SIZE MATTERS, WEIGHT TOO – DISC FILTER DESIGN FOR THE FUTURE

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ABSTRACT

Filtration of coarse and fine seed downstream the secondary or tertiary thickener or in continuation of hydrocyclones, respectively, influence the effectiveness, the operational cost and the quality of the final product in Alumina precipitation plants remarkably. Seed filtration is characterised by the tremendous flow rates which have to be processed on the filters and by changing product characteristics such as slurry density or grain size etc. Consequently, the used filtration equipment must ensure a high availability and has to be capable to cope with high slurry feed rates and with slurry characteristics which can change in a wide range during filter operation. With the introduction of the Boozer disc filter two decades ago BOKELA have set a new standard in seed filtration with decisively improved filter capacity and reduced maintenance and operation cost. Now, BOKELA have redesigned and upgraded this disc filter type. The new design improves filter operation, filter maintenance and economy (OPEX and CAPEX)

1. INTRODUCTION

Big diameter disc filters are the most advanced filter technology for seed filtration which were developed and installed for the first time in the early 70's. With the Boozer disc filter BOKELA have developed a new generation of big diameter disc filters which set a new standard for coarse and fine seed filtration. Now, BOKELA have redesigned and upgraded this disc filter type. Based on 20 years of operational experience with numerous filter units in many alumina refineries but also in other industries the design of the Boozer has been modernized to make this successful filter type fit for future.

2. BOOZER DISC FILTER – THE FIRST GENERATION

Beginning with the first supply of 6 Boozer disc filter units in 1995 BOKELA started a new era for high performance disc filter in seed filtration. In the meantime Boozer disc filters are operated for fine seed, coarse seed and even for product filtration in numerous Alumina refineries but also for applications in other industries worldwide.

Based on the experience gained in more than 250 filter optimisation / revamping projects for all major filter types and OEMs, BOKELA have developed the Boozer which has established a new standard for disc filters incorporating a number of innovative changes to conventional design practice. Most of these innovations have been made to resolve capacity and performance problems related to hardware bottlenecks and/or poor hardware design of vintage disc filters. The outstanding hydraulic characteristics of the Boozer disc filter were achieved by improving each detail of the vacuum disc filter design such as filter discs and segments, filtrate pipes, centre barrel and bearings, filter trough, control head and cake discharge.

This has led to the following results (Hahn et al, 2002):

- low wear metal segments with massive hydraulic capacity to process the large filtrate flow
- metal segments of only 19.5 kg with quick release bayonet connections witout tie rods
- quick fit filter bag system with cable ties
- filter designed to use poly bags which are easier to replace and more cost effective,
- permanent walkways to allow easy access to replace segments with torn cloths
- centre barrel and bearings designed for the high loads encountered with high capacity and high speed
- gearbox and motor designed for high loads at low speeds
- filter trough designed to eliminate agitators by being self agitating
- level control system to prevent overflow back to feed tank

- control head with low pressure losses (low wear) at high capacities, and
- back suck on the filter cloth to prevent damage on the scrapers during cake discharge.

Consequently all the above changes have resulted in:

- extraordinary high performance capacity
- drastically improved cake pickup due to the high vacuum achieved inside the disc
- better cake moistures than other filters of the same area at the same tonnage
- excellent discharge of the cake with 95 to 100% reporting to the product
- vacuum always being at appropriate performance level
- high operational safety and reliability
- low maintenance and operation costs.

3. MORE IN SIZE, LESS IN WEIGHT – THE NEW BOOZER XL

After 20 years of operational experience with numerous filter units in many alumina refineries BOKELA have redesigned and upgraded the Boozer to make this successful filter type fit for future.

It was the target of the new design to improve the high standards operators associate with the Boozer by simultaneously reducing cost and weight. Motto of the new design was “high performance for less money”. The following targets have been the guidline for the design of the Boozer XL:

- high – i.e. same or even increased – performance capacity
- light filter segment made of polymer considerably below 15 kg
- reduction of total weight of a unit
- further improvement of filter operation and maintenance
- significant cost reduction

3.1 Modifications and Technical Data

To achieve this ambitious aim BOKELA engineers have enhanced the proven and successful Boozer filter design and have created the Boozer XL (figure 1) which incorporates a series of new design features and improvements.

As main characteristics of the new design can be named

- new filter segment made of plastic with less than 12 kg in weight which facilitates segment lifting significantly both for male and female operators
- increase in filter size from Boozer L-type to XL-type which means increase in filter area from 44 m² to 50 m² per disc by increase of the disc diameter from 5.6 m to 6 m
- modifications in trough design to improve operation and to reduce cost and weight
  - mainly by lowering the slurry level to below the barrel centre during operation
  - simplification of barrel bearings and seals possible through the new trough design
- reduction of operational weight (unit weight plus slurry in trough) by 30% through adapted trough design

The increase in filter area allows nominal and maximum filter performance under improved conditions at lower filter speed. Maximum performance is achieved with a filter speed of only 4 rpm instead of 6 rpm. Thus, the filter drive of the new Boozer XL requires less energy for operation both for nominal and maximum filter performance.

As consequence of the lower slurry level the submergence of the filter disc decreases which leads to an increase of the dewatering angle α_2 and less moisture in the filter cake accordingly. On the other hand the cake formation angle α_1 reduces somewhat through the lower submergence of the filter disc. This loss of cake formation time which means reduction of specific solids throughput per one disc rotation is, however, overcompensated by the increased filter area.

Technical data of the new Boozer XL are shown in table 1.

filter area per disc	50m²
No. of discs/unit	2 - 4
filter area	100 m² - 200 m²
disc diameter	6000 mm
rim diameter	6200 mm
distance between discs	700 mm
No. of polymer segments/disc	30
Weight of polymer segment	12 kg
angle of cake formation	132° max
angle of cake dewatering	170° max
filter speed	0.2 - 4 rpm
submergence of disc	47 %

Table 1. Technical data of Boozer XL

3.2 New Light Weight Filter Segment of Polymer

A core element of the new Boozer XL is the light filter segment made of polymer. With this novelty BOKELA responded to a long time objective of operators which have always desired a filter segment with less than 15 kg to facilitate handling during re-clothing. With only 12 kg in weight the new BOKELA polymer filter segment is even considerably below this target mark although it is increased in length to allow increase of filter area from 44 m² to 50 m² per disc.

When BOKELA introduced the Boozer light weight metal segments with 19.5 kg compared to 28 – 35 kg per segment of first big diameter filters this was a progress with respect to operator convenience. However, this weight may easily increase up to 22 – 23 kg per segment with the filter cloth mounted and internal scale build up. This means a severe health and safety issue for the maintenance people having to lift the segments when change of filter cloth is required.

Now, with the new polymer segments the weight of a segment is reduced by 40% to 12 kg. This enormous weight reduction could only be realized by a change from metal to polymer as material of construction.

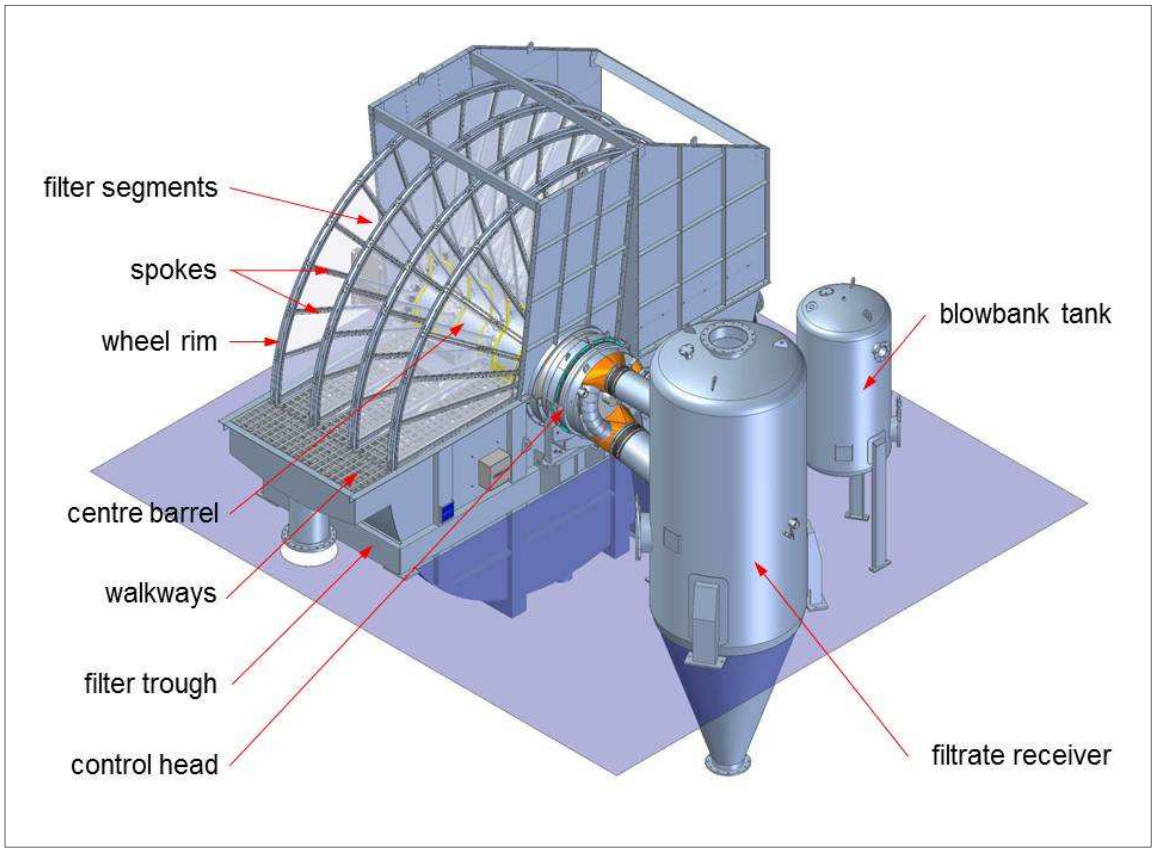

Figure 1. View of the new Boozer XL

While the metal segments have an optimised design in regards to internal hydraulics, lowest possible weight and stability and lifetime respectively, the design of the new polymer segments follows the philosophy of a segregation of functions.

With change to polymer as material of construction the duty of the new segment is to ensure low weight for the convenience of the operators and excellent internal hydraulics to provide for fast filtrate drainage which is decisive for enabling a high filter performance. Stability of the filter disc, however, is achieved by a spoke wheel construction which holds the filter segments and which provides for the alignment and concentricity of the filter disc during operation.

Main Characteristics and benefits of the new polymer segment can be summarised as:

- light weight of only 12 kg
- excellent internal hydraulics
- segment has not to take up any forces except to withstand pressure differences during filtration and compressed air blowback during cake discharge
- mounting and dismounting of segments nearly without tools
- ease of re-clothing by light weight and easy mounting leading to improved acceptance by operators and improved maintenance
- reduced cost per unit

Figure 2. light weight polymer filter segment

3.3 Filter Disc

Each filter disc consists of 30 polymer segments which are fixed through a spoke wheel which holds the filter segments. Beside holding the segments the function of the spoke wheel is to provide for the alignment and concentricity of the filter disc during operation.

Rigidity and concentricity of the filter disc is a basic necessity for trouble free operation and high performance due to following process requirements and mechanical requirements:

- for ensuring 100% cake discharge each filter disc has to pass the discharge scrapers as close as possible what requires rotation with high degree of accuracy
- the disc has to withstand
  - flow forces caused by the slurry inflow into the trough
  - shear forces caused by the disc rotation
  - load from filter cake and filtrate
  - momentum/vibrations from compressed air blowback during cake discharge.

The spoke wheel has a self supporting construction forming trapezoidal spaces for the segments. It consists of following components:

- radial spokes incl. mechanical brackets for segment adjustment during assembly
- rim composed of single elements to connect the radial spokes at the outer radius
- spoke supports at the barrel circumference to connect barrel ports to the segments

The spoke wheel is assembled and adjusted during filter installation and needs no further work then. During filter operation only the segments have to be mounted and dismounted for re-clothing.

The segments are placed between the trapezoidal spaces of the spoke wheel as shown in figure 3. Mounting of a segment is easily done in 3 steps without need of special tools: The segment is plugged in one of the rubber connections to the barrel ports for which it is in a position at right angles with the rim. The segment is then turned through 90° until it is in the correct position given by the segment brackets of the spoke supports. Following, the segment is fixed to the rim and held in position via clamp springs which are attached to the U-profiles made of polymer material which also serve for sealing of the filter bag at the brought end of the segment (figure 4).

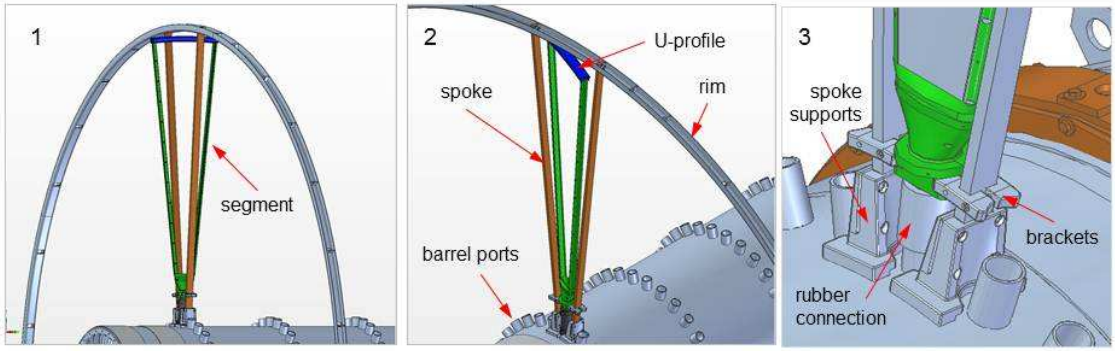

Figure 3. spoke wheel construction and mounting of a segment (1: plug in of segment to barrel ports, 2: turning of segment through 90°, 3: segment in en d position)

3.4 Filter Trough

The filter trough of the new Boozer XL is of the proven Boozer "joint-single" trough design which is operated without agitator as described by Hahn et al (2002). To improve operation and to reduce cost and weight some design modifications have been realized following the motto "no slurry above the barrel centre line". Accordingly, the new trough design incorporates following changes:

- reduced disc submergence by lowering the slurry level below the barrel centre
- overflow level below barrel centre line
- narrow compartments (i.e. single troughs) at the slurry inlet side with only half of the previous width
- large cake discharge boxes with 50% increased width
- simplification of barrel bearings and seals possible through the new design
- reduction of operational weight (unit weight plus slurry in trough) by 30% through reduced slurry volume in the trough

This new narrow trough design is successfully in operation in applications of coal and tailings filtration since 4 years and is now the assigned trough design for the new Boozer XL. Operational behaviour is improved, maintenance efforts are reduced, filter performance is not affected but increased and operational weight significantly reduced by this new design.

Since the slurry level is below the barrel centre line the submergence of the filter disc decreases from 50% to 47% and the dewatering angle α_2 increases to 170° maximum which results in longer dewatering times and less moisture in the filter cake accordingly. On the other hand the cake formation angle α_1 reduces from 150° maximum to 132° maximum through the lower submergence of the filter disc which leads to reduction of specific solids throughput per one disc rotation. This loss, however, is overcompensated by the increased filter area.

The narrow compartments (i.e. single troughs) at the slurry inlet side improve the stirring effect and slurry homogenization through the rotating discs what improves filter cake formation. The reduction in width of the compartments means gain in space for the cake discharge boxes which can be built broader what reduces risk of plugging by sticking of discharged filter cake.

3.5 Reduced Weight

Through the narrow trough design the slurry volume in the trough reduces by 40% and thus the operational weight of a filter unit reduces by 30%. For a Boozer XL with 4 discs the operational weight reduces from 64 t to 45 t (for Al-hydrate seed filtration), the maximum weight reduces from 72 t to 51 t. The footprint of a filter unit is not affected by the new design but remains the same what means less weight but more filter area per sqm. Both aspects are relevant and beneficial with respect to the statics of the filter building and especially if a filter installation on-top of the precipitators is planned.

3.5 Operational Experience with the New Design at Alcoa Wagerup Refinery

The new design of the filter discs and the new light weight polymer segments have been tested at Alcoa Wagerup Refinery. For this test operation a Boozer L4 has been equipped with

one disc of new design and polymer segments (figure 4 and 5). After more than a half year of operation the operators are more than satisfied with the new design. The filter disc is absolutely steady and runs accurate without any wobbling, the formation and dewatering of the filter cake on the new polymer segments is excellent and filter discharge is 100%.

Figure 4. spoke wheel construction

Figure 5 fixation of segment to the rim via clamp springs (during test operation)

4. CONCLUSION

Boozer disc filters are operated for 20 years in numerous Alumina refineries for fine seed, coarse seed and even for product filtration but also for applications in other industries worldwide. Based on this comprehensive operational experience with numerous filter units and based on the operators feedback BOKELA have redesigned and upgraded the Boozer. The design of this new Boozer XL reduces cost and weight and improves the high standards operators associate with this filter type which has established a new standard for disc filters incorporating a number of innovative changes to conventional design practice as described in Pos. 2.

The design of the new Boozer XL incorporates a series of modifications and new features. A core element is the light filter segment made of polymer with only 12 kg in weight which significantly facilitates re-clothing for the convenience of the operators. With change from metal segments to light weight polymer segments the design of filter discs also changed to a spoke wheel design. The filter area per disc increased from 44 m² to 50 m² what allows maximum performance at lower filter speed of 4 rpm instead of 6 rpm.

Further main design modifications refer to the design of the proven “joint-single” trough leading to lower slurry level with less slurry in the trough, improved slurry homogenisation by narrow compartments and improved conditions for cake discharge by enlarged discharge boxes.

The characteristics of the new design can be summarized as:

- high specific performance capacity
- increased filter area on identical footprint
- reduction of total unit weight
- further improvement of filter operation and maintenance
- significant cost reduction.

REFERENCES

Hahn, J., Bott, R., Langeloh, Th. 2002, “New performances in seed filtration by modern disc filters: a feasibility review”, 6th Alumina Quality Workshop, Brisbane, Australia