Industrial Trials of Spent Tricalcium Aluminate Recycling into Digestion Process of Timan Bauxite (Stage 1)

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Abstract

Currently, at RUSAL Kamensk-Uralsky Refinery, spent Tricalcium Aluminate (TCA) containing up to 40 % CaO is pumped as slurry from security filtration to the mud washing circuit and become a total loss with the disposed red mud. It is not used in alumina production, while an opportunity is evident of TCA involvement into the process (as Ca containing additive) to replace lime in digestion of Timan bauxite, thus reducing process consumption of fresh purchased lime. This paper presents technical, engineering and technological solutions to reduce the specific consumption for lime introduced into production, thereby, reducing alumina production cost. The results of pilot testing of the filtration of a spent TCA suspension in a Diemme press filter are presented. Pilot tests conducted on site of RUSAL Kamensk – Uralsky Refinery, showed that filtering of TCA suspension using the available RUSAL Kamensk - Uralsky process flow is possible.

Keywords: filtration, suspension, TCA, lime substitution, green liquor.

1. Introduction

Over 125 year history of Bayer alumina production, various materials were tested in industry for the “polishing” filtration of the aluminate liquor (that is, the separation of red mud fine particles from the thickener discharge/blow off):

- pulp (used at Zaporozhye Aluminum Smelter);
- cuts of solid diasporic bauxite (used at Nikolaev Alumina Refinery in Epos tank filters, Frigia Alumina Refinery in Guinea, AoG in Greece, and Aluminium Pechiney aluminum refineries (Gardanne, Solendras, La Baras);
- Hematite sands extracted from red mud (still in use in bulk filters at the Aughinish Refinery);
- cuts of solid limestone of various grain size (currently in use at Nikolaev Alumina Refinery in Epas French tank filters);
- tricalcium hydroaluminate (global practice);
- aluminum hydroxide (currently in use at Aluminum Oxid Stade GmbH, Germany);

At present, the global practice to use specially synthesized tricalcium hydroaluminate as a filter layer (hereinafter referred to as TCA) with its further "utilization" as a Ca additive for bauxite digestion prevails. TCA is double calcium hydroxide aluminum. This is a low soluble compound with the chemical formula: $Ca_3Al_2(OH)_{12}$ or $3CaO{\times}Al_2O_3{\times}6H_2O$. TCA is a result of the interaction of aluminate liquor and lime milk (slaked lime $Ca(OH)_2$). See reaction 1:

$$3Ca(OH)_2 + 2NaAlO_2 + 4H_2O \rightarrow Ca_3Al_2(OH)_{12} + 2NaOH \quad (1)$$

In 2018, RUSAL ETC branch, St. Petersburg, in laboratory conditions with Bayer branch RUSAL Kamensk-Uralsky spent liquor, bauxite and lime supplied, tests were performed to digest STBM bauxite using spent TCA as a Ca additive. Laboratory confirmed that the use of spent TCA as the Ca additive reduces the consumption of CaO from 4.34 to 3.47 wt %, with no reduction in chemical extraction and aluminate liquor quality.

It was recommended to carry out site testing at RUSAL Kamensk-Uralsky to verify the laboratory test results on digesting STBM bauxite with spent TCA.

2. Experimental Procedure

To study the technical capability of filtering suspension of spent TCA with the existing Diemme press filter (Italy) in actual production conditions on site at RUSAL Kamensk-Uralsky Refinery, it was decided to install a pilot process flow. The flow includes tankage (tank agitators), pumping facilities, pipelines for pumping liquors, the Diemme Filtration GHS 1000 chamber diaphragm filter press. TCA is fed by pumping from tank agitators into Diemme chamber diaphragm press filter. The products of the filtration process of the TCA suspension are the cake, i.e. filtered TCA and filtrate (aluminate liquor with $Na_2O_k \sim 152$ g / dm^3). Filtered TCA is transported by vehicles to the bauxite warehouse, where it is involved as Ca additive into the production process. The filtrate is also recycled by pumping into the agitator of the Digestion & Thickening Facility.

A feature of the flow diagram is that the equipment used for collecting, pumping and filtering the suspension of the spent TCA is located in the buildings and galleries of individual departments: sections No. 2&8 of the digestion & thickening area, section No. 7 of the raw material preparation shop. See Figure 1:

- Diemme press filter;
- tankage;
- pumping facilities;
- suspension and filtrate pipelines.

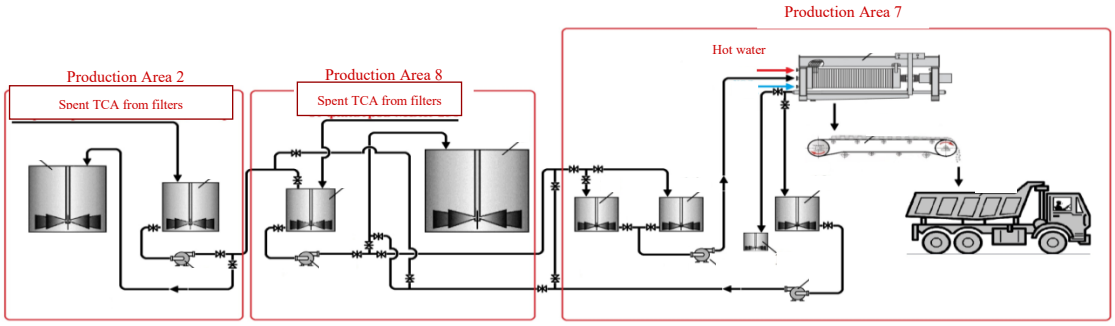

Figure 1. Pilot - Spent TCA filtration process flow diagram.

In May - June 2019, as a part of Stage 1, construction and installation work was carried out, which included pumping of spent TCA suspension in the Digestion & Thickening Facility to Filtration Facility for preparing raw materials for filtering.

The first stage of site testing was conducted within a June 20 - July 07, 2019 period. Site tests of the filtration process of spent TCA in Digestion & Thickening Facility subject to existing process flow included the following processes:

- transportation of spent TCA suspension through the pipeline Area 8, Digestion & Thickening Facility to Area 7, Filtration Facility with further recycling of the filtrate, including regular flushing of the pipeline;
- filtering of spent TCA.

3. Site Test Results

Data on TCA volume transported, TCA solids content, cake moisture of the filtered TCA and single sampling data, obtained on test results, are presented in Table 1.

Table 1. TCA filtering test results.

Date	TCA transported, m^3/day	TCA solids content, г/л	Cake moister, %
June 24-28, 2019	**140,8**	**134,3**	**27,6**

When conducting pilot site tests, filtered TCA was sampled for chemical analysis, the data are presented in Table 2. The results obtained correlate with the data obtained by RUSAL ETC, Kamensk-Uralsky in March 2019. In laboratory conditions, spent TCA of Area 8, Digestion & Thickening Facility was filtered. The data are presented in Table 3.

Table 2. Spent TCA chemical composition (alkali removed/not removed).

Al_2O_3	Fe_2O_3	SiO_2	TiO_2	CaO	MgO	Na_2O_{total}	K_2O	MnO
TCA cake (alkali not removed)								
25,1	2,0	1,5	0,19	36,1	0,24	4,9	0,92	0,02
TCA cake (alkali removed)								
25,2	2,8	1,9	0,2	42,6	0,35	0,51	0,08	0,02

Table 3. Spent TCA chemical composition (alkali removed and filtered in lab conditions).

Al_2O_3	Fe_2O_3	SiO_2	TiO_2	CaO	MgO	$Na_2O_{общ}$	K_2O	MnO
TCA cake (alkali removed) filtered in lab								
24,2	2,3	2,6	0,16	41,9	0,28	0,44	0,08	0,06

Table 4. Filtrate chemical composition and solids content.

Fe_2O_3	Na_2O_{total}	Filtrate solids content
Diemme filtrate		
0,007	151,1	0,6

4. Available Results Analysis

The results obtained during the tests did not reveal the dependence of the moisture value of the press filter cake on solids content in feed slurry. A slight correlation of the values of cake moisture of filtered TCA is observed only when filtration modes change: dripping, press time, feed pump performance.

Chemical analysis data of filtered spent TCA cake presented in Table 3 correspond to the previously stated results, obtained in laboratory testing.

It is worth noting that during site tests there was a decrease in filter performance due to clogging of filter cloth. This fact is explained by spent TCA temperature drop, which is based on the aluminate liquor when filtering and at the start of decomposition of the aluminate liquor with aluminum hydroxide being formed. In order to improve the technical characteristics of the filter cloth during the site testing stage, the pipeline was installed to supply spent liquor containing $Na_2O_{tot.}$~ 295gr/dm^3 to the filter for regular filter cloth cleaning. For improving filter cloth cleaning efficiency, spent liquor is heated up.

5. Conclusion

Conducted pilot site tests, with RUSAL Kamensk-Uralsky liquors being used, proved that press filters for filtering spent TCA suspension can be used. At RUSAL Kamensk-Uralsky Refinery, filtration was carried out with Diemme press filter. The technical characteristics of the press filter used in the process flow, as well as the characteristics of the spent TCA suspension, make it possible to obtain filtration products of the required quality. The average value of moisture in spent TCA cake was 27.6 %. This makes it possible to transport and further stack for temporary storing before being involved in production. The filtrate solids content recycled to Digestion & Thickening Facility averaged 0.6 gr solids / dm^3 .

The filtrate chemical composition in terms of the total alkali content practically corresponds to the concentration of the aluminate liquor (150-155 gr / dm^3) and the content of Fe_2O_3 - 0.012-0.013 gr / dm^3. The showcased chemical composition allows us to suggest the option of pumping the filtrate to the drain tank before the control filtration, and not to the tank agitator, as they do it now. Chemical analysis of the product obtained in pilot site tests of the CaO content verifies the results previously obtained in laboratory filtration. For maintaining the filter performance, it is suggested that filter cloth should be regularly flushed with heated spent liquor containing Na_2O_{total} ~ 295 gr / dm^3.

In the time period of site pilot testing under Stage 1, 300 tons of TCA were filtered; this volume will be used in production during Stage 2 of site testing.

6. References

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