Using Digital Tools to Further Optimize Product Quality and Calcination Performance

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Abstract

Recent technology developments have targeted improving the alumina calcination process and aligning benchmarks closer to the theoretical minimum energy consumption. Significant efforts have also been made to better understand the impact of alumina quality parameters on the calcination process, with the outcomes considered in new designs. With a more comprehensive understanding of the overall process as well as the relevant quality parameters, it is also possible to optimize the operation of the calcination plant. By introducing a performance indicator that Outotec calls the *Perficiency* factor, plant performance based on technically achievable levels can now be measured. Improvement of the *Perficiency* factor is done via Outotec's Pretium Advisor. As a digital operational support, incorporating the plant manufacturer's process, material and equipment know-how, the tool provides operational assistance by continuously comparing optimized plant operation with measured data. By monitoring the progress of digitally supported plant operation up to fully automated production processes, plant operation is safer, cleaner and more efficient. The tool also allows a number of optimization strategies as well as drawing conclusions on the operation of other connected process units, such as hydrate filtration.

Keywords: Bayer process, product quality, alumina calcination, Perficiency, Outotec Pretium Advisor

1. Introduction

Since its invention in 1888, the Bayer process has been continuously improved in terms of energy efficiency, production capacities and product quality control. Alumina refineries also place a strong focus on becoming low-cost producers. With an existing alumina refinery location, production costs primarily result from [1]:

- Energy costs (electrical and thermal);
- Soda costs;
- Bauxite costs;
- Maintenance costs.

Naturally, the specific costs vary with the refinery location as well as with the bauxite mineralogy. Within this framework, alumina refineries are eager to improve the efficiency of energy, soda and bauxite use while also decreasing maintenance costs. This implies that availability needs to increase with unforeseen downtimes kept to a minimum. Overall equipment efficiency (OEE) or total effective equipment performance (TEEP) are metrics which provide indicators of a typical improvement journey.

How OEE is calculated:

$$OEE = availability \times performance \times quality \quad (1)$$

where: a*vailability = available time / scheduled time*
performance = actual capacity / design capacity
quality = good product produced / total product produced

How TEEP is calculated:

$$TEEP = loading \times OEE \quad (2)$$

where: *loading = scheduled time / calendar time*

The factors are defined as:

- Loading: the portion of the TEEP metric representing the percentage of total calendar time scheduled for operation.
- Availability: the portion of the OEE metric representing the percentage of scheduled time the operation is available to operate. Often referred to as 'uptime/running time'.
- Performance: The portion of the OEE metric representing the speed/production rate at which the plant runs as a percentage of its designed speed/production rate.
- Quality: The portion of the OEE metric representing good quality product produced as a percentage of the total production.

Using OEE and TEEP, a metric can be created to assess the effective or useful plant production time. An OEE score of 100% would represent perfect production at design capacity with no unscheduled downtime and no out-of-spec product produced. A TEEP score of 100% would also indicate that the plant requires no downtime and thus produces at design rate throughout the entire year.

Mainly, the metrics are used for assessment of production machines with non-continuous processes while not taking energy efficiency or environmental footprint into account. However, there is literature proposing such extensions and also the application to continuous production processes [2], [3].

However, OEE and TEEP do not measure the efficient use of energy, raw materials nor utility. Furthermore, emissions such as dust or particles are also missing. This paper takes a look at how availability, product quality, efficiency and emissions can be used in a new metric, *Perficiency* and how *Perficiency* is improved in the calcination process with the Outotec Pretium Advisor.

2. The Calcination Process as Part of a Bayer Refinery

In a Bayer refinery, alumina is produced from bauxite. Figure 1 shows the Bayer circuit and illustrates its process steps or 'plant units'. Each plant unit's availability, product quality fluctuation or efficiency can impact the next plant unit's performance and thus the performance of the entire alumina refinery. In an alumina refinery's final process step - alumina calcination - the focus is on production rate, specific thermal and electrical energy consumption, minimizing shutdown times as well as utilities usage and product quality.

Hiltunen et al. provides an analysis of the impact of assorted equipment failures within a calcination plant and its economics [4]. Since an alumina calciner is an integrated plant unit within the Bayer refinery, it is influenced by disturbances beyond its battery limits. Thus, Hiltunen et al. were able to adjust the available operation time by several factors beyond the

been introduced to have a metric covering not only production time and effectiveness, but also technological excellence in terms of the responsible and sustainable handling of natural resources. Furthermore, these resources are increasingly cost drivers in the production process and can be fully captured using the *Perficiency* rating.

The utilization of the *Perficiency* rating allows bottlenecks in process plants to be identified by comparing single plants or plant units to individual target values and to technological reference values, representing the best achievable *Perficiency* rating for the respective technology. Revealing indicators with shortfalls against reference values, measures can be taken to bring the process plant to the highest operational and technological levels.

To bring the plant to operational excellence, Outotec has developed the Pretium Advisor, a digital solution incorporating the plant manufacturer's theoretical process know-how and operational experience. The tool provides advice and assumes responsibility for certain high-level operational tasks as well as monitoring and fault detection, which have proven too demanding for human operators. Thus, the production process can be streamlined, resulting in improved energy efficiency, with stable and increased production rates. The outcomes resulting from the improved *Perficiency* rating by operational support can be observed. Based on solid theoretical background, the Outotec Pretium Advisor can be extended to upstream and downstream plant units, such as hydrate filtration and precipitation as seen in the example of alumina production. Utilizing an ever-increasing set of digital tools such as the Outotec Pretium Advisor will change the way a plant operates in the future in terms of automation. Based on the features described and the impact of the Outotec Pretium solution, the first steps towards 'autopilot' operation have been made.

As a second measure to improve the *Perficiency* rating, process technology and equipment have been improved to close the gap between technologically possible and measured plant performance. The combination of the digital tool supporting the operation and the mechanical process upgrades allows operating companies to fully utilize the production facilities and to operate process plants at the highest level.

7. References

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