Caustic cleaning quality: Condition crucial to increased system availability in a Bayer plant

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Abstract

Caustic cleaning is critical to the routines of a Bayer plant, guaranteeing the cleanliness of equipment and system availability. The control of temperature and caustic concentration is essential to the solution efficiency. This study shows that: 1) Caustic cleaning time in decantation tanks and mud wash is decreased by 50 % after rigorous control of the temperature; 2) Caustic cleaning time in crust filter is decreased by 80 % after rigorous control of the temperature; 3) Increase of the caustic cleaning time as compensation for loss of temperature will not increase the efficiency of the solution and will compromise the availability of the equipment; 4) There will be no control of the caustic concentration without temperature control. Formation of some complex compounds (for example calcium aluminate hydrate - $C_4ACO_2H_{11}$) significantly decreased the efficiency of the solution in caustic cleaning solutions at a temperature below 75 °C.

Keywords: Bayer process caustic cleaning; control of temperature and caustic concentration; temperature of caustic cleaning solutions.

1. Introduction

Most alumina refineries **cl**arifies bauxite digested pulp using a combination of sedimentation and filtration. More than 99 % of the sludge solids are removed in the decanter, while the remaining solids in the overflow of the decanter are removed by filtration under pressure. This study shows laboratory tests that indicate the importance of temperature control in caustic cleaning process, some caustic cleaning routines that increased cleaning time compromising system availability and industrial tests that have significantly reduced cleaning time with rigorous control the solution temperature above 75 °C.

2. Materials and methods

2.1. Decanting and mud wash

Most alumina refineries clarifies bauxite digested pulp using a combination of sedimentation and filtration. More than 99 % of the sludge solids are removed in the decanter, while the remaining solids in the overflow of the decanter are removed by filtration under pressure.

2.2. The composition of bauxite as an important factor in the speed of crusting

The process of problems associated with scale formation would be insignificant if the gibbsite and boehmite were attacked by pure caustic soda and then the precipitated alumina trihydrate was. However, the real situation is quite different from the ideal. Quantities silica variables and organic matter, depending on the quality of bauxite and liquor composition, will dissolve and precipitate. When processing a high reactive silica bauxite (> 1.5 %), it is readily dissolved and reprecipitated in the form of Bayer sodalite. On the other hand, when an ore processing with a low reactive silica content, this dissolves, but is not easily

precipitate in the liquor. In addition, a liquor concentration of soda and the alumina/causitc can retain high levels higher SiO_2 in solution than a soda liquor concentration and ratio alumina/caustic lower. Similarly, bauxites with higher content of organic ash will result in higher concentrations of carbon and sodium oxalate in the liquor. High concentrations of both silica as oxalate, will help to increase crusting speed tanks and pipes.

2.3. The temperature as an important factor in the speed of crusting

The temperature exerts strong influence on the precipitation of silica, hydrate and oxalate. The solubility of silica decreases as the temperature increases. On the other hand, the solubility of the oxalate hydrate and increase with increasing temperature for a given liquor. As the main component of the sodalite crusts, especially in the case of heat transfer surfaces, factors that determine their formation must be studied in more detail. The relative speed of dessilication Bayer different solutions can be calculated from the equations that describe the kinetics of the reactions.

2.4. Crust formation in Bayer Plant

In the Bayer process extracting alumina is 50 % of the dry bauxite. The rest consists of impurities such as oxides of iron, silicon, calcium, titanium and organic matter. Some of these impurities are dissolved and can precipitate in the form of complex compounds in different parts of the Bayer process. These compounds and some salts contained in industrial water form different types of crusts in the equipment causing problems in pipes, heat exchangers and tanks.

2.5. Caustic cleaning routines

Decanters and mud thickener -The solution is prepared with virgin soda and water and pumped into the heated interior of the filter. Heat exchangers guarantee the maintenance of the temperature in the specification. The quality of the cleaning solution is assessed by ratio alumina/soda.

2.6. The influence of temperature and caustic concentration in the cleaning process

Figure 1 (laboratory tests) shows the Pareto chart that ranks the effects on the ratio alumina/caustic in order of significance. The conditions which bars exceed the red line have significant effects. The big influence was the association between the variables caustic concentration and temperature. The isolated variables as well as other associations between variables, did not exercise significant influence.

Figure 2 (laboratory tests) shows the response surface plot for dissolution rate with the cleaning solution prepared with virgin soda and spent liquor, where the maximum response region occurred in the conditions under which the solution parameters were maximum value: 487 g/L, 90 °C and 6 hours. The dissolution rate in the intermediate condition was 90.8 %, also higher than the other studied conditions. This confirms the strong interaction between temperature and caustic concentration. In caustic cleaning solutions at a temperature below 75 °C occurs the formation of some complex compounds (for example calcium aluminate hydrate - $C_4ACO_2H_{11}$) significantly decreased the efficiency of the solution.

2.7. Examples of increase in caustic cleaning time to compensate for the lower temperature of the solution

2.7.1. Routine cleaning filter crust

The cleaning time is seventeen hours. It is not necessary to control the temperature within specification and may decay to below 75 °C. The filter crust is to protect the mechanisms of the

pumps that are positioned in the discharge of thickeners tanks mud. Over time, the interior will embedding reducing the pump suction flow and affecting the transfer of the pulp slurry to the remaining stages of the wash circuit. The cleaning solution is prepared with virgin soda and water with caustic concentration of 400 ± 50 g/L, temperature 80 ± 5 °C, flowrate of 240 m³/h and ratio alumina/caustic < 0,200.

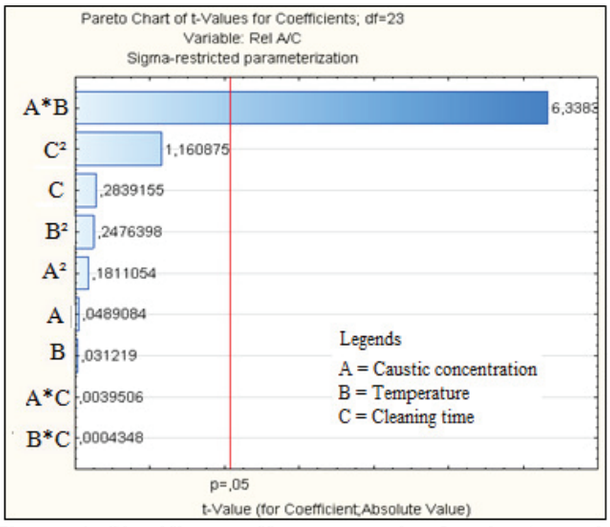

Figure 1. Significant effects on ratio alumina/caustic.

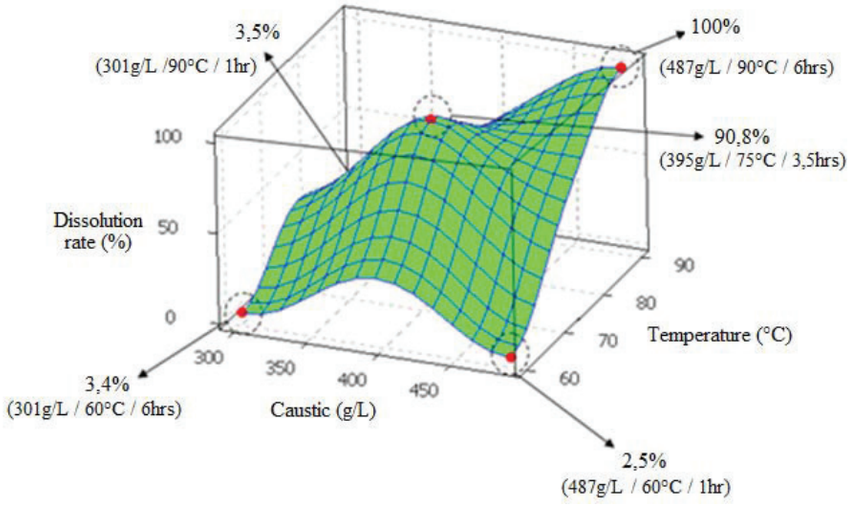

Figure 2. Response surface plot showing the effect of interaction between variables on the dissolution rate of the crust hydrate, with cleaning solution prepared with virgin soda and spent liquor.

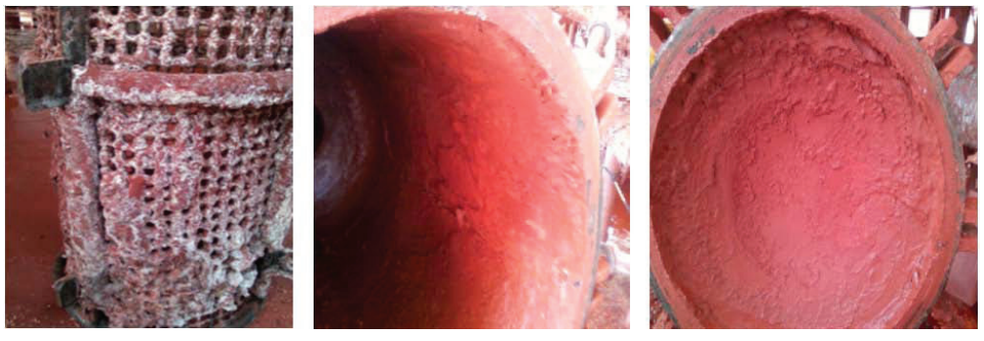

Figure 3. Crusting filter condition before the caustic cleaning.

2.7.2. Third mud washing stage and overflow tank

The total cleaning time is 35 days: 21 days caustic cleaning, 7 days for scaffolding, 7 days for mechanical cleaning. Not required temperature control. After washing internal inspection is performed. If there are still large quantities of this crust, mechanical removal becomes necessary through hammer. The availability of tanks is of fundamental importance to the routines of a panta Bayer. Tank dimensions: height 19.6 meters, diameter of 19.5 meters and useful volume 4 437 m^3. The overflow tank has a height of 11.30 meters, diameter of 12.50 meters and useful volume 1 386 m^3. Over time occurs crusting of the side walls, bottom and scrapes, requiring periodic cleaning.

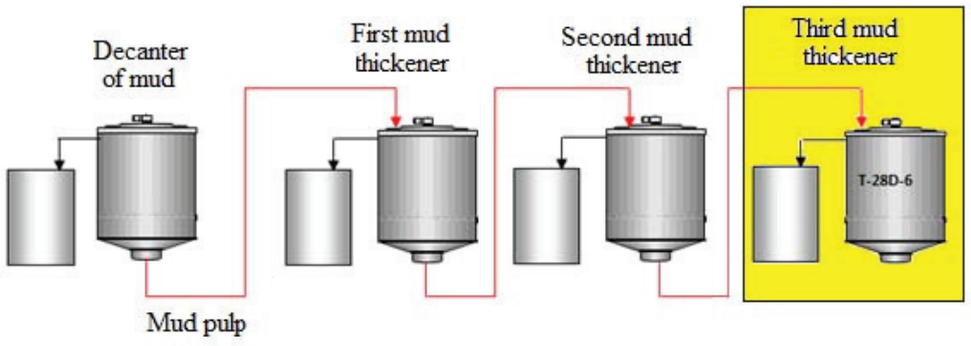

Figure 4. Representation of decantation and mud washing circuit, especially the tanks of the third washing stage.

Figure 5. Incrustation: the bottom and side wall of the third mud washing stage.

2.7.3. First mud washing stage and overflow tank

The total cleaning time is 35 days: 21 days caustic cleaning, 7 days for scaffolding, 7 days for mechanical cleaning. Not required temperature control. After washing internal inspection is performed. If there are still large quantities of this crust, mechanical removal becomes necessary through hammer. The first stage of mud washing circuit is a tank for operation transition temperature below 80 °C and ratio alumina/caustic ranging from 0.400 to 0.600. Such conditions provide intense training crust. The Bayer liquor overflowing tank that is considered a reject process by its high instability and, consequently, the crust is generated therein which provides increased difficulty of dissolving the entire refinery. Due to this condition, the caustic cleaning process requires a longer time. Tank dimensions: height 19.6 meters, diameter of 19.5 meters and useful volume 4 437 m^3. The overflow tank has a height of 11.30 meters, diameter of 12.50 meters and useful volume 1 386 m^3. Over time occurs crusting of the side walls, bottom and scrapes, requiring periodic cleaning.

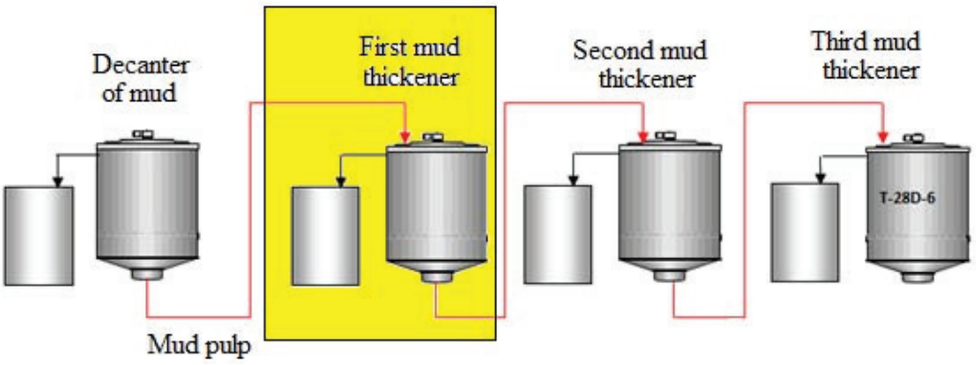

Figure 6. Representation of decantation and mud washing circuit, especially the tanks of the first washing stage.

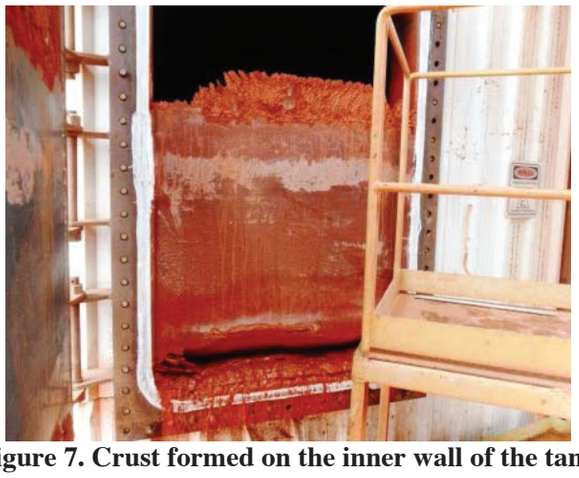

Figure 7. Crust formed on the inner wall of the tank

2.7.4. Decanter of mud washing stage and overflow tank

The total cleaning time is 35 days: 21 days caustic cleaning, 7 days for scaffolding, 7 days for mechanical cleaning. Not required temperature control. After washing internal inspection is performed. If there are still large quantities of this crust, mechanical removal becomes necessary through hammer. The bauxite residue is thickened in decantation stages, and the decanted slurry is pumped to the sludge thickening stage. The purpose of these washing operations is to remove the liquor bauxite residue to minimize the costs related to the loss of soda. Installed decanters are designed to provide high levels of sludge thickening, with concentration ranging from 600 to 700 g/L. The net volume of the decanter is 2 100 m^3 and transferred from tank has useful volume 1 452 m^3.

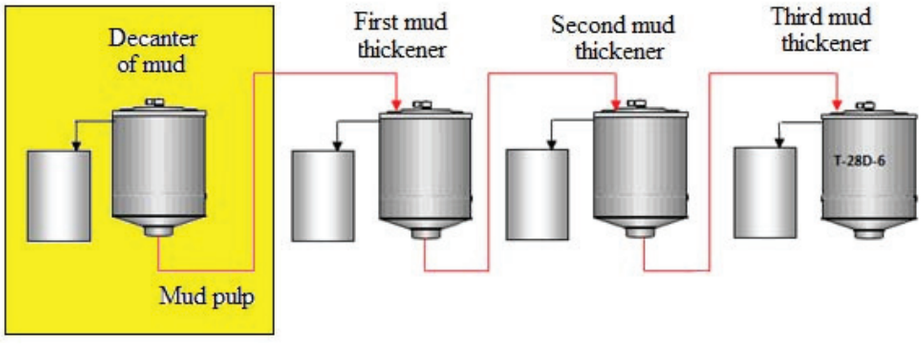

Figure 8. Representation of decantation and mud washing circuit, especially the tanks of the decanter of mud.

Figure 9. Crust formed on the inside wall of the tank.

2.8. Cleaning filter metal mesh VPFs combining caustic cleaning and jetting with water

The caustic cleaning routine could not perform the cleaning of the wire mesh due to the impossibility of controlling the temperature of the solution in the specification. Another factor that is difficult to dissolve the greater presence of silica (24.23 %) in the crust as indicated in Table 1. With the possibility of reducing the production and the high cost of replacing a set of wire mesh, a cleaning test was conducted for 18 hours circulating caustic solution accurately controlling the temperature in the specification 80 ± 5 °C with screens positioned in a pressurized filter. After washing, the crust still present in the interstices are removed by water jetting.

Table 1 -Analysis of this mud crust in the sample of the mettalic screen.

Al_2O_3 (%)	Fe_2O_3 (%)	SiO_2 (%)	TiO_2 (%)	CaO (%)	Na_2O (%)	Na_2O (%)
39,83	2,90	24,23	3,63	3,78	15,74	2,37

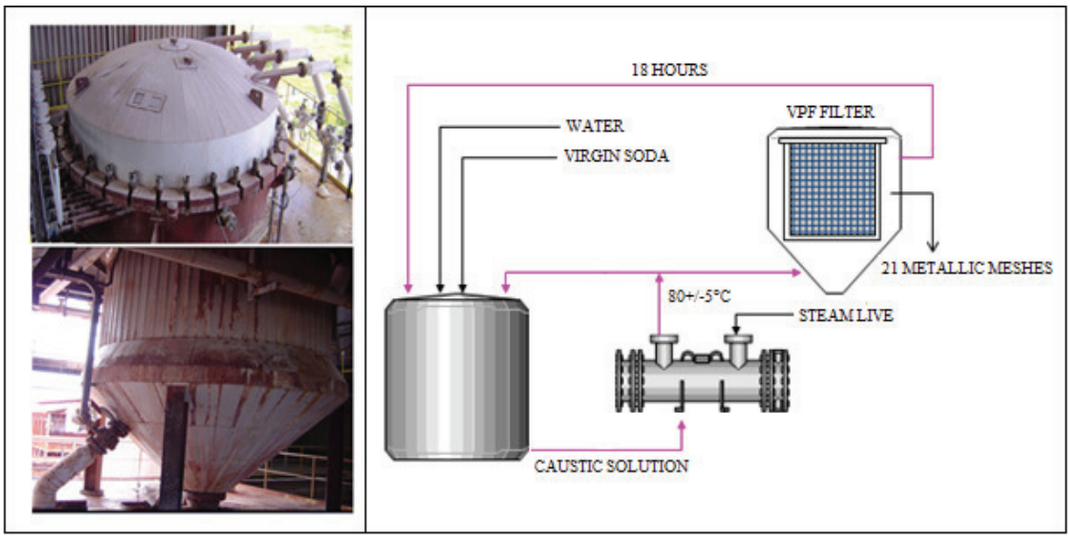

Figure 10. VPF filter and representation of caustic cleaning test of mettalic screen.

3. Results and discussion

3.1. Caustic cleaning of the filter crust controlling the temperature at 90 °C

The cleaning time was reduced by 81.0 %. The time of 3 hours and twenty minutes for caustic cleaning was sufficient to completely clean the interior and crust of the filter screen. In addition to the 483 g/L of caustic solution concentration, strict temperature control at 90 °C was the determining factor for there to be complete dissolution of this crust on the equipment. If the solution temperature is below 75 °C, soda loss occurs due to formation of compounds formed from the combination of soda with other elements present in the Bayer liquor as the compound $C_4ACO_2H_{11}$.

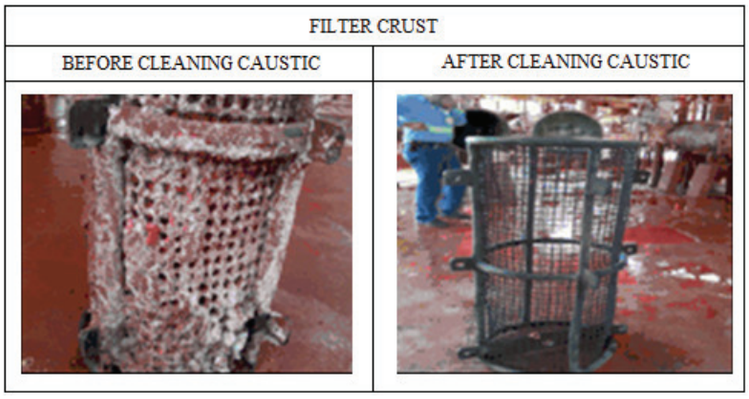

Figure 11. Metallic screen before andafter the caustic cleaning.

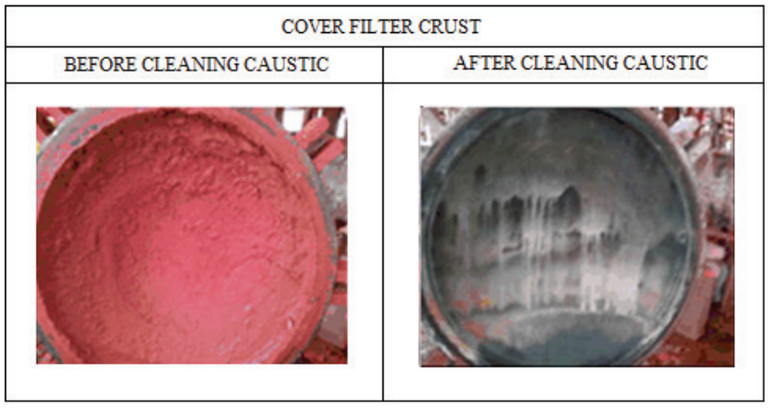

Figure 12. Cover filter crust before and after cleaning caustic.

3.2. Caustic cleaning of the third stage mud washing and overflow tank controlling the temperature at 85.°C

The cleaning time was reduced by 51.0 %. The caustic cleaning fifteen days was enough to clean almost completely thickener tank and transferred from tank, two days for the mechanical cleaning of the material from the bottom of the tanks. The total time for tank cleaning was seventeen days. In addition to the 480 g/L of caustic solution concentration, the strict control of the temperature at 85 °C was the determining factor in that there was dissolution of a lot of this crust inside the tanks. There was no need for scaffolding in two tanks to remove the residual crust as hammer. The material that was deposited at the bottom was removed by blasting. If the solution temperature is below 75 °C, soda loss occurs due to formation of compounds formed from the combination of soda with other elements present in the Bayer liquor as the compound $C_4ACO_2H_{11}$.

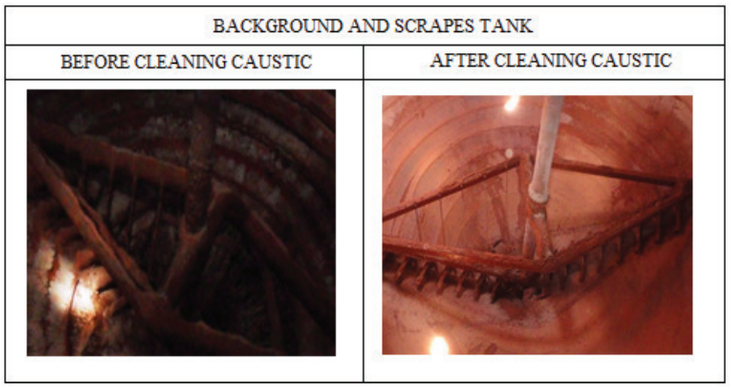

Figure 13. Background and scrapes the tank before and after caustic cleaning.

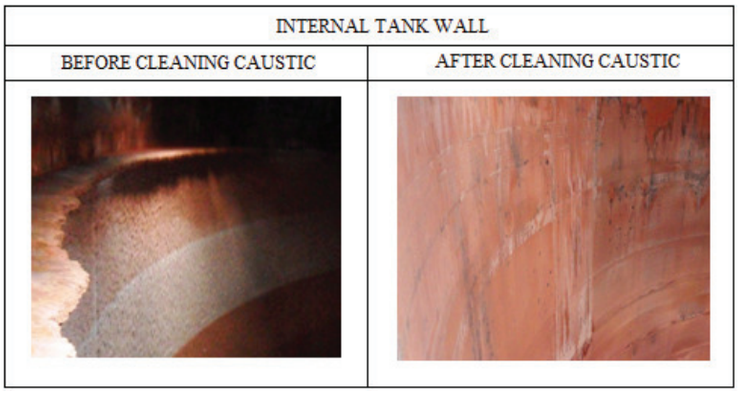

Figure 14. Internal tank wall before and after caustic cleaning.

3.4. Caustic cleaning of the first stage mud washing and overflow tank controlling the temperature at 85 °C

The cleaning time was reduced by 51.4 %. The caustic cleaning seventeen days was enough to clean almost completely thickener tank and transferred from tank, two days for the mechanical cleaning of the material from the bottom of the tanks. The total time for tank cleaning was seventeen days. In addition to the 475 g/L of caustic solution concentration, the strict control of the temperature at 85 °C was the determining factor in that there was dissolution of a lot of this crust inside the tanks. There was no need for scaffolding in two tanks to remove the residual crust as hammer. The material that was deposited at the bottom was removed by blasting. If the solution temperature is below 75 °C, soda loss occurs due to formation of compounds formed from the combination of soda with other elements present in the Bayer liquor as the compound $C_4ACO_2H_{11}$.

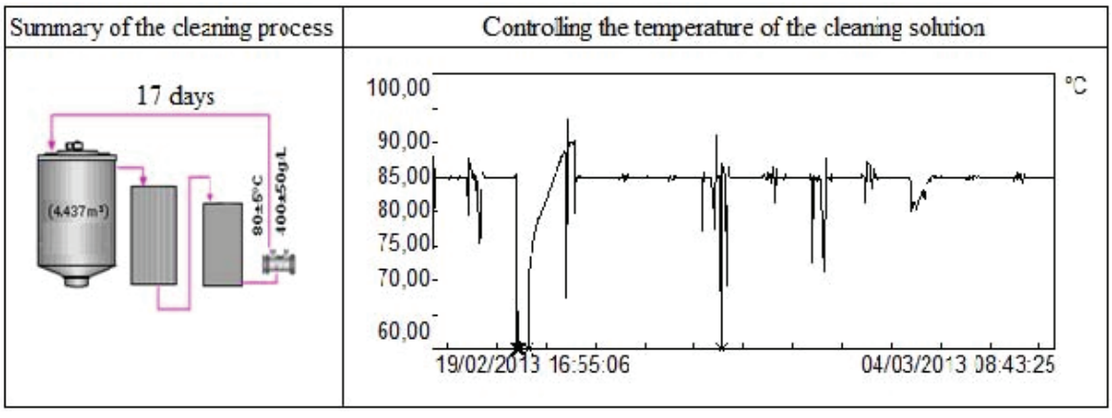

Figure 15. Summary of caustic cleaning process and solution temperature control.

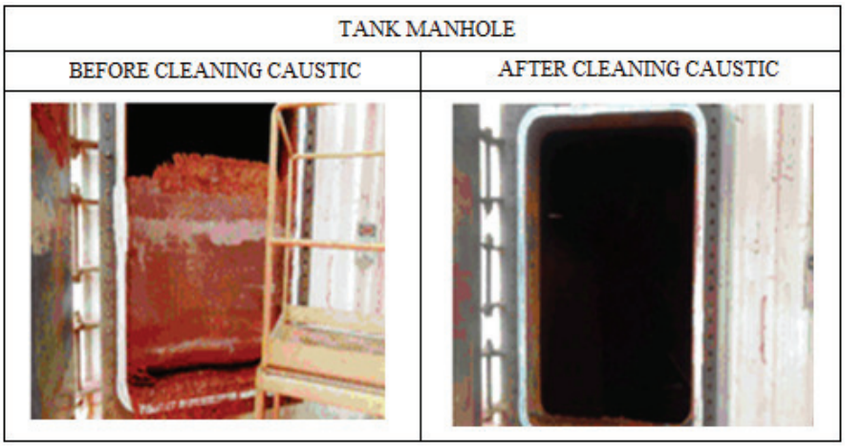

Figure 16. Tank manhole before and after cleaning caustic.

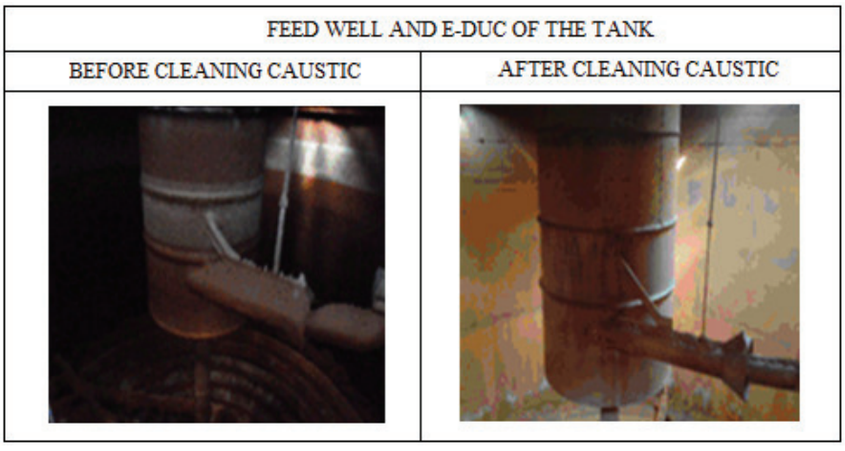

Figure 17. Feed well and e-duc of the tank before and after cleaning caustic.

3.5. Caustic cleaning of the decanter mud and overflow tank controlling the temperature at 85 °C

The cleaning time was reduced by 51.0 %. The caustic cleaning seventeen days was enough to clean almost completely thickener tank and transferred from tank, two days for the mechanical cleaning of the material from the bottom of the tanks. The total time for tank cleaning was seventeen days. In addition to the 465 g/L of caustic solution concentration, the strict control of the temperature at 85 °C was the determining factor in that there was dissolution of a lot of this crust inside the tanks. There was no need for scaffolding in two tanks to remove the residual crust as hammer. The material that was deposited at the bottom was removed by blasting. If the solution temperature is below 75 °C, soda loss occurs due to formation of compounds formed from the combination of soda with other elements present in the Bayer liquor as the compound $C_4ACO_2H_{11}$.

3.6. Caustic cleaning metal screen controlling the temperature combined with water jetting

After eighteen hours of washing with strict temperature control at 80 ± 5 °C had the presence of crust in the interstices of wire mesh, indicative of the difficulty that the cleaning solution found to dissolve the crust. Even with the removal force provided by the flow rate of 300 m^3/h solution was not sufficient to loosen the aggregate material and increase the free area of the screen interstices, requiring the use of jetting. The effectiveness of water jetting was only possible due to the lower resistance of the crust after the caustic wash temperature control.

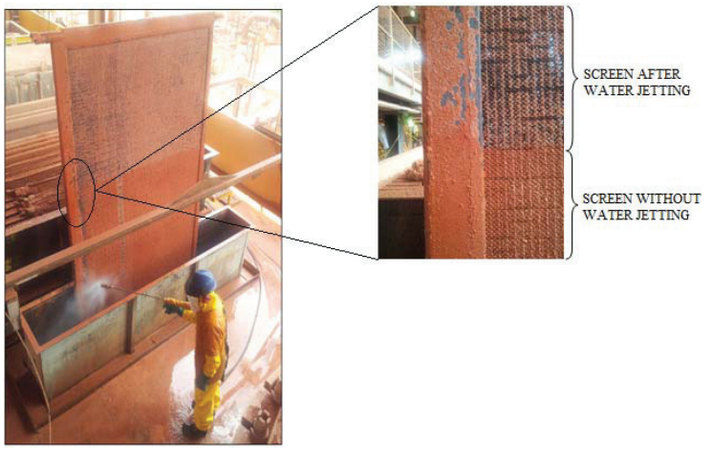

Figure 18. The metal screen conditions after caustic wash 18 hours after blasting with water to remove the present in the interstices crust.

4. Conclusion

The quality of the caustic cleaning solutions in Bayer refinery is monitored by the ratio alumina/caustic. Temperature decrease occurring below 75 °C soda loss occurs due to the formation of complex compounds and a false indication of efficiency. The study showed that it is a mistake to increase the cleaning time to compensate for the decontrol of temperature. This action contributes to deconcentrate the solution and compromises the system availability. The industrial-scale tests have shown that strictly controlling the caustic concentration and temperature of the cleaning solution was greater than 50 % in the availability of equipment. These results point to the need for investments in heat exchangers to ensure the heating of the solutions in the specification 80 ± 5 °C.

5. References

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