Thermal areas synergy in an alumina refinery

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Abstract

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The three thermal areas, Digestion, Heat Interchange Department (HID), and Evaporation, are joined via the main plant stream of Spent liquor and influence each other strongly. They are responsible for the plant water balance and their synergy has a very significant influence on the overall energy consumption in the plant. Process parameters of highest priority are: Digestion temperature, Digestion slurry fed to the thickeners flashed to atmospheric pressure, Pregnant liquor feed temperature to Precipitation. Achieving these requirements in the most economical way and with existing equipment was the subject of optimization. In an existing refinery the heat transfer capacity for energy recuperation is a given. At CBA there is no space for an upgrade of the existing facilities. With the current set-up, the above main target of achieving optimum process parameters is sometimes in conflict with the goal of minimizing energy consumption. The concept of the proposed optimized solution consists of converting the existing Evaporation and one HID into a more efficient "Superevaporation" and installing a new HID with plate heat exchangers. The Test Tank temperature will be controlled by means of a Trim Flash vessel.

Keywords: Thermal Areas, Synergy, Energy consumption, Process optimization

1. Votorantim Metais-CBA refinery history

Votorantim Metais-CBA (VM-CBA) refinery started operation in 1955, and its primary aluminium production was about 125 kt per year. At that time, VM-CBA refinery had only two mills, one Digestion unit with four autoclaves, three decanters, 20 security filters, one HID, 30 precipitators of 470 m^3, six drums filters for seeds and product filtration, 1 compact evaporation unit, and 2 rotary calciners.

In the 1970s, VM-CBA started an expansion, substituting almost all equipment to achieve overall production of 300 kt per year of primary aluminium. Following this expansion, equipment that remained from the old plant were the drum filters, boilers, and precipitators.

In the seventies, new equipment included: 2 mills with higher capacity, a new digestion with flash tanks and shell and tube heaters, 2 new HIDs were installed. Other equipment included an evaporation unit with flash tanks and shell and tube heaters, 1 rotary calciner, 7 decanters and 4 drum filters for the bauxite residue, and 38 precipitators of 1000 m3.

In the eighties further upgrades included the second digestion unit, a new security filtration area, the fourth boiler, a fourth rotary calciner and the first CFB calciner together with hydrate pan filters.

In the nineties, a third digestion unit was created and the sixth calciner (also using CFB technology) were installed.

The second expansion, from the year 2000 forward, had the objective to increase production to 470 kt per year. At this time, the CBA refinery added to its process a fourth mill, paste heater batteries and desilication tanks, the fifth boiler, trim flash / heaters to the second and third digestion units, 7 precipitations tanks (five of 3300 m3 and two of 4400 m3), and a cyclone classification system to separate hydrate seed from the product.

In 2005, targeting a production of 520 kt per year of primary aluminium, the refinery added to its installation coarse seed filters and the sixth boiler.

2. Specific situation at Votorantim Metais-CBA

2.1. Digestion units

VM-CBA refinery has three Digestion units operating most of time together. Two of them have lower capacity than the newer one. Each unit has three autoclaves that receive bauxite slurry and heated strong caustic liquor. In the autoclaves the ore's alumina trihydrate ($Al_2O_3.3H_2O$) is dissolved under high pressure and temperature. Then, the autoclaves product flows to flash tanks in which the temperature is reduced to avoid boiling in the atmospheric decanters. The flashed steam is sent to recuperative heaters, where the strong liquor from the test tanks is heated. Afterwards, the strong liquor flows to live steam heaters and soon after to the autoclaves. The live steam flow in the live steam heaters is controlled according to autoclaves set point temperature (close to 144 °C).

The challenges in this Digestion process include controlling the reaction temperature and the liquor blow-off temperature that feeds the atmospheric thickener. To attend to production demands, the plant flow has increased, pushing the Digestion units to their limits. Furthermore, there are no spare heaters in the Digestion units. Additionally, the test tanks that feed the heaters have no homogenization system, presenting great variability in the caustic concentration and temperature of the liquor. Due to these limitations, Digestion units operate with a higher than usual steam consumption.

Furthermore, Digestion areas have no space for new upgrades and the footprint is not well organized. It also has a large number of pumps, increasing the quantity of gasket water to the process, which impacts the amount of water to be evaporated in the refinery.

2.2. HIDs and EVAP

There are two HIDs and only one evaporation unit, all of them without spares for maintenance. They are sharing the same refinery area with a restricted footprint, as can be seen in the picture below.

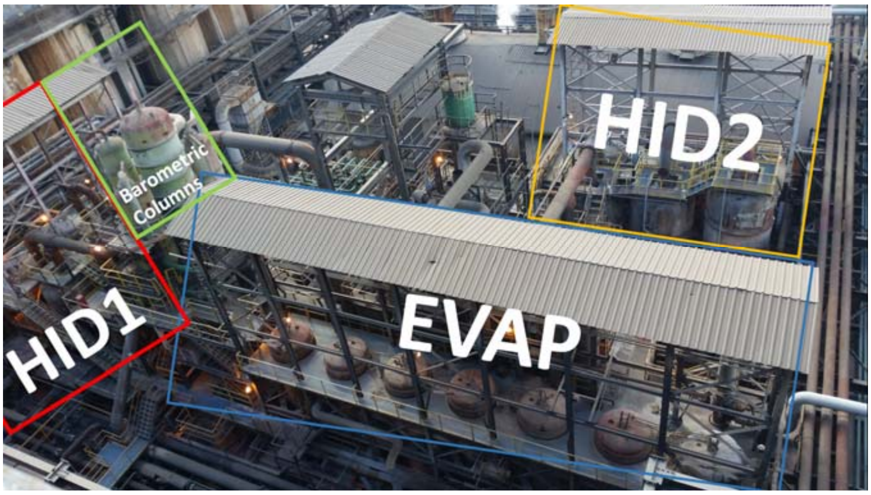

Figure 1. EVAP and HIDs footprint.

Each HID unit has three flash tanks operating with shell and tube heaters and one flash tank operating with a barometric column. EVAP has one live steam heater to control spent liquor temperature in to the inlet of flash tanks, flash tanks operating with shell and tube heaters

5. Expected benefits

5.1. Benefits for process

The new pregnant liquor cooling with plate heaters will provide a better temperature control and stability to the precipitation.

a) Additional evaporation capacity is targeted in the SuperEVAP. This will make the plant volume control easier, particularly during wet season period.
b) With HID trim flash an additional evaporation capacity will be introduced in the correct location of the process: before Digestion, and not downstream of Digestion as is the case now when test tank temperature is too high.
c) Homogeneous chemical conditions of the feed liquor to the three Digestion units will result in better bauxite charge control and hence in better utilization of the resources (bauxite, live steam, energy, caustic).

5.2. Benefits for energy consumption

Improved synergy between HID and Digestion will reduce the overall energy consumption.

a) Reduced specific steam consumption of the SuperEVAP at higher evaporation capacity.
b) Reduced specific cooling water requirement in the SuperEVAP due to improved recuperation due to higher number of recuperative flash stages.

5.3. Benefits for plant maintenance

By replacing one HID pregnant liquor flash cooling by cooling with plate heat exchanger, it is expected that the maintenance of the plate heat exchangers will be easier. By installing additional pregnant liquor standby cooling capacity it will be possible to clean the units more frequently with less interruption to production.

6. Conclusion

The CBA refinery has restricted space for new upgrades and a disorganized layout, which presents a challenge to change the plant to improve energy performance using the existent facilities with minimum changes. The objective of this study is to find synergy between the thermal areas of Digestion, HID and EVAP, seeking to achieve optimum process parameters and stability.

The proposed modifications will bring better operational flexibility and volume control. The new plate heaters will provide better temperature control and stability to the precipitation area. It is expected that a reduction of 4 g/L on the caustic liquor concentration will provide an increase of 0.7 g/L in precipitation productivity.

7. References

1. Lawrie Henrickson, “The need for Energy Efficiency in Bayer Refining”. Essential Readings in Light Metals, 2013, Vol 1, pp 691-696.