Energy Consumption Optimization in Alumina Production

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Abstract

The alumina production process consumes not only raw materials, but also different forms of energy such as electrical, natural gas and steam. Energy is a key component of production cost, and the alumina industry works toward energy consumption reduction to maintain or improve their place in the world market. Energy is primarily used in the Bayer process as steam in the digestion and evaporation areas. The ETI alumina refinery in Seydişehir has been examining ways to reduce energy consumption and improve the overall energy efficiency of the refinery. This has included evaluating process design parameters, equipment efficiency, and waste heat recovery. In this paper, an understanding the `overall refinery energy usage is first established, then the operating efficiency in terms of energy consumption is evaluated by examining the major energy consuming areas of digestion and evaporation. The study has shown that the energy efficiency of the ETI alumina plant can be improved in the digestion area by lowering the molar ratio and in the evaporation area by by-passing spent liquor around the evaporation circuit.

Keywords: Bayer Process; Energy Optimization; Evaporation; Digestion; Steam

1. Introduction

The Eti Alumina plant is located in the south of Turkey, and has been processing bauxite mined from the Seydişehir deposit in the Konya Province since 1973. To maintain its profitability, all consumptions by the refining process must be critically checked, calculated and controlled.

The Bayer process for alumina production is a highly energy intensive in practice. The cost borne by refiners in meeting this energy requirement represents a significant percentage of the unit cost of producing a tonne of alumina. Energy use in the alumina refining process is usually in the form of fossil fuels such as diesel, gasoline, natural gas and coal, or as electricity. The theoretical energy consumption for alumina production is thermodynamically calculated for all the reactions in the process to determine the lowest possible energy consumption for alumina production. Thermodynamically, the variation in the theoretical energy consumption for producing alumina from diaspore, boehmite and gibbsite primarily relies on the key reactions and their conditions; temperatures and concentrations etc. Figure 1 illustrates that the heat of dissolution for all sorts of alumina minerals in caustic liquor is small compared to the total energy consumption in alumina production. This gap widens for monohydrate bauxites, when the dissolution temperature steps up, often to more than 250 °C

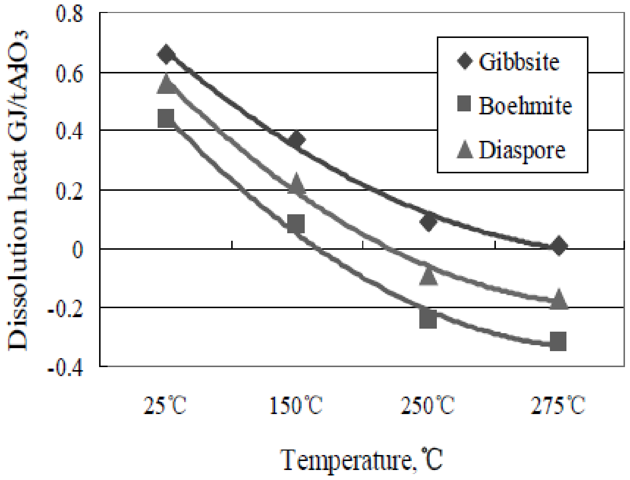

Figure 1. Dissolution heat for different alumina minerals in caustic solution

The literature suggests that theoretical energy consumption in chemical reactions is less than 1 GJ in the Bayer process. Energy used for hydrate calcination to alumina is about 1.4 GJ per ton of alumina and 70% of total theoretical consumption in chemical reactions. Heat transfer processes incur losses which increase the lowest achievable energy consumption beyond this theoretical value. However, real energy consumption in the Eti Alumina refinery is much higher and about 6-7 times this theoretical energy consumption estimated above. Detailed analysis of the energy consumption by all the stages of Bayer cycle and calcination discloses that most of this extra energy is used in efficiency losses in processes and equipment.

The real energy consumption for alumina production involves not only the heat of reaction in digestion, precipitation and hydrate calcination, but also the energy used in range of the physical processes in all the stages of the Bayer process, e.g. preheating for temperature elevation of slurry, evaporation for raising liquor concentration and heat loss from pipes & vessels. It is obviously valuable to reduce the energy consumption for operational cost cutting in alumina production, particularly for the high energy consumption processes and where energy costs are high.

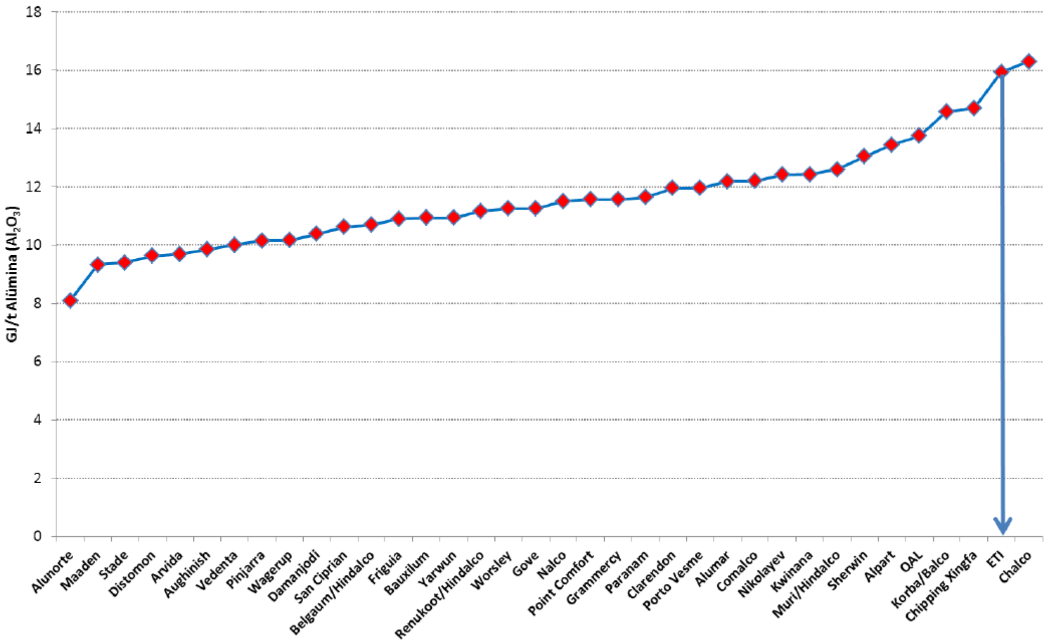

Figure 2. Energy consumption of some refineries over worldwide

concentration of 250 g/l Na_2O. Operating the evaporators to produce a lower caustic concentration as required in digestion, will result in the evaporation economy suffering, increasing specific steam consumption (per ton of water evaporated). To maintain the higher evaporation economy, and produce a lower caustic concentrated liquor, a line will be installed to bypass up to 22 percent of the spent liquor around the evaporators, to then be mixed with the 250 g/l Na_2O liquor exiting evaporation.

3. *Reduce Evaporation rate toward 3 T per ton Alumina production*

   It has been concluded that the wash water rate used at the Eti refinery is excessive. The red mud wash water consumption will be reduced from 5.5 ton/ton mud to 3 ton/ton mud, with just loss of 0.001 to 0.005 tonne caustic / tonne alumina.

3. Conclusions

Energy consumption in both digestion and evaporation will change when the molar ratio is adjusted and the evaporation economy is improved. The bauxite characterization study confirms that a lower molar ratio in the digestion autoclaves is feasible. This permits reducing liquor flow rate to digestion without reducing alumina production. The lower flow rate to digestion results in significant reduction in high pressure steam to Digestion, and an increase in low pressure steam to Evaporation.

This study highlighted the interrelationship of red mud washing and evaporation, and opportunity for process optimization with respect to energy conversation.

4. References

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