Outotec was commissioned to design a calciner for ETI Aluminyum that would operate more efficiently than a rotary kiln while also being capable of producing both smelter and special grade alumina products. The success of this challenging project brings added value through increased flexibility, new revenue streams, and reduced operating costs.

### CHALLENGES
- High specific fuel energy consumption with rotary kilns
- Two quality grades with very different characteristics
- Wide operating temperature range required
- Small-capacity plant compared to other stationary calciners

### SOLUTION
- Testwork in Outotec’s fluidized bed pilot plants to establish the required operating parameters
- Special design consideration paid to mechanical equipment and refractory to allow operation at different temperatures
- Latest Generation 5 flowsheet to minimize fuel energy consumption
- Equipment scaled down to required plant size

### BENEFITS
- Ability to produce two distinct alumina quality grades in a single equipment
- Superior alumina quality compared to rotary kilns with benefits in downstream aluminum smelter operation in terms of dissolution, HF removal, feeding, and handling
- Increased operational flexibility allowing ETI Aluminyum to take advantage of alternative revenue streams
- Significant (>25%) fuel energy consumption savings compared to rotary kilns
ETI Aluminyum Inc., located in Seydisehir, Turkey, operates an integrated facility with bauxite mining, alumina refinery and aluminum smelter operations. With surplus hydrate production in their refinery operation, compared to what is required for the smelter operation as smelter or metallurgical grade alumina, ETI Aluminyum Inc. is also producing and selling other hydrate and alumina-based products. The refinery was started up in 1973 and employed rotary kilns for the calcination step in the refinery.

Calcination is the last step in the process and is critical as this determines several of the key product quality parameters which are important for how the material performs when used as a dry scrubbing medium and feedstock in the aluminum smelter. Having recently converted the smelter operation from Söderberg cells to Pre-baked, a higher demand is put on the alumina quality. In addition, as the calcination reactions are highly endothermic and the temperatures required to meet the product quality are very high (up to 1000°C), vast amounts of energy are consumed in the calciners. With rotary kilns with heat recovery the specific fuel energy consumption is typically more than 4 GJ/t, thereby representing a large part of the production cost for the alumina.

In 2014, ETI Aluminyum commissioned Outotec to design a calciner capable of producing both smelter grade alumina (SGA) and ceramic grade alumina (CGA), which requires a much higher operating/calcination temperature. Another objective was to significantly reduce operating costs by minimizing the specific fuel energy consumption. The solution was a purpose-built plant that minimizes energy consumption and investment costs while catering for the wide range of processing conditions needed to produce these very different alumina qualities. Close cooperation combining the technical expertise of both companies was vital, and SGA and CGA of the required quality are now produced in one calciner, opening up new revenue streams.

**Serving Turkey’s aluminum needs**

ETI Aluminyum is Turkey’s only integrated aluminum plant capable of extracting aluminum from ore as well as handling production from mining to final product. As the company has more hydrate production in their refinery operation than is needed for smelter operation or metallurgical grade alumina, it also produces and sells other hydrate and alumina-based products.

The company currently provides 10% of Turkey’s annual aluminum requirement – some 82,000 tons – from its Konya Seydişehir plant. Annually the plant can treat 550,000 mt of bauxite ore and produce 160,000 mt of cast products, as well as 260,000 mt of aluminum oxide (alumina) using 600,000 mt of aluminum hydroxide produced at the plant.

**Solving a design challenge**

ETI Aluminyum wanted to reduce the specific fuel energy consumption and explore alternative revenue streams at its Konya Seydişehir plant, so the company approached Outotec to design a calciner capable of producing both SGA for use in their own smelter as well as CGA. This challenging request required a dual-purpose plant that could cater for the wide range of processing conditions needed to produce these very different alumina qualities. It also required deep understanding of the plant and its targets, from layout, to programming, controls, and maintenance.

Getting the design aspects right in the early stages was key to the project’s eventual success. This required the process parameters to be established early in order
to ensure SGA and CGA could be produced with the desired characteristics. Establishing these defined the parameters of the main vessels, as well as the size of several other key vessels.

**Optimization through extensive testing**
Calcination time and temperature have an impact on alumina properties, which are also utilized in the calciner control, for example by adjusting the furnace temperature to achieve the target SGA properties. A series of tests were carried out to determine the optimal operational temperature for the target SGA and CGA qualities. This was carried out in a pilot-scale circulating fluidized bed (CFB) reactor, where the heat and mass transfer mechanisms and kinetics are comparable to industrial CFB calciners. The test work mainly focused on the formation of alumina as a function of time and temperature, thereby allowing reaction kinetics to be derived and the design temperature and residence time of the main vessels to be determined. Other quality parameters such as BET (specific surface area) and LOI (loss on ignition) were also measured.

At temperatures above 1100°C, retention time starts to play a more important role. Based on these tests the set point for the production of CGA and the operation of the plant was selected as between 1100 and 1200°C, with SGA operational temperatures between 900 and 1000°C. This wide temperature and effective gas volume flow range had an impact on both mechanical and refractory design. In addition, as the plant has a relatively small capacity of 500 tons per day, designs had to be scaled down rather than up.

**A specialized process layout**
Outotec’s fifth-generation CFB calciner flowsheet was chosen as the basis for the plant design, with the layout and certain equipment adapted according to ETI Aluminyum’s specific needs. Equipment and vessel heights and widths, and thus velocities, were carefully selected to assure flowability of the material throughout the plant at any production mode and capacity.

An improved hydrate bypass was also integrated into the layout to bypass preheated hydrate around the circulating fluidized bed furnace and calcine it in a purpose-designed mixing vessel with the heat of the fresh calcine alumina coming out of the furnace in SGA production mode. This allows significant savings in fuel consumption. The hydrate bypass also improves plant reliability by allowing a fixed amount of hydrate to bypass without the use of rotating devices in the solids flow. The design also
allows the bypassed preheated hydrate to be moved to the second preheating stage when the plant is operated in CGA mode, to ensure that the target alpha alumina content required for the CGA grade is continuously achieved.

All equipment, vessels, and ducts were evaluated to ensure they were applicable for a dual production calciner, with computational fluid dynamics used to perform more detailed assessments for certain equipment and sections. Particular attention was made to determine the design velocities and pressure profile, to ensure solids transport and flowability at any production mode and rate. Due to the high temperatures and the temperature difference between the two modes at the CFB reactor, the recycling cyclone vortex finder was replaced by a smart arrangement with an inlet ramp into the vessel.

**Custom-designed equipment**

When the plant is operated in SGA mode, the solids entering the fluidbed cooler are typically around 300°C, whereas in CGA mode (with the hydrate bypass disabled to ensure high alpha alumina conversion) the maximum material temperature rises to 500°C. To allow the fluidbed cooler to handle the two very different operating modes, a new, customized cooler design was developed. By improving the material flow and thereby the heat exchange in the cooler, very compact bundles can be used. This allows for efficient heat transfer as well as easy accessibility and good maintainability of the equipment.

Refractory design started with material selection for the refractory itself, and the anchors for support. A unique, custom-made concept was needed: unlike in standard SGA plant refractories which use mainly concrete castings and sprayed insulation materials, the dual-purpose calciner is lined with brick at the top and a combination of brick and monolithic lining with ceramic anchors at the bottom.

**Cooperation leads to success**

The plant hot commissioning commenced in December 2017 as a true collaborative effort between ETI Aluminyum and Outotec’s process and commissioning experts. During plant operation the performance was carefully monitored and evaluated in both operating modes and all operational, quality, and consumption targets were achieved for both SGA and CGA. The project demonstrates how small refineries, or those with surplus hydrate production capacity, can create additional value by tapping into different types of products and new revenue streams when there is additional capacity in the upstream refinery process.