

## Modern Concept for the Desanding of Red Mud

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### Abstract

Red Mud is a waste product from the aluminum production process. Due to its high sodium and high iron oxide content, it is difficult to use unprocessed bauxite residue in the steel industry as a substitute for iron ore. Therefore, a common way until now is to deposit the untreated red mud in various places, although this represents a significant risk to the environment because of potential pollution of surrounding soil and groundwater (e.g. the sodium content). Due to a poor exploitation of this resource, the industry faces here more and more important market challenges, since the volume of red mud is constantly increasing and the places for landfilling or deposition are reaching their limits. Among other things, the players also suffer from the high landfill costs. To relieve the landfills (reduce volume) and enable dry stacking, the use of filters prior to deposition is more and more adopted. Therefore, to protect the process pumps and filter cloths against wear, the coarse sand particles might be separated by special hydrocyclones before filtration step. To receive valuable fractions from the red mud, the desanding and recovery technology from AKW Equipment + Process Design is used. For the challenging conditions of red mud desanding and classification, special designed hydrocyclones AKA-VORTEX, in wear and temperature resistant Polyurethane or cast steel lining, followed by a washing/dewatering screen unit or also combined with a teeter bed separator AKA-SIZER, would be the effective solution. An introduction of the installation and operation of such highly specialized desanding unit will be presented in this paper.

**Keywords:** Alumina, Red mud, Desanding, Hydrocyclones, Washing.

### 1. Originating of Bauxite Residue

Bauxite residue is a by-product generated from the Bayer process for refining bauxite to alumina. The amount of bauxite residue produced by an alumina plant or refinery is mainly dependent on the bauxite composition (country of origin) and on the extraction conditions. The “residue factor” (or mud factor) is often represented as the tonnes of dry residue per tonne of alumina produced and ranges from 1.0 to 2.5, with an average of 1.23 [1].

Since 1893 the Bayer process has been mostly used and there are approximately more than a hundred plants running with this process around the world, with more than 60 plants in China only. Especially there, the number of alumina refineries continues increasing rapidly, to fulfill the rising demand of aluminum that enjoys an average growth rate of 6 % per year. Therefore, the annual bauxite residue generation is currently around 150 million tonnes, to be added to the already accumulated quantity of old bauxite residue, estimated at nearly four billion tonnes [2].

## 2. Composition of Bauxite Residue

The bauxite residues composition is highly influenced by different factors such as the bauxite source and composition (gibbsitic, boehmitic or diasporic bauxite), but also the temperature and the pressure level used in the transformation of the bauxite into alumina. Bauxite residues composition consists of iron oxide, titanium oxide, silica and undissolved alumina. These materials are found mixed with some other oxides depending on the country of origin of the raw bauxite. The high concentration of iron compounds in the bauxite residue is responsible for the reddish color and therefore called “red mud.” The typical chemical and mineral compositions are given in Table 1 and in Table 2. It is highly alkaline with pH around 13 [3].

**Table 1. Chemical composition for bauxite residues [3].**

Component	Typical Range (%)
Fe <sub>2</sub> O <sub>3</sub>	20–45
Al <sub>2</sub> O <sub>3</sub>	10–22
TiO <sub>2</sub>	4–20
CaO	0–14
SiO <sub>2</sub>	5–30
Na <sub>2</sub> O	2–8

**Table 2. Mineralogical composition for bauxite residues [5].**

Component	Typical Range (%)
Hematite (Fe <sub>2</sub> O <sub>3</sub> )	10–30
Magnetite (Fe <sub>3</sub> O <sub>4</sub> )	0–8
Goethite (FeOOH)	10–30
Silica (SiO <sub>2</sub> )	3–20
Calcium aluminate (3CaO.Al <sub>2</sub> O <sub>3</sub> .6H <sub>2</sub> O)	2–20
Titanium Dioxide (TiO <sub>2</sub> )	2–15
Muscovite (K <sub>2</sub> O.3Al <sub>2</sub> O <sub>3</sub> .6SiO <sub>2</sub> .2H <sub>2</sub> O)	0–15
Calcite (CaCO <sub>3</sub> )	2–20
Kaolinite (Al <sub>2</sub> O <sub>3</sub> .2SiO <sub>2</sub> .2H <sub>2</sub> O)	0–5
Sodalite (3Na <sub>2</sub> O.3Al <sub>2</sub> O <sub>3</sub> .6SiO <sub>2</sub> .Na <sub>2</sub> SO <sub>4</sub> )	4–40
Gibbsite (Al(OH) <sub>3</sub> )	0–5
Perovskite (CaTiO <sub>3</sub> )	0–12
Cancrinite (Na <sub>6</sub> [Al <sub>6</sub> Si <sub>6</sub> O <sub>24</sub> ].2CaCO <sub>3</sub> )	0–50
Diaspore (α-AlO(OH))	0–5
Boehmite (γ-AlO(OH))	0–20

### 3. Processing of Bauxite Residue

Dilute Bayer liquor containing sodium hydroxide and other valuable sodium compounds remains also with the bauxite residue. By the red mud settling the contained high amount of caustic solution should be recovered. The caustic solution would overflow with the resulting supernatant, whereas the thickened red mud is being discharged as underflow. However, such discharges suffer from severe pipe blocking issues due to the settling of still present sand particles in the mud [4].

Moreover, dry stacking of red mud usually requires treatment by filter systems to significantly reduce the moisture content. The de-sanding of the red mud is a significant advantage to protect these filters and the related pumps against the high wear caused by the undissolved particles.

Many patents have been issued and there have also been thousands of experiments done on the various uses of bauxite residue, but only a small have been commercialized. Appropriate marketing plans have been worked out for these applications, and the biggest challenge is how to match the annual tonnage generation with potential and commercial applications, economically viable [5].

### 4. Overall Process and Integration of AKW A+V Equipment

Bauxite residue slurry generated from the Bayer alumina refineries will be diluted with the liquor process stream and washed in a number of washing silos to reduce the soda concentration to the range of 70–80 g/L with 7–10 % solids concentration. The washing process temperature is usually in the range of 70–80 °C.

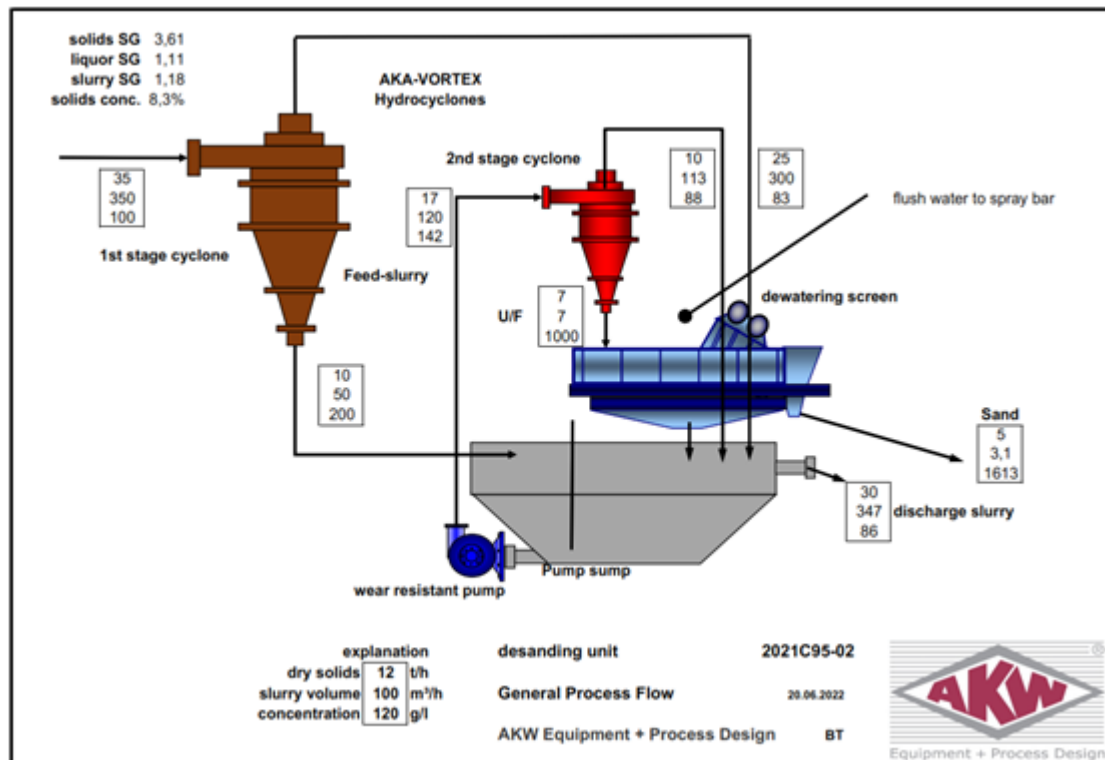


Figure 1. Exemplary process flow for test unit scale [6].

Such an exemplary red mud stream is composed of e. g. approx. 80 % sludge and approx. 20 % undissolved silica particles above 100 µm. As illustrated in Figure 1, through a first stage of

hydrocyclones the undissolved silica particles in the bauxite residue will be separated and up-concentrated in the underflow, while the overflow is recovered and reinjected into the washing liquor going into the washing silos. A second stage of hydrocyclones will achieve a further up-concentration of the silica fraction, and a separation of the unwanted fines. Then, the highly concentrated sand slurry can be discharged onto a specially designed linear moving dewatering screen. Suitable screen mesh, appropriate to the occurring conditions, and spray bars for wash water application complete the task of this dewatering screen.

Due to the severe process conditions, the hydrocyclones system is made out of high wear and temperature resistant polyurethane. The modular and flawless design of the AKA-VORTEX hydrocyclones makes it perfectly suitable for these process conditions [6].

Such a concept, which has already shown success at specific site (Figure 2), is completed with a fully equipped monitoring and controlling system, allowing to adjust the process flow: flow meters, pressure gauges and pressure regulators, temperature sensors as well as sampling points before and after each stage can be integrated in the solution, based on customers' requirements or wishes.

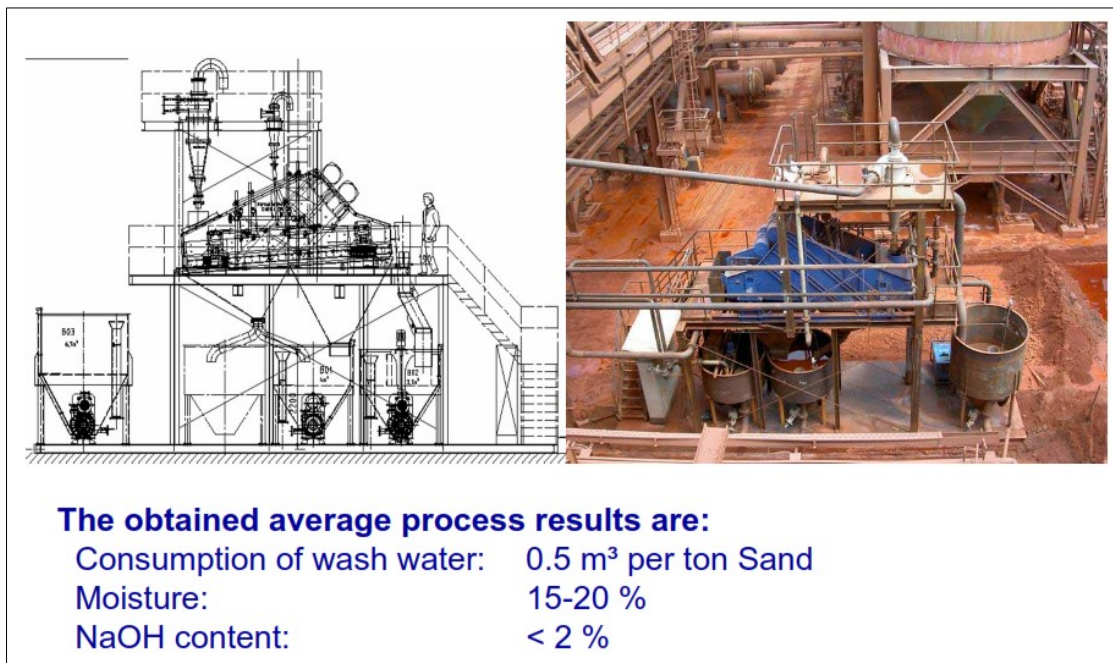


Figure 2. Full scale unit – design sketch and executed installation [6].

## 5. Hydrocyclone AKA-VORTEX Principle and Selection

In principle, the hydrocyclone is a solid bowl centrifuge of “slim” design. It can be compared to a high-speed tubular centrifuge but also with a long-tube decanter. In the case of the hydrocyclone, however, the body is stationary. A rotation is initiated by the flow arising from the tangential feed under pump pressure. As illustrated in Figure 3, the fluid is subjected to centrifugal forces, that lead to the creation of a primary vortex, which is directed downwards, and an internal secondary vortex directed upwards. This leads to a segregation effect of the particles present in the fluid due to radially outward sedimentation [6].

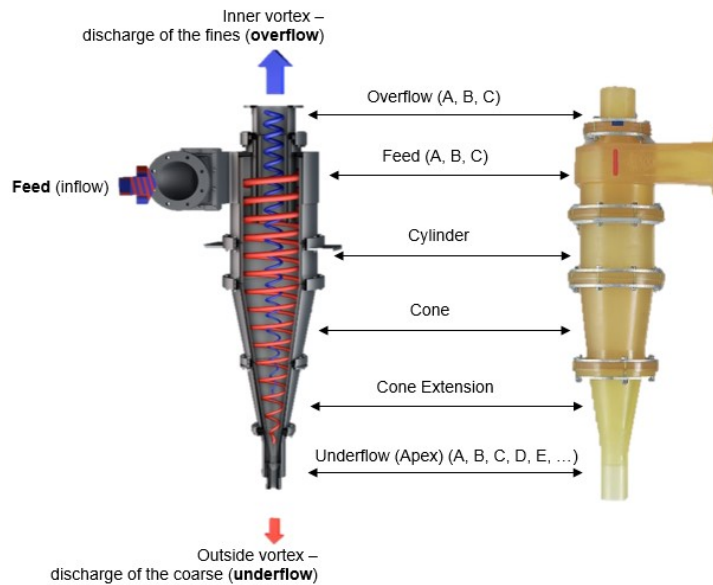


Figure 3. Operation principle / different sections of a hydrocyclone AKA-VORTEX [6].

The AKA-VORTEX hydrocyclone consists of several replaceable sections connected by means of clamps and flanges as illustrated in Figure 4.

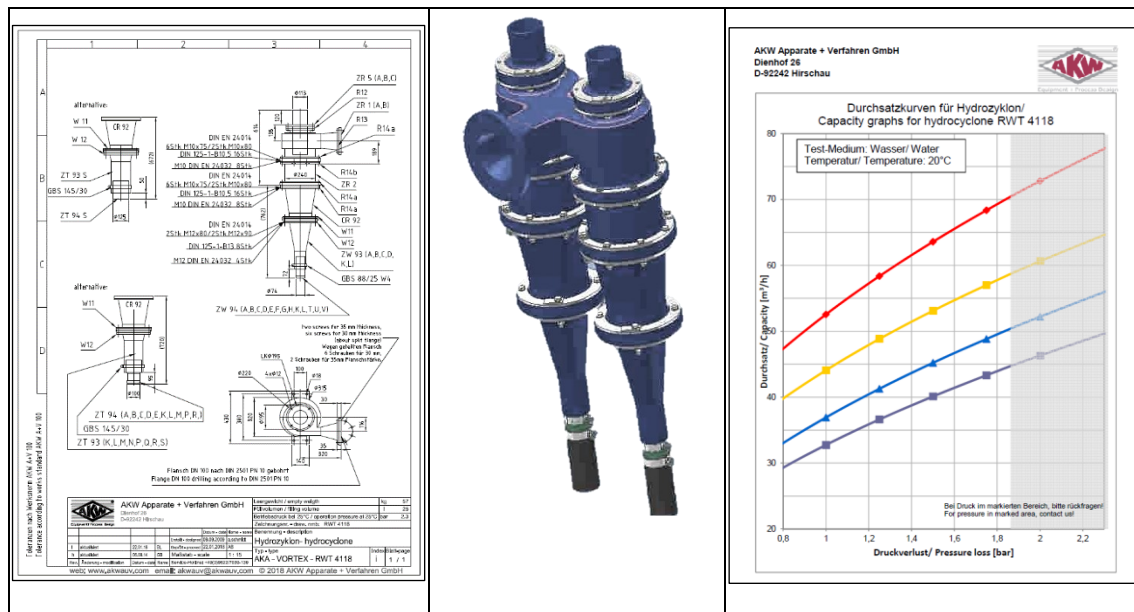


Figure 4. (a) Exemplary installation drawing, (b) 3D visualization, (c) capacity curves (m<sup>3</sup>/h) vs.  $\Delta p$  (bar) [6].

## 6. Selection of Dewatering Screens

Regarding the selection, sizing and functionality of the dewatering screen several aspects need to be considered. Dewatering screens are generally known for further dewatering of up-concentrated particle slurries to reach a bulky material level that can be easily transported by conveyor belts or also by trucks. Contrary to the circular moving classification screen, the dewatering screen has a linear movement pattern. The created vibrations generate a material bed where the liquid is drained through the screen mesh and the bulky material is transported to the discharge chute (Figure 5).

Specifically for the red mud de-sanding application, a caustic and temperature resistant material for the screen frame as well as for the screen mesh need to be selected. Therefore, stainless steel is the appropriate material to resist against these conditions [7].

For the handling of the separated sand on the screen, a further washing step with process water has to be considered. This is aimed at further reducing the caustic content in the sand in order to help the potential use of the sand in several valorization applications. Such a washing concept will be realized by so-called spray bars. The number of spray bars equipped with special spray nozzles should be related to the wanted wash effect and the needed water amount. This additional wash water amount needs to be considered by sizing the required screen mesh area to reach the requested dewatering effect.



**Figure 5. Dewatering screen, discharge of separated and dewatered sand [6].**

## 7. Conclusions

In order to minimize the environmental impacts of bauxite residue deposits, use of filtration prior to stacking is more and more adopted by the industry. However, coarse fractions in bauxite residue can have negative impacts on this step. AKW Equipment + Process Design has gained strong knowledge in this field over several years of tight cooperation with major aluminium refineries and was able to develop solutions that offer appropriate treatments for the bauxite residue chain by focusing on the handling of the waste generated and targeting a reduction of the environmental impact and reusability of part of the waste flow. As such, these solutions contribute to the concept of a circular economy in this demanding and growing aluminum industry.

The AKA-VORTEX hydrocyclones, made of high wear and temperature resistant polyurethane (PU), are an important addition to the alumina industry. Their unique designs ensure a specific cut size for the separation, while offering the needed flexibility to adjust the separation specificities in order to maximize the overall production yield and minimize the energy demand.

## 8. References

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