Filtration of Digester Blow-off - an Option for the Refinery Design of the Future

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Abstract

Rotary vacuum disc filters are successfully used in Alumina refineries since decades in seed deliquoring and wash applications. However, the limitation of the acting pressure difference to the conditions generated by vacuum pumps have restricted the field of applications. With the installation of these rotary disc filters in pressure vessels and the development of reliable solids discharge systems, the so-called hyperbaric filters have made their way into the Alumina refining process. At the moment they are used for Bauxite filtration if the bauxite is sent to the refinery through a pipeline as water/bauxite mix. This water must be removed as much as possible to keep the water balance in the process and to minimize the energy impact. But this may not be the only suitable filtration step for this filter technology. Bauxite residue is certainly a vital option although filter presses are state of the art technology at the moment. However, the discussion about the refinery design of the future always includes options for direct filtration of the digestor discharge that may replace the decanter and washers either partially or in total. The most appropriate filter technology for this application would be the hyperbaric filtration. It would allow to filter at high temperature of up to 200 °C and high pressure of up to 1000 kPa (10 bar). Backpressure operation could avoid flashing and moderate cake wash promises to eliminate washer in total. As the bauxite residue could be discharged with a moisture of 30 wt% or less, there would as well be no need for extra bauxite residue filters. The footprint of the Alumina refinery could be drastically reduced.

Keywords: Filtration, Bauxite Residue, Bayer, Hyperbaric, Digestion.

1. Introduction

Many production processes such as the Bayer process run at high temperature and high pressure to enable or improve specific reactions, to keep wanted or unwanted components in solution or to improve the process efficiency. Slurries from such processes have to be handled in a careful way. A drop of pressure and/or temperature would be associated with implications which have to be avoided such as boiling/flashing and evaporation of the liquid or product contamination due to unwanted reactions and/or crystallisation of unwanted by-products etc.

Such slurries should ideally be filtered at high temperatures and high pressures and the filtration process should meet the following challenging requirements:

- maintaining temperature and pressure at the low-pressure side (filtrate side) above a certain level to prevent flashing/boiling (T_b, p_b) of the filtrate
- continuous filtration with short residence time
- prevention of unwanted reactions and/or crystallisation/scalings in the filter cloth and filtrate pipe system
- applicability in corrosive, toxic or explosive atmosphere
- withstand high material stress
- filter sizes for small, medium and large (e.g. in alumina refineries) production rates
- reliable operation control with different sequences for heating procedure, start of operation, continuous operation and maintenance

Since no suitable filtration technologies were available that would meet the above requirements, the solid-liquid separation of such sludges is often carried out as a complex, multi-stage separation process with a number of individual steps in order to avoid or at least minimize the undesirable complications mentioned. Now, BoHiBar Filtration has made its way into the petro-chemical industry filtering the base components of polyester at high temperature of up to T > 200°C and high pressures of up to p_{abs} = 700 kPa and has shown its capability to operate in a reliable way under such challenging conditions in many reference applications.

The BoHiBar Filtration process can be performed with a high filtration pressure difference $\Delta p = p_1 - p_2$ (p_2 = atmospheric pressure) and as a counterpressure filtration process with high vessel pressure p_1 and a filtration pressure difference $\Delta p = p_1 - p_2$ with a back pressure p_2 at the filtrate side above the flashing/boiling point T_b, p_b of the flash curve ($p_{atm} < p_b < p_2 < p_1$). This allows the filtrate to be discharged at high temperature and pressure without flashing/boiling and crystallization effects and allows the hot filtrate to be further processed in hot downstream process steps.

2. Historical Review of the Filtration of Digester Blow off

For alumina refineries the extraction yield of bauxite processing has been a major focus for decades and accordingly there have always been efforts to minimize the loss of extractable alumina in the process chain. Loss happens in the digestion reactor where extractable alumina (gibbsite) stays undigested, in the settlers and in the bauxite residue washers which sums up to a loss of about 6 % and is therefore a topic of economical relevance [1], [2]. As a rule of thumb [2], in the settlers up to 2 % gibbsite reversion is lost and 2 more percent points are lost during bauxite residue washing mainly due to the following reasons:

- cooling down of the liquor to less than 100 °C together with long residence time in the settler and bauxite residue washers with contact of the pregnant liquor with the bauxite residue (the liquid phase becomes oversaturated for aluminium hydroxide (gibbsite));
- precipitation of aluminium hydroxide (gibbsite) enhanced by the presence of seed;
- decreasing of the alumina solubility along with the decreasing caustic soda concentration due to the more diluted conditions in the bauxite residue washers.

If it was possible to separate the bauxite residue and wash it from the highly caustic and hot slurry quickly and directly just after digestion without cooling and with a short residence time, a lot of extractable alumina could be saved. In the early years of the Bayer process often plate and frame filter presses were used for the direct filtration of the blow off slurry and the cake was washed with condensate. Operational and maintenance cost, however, were immense especially due to cost for filter cloth wash water and manual efforts for cake discharge. In some refineries they were replaced by Kelly filters which showed a better separation performance and reduced maintenance and labour cost. But also Kelly filters could not establish for direct filtration due to the high loss of soluble soda and alumina.

In 1973 B. Schepers performed pilot scale testwork on direct filtration of the bauxite residue directly after the digestion reactor with continuous pressure filters in the Guilini Werk in Ludwigshafen, Germany [3]. The testwork was performed with an old vintage rotary pressure drum filter of 0.75 m² filter area. Maximum pressure that could be realized with this pilot filter was 3 bar, i.e. the filtration pressure difference was Δp = 200 kPa. Feed temperature of the slurry was 100 °C while the filtrate was drained off with a temperature of T = 60–70 °C. Solids concentration of slurry feed was 47 g/l, particle sizes were not recorded but it can be assumed that they were in the typical range of x_{50} < 10µm. The filter cake was washed with boiler feed water of 100 °C and discharged with a discharge roller. The filtrate performance was in the range of

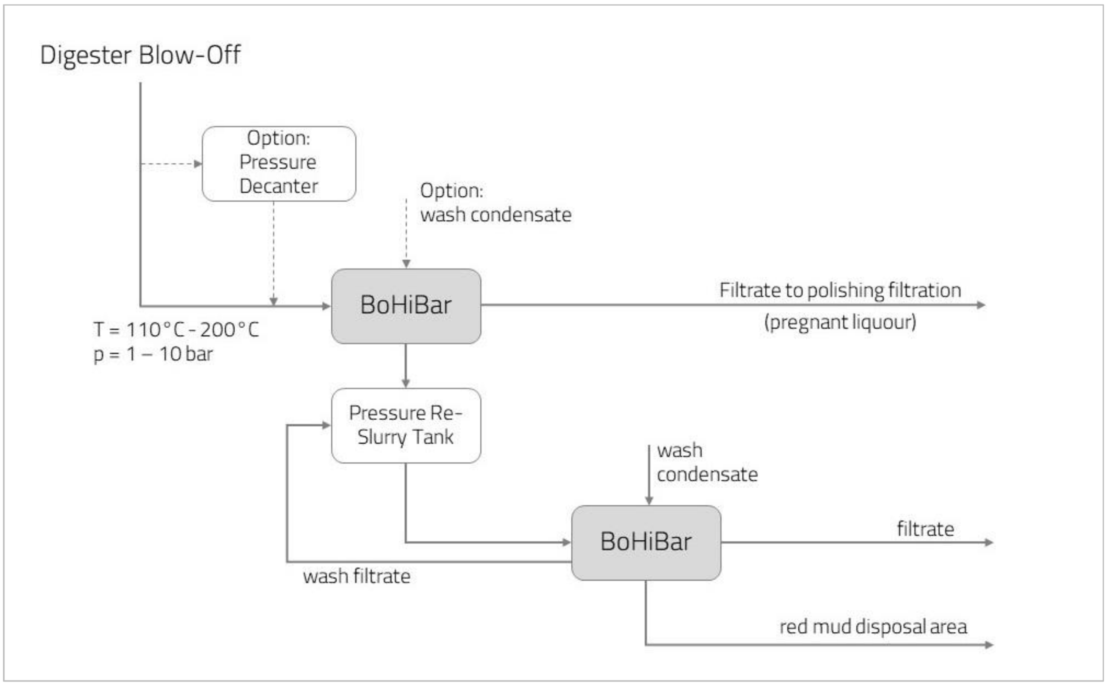

Figure 5. Flow sheet of digester blow off filtration with two filtration stages

The filter operation at temperatures in the range of 140–200 °C of the digester blow off is a challenge for the materials of construction as well as for the operation of the filter, but also a challenge for the filter fabric. The temperature in combination with the high pH-value is a bigger challenge than the abrasive nature of the solids is. The possible success of this technology is certainly linked with the operation and maintenance procedure and strategy. The filters already in operation at high temperature and pressure are running well because preventative maintenance strategy is in place with a strict adherence to the given maintenance schedules in combination with a smart sequence of how to cool the filter before servicing. It would be great to see this change to digestor blow off filtration in the next years and to contribute with this technology to the CO_2 emission reduction, the safety of the bauxite residue storage facilities and the efficiency of the refinery process.

5. References

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