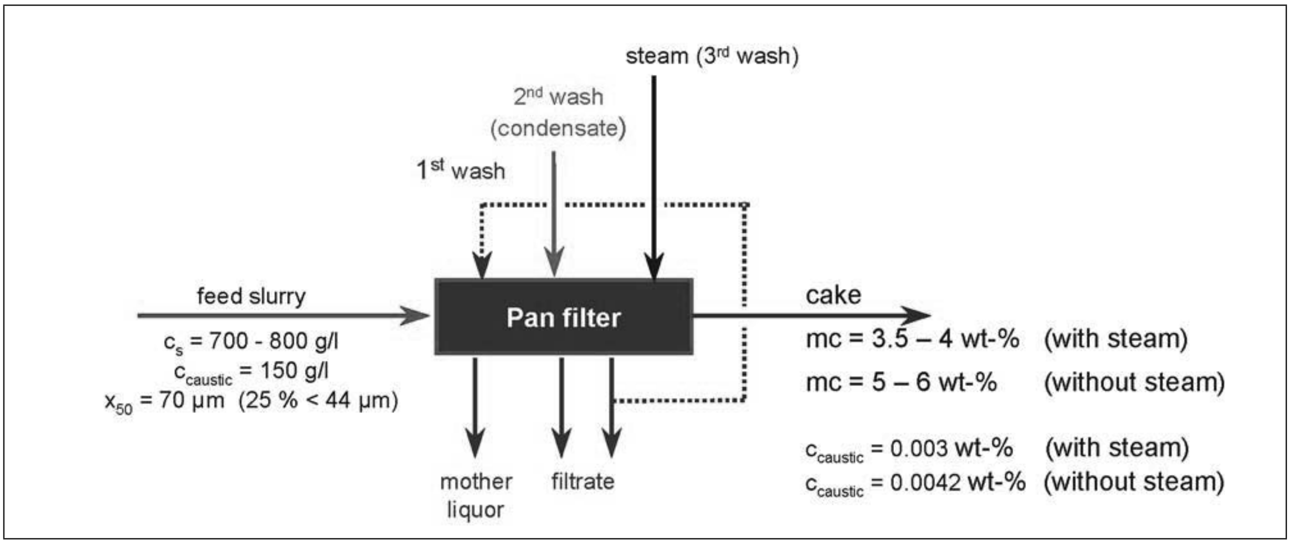

Figure 2: **Process scheme and process data of one-step filtration with the new pan filter.**

The special design of the new pan filter generation consists of the following described features.

3.2.1 Forced feeding system

The motorized slurry distributor supplies equal amount of slurry to each of 4 equal filtering areas of the pan surface. This forced feeding system ensures an equal and homogenous cake thickness at the whole filter surface by even slurry distribution.

3.2.2 Cake wash system

The 2-step cake wash system with wash fluid distribution by overflow weirs ensures an equal wash water distribution onto the filter cake. The free-flow construction over a set of weirs prevents blocking of nozzles and distributes a homogenous water flow which ensures an equal washing of the cake. Counter current washing minimizes the wash liquor consumption.

3.2.3 Quick drainage cell design

The quick drainage cell design is essentially characterized by a planar base and a flat bottom with a slope towards the filter centre to ensure a faster flow of the filtrates out of the filter cells Thus, the drainage in the pan filter cell is accelerated and carryover of filtrate between the filter zones is minimized. Less remaining filtrate and thus less carryover of filtrate achieves better washing efficiency and reduced amount of wash water/condensate. 25 % less wash condensate can be guaranteed.

3.2.4 Steam cabin

The steam cabin (optional) allows optimized washing and dewatering by heating of the hydrate and by condensation of steam in the filter cake. 10 kg of steam per t of hydrate typically reduces the cake moisture by 1.0 – 1.5 wt% and 20 - 25 kg of steam per t of hydrate typically reduces the cake moisture by 2.0 – 2.5 wt%.

3.2.5 Pre-separation control head

Sharp splitting and fast drain of the filtrates and pre-separation of liquid and air is realized in the Pre-separation control head. Thorough engineering of the main part of the hydraulic system is necessary to minimize scaling and leakages and results in significantly lower pressure loss in the filtrate system.

3.2.6 Discharge scroll

The thorough manufactured discharge scroll with wear resistant flights (Hardox 400) and its fixing from the top beam (no centre bearing) allows to achieve a minimal thickness of the remaining heel layer and thus less recycled washed hydrate.

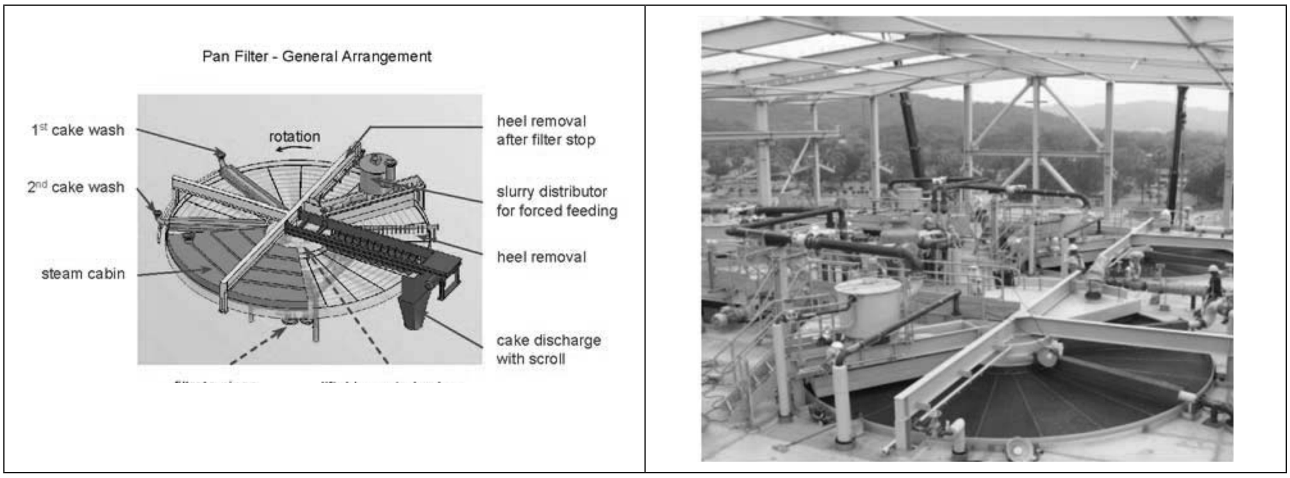

Figure 3: **View of a BOKELA product pan filter**

3.2.7 Heel removal system

The heel removal system removes the remaining heel layer from the filter cloth using an air blow impulse for breaking up the heel and applying pressurized filtrate (optional) from the 1st wash zone for re-slurrying. This two-step heel removal procedure which is operated on the new pan filter results in longer filter cloth lifetimes, better washing of the hydrate and longer intervals for caustic cleaning which prolonged 4 times from every 150 h to only every 600 h. The re-slurry procedure however required the installation of a stirrer into the filtrate tank due to a somewhat higher content of filtrate solids ranging from 5 – 10 g/l.

3.3 Filter cloth fixing with FrameTrak™

The new pan filter is the first pan filter installation worldwide that is equipped with FrameTrak™. FrameTrak™ is a new method of attaching filter media on rotary filters such as pan and drum filters that has been developed by BOKELA and ClearEdge [1]. FrameTrak™ has been installed for the first time on drum filters at Worsley Alumina in Australia. After a successful extended production trial of FrameTrak™ on a first drum filter in 2005 FrameTrak™ became Worsley Alumina´s preferred cloth fixing technology for rotary filters [2] and conversion of all 10 fine seed drum filters - first stage drum filters and second stage drum filters – was carried out in 2009 and 2010. Now, for the first time FrameTrak™ has been installed on a pan filter.

FrameTrak™ replaces the traditional caulking or bolt down clamping methods on pan and drum filters. Its main function is to eliminate the numerous Operational Health & Safety issues associated with the existing methods of re-clothing filters. With FrameTrak filter cloth can be secured to a filter without the use of power tools and it is a simple operation to both install and remove individual cloths. The time for re-clothing is remarkably shortened and filter cells can be re-clothed selectively according to the demand i.e only filter cells which need new filter media will get re-clothed.

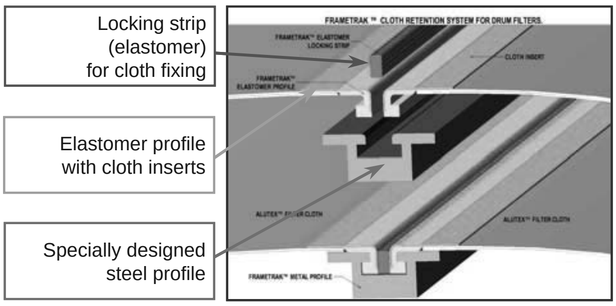

Figure 4: Principle of the cloth retention system FrameTrak™

FrameTrak™ consists of three parts a special designed steel profile, an extruded elastomer polymer profile with cloth inserts and a second extruded elastomer polymer profile, which acts as a locking strip (fig. 4):. The steel profile replaces existing caulking grooves and the filter medium is fixed to the elastomeric polymer cloth profile. This profile is then simply "hooked" over the specially designed metal profile and secured with the locking strip profile. Inserting the locking strip profile can be easily fitted by hand with a special tool (fig. 4) and the cloth is securely retained. As the material used in the profiles is a special elastomeric polymer it is impervious to caustic and inhibits scale growth. To remove cloths the locking strip profile has to be taken out easily by hand.

The main advantages of FrameTrak™ are

- elimination of the numerous Operational Health & Safety issues associated with the old methods of filter re-clothing such as hand and wrist injuries
- shortened time for re-clothing - only a 1/3 of time required compared to old methods (in total only 10% of previous re-clothing time is necessary since one pan filter with FrameTrak™ replaces the three old drum filters with traditional cloth fixation method)
- no danger of popping out of caulking ropes from the omega profiles what often happens with new filter cloth after re-clothing
- selective re-clothing of individual filter cells according to demand.

It is an important aspect associated with FrameTrak™ to keep tight manufacturing tolerances both for the cloth panels and the steel profiles. With the special cell geometry of pan filters this is somewhat more challenging than with the rectangular shaped filter cells of drum filters. Therefore design adaptations have been necessary at the new pan filter to meet the requirements of the FrameTrak™ technology and the filter cells are designed and manufactured in a pie slice shape.

Figure 5: Mounting of FrameTrak™ filter panels on the pan filter - inserting the locking strip with a special tool

3.4 Operation control

The pan filter runs fully automatic according to the BOKELA control philosophy which means adapted filter performance by filter speed control instead of continuous slurry overflow, fully automatic filter operation instead of visual control by the operators, controlled and simple maintenance and easy operation. Three control loops provide for safe operation and optimal performance results. Loop 1 includes filter speed control via measurement of cake thickness, loop 2 provides for constant wash water ratio controlled via filter speed and cake thickness and loop 3 provides for constant steam ratio controlled via filter speed and cake thickness.

4. Operation results and process improvements

The new pan filter has been installed and commissioned in January 2011 (fig 5). Al-hydrate product filtration which has been carried out on three drum filters in series up to this time is now carried out on only one pan filter. Product, process and performance data are summarized in table 2.

Table 2: Performance results of the new pan filter, product and process data

Product and Process Data	
solid concentration in slurry	700 – 800 g/l
size of particles	x_{50} = 70 µm / 25% < 40 µm
slurry density	1600g/l
Performance Data	
solids throughput	up to 95 t/h
moisture content with steam / without steam	3.5 – 4 wt-% / 5 – 6 wt-%
leachable soda content (ref. to dry hydrate) with steam / without steam	0.003 wt-% / 0.0042 wt-%
wash water ratio	0.3 t / t solids
steam consumption	25 kg / t solids

Replacing of three filter units and two re-slurry stations (including two pumps) by only one filter unit led to significant process simplification, free space, improved handling, less maintenance efforts and less operation cost. The high performance capability of the modern new pan filter also led to significant improvement of the product quality in terms of moisture content and solids purity i.e. soluble soda content which are essential for the refinery's targets to generate higher sales prices and to allow entry to new markets with chemical grade product.

Figure 5: The new pan filter in operation for Al-hydrate product filtration equipped with FrameTrak™

The main important operation results and improvements after one year of operation can be summarized as follows

- the filter can handle solids throughput values above 95 t/h (dry solid basis)
- the cake moisture ranges from 3.5 – 4 wt-% (with steam) and 5 – 6 wt-% without steam; since previous moisture content of the drum filters was some 10 wt-% the throughput of the calciner is now improved thanks to the lower moisture content
- leachable soda content in the filter cake ranges to 0.003 wt-% with a wash ratio of 0.3 t wash condensate per t dry hydrate and 25 kg steam per t dry hydrate and to 0.0042 wt-% without steam which is a 10 times lower value than before and a much better product purity
- wash condensate consumption reduced by some 50%
- caustic cleaning intervals prolonged 4 times from every 150 h to only every 600 h thanks to heel re-slurry

FrameTrak™ technology and reduction of filter units reduces downtime for re-clothing to only 10% of previous re-clothing time

5. Summary

Plant experience at several Al-refineries with the new generation of rotary pan filters verify that the filtration and washing of Al-hydrate product is performed with improved filter capacity, improved product quality and reduced operation and maintenance cost. Now, the first pan filter equipped with FrameTrak is in operation replacing a 3-step drum filter plant in an alumina refinery. One year of operation has proven that FrameTrak™ the new method of attaching filter media is a reliable technology with essential advantages over the traditional cloth fixing methods. Performance results of the new pan filter show that the refinery's new targets with respect to improved plant and filter operation, cost reduction and improved product purity for generating higher sales prices and to allow entry to new markets could be realized.

6. Acknowledgements

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