K-4 Impact on Dehydration Process of Red Mud Settling

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Abstract. The article represents the results of a study on the red mud dehydration process (thickening, filtration, filtration washing) obtained in the alumina production during the processing of the low-silica bauxites. The synthetic flocculant K-4 has been used in order to intensify the red mud dehydration process. The main washing periods have been studied in the process of the filtration washing analysis. The expendable module impact on the effectiveness of aluminate solution cleaning (mother liquor) obtained from the mud settling has been represented. The settling washing, treated by the flocculant, has been established to allow increasing the quantity of the specific effective moisture at the cost of the mutual volume of the standing pores and the grow of free moisture volume.

1. Introduction

In the alumina production, the red mud is obtained after the autoclave leaching of the milled ore. The red mud here is to be washed away of some valuable aluminate solution, most of all in the open-loop counter-current configuration with a completed washing cycle in thickeners [1, 2, 3]. A significant dispersion of particle bauxites (size of the mud particles is thinner than 50 mk) is observed due to the autoclave leaching. Hence, a slow lightening of the mud pulps takes place in the thickener – washer. The aggregate stability of the particles and a high level of their hydration also complicates the thickening process [4, 5].

The mud thickening process increases greatly [6, 7, 8, 9] when adding some mineral (flour, starch, etc.) and synthetic flocculants (polyacrylamide, separan, etc.). The flocculant action is based on its adsorption on the surface of the mud particles. The mutual attraction strength between the adsorbed compounds or flocculant ions creates the conditions for the adhesion of the particles into greater aggregates [10, 11, 12].

After the multiple red mud washing the aluminate solution concentration in the mother moisture of the thickened settling is decreased greatly in the cone of the gradual washer (to 1 g/ dm³ NaO).

Hereafter in order to reduce the losses of the dump mud the necessity of the carrying out the filtration or the filtration washing may occur [13, 14, 15, 16].
Filtration washing of the settling has become widely used in chemical, mining and chemical, ore mining and smelting branches of economics, etc. [17, 18, 19]. The equipment, including the filtration baffle (vacuum-filter, filter presses, filtration centrifuge) is used in order to wash the settling.

During the washing process, the washing solution is supplied to the settling surface. The solution atomization is used on the constantly operating filters. It leads to the moving of the double-phase air liquid steam in the settling pores. Temporarily operating filters use the washing by means of the mother liquid expulsion from the settling.

The settling washing on the filters is a hard hydrodynamic process. It is identical to the filtration process at a constant settling thickness. The washing speed is depended not only on the pressure of the solution viscosity, but also on the settling resistance and its physical and mechanical properties.

2. Methodology
At present flocculant additives are widely used to improve the settling texture and to provide the improvement of the dehydration process of the technical dispersion. For this purpose, synthetic flocculants have a significant outspread.

K-4 is a synthetic highly molecular flocculant of the polyacrylamide type. K-4 was synthetized by K.P. Akhmedov and S.P. Zaynutdinov at the Institute of Chemistry of the Academy of Sciences of the Uzbek SSR. The synthetic flocculant is obtained at the incomplete polyacrylamide saponification in the water solution of the caustic alkali. K-4 is produced in the form of a pasty-like mass. The flocculant is easily decomposed when mixed in warm water. A 0.5 % solution, that was dilute till 0.10 % during the filtration, has been prepared in advance. The highest filtration rate is mentioned for the flocculant doze of 24 g/t of mud.

The study on the filtration process of the red mud settling washing has been realized on the filtration equipment with the application of a laboratory model of Nutsche filter. It was installed into the temperature-controlled cell, connected with a thermostat. The pulp of needed thickness has been filtrated in order to get a settling of the specified thickness. After that, the settling has been washed by water or water solution of dilute concentration alkali at the full connection with the settling surface.

To run thickening experiments a pulp of the red mud has been used (the pulp contains 65 g/dm$^3$ of hard and 160 g/dm$^3$ Na$_2$O, that is prepared by thickened pulp). The mud detention has been carried out in the volumetric cylinders V = 100 ml. at T = 96-98°C. The data obtained has allowed plotting sedimentation curves. These curves have become basics for evaluating the speed of the pulp subsidence.

The red mud samples from The Pavlodar Alumina Plant have been used in the experiment. Grain-size analysis data show that fraction quantity in the sample of less than 50 mk contains more than 90,4 %. The specific surface area, defined by Chromatographic method, is about 7 mg/g.

Mineralogical analysis has allowed establishing a composition of the following factions: ooze faction (kaolinite, zeolite, hydargillite, goethite, limonite, hydrogoethite), light sand faction (quartz, feldspar, kaolinite, mica, calcium, etc.), hard sand faction (magnetite, limonite, goethite, hydro goethite, hematite, rutile, melnicovite, etc.).

3. Result of the experiment
The experiment represents the impact of the solution concentration K-4 on the speed of the red mud pulp lightening and the overflow turbidity. The upper margin of the flocculant concentration is limited by the solution viscosity. The strength solution application complicates the flocculant dosage and deteriorates its distribution over the pulp volume. Excessive watering is connected with the processing and boiling-down an additional quantity of the technological solution.

The deterioration of the technological indices of the thickening process, applying the flocculant solution concentration, can be described by the following: super molecular features (sweep) occur in such solutions as a result of the macromolecule associations, which are not active enough. The macromolecule sweeps at the same flocculant dosage reduce the effective flocculant concentration and
complicate their macromolecule hydrolysis with the formation of active anions groups in sorption relation [20, 21].

When water solution is too dilute, the flocculant is found in the molecule and ionic form. At the same time, the polymer macromolecule has a tendency to the coagulation that reduces its flocculant properties, too.

The experiment of the red mud pulp thickening process with K-4 application has allowed establishing its optimal dosage – 25 g/m^3.

The speed of the red mud pulp lightening with optimal K-4 doze is 16,8 mm /min in the interval of the flocculant concentration 0,10 – 0,50 %.

Filtration washing of the red mud settling is characterized by three periods: expulsion, hydro-chemical humidification and molecular diffusion [22, 23]. Washing with K-4 application also has three periods, but their duration and washing effectiveness differ from the original version (Figure 1).

![Figure 1](image_url)

**Figure 1.** Time \( \tau \) duration impact on the dimension of the alkali concentration in the washing filtrate: 1 – without additive, 2 – K-4.

K-4 processing leads to the decreasing of the first period duration, where the mother liquor expulsion occurs about 4 min. in comparison with 5 min. without flocculant processing. The flocules formation defines the capillary formation with larger radius values than not processed K-4 settling has. Whilst due to the grow in the pore proportion per free moisture, insignificant grow of watering by the second period is provided till 0,49 (without flocculant processing till 0,42).

During the washing process, the growth of the washing effectiveness is observed by the beginning of the third period due to the pore volume reduction and its volume on the stagnant water. However, it is an insignificant increase until 4-5 %.

4. Conclusion

Thus, according to the experiment showing the results of filtration washing of the red mud settling (ОАО «ПАЗ» - The Pavlodar Alumina Plant), the following conclusions can be drawn:

1) K-4 application makes a positive impact on the kinetics of the red mud thickening process. The grow of the lightning speed reaches 60-70 % (16-17 mm/min);
2) The major periods of filtration washing has been established during the washing process;
3) K-4 application does not significantly increases the filtration washing efficiency of the red mud settling.

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