AA12 - The Hydrate Dryer Story – From Lab to Industrial Implementation

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Abstract

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Metso Outotec's alumina calcination solution based on circulating fluidized bed (CFB) technology offers excellent performance in terms of product quality, plant flexibility and energy consumption. The two main heat losses in an alumina calcination plant is heat with the stack off-gas and heat with the cooling water circuit which is used to cool down the product alumina to safe handling temperatures. The total heat lost through the stack and with the cooling water can amount to more than 20 % of the overall energy consumption. To further reduce the heat loss and hence reduce the specific fuel energy consumption of the CFB calcination technology, Metso Outotec developed, designed and implemented the Hydrate Dryer, which can be integrated into calcination plants for additional efficient low temperature heat recovery. The Hydrate Dryer is designed as a stationary fluid bed, and is used for pre-drying a significant fraction of the total hydrate feed to the calciner by means of indirect heat transfer from the fluid bed cooler using a heating medium such as steam, pressurized water or thermal oil. In the paper, details regarding the development, design and functionality of the Hydrate Dryer, potential calciner flow sheet upgrade options as well as experiences from operating systems are presented. Furthermore, potential specific fuel and utility consumption savings will be discussed.

Keywords: Alumina calcination, circulating fluidized bed, hydrate dryer, specific energy consumption.

1. Introduction

The precipitated hydrate is extracted from the hydrate washing and filtration section of the Bayer process with a remaining free surface moisture of some 4-10 %. The motivation to externally remove this moisture by drying the hydrate is two-fold, depending on the subsequent use or processing of the hydrate:

Firstly, in the case of subsequent calcination to smelter/metallurgical grade alumina as the final step in the Bayer process: In the calcination plant, the surface moisture is usually driven off in the first preheating section. Here, pre-drying the hydrate before entering the calciner offers the possibility to reduce the specific energy consumption of the calciner by efficiently re-integrating waste heat streams (either from the calciner directly or from elsewhere in the refinery) in the energy balance. In a typical calciner, about ~ 11 % of the specific fuel energy is lost with the cooling water in the fluid bed cooler [1]. Part of this heat loss (in the first water-cooled chamber of the fluid bed cooler) happens at a temperature range suitable for hydrate drying, hence a use of this energy offers the aforementioned lower specific energy consumption in the calciner in combination with a significant reduction in cooling water consumption.

A second motivation for hydrate drying can be the direct sale of dry hydrate to the market, where it is used as e.g. fire retardant or in the pharmaceutical industry. Furthermore, the drying enhances the fluidizablility of the product and hence, facilitates transport and storage of this product. For these applications, the dry hydrate can directly be extracted from the calciner-integrated dryer, or a standalone hydrate dryer, independent from a calciner, can be used. When, in the latter case, existing heat streams (e.g. steam) are used, hydrate drying can lead a way towards a more economical energy balance in the refinery.

A further benefit from using a hydrate dryer is that similar fuel energy savings can be achieved as with dewatering chemicals. This can reduce or completely eliminate the need for expensive dewatering chemicals, which has two further positive aspects: 1) avoids contamination of the dried hydrate in case this is marketed as a product, and 2) reduces CO emissions stemming from partial decomposition / volatilization of the dewatering chemicals in the preheating stages of the alumina calciner.

In this paper, general design considerations regarding the development of Metso Outotec's Hydrate Dryer will be discussed together with potential applications and benefits for greenfield and retrofit calcination projects. Also, experiences from the operating industrial CFB alumina calciner with a hydrate dryer at AOS Stade [2] are discussed.

2. The Hydrate Dryer - Equipment and Process Design

Given the extensive experience in designing and operating fluidized beds and the well-known excellent heat transfer of immersed heat exchanger tubes in fluidized beds, Metso Outotec's hydrate dryer was developed as fluidized bed dryer [3].

In conjunction with the initial design of the dryer, testwork at the dryer test stand at Metso Outotec's R&D Center in Frankfurt, Germany (see Figure 1) was successfully conducted to determine and confirm fundamental design data of the future drying concept, such as optimum fluidization conditions, heat transfer coefficients between the immersed tubes and the fluid bed, optimum tube arrangement in the bed to allow for good material movement and the suitable combination of temperature and solid residence time required for a satisfactory drying result of the product. The extensive testwork confirmed the suitability of a fluid bed dryer for this application, as well as its robustness and flexibility.

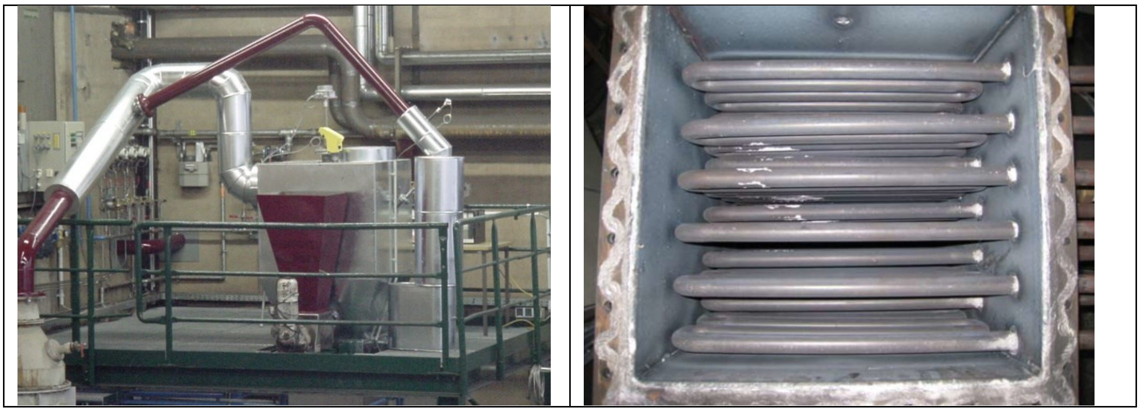

Figure 1. The Fluidized Bed Dryer Test Facility at Metso Outotec's R&D Center.

The main driver for the development of a hydrate drying solution was the constant demand to increase the efficiency and competitiveness of our CFB calcination process [4] by using what is usually a waste heat stream from the fluid bed cooler to optimize the energy balance of the process. Hence, the hydrate dryer solution presented hereafter (see Figure 2) follows this application but can be adapted to serve as a standalone drying solution.

In general, also a flexible solution is viable, with the hydrate dryer being integrated in the calcination plant, but also allowing for dry hydrate production in parallel to the calcination. This requires a separate discharge line from the hydrate dryer vessel.

Based on the positive experiences with the operation of the hydrate dryer, Metso Outotec has also explored applying the hydrate dryer in other mineral, concentrates and ore processes. Testwork in the lab and studies were conducted for these purposes, in principal fully confirming the feasibility to apply the concept also to the drying of bauxite ores. The only limitation observed so far with the dryer is on the particle size of the material to be dried, as the dryer is based on a fluidized bed principle and the material needs to be fluidizable. Therefore, typically a maximum particle size applies, which is normally in the range of several mm (depending on the density of the solids). The minimum particle size to be treated in the fluid bed dryer is usually limited by increased dust entrainment and unfavorable fluidizing behavior of very fine particles.
With a pre-crushed and ground bauxite ore with a size in the mm range it is highly likely that the dryer would be suitable. Testwork and validation to derive design and scale-up parameters, can be conducted in the pilot plant facilities in Metso Outotec's laboratories in Frankfurt.

5. Conclusions

Through specific fundamental testwork in our R&D center and the vast experience in fluidized bed design, Metso Outotec has developed a solution for efficient hydrate drying based on stationary fluidized bed technology. The successful engineering, construction and commissioning of the hydrate dryer system at AOS Stade pushed the specific energy consumption to a record low of < 2.7 GJ/t of alumina, and we see great potential in applying this energy saving technology in existing and new plants.

The hydrate dryer, whether implemented in a greenfield project from the start or as a retrofit option for existing calcination units, offers proven substantial savings in operational cost for utilities such as fuel, cooling water and dewatering aid. Furthermore, the fluidized bed dryer is suitable for stand-alone dry hydrate production and can also be applied to other minerals, concentrates and ores, such as for example bauxite drying.

6. References

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