IMPROVING THE PERFORMANCE OF THE RED MUD DRUM FILTERS AT EURALLUMINA WITH THE BOKELA REVAMPING PROGRAM

Langeloh T[1*], Bott R[1*], Hahn J[1], Ventura L[2] , Ferraro L[2]
[1]*BOKELA GmbH, Karlsruhe, Germany*
[2]*Eurallumina S.P.A., Portoscuso, Italy*

Abstract

EURALLUMINA S.P.A. operates 6 drum filters of 100 m² each for red mud filtration in the Alumina refinery at Portoscuso. Since these drum filters did not longer meet the increased requirements of EURALLUMINA with respect to throughput capacity, cake washing and cake moisture, BOKELA GmbH from Karlsruhe, Germany was selected to provide a de-bottlenecking solution with the BOKELA filter revamping program which comprises the following three phases

- Diagnostic step,
- Engineering step,
- Realsation step.

The program started with laboratory and plant trials that were performed by BOKELA and which revealed a potential of 40% increase of filter capacity by carrying out some modifications of the filter design. The test results and the proposed design modifications convinced EURALLUMINA to start with the upgrading of the first red mud drum filter. This filter revamping project was realised in a step by step co-operation of BOKELA and EURALLUMINA according to the following schedule:

- Modification report by BOKELA with proposal of modifications in the drum filter design
- Decision of EURALLUMINA on the design modifications to be realised
- Manufacturing drawings by BOKELA
- Machining and fabrication by EURALLUMINA
- Installation by EURALLUMINA supervised by BOKELA
- Commissioning supervised by BOKELA

The main upgrading measures that were carried out this way are:

- Improvement of the cake discharge
- Modifications to the control valve
- Improved cake washing
- Modification to the filter drive

Thus, the foreseen increase of the throughput capacity could be achieved while the cake washing was also improved. This success motivated EURALLUMINA to proceed with the de-bottlenecking of the other 5 red mud drum filters.

1 Introduction

EURALLUMINA S.P.A. operates 6 drum filters for red mud filtration in the Alumina refinery at Portoscuso. A planned increase of the production capacity made it necessary to check all parts of the refinery and to carry out performance adaptations – wherever it was necessary. Since the red drum filters did not longer meet these increased requirements BOKELA GmbH from Karlsruhe, Germany, was selected to provide a de-bottlenecking solution with the BOKELA filter optimisation program

In the course of the filter upgrading project EURALLUMINA changed the bauxite material from Weipa grade D to Weipa grade A, which caused variations to the process. This new situation endangered the challenging plant upgrading targets and particularly affected the red mud filter stage. Thus, new modification measures have been necessary. As the biggest influences on the filtration of the Weipa A mud are the particle size, which changed from $x_{50,\ Grade\ D}$ = 3.2µm to $x_{50\ Grade\ A}$ = 1.6 µm, the feed concentration and the soda content in the feed. Due to this the plant average volumetric throughput decreased from 40m^3/h /filter with grade D to 25 -30 m^3/h with Grade A (with almost no washing water in case of grade A) while the moisture content increased as well as the soda content in filter cake increased because there was nearly no washing possible with grade A.

Table 1: Operation data of the red mud filtration for Weipa grade D and Weipa grade A bauxite before the filter modification

Operation data of the red mud filtration before the filter modification			
		Grade D 100 %	Grade A 100 %
Feed flow	[m³/h]	approx. 50	approx. 30
Feed temperature	[°C]	75	75
Feed density	[g/l]	1.28 – 1.32	1.35 – 1.38
Feed concentration	[g/l]	306 – 401	356 – 444
Particle size x50	[μm]	3.2	1.6
Soluble soda content in feed	[g/l]	21 – 27	40 – 45
Slurry level in the trough	[%]	50	40 – 50
Wash water flow	[m³/h]	3 – 8	2 – 6
Filter speed	[rpm]	2.1 – 2.3	1 – 1.1
Wash ratio	[t water / t red mud]	0.4	0 – 0.1
Moisture content	[wt-%]	40 – 43	42 – 45
Sol. soda cont. in cake	[g/kg dry mud]	14 – 22	20 – 30

The red mud drum filters are of Krauss Maffei design and characterised by the following main data:

- Filtration area: 100m²
- Drum diameter: 4,9m
- Number of cells: 32
- Number of collecting pipes per cell: 1
- Cake discharge by discharge roller
- Suspension feed via 6” pipe located at the filter drive side at the drum emerging side
- Cell ventilation by a nozzle in the control head, a cell ventilation system at the opposite side of the control head was present but not operative since filters start up

2 The 3-Phase Filter Optimisation Program

On the basis of numerous filter revamping projects in nearly all industries BOKELA developed a specialist program for filter optimisation in three steps. It is carried out with the know-how and the experience, which have been gained by upgrading of drum, belt, disc and plate filters, filter presses, Niagara filters Kelly filters etc. of nearly all OEMs.

Generally, a filter revamping project includes the following performances:

In the *first phase*, the filtration behaviour of the product and the filter performance are examined in lab and field tests. This analysis of the actual state defines the real capacity of the filtration plant and exposes the “bottle-necks”. A “Test Report” gives very concrete details about the optimisation potential and first costs estimates and profitability estimates can be made.

In the *second phase* modification measures for the re-engineering of the filtration plant are worked out, presented in a “Modification report” and discussed with the customer who decides, which of the recommended measures shall be realised. BOKELA then works out the required specifications and drawings.

The *third phase* – i.e. the modification works and the commissioning of the filtration plant – starts when the specifications and drawings are checked. If the filtration plant consists of several filter units, at first only one filter unit will be modified. Most of the purchases are organised and made by the customer itself and the modifications are carried out in the customer’s workshops as far as possible while BOKELA supervises the re-building.

When the first filter modification is finished, the improved filter performance is determined in a test run and compared with the calculated data obtained from the tests made in the first phase. Then, the customer itself can modify all further filter units in an analogous way.

In many cases the revamping of running filtration plants improves the filter capability to such an extent that the required targets can be achieved as good and reliable as with new equipment. The upgrading of running filter plants is realised much quicker and impairs the whole production process quite less than the planning and implementation of new equipment. Thereby, capacity increases of 50 % up to 150 % can be achieved.

Compared to the comprehensive and “administrative” procedure of a new investment project the revamping of existing filter equipment is carried out much simpler and much straighter. The modernisation and upgrading measures normally cause less or no changes to the building and the repercussions on the periphery of the filter plant are widely reduced. The existing equipment is upgraded at the site and stays on its place, so, the efforts for pre-engineering, logistical planning, inquiring and ordering of supplementary peripheral equipment etc. are minimum compared to the installation of new equipment. The revamping of running filter plants can be realised fast, short-termed and with significantly less costs.

3 Step by Step Optimisation of the Red Mud Drum Filters

3.1 *Targets of the Filter Optimisation*

The targets of the drum filter optimisation, required by EURALLUMINA, had been:

- Increasing the solids throughput by 40 % or more for being equipped for the increased plant capacity without investing in new filters
- Decreasing the soluble soda level
- Maintain the moisture content

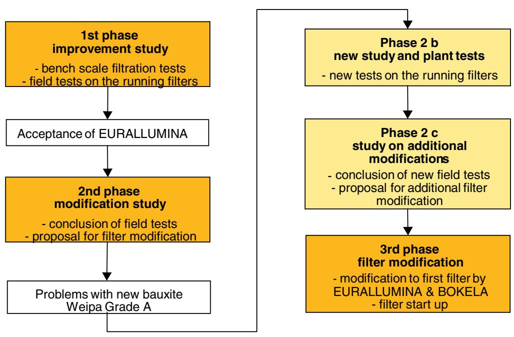

Figure 1: Schedule of the red mud drum filter optimisation by BOKELA and EURALLUMINA at the Portoscuso Alumina refinery

3.2 *Schedule of the Filter Optimisation*

The red mud drum filter optimisation at the alumina refinery at Portoscuso was carried out in cooperation of the EURALLUMINA and BOKELA experts according to the following schedule:

- Diagnostic step: determination of the optimisation potential of the drum filters
- Engineering step: elaboration of upgrading measures and creation of specifications and drawings, presentation of a detailed "how to do it" manual and discussion with the EURALLUMINA experts
- Additional engineering step: elaboration of additional upgrading measures
- Realisation step: modification of at first one red mud drum filter
- additional diagnostic step: due to problems with the new bauxite Weipa grade A it was necessary to react flexible on the new situation and perform an additional study and plant tests

3.3 *Diagnostic Step*

First lab and field tests were performed by BOKELA with red mud resulting from the processing of Weipa grade D bauxite. These tests showed that the required 40 % throughput increase could be reached with a modification of the running filters. A 10 % soda reduction without increase of moisture content was also predicted by BOKELA on the basis of these tests.

The introduction of the new Weipa grade A bauxite resulted in an unforeseen large trouble and throughput reduction in the mud filtration area. This was mainly caused by cake discharge difficulties connected with moistured cake on the discharge roller and poor cell ventilation in front of the discharge roller. These new effects of the grade A bauxite mud made it unsure that the required throughput increase would be reached. To react on this situation EURALLUMINA asked BOKELA to revise the previous improvement study in order to adapt the modification report by additional modifications to the new conditions.

3.3.1 *Lab-Tests*

The laboratory tests have shown that the new slurry properties do not influence the theoretical throughput rates in the same range as on the filters. Figure 2 shows the solid throughput rates of three test periods: The evaluated theoretical solid throughput rates for the new bauxite types (WEIPA Grade A) confirmed that an improvement of 40 % filter capacity compared to the not modified filters is possible.

In contrast to the influence of filtration pressure to the performance of bauxite type Weipa Grade D and Weipa Grade A1 (70 % Weipa grade A and 30 % Weipa grade D), the bauxite A2 (100 % Weipa grade A) shows almost no increase in throughput with increased filtration pressure. This is mainly caused by the modified flocculation and as a fact of this the compressibility of the filter cake.

3.4 *Field-Tests with the Running Filters*

The analysis of the field tests carried out by BOKELA revealed several factors for the mentioned problems of the red mud filtration stage.

3.4.1 *Solids under the filter cloth*

The smaller particle size distribution caused a higher amount of solids passing through the cloth during the first step of the filtration process. As a consequence the grids under the filter cloth get blocked with solids.

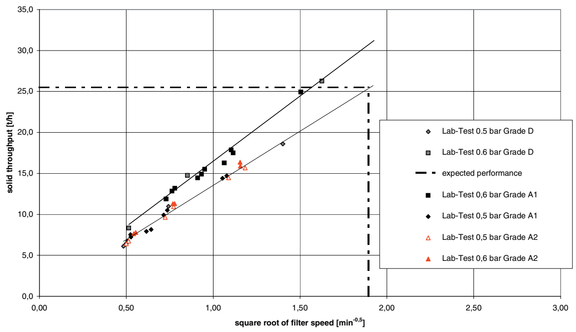

Figure 2: Theoretical throughput rate of three types of bauxite (bauxite A1 = 70 % grade A and 30 % grade D, A2 =100 % grade A, D = 100 % grade D)

3.4.2 *Filtrate in the filter cells*

During the dewatering phase the filtrate and the passed solids moved from the tailing edge of the filter cell to the leading edge. As the outflow of filtrate through the filtrate-collecting pipe was not completed some liquor poured out at the leading edge of the cell after the discharge zone. Due to this effect particles remained in the filter cloth and in the filter cell. With increased operation time of the filter the solids accumulated in the whole filter cell and especially at the leading edge.

The main reason for the not drained filtrate that was caught in the filter cells at the cake discharge point was the poor filtrate collecting pipe system.

The blocked filter cloth and the grids reduced the filtration capacity of the drum filter. To improve the filter performance EURALLUMINA washed the filter periodically with water or caustic soda but the performed wash procedure did not reduce the amount of solids in the filter cell and under the cloth.

3.4.3 *Inefficient cake washing*

With the original filter design one wash pipe was used on top of the drum (11 o'clock position). Thus, the distribution of the wash water was very poor and the wash water was not distributing equally. It run down the drum building water channels on the cake surface. Approximately half of the washing area was not covered with wash water.

3.4.4 *Incomplete cake discharge*

The filter cake discharge was incomplete mainly due to the following reasons:

- the poor cake washing and the not drained filtrate in the filter cells effected a wet filter cake which reduced the cake adherence that is necessary for roller discharge
- the poor cell ventilation caused a too high vacuum in the cell at the discharge point holding back the cake
- the alignment of the scraper comb was not correct and at several positions the distance between comb and discharge roll was too small. At these positions the comb discharged the whole layer of filter cake from the roll. Without cake layer, however, there is no contact between filter cake and discharge roll in the kneading zone and the cake can not be discharged at these areas.

3.5 *Engineering Step – Modification Report*

The results of the lab and field tests showed that the required targets of EURALLUMINA can be achieved by the following measures

- Modifications to the cake washing system
- Modification to the filter cells
- Restoration of the vent pipe system
- Modification of the filter drive
- Modifications to the control head
- Modification of the cake discharge system
- Installation of a caustic washing system
- As additional measure, modifications to the feeding system can be carried out.

The test results showed that these measures would increase the solids throughput of 40 % while at the same time the soluble soda content of the filter cake would reduce by 15 % due to the modification of the cake wash system. The moisture of the cake was predicted to remain on the accepted level of 40 – 43 wt-%.

The modification measures were presented to experts of EURALLUMINA in a modification report. In order to realise the optimisation potential and to achieve the production targets the proposed list of modifications was then discussed between the experts of EURALLUMINA and BOKELA.

3.5.1 *Modification to the cake washing system*

For improving the cake washing on the red mud drum filters four wash bars were installed as shown in Figure 4. They are fixed at the existing U-profiles (channels) with 'wash bar supports. Which are mounted every 13° starting at the horizontal position on the emerging side of the filter drum. The wash bars are connected with the distributor by hoses. The spray nozzles in the wash bar have an angle to the surface of the filter cake in order to avoid a re-slurry on the cake surface (canyon-building).

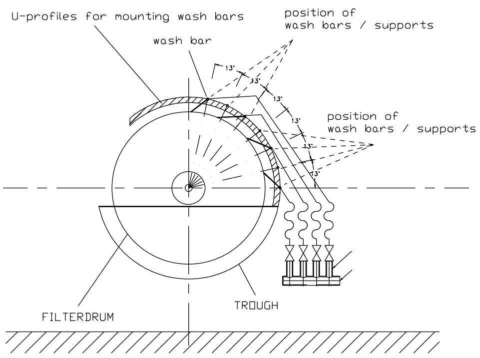

Figure 4: New arrangement of wash bars

There are two different types of wash bars (Type A and Type B). The distance between the nozzles is the same for type A as well as for type B but the number of nozzles varies and therefore the distances from the end of the bars. The wash bars are installed in such a way that an ideal overlapping of the wash water can be achieved which results in full wash water coverage of the wash area. Almost no wash water runs down into the filter trough (which would dilute the slurry and reduce the filter performance).

The nozzles are chosen in order to meet the requirement of:

- Pressure in wash water line: 2 – 3 – 4 bar
- Total wash water flow: max. 13,5 m³/h at 3 bar

To ensure a trouble-free operation of the spray nozzles the wash water has to be particle-free (max. allowed particle size x = 0,3 mm). Therefore the wash water has to be pre-filtered with a small cartridge filter.

This cake wash system allows also for an easy relocation of the spray bar position and of the nozzles depending on the particular kind of mud filtered (in case of a bauxite change), for example some mud may require a longer drying time.

3.5.2 *Modification to the control plate*

According to the filtration theory (equation 1) the solids throughput is directly linear to the square root of the filter speed:

$$\dot{m}_s = \rho_s (1-\varepsilon) \cdot \sqrt{\frac{2}{\eta_L r_c}} \cdot \sqrt{\kappa} \cdot \sqrt{\Delta p} \cdot \sqrt{n} \cdot \sqrt{\frac{\alpha_1}{360^0}} \quad (1)$$

Δp [bar] = filtration pressure difference
κ [–] = concentration parameter
n [rpm] = filter speed
η [kg/ms] = viscosity
α_1 [°] = cake formation angle
r_c [1/m] = cake resistance
ε [-] = porosity

But with higher filter speeds the height of the filter cake decreases if the formation angle $\alpha 1$ keeps unchanged. This would have made problems at the cake discharge. Therefore, a further precondition for the increase of the filter throughput was a larger cake forming zone by starting the cake formation earlier. For this, the control plate has been modified by enlarging the cake formation angle. Thus, more cake is built and the filter cake is thick enough to be discharged even at the filter operation with the high filter speed.

3.5.3 *Modification to the filter cells*

Of special importance for the improved filter performance was the installation of an additional collecting pipe to each filter cell. That way it could be insured that the filtrate drains completely before the cell reaches the discharge point.

3.5.4 *Restoration of the vent pipe system*

The vent pipe system has been adapted to the higher filter speed, in order to give the atmospheric air enough time to break the vacuum in the filter cell in total before reaching the cake discharge point. To avoid that the atmospheric air is blowing off a part of the red mud cake, damages the filter cloth and disappears through the filter cloth, the opening is now covered with a 'cap'.

Figure 5: Cake washing before modification (the wash water is not equally distributed and runs down the drum to the cake discharge zone)

Figure 6: Cake washing on the modified filter with new washing system provides for good wash liquor distribution

3.5.5 *Modification to the cake discharge*

The above described modifications to the vent pipe system, the additional filtrate pipes together with the improved cake washing and other optimisation measures improved the conditions for the cake discharge such as:

- no wash water running down the drum to the discharge point
- no filtrate inside the cell wetting the cake
- total breaking of the vacuum exact at the discharge point

Additionally, the discharge scraper can be equipped with fasteners / supports which can be easily adjusted to the right position by screws.

3.5.6 *Modification to the filter drive*

Due to the carried out modifications filter performance has improved significantly and the red mud drum filters now run with a high speed of 3.6 rpm. Thus, it was necessary to adapt the filter drive (motor, gear box, frequency converter) to the higher speed and torque and to the resulting power requirement.

3.5.7 *Caustic washing system*

Due to scale in the filter trough, inside the filter cells and inside the filtrate pipes the filter performance was influenced negatively. To improve the operation of the filters a procedure for a caustic washing of the filter was elaborated. It is very important to rotate the filter during this wash procedure, which ensures that the caustic also removes the scale inside the filter cells and inside the filtrate pipes. To prevent that the caustic flows into the filtrate system a blind has to be set in the filtrate pipe after the receiver. The installation of a globe valve risks a blocking of the filtrate pipe during operation.

The duration of the caustic washing depends on the degree of scaling (typically 1 – 2 hours every 4 weeks)

3.5.8 *Cooperation of EURALLUMINA and BOKELA*

The optimisation of the first red mud drum filter at the Portoscuso Alumina refinery was carried out in a cooperation between the experts of BOKELA and the experts of EURALLUMINA with different tasks and responsibilities as shown in table 2.

After the successful commissioning of the first modified drum filter which showed excellent performance, the other red mud drum filters were optimised in the same way by EURALLUMINA itself.

4 Operation Data of the Modified Drum Filter

As result of the modifications the filter performance improved significantly. The filters can now run with a filter speed of 3.6 rpm and the solids throughput increased by 50 % with grade A, which is 10 %-points more than the target value. At the same time the soluble soda content of the filter cake decreased due to the improved cake wash. Although the wash ratio and consequently the wash water throughput increased, the moisture content of the cake remained the same as before. The cake discharge system now works reliably and ensures a secure and complete filter cake discharge.

Table 2: Cooperation of EURALLUMINA and BOKELA during the red mud filter optimisation

Revamping steps	Performed by
Lab and field tests	BOKELA
Modification engineering	BOKELA
Decision which measures should be realised	EURALLUMINA
Realisation of 1st filter optimisation	BOKELA and/or EURALLUMINA
Supervision of 1st filter optimisation	BOKELA
Optimisation of the other filters	EURALLUMINA

Table 3: Performance values of the optimised red mud drum filter

	Old filter	Optimised filter
Filter speed	1.1 rpm with Weipa grade A 1.8 – 2 rpm with Weipa grade D	1.5 (2 rpm) with Weipa grade A 2.5 – 3 rpm with Weipa grade D
Increase of volumetric throughput		40 % – 50 % with grade A with grade D no long term measurement available yet, but as a consolidated value an increase of 20 % is proved
Wash water throughput	no change	no change
soluble soda content in the cake		The soda content reduced due to better cake washing, but no long term measurement available yet (15 % decrease obtained during commissioning)
Moisture content	40 [%]	40 [%]

5. Summary

The red mud drum filter optimisation at the refinery of EURALLUMINA in Portoscuso was carried out in a good and productive cooperation between the experts of EURALLUMINA and the experts of BOKELA. The new situation that resulted from the changed filtration conditions in the course of the project due to the change of the bauxite from Weipa grade D to Weipa grade A showed how flexible this filter revamping project was carried from both sides. The changed conditions were answered by prompt reactions with new investigations and with additional and adapted design measures. Thus, the optimisation target of 40 % throughput increase with Weipa grade A was not only reached but exceeded since the optimised red mud drum filters run with 50 % more throughput compared to the original filter design.