Report on Tailings Dewatering with High Performance Disc Filters

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ABSTRACT

The treatment of tailings and paste from ore processing filtration and dewatering has gained more and more significance in the recent years. The recovery of water from the process is an important target with respect to both economic and environmental aspects because water is a valuable resource. The dewatering of tailings allows dry-stacking which is environmentally more acceptable, safer, and cheaper and especially with mine backfill it allows to reduce the amount of cement to be added which may save millions of dollars per year.

The most common dewatering technologies for the filtration of tailings and paste from ore processing are filter presses, belt filters and rotary vacuum disc filters. Among these the vacuum disc filter is the most economical technology in most applications - both in CAPEX and OPEX – especially, when high performance disc filters of modern filter design are used. The Boozer disc filter is a modern high performance vacuum disc filter which has set the pattern in a multitude of applications. In the recent years this filter type has established itself in many applications of tailings dewatering initiated by a first reference application which started operation in 2010. In this application the use of two Boozer disc filters allowed to reduce the input of cement by about 60 %.

The reasons for the successful operation of this disc filter in tailings dewatering are: the high throughput and dewatering performance, the excellent operational reliability even in case of varying feed conditions, the simple and robust design, the ease of maintenance and last but not least the small footprint.

The paper reports on operation experience and operation results of tailings dewatering with the Boozer disc filter from 3 different plants with 3 different tailings. In one of these plants a Boozer disc filter is operated in the Andes in more than 4000 meter above sea level.

INTRODUCTION

The treatment of tailings and paste from ore processing filtration and dewatering is becoming increasingly important. Firstly, the recovery of water from the process reduces the input of an important resource – water. This can make the difference between ‘yes, we can operate’ or ‘no, we cannot’. Secondly, the filtered tailings can be dry-stacked, which is safer, cheaper, and environmentally more acceptable. Thirdly, especially with mine backfill, the amount of cement to be added can be reduced, which may save millions of dollars per year.

Typically, filter presses, belt filters and rotary vacuum disc filters are used for this dewatering duty. Among these technologies, in approximately more than 80% of all applications, the vacuum disc filter type is assumed to be the most economical solution with reference to both CAPEX and OPEX aspects – especially, when modern disc filters are used. A characterizing outline and a comparison of CAPEX/OPEX data of these technologies has been presented by Hahn, Bott & Langeloh (2014).

TYPICAL PROPERTIES OF TAILINGS

Tailings from ore processing are generally non-valuable products which have to be disposed of in an environmentally sound, secure and economic way. Typical properties of tailings, with respect to filtration, can be summarised as follows:

- Very fine particle sizes, mostly in the range of d50 = 1 micron up to 50 micron.
- The formed filter cakes have a sticky behaviour and are difficult to release from filter fabric.
- The pH value is often low or high, i.e. tailings often have corrosive properties.
- Solids content is typically in the range of 50-70 wt.% due to thickening.
- Clay content depending on orebody can hinder filtration and dewatering.

DESIGN OF THE BOOZER HIGH PERFORMANCE DISC FILTER

With the high performance disc filter Boozer BOKELA Company has developed a new generation of big diameter disc filters which have set a new standard for seed filtration in the alumina industry and in the dewatering of coal slurries. This type of disc filter is now getting more and more established in applications of paste dewatering.

The outstanding hydraulic characteristics of these modern disc filters were achieved by improving each detail of the filter design, leading to extraordinarily high performance capacity, high operational safety and reliability, and low maintenance and operation costs. The main features of this new disc filter generation are as follows:

- minimised pressure drop leading up to 100% higher pressure difference at the filter cloth, compared to conventional disc filters
- double capacity, compared to conventional disc filters
- high filter speed of 6 rpm
- high operational reliability and flexibility
- easy maintenance
- fully automatic and safe operation due to superior process philosophy realised in a programmable logic controller system

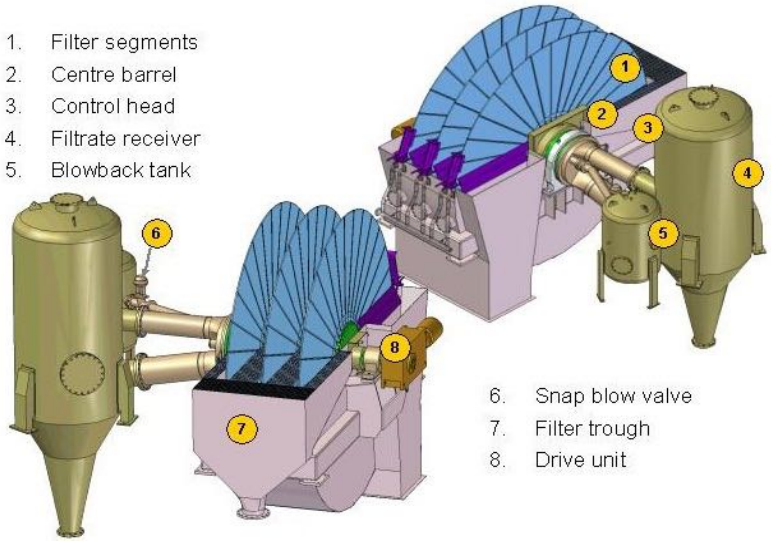

Figure 1. View of a Boozer disc filter with three discs

Disc diameters range from 1.7, to 4.2, to 5.6 m. For filtration of large slurry feed rates, such as tailings, a filter with large disc diameter of 5.6 m (L-type) is the appropriate filter size; this is available with one to four filter discs. A more detailed description is given by Hatzenbühler, Hahn & Bott (2013).

These disc filters can be operated in a fully automated mode and thus can react online to changes in the filtration properties of the thickened tailings to maintain the required moisture. Furthermore, modern disc filters are very reliable with regard to cake discharge, no matter how much fines are fed or how the feed solids content changes. The operation, even with high amounts of fines and the constant cake moisture, allows use of tailings for mine backfill without the need to split it into fine or coarse fractions. This reduces the process equipment required, the investment cost and the amount of cement added to the tailings.

Re-Design of the Boozer

After 20 years of operational experience with numerous filter units in many industries BOKELA have redesigned and upgraded the Boozer based on the operator's feedback.

The new BOKELA Spoker Boozer incorporates a series of design modifications and new features which improve the high standards operators associate with this high performance disc filter:

- new lightweight filter segment with less than 12 kg in weight
- increase in filter size from Boozer L-type to XL-type through increase in filter area from 44 m² to 50 m² per disc
- maximum performance at lower filter speed of 4 rpm instead of 6 rpm
- modifications in trough design to improve operation and to reduce cost and weight
- reduction of operational weight by 30%

A detailed description of the new design is given by Hahn, Bott & Langeloh (2015).

Lightweight Filter Segment

The new lightweight, snap-on filter segment is a core element of the BOKELA Spoker Boozer. With this novelty BOKELA responded to a long time objective of operators who always desired a lightweight filter segment for easy handling.

With less than 12 kg (27 lbs) the new filter segment, which is made of fibre enforced polymer (FRP), facilitates lifting and re-clothing for one person with ease and no need for cranage.

Characteristics and benefits of the new lightweight filter segment:

- only 12 kg in weight
- facilitates lifting and re-clothing for one person with ease and no need for cranage
- snap on design - mounting and dismounting of segments nearly without tools
- excellent internal hydraulics to ensure fast filtrate drainage which is decisive for a high performance
- made of fibre enforced polymer (FRP)
- reduced cost per unit

The new segment is of increased length compared to the proven Boozer metal segment to allow increase of filter area from 44 m² to 50 m² per disc.

Figure 2. New lightweight snap-on segment of only 12 kg in weight (left), mounting of new segments onto a Spoker Boozer (right)

Conditions for Use of a Disc Filter in Tailings Dewatering

Vacuum disc filters are suitable for applications of tailings dewatering where the following conditions and targets apply:

- if the clay content in the solids is low
- if mine backfill is processed
- if the tonnage is > 50 t/h and big filter sizes can be applied
- if a moisture of > 18 wt.% is accepted
- if energy efficiency is important
- if there is a space constrain
- in third world countries where little know how for operation has to be assumed
- if amount of flocculent shall be limited
- if operation cost shall be minimised.

TAILINGS DEWATERING WITH THE BOOZER DISC FILTER

The Boozer disc filter has set the pattern in a multitude of applications e. g. in the alumina industry and in the dewatering of coal slurries. In the last years this type of disc filter has established itself more and more in applications of tailings dewatering. The reasons for its successful operation in tailings dewatering are: the high throughput and dewatering performance, the excellent operational reliability even in case of varying feed conditions, the simple and robust design, the ease of maintenance and last but not least the small footprint.

Dewatering of Gold/Copper Tailings

The first Boozer disc filter for tailings dewatering started operation in 2010 at Chelopech mine in Bulgaria where the tailings are used for mine backfill. For this application a Boozer L4 disc filter with

176 m² filter area and 5.6 m disc diameter is in operation. The implementation of the Boozer L4 disc filter for this dewatering duty was part of the mine upgrading and modernization project when Chelopech switched the mining method away from the environmentally challenging caving method to a drill and fill method (D. Liston, 2014*)* to increase both production rate, production reliability and sustainability.

During layout tests the tailings consisted of particles with a mean diameter size of d_{50} of 20 to 30 microns and were concentrated to > 50 wt.-%% in a thickener. Target value for solids throughput was specified to 100 t/h and target cake moisture was specified to 23 wt.-%-%. Layout tests showed that the required 100 t/h solids throughput could be achieved with one disc filter of 176 m² filter area, which requires a minimum specific solids throughput of 568 kg/m²/h to ensure target solids throughput of 100 t/h.

Since filter commissioning the characteristics of the slurry have changed especially with respect to particle size distribution. The mean particle diameter d_{50} increased from d_{50} = 25 µm to d_{50} = 40 µm and solids throughput increased accordingly to rates higher than needed. As a consequence, flocculent dosage could be reduced stepwise and the filter can be operated even without flocculent. The achieved filter performance is 110 t/h for solids throughput rates and residual cake moisture ranges to 19-22 wt.-%-%. After nearly six years of operation the filters are in excellent condition thanks to the preventive maintenance concept of the plant.

A more detailed description of this application is given by Hatzenbühler, Hahn and Bott (2013).

Figure 3. Disc filter (176 m² filter area) assembled in the gold/copper mine; view of control head side (left); and view of the four filter discs with walkways (right)

Dewatering of Zinc Tailings

For dewatering of zinc tailings from a copper and zinc mine in Australia, Qld two Boozer ME8 disc filters have been installed and started operation in 2014. Each filter has a filter area of 141 m² and consists of 8 filter discs with a diameter of 4.1 m.

This project started already in 2004 when the client ordered a filter assessment to investigate the options of a capacity increase of the paste plant by retrofitting the existing vacuum disc filters. The paste plant operated 2 vacuum disc filters for zinc tailings dewatering. Each filter was filtering about 120 t/h of tailings (on dry solids basis) and both filters were separating about 240 t/h while the total plant capacity

of tailings was 350 t/h. In 2013 the project was finally launched. Now the target was to replace the existing two filters with two new filters in order to meet the total plant capacity of 350 t/h of tailings. This is an almost 50 % capacity increase on basically the same filtration area. It was essential that the two filters should fit into the existing filter floor space with a minimum of modification work. The new operating data of the two existing filters have been compared with the filter assessment back in 2004 and have shown a good relation. Additionally, a site visit of a BOKELA expert has confirmed filter operation still to be similar to the operation in 2004. Based on this, two new Boozer ME8 disc filter were chosen for the replacement project and were commissioned in 2014.

The tailings slurry mainly consists of silicates. Product characteristics of the feed slurry and target values with respect to solids throughput and cake moisture are as follows:

- feed solids: 60 - 65wt.-% solids
- particle size distribution i.e., mean particle diameter d_{50}: 50µm
- target solids throughput on dry solids basis: 350 t/h resp. 175 t/h per filter
- target cake moisture content: 20 – 22 wt-%.

In table 1 both the expected performance values and operational values of the running filters are shown.

Table 1. Expected and achieved operational values of solids throughput and cake moisture

Dewatering of zinc tailings		Predicted value per filter	Operational value per filter
Solids throughput			
normal	[t/h]	175	> 175
peek (max.)	[t/h]	200	210
Filter speed for normal operation	[rpm]	1.5	≤ 1
Cake moisture	[wt.-%-%]	20 - 22	17 – 20
Flocculent dosage	[g/t DS]	depending on feed charge	0 – 50 depending on feed charge

Figure 4. Two Boozer disc filter ME8 (141 m² filter area each) for zinc tailings dewatering in the filter building (left); discharged filter cake (right)

The two disc filters are operated in a fully automatic way i.e., filter start up, filter operation and filter shut down are carried out automatically. An automatic filter operation control adapts filter performance to changing slurry and process conditions and avoids emergencies. The design and the outstanding hydraulic capacity of the Boozer disc filters is the basis of the specific operation philosophy for improved filter operation without continuous slurry overflow (Hahn, Bott & Langeloh, 2011).

Depending on the slurry feed charge it can occur that the discharged filter cake is too dry for downstream processing in the mixer. This can be prevented by adapting i.e., throttling the pressure difference in the dewatering vacuum line which effects higher moisture content values of the filter cake. Experiences gained from filter commissioning and filter operation can be summarized to following recommendations to ensure safe and reliable filter operation:

- an exact mounting and fixation of the filter bags onto the filter segments prevents solids from penetrating into the filtrate piping
- routine inspections by a well trained operator and maintenance team
  - to detect defective filter bags which should be replaced as prompt as possible
  - to detect initiating damages through the abrasiveness of the slurry in an early stage.

Dewatering of Tailings from a Gold/Silver Mine in 4,800 m Above Sea Level

For dewatering of tailings from a gold/silver mine in Peru two Boozer L4 disc filters have been installed and will start operation in March 2016. Each filter has a filter area of 176 m² and 4 filter discs of 5.6 m disc diameter. The filtered and dewatered tailings will be mixed with cement and will be backfilled into the exploited mine areas.

A worldwide operating engineering company was looking for filtration equipment to dewater these tailings coming from a gold/silver mine which is located 4,800 m above sea level (MSL). This was a big challenge as the client was looking for a cost efficient filtration solution. On the one side it was required from the equipment to have a small footprint for reducing building cost and logistic efforts to get all the parts in the remote area of the plant site. This basically took the option for four large vacuum belt filters out of the focus and favoured pressure filtration. On the other side it was required from the filtration equipment to be low in operation cost as electricity is limited and the overall OPEX should be as low as possible. This disqualified the pressure filtration option. As a final result the high performance Boozer disc filter fulfilled both requirements in the best way and were chosen to be the most suitable dewatering technology for this application.

Product characteristics of the feed slurry are as follows:

- feed solids: 60 wt.-% solids
- particle size distribution $d_{20}/d_{50}/d_{80}$: 6.7 µm/22 µm/52 µm
- pH-value: 11

Based on filtration test work conducted by a third party and the experience of BOKELA in the field of tailings filtration the following filter lay out has been made:

- solids throughput on dry solids basis: 88 t/h resp. 44 t/h per filter
- cake moisture content: $\leq$ 20 wt.-%.
- flocculent dosage: 10 – 50 g/t dry solids

Figure 5. Tailings dewatering from a gold/silver mine with a Boozer disc filter L4 (176 m² filter area) – complete cake discharge during pre-commissioning

The two disc filters will be operated in a fully automatic way i.e., filter start up, filter operation and filter shut down are carried out automatically. First test during pre-commissioning phase proved that the filter can be operated within the required and predicted performance range. Commissioning and start of operation will take place in March 2016.

CONCLUSION

The Boozer disc filter has set the pattern in a multitude of applications in many industries e. g. in the alumina industry and in the dewatering of coal slurries. In the recent past this modern high performance disc filter has established itself more and more in applications of tailings dewatering, especially – but not exclusively - where mine backfill is processed. Among competitive technologies such as filter presses or belt filters, vacuum disc filters of modern design are the most economical solution with reference to both CAPEX and OPEX in a wide range of tailings applications. The reasons for its economic efficiency and successful operation in tailings dewatering are: the high throughput and dewatering performance, the excellent operational reliability even in case of varying feed conditions, the robust design, the ease of maintenance and last but not least the small footprint.

ACKNOLEDGEMENT

We would like to thank our customers for their trust in our technologies and their kind support.

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