Energy efficiency in alumina refineries - Combining hydrate filtration with alumina calciner

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Abstract

Energy efficiency in modern alumina refineries is one of the key parameters for the economic success of the plant. Roughly one third of the overall energy consumption of the alumina refineries is coming from the calcinations area. Recently the introduction of the CircoCalTM has further proven to increase the energy efficiency of Circulating Fluidized Bed (CFB) calcination plants. Nevertheless there are further options to improve the energy efficiency via combining the calciner with the hydrate filtration section. Outotec has constructed many of its calcination plants with integrated hydrate filtration. The advantages for operation and combined improvement of energy efficiency are shared below. Besides the operational advantages also the effect for new installations will be explained.

Keywords: Energy Efficiency, alumina calciner, alumina refineries, hydrate filtration, plant combination.

1. General

The specific energy consumption from the refining of alumina with the Bayer process from Bauxite currently spreads from 21 GJ/tonne to 7 GJ/tonne using a wide array of digestion and calcination techniques, which are the two main energy consumers in the Bayer process. Both can constitute up to almost eighty percent of refinery thermal energy consumption. [6]

Since the development of circulating fluidized bed technology for the calcinations of alumina in the 60s the reduction of energy consumption continued. The reduction in energy consumption was achieved by recovering the heat from the claimed product and the waste gas flow more efficiently. This evolution progressively decreased the energy consumption (see figure1) [1]. The latest achieved specific energy consumption reached was already below 2700 kJ/kg Alumina [2, 3]. It should be mentioned that this was a revamp to a plant which was at that time already in operation of some 40 years.

Further operational benefits and costs savings can be achieved through automation improvements [4] and inclusion of equipment for energy reduction such as hydrate bypass and/or hydrate dryer [5].

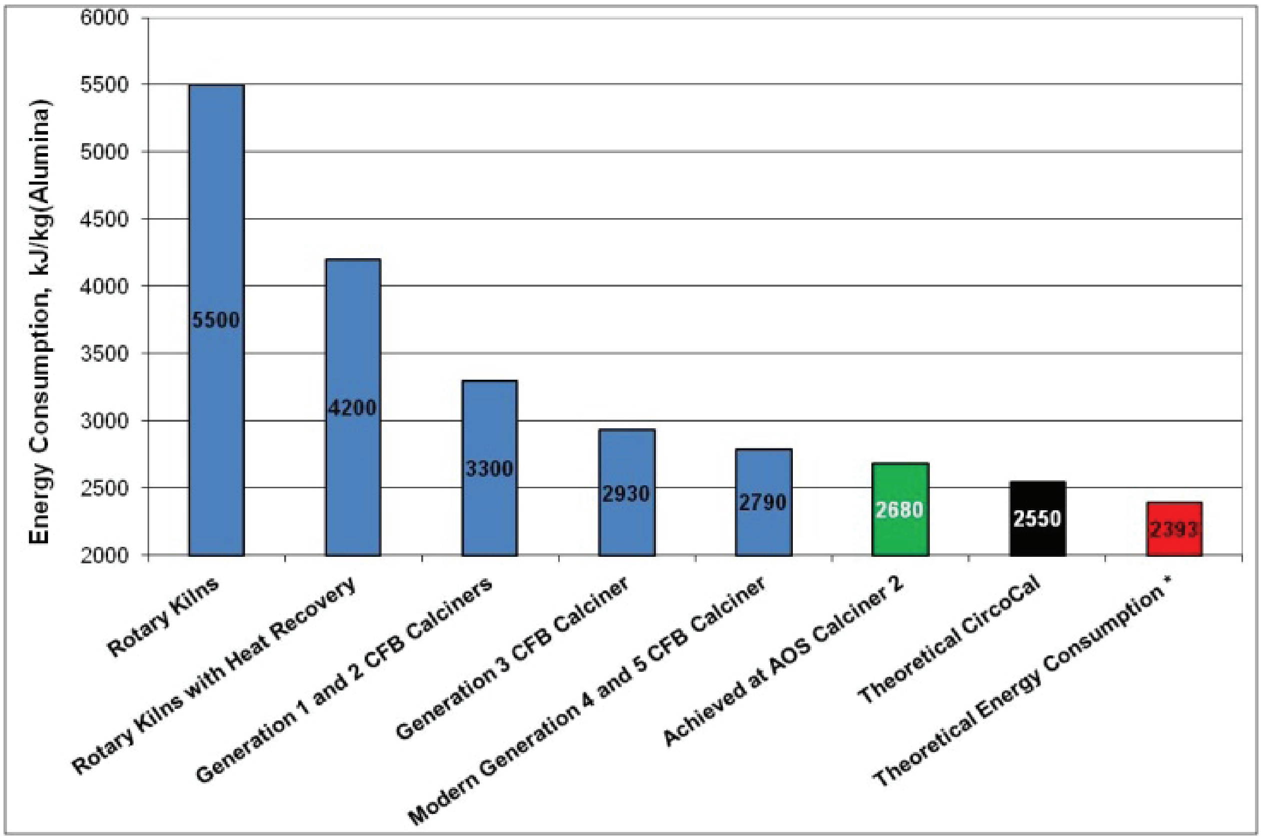

Figure 1. Energy efficiency at different installations [1].

* Note: The Theoretical Energy Consumption is based on a hydrate moisture of 6 %.

2. Combining hydrate filtration with alumina calciner

The thermal efficiency of the CFB calciner taking heat losses into account is more than 95 %. Even considering insulating the stationary calciner, the potential for energy saving by reducing heat losses is minimum. However the main sources contributing to less efficiency are:

1 – Heat loss with the waste gas .77 GJ/t Al_2O_3
2 - Heat loss with cooling .35 GJ/t Al_2O_3

The recovery of the waste gas loss is very complicated and capital intensive. To minimize the gap to the theoretical specific energy consumption in the calcination area further heat exchanging stages might be necessary [5].

The potential of the cooling water of approx .35 GJ/t Al_2O_3 and can be recovered by moderate efforts e.g. the preheating of filter wash water, incorporation of hydrate dryer, production of low pressure steam for example for steam hoods etc. A hydrate dryer was recently incorporated in one CFB alumina calciner, helping to reduce the specific fuel consumption to less than 2.7 GJ/t alumina

The above mentioned measures to utilize the potential to save energy with the cooling water, has the added benefit that they also reduce the moisture with the hydrate feed. This moisture reduction in itself also reduces the specific fuel energy consumption, up to approx 30 kJ/kg Al_2O_3 calcined. This implies that the total energy saved can be greater than just that of reducing energy wasted with the cooling water.

One of the steps discussed above, and the topic of this paper, is in combing the hydrate filtration with the alumina calcination.

The decrease in the specific energy consumption in figure 1 is based on hydrate moisture of 6%. If the moisture could be lowered than also further reduction in the specific energy consumption of the alumina calciner can be assumed. Currently the industry trend is to reduce moisture by the use of hydrate dewatering agents, however given the close link between hydrate filtration and calcination also other options with lower opex costs should be considered (such as pre-drying of the hydrate or hydrate wash water preheating utilizing the available heat from the calciner fluid bed cooler). As hydrate filtration and alumina calcination are located very close the distance for transportation of the heat is very small.

2.1. Influence on energy consumption

The alumina calcinations process is an example for a very good counter current heat exchange where the combustion are is preheated with the calcined alumina. Nevertheless there is still the need for cooling the alumina to its final outlet temperature. Since the temperature difference of the air entering the calciner and the alumina is marginal the installation of further cooling steps is economically not viable. Therefore the final cooling stage consists of a fluid bed cooler with water bundles.

Figure 2 shows a flowsheet for the combination of a hydrate filtration and an alumina calciner. In this flowsheet the wash water for the hydrate filtration is heated up in the fluid bed cooler of the alumina calciner. The heated wash water is fed into a flash pot where the hot wash water and steam are separated.

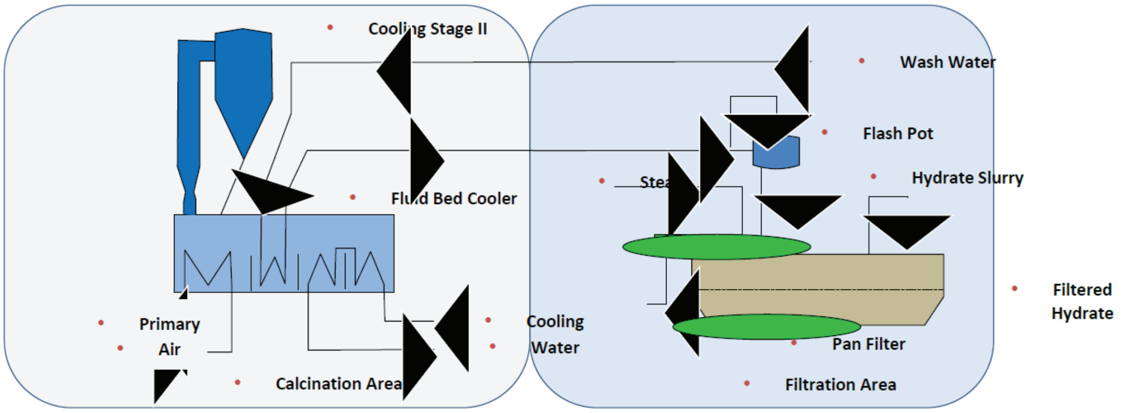

Figure 2. Flowsheet for the combination of hydrate filtration and alumina calcinations.

The calciners' specific heat consumption will benefit from an increased hydrate inlet temperature to the calciner as well as from a reduction in the moisture of the hydrate.

Figure 3 shows the reduction of hydrate moisture over the steam ratio applied to the hydrate filter.

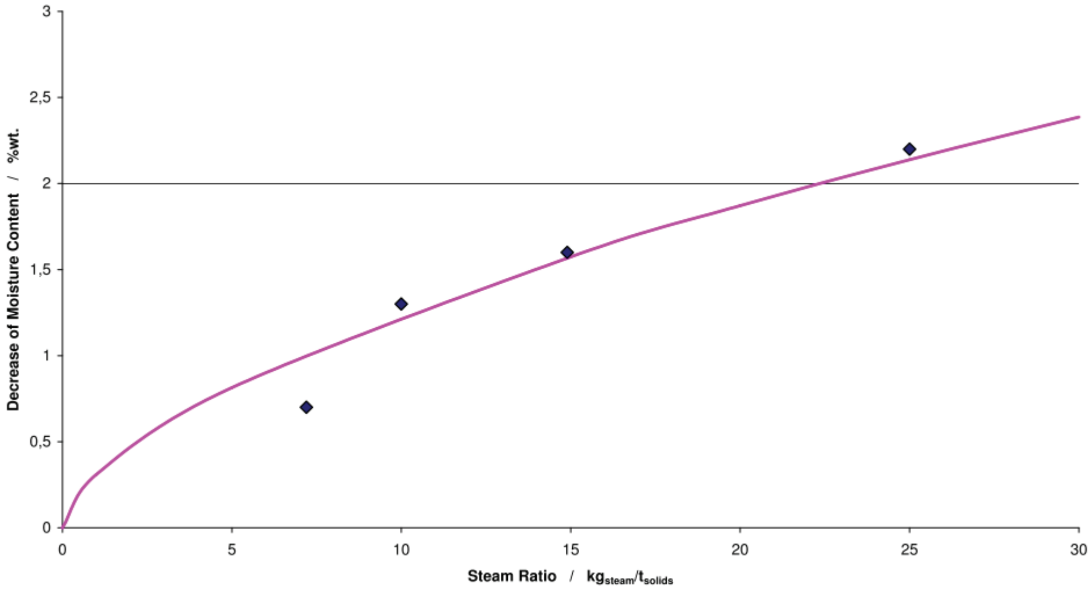

Figure 3. Decrease of moisture content in hydrate over steam ratio.

Reduction of the hydrate moisture by about 1 % will reduce the energy consumption of a calciner by about 30 kJ/kg.

2.2. Influence on installation and operation

Beside the positive effect on energy consumption there are also advantages in the capital expenditures. This advantages are caused by:

- Optimization in structural steel
- Short transport ways from hydrate filtration to alumina calcinations
- Reduced cooling water circuit capacity.

Figure 4 depicts an integrated hydrate filtration and calcination plant. On the left hand side the hydrate filtration plant and on the right hand side the calcinations plant can be seen. Both share part of the structural steel and thus allow for a reduction compared to stand alone plants.

From the picture the short transportation distances can be seen. This leads to further savings compared to a standalone version.

Looking at Figure 2 than Furthermore the cooling tower design for cooling of the cooling water of the alumina calciner can be reduced since the heat will be transferred and used in hydrate filtration. This allows to minimize the cooling towers for the alumina calciners.

The use of heat from the fluid bed cooler to preheat filter wash water is already implemented in several refineries using CFB calciners.

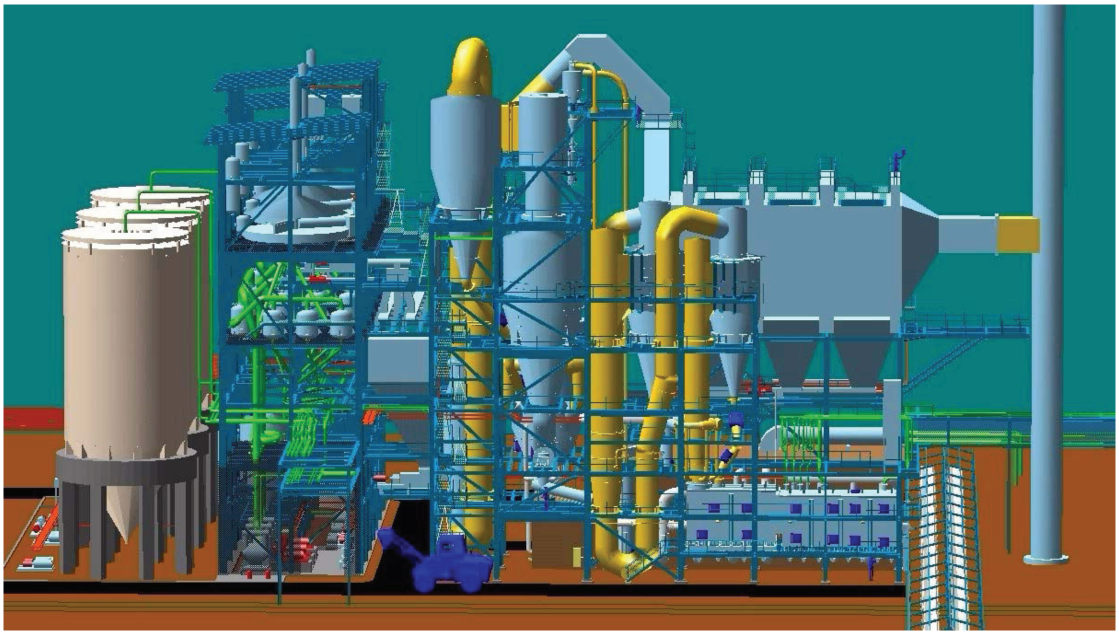

Figure 4. Integrated hydrate filtration and calcinations plant.

3. Conclusion

Decreasing of the overall energy consumption in alumina refineries is playing an important role. It will determine the financial viability of the refinery throughout the lifetime. The presented option to combine the hydrate filtration with the alumina calcination will help to reduce the energy consumption in refineries. In Greenfield projects it will even positively affect the installation costs.

4. References

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