Overcoming Caustic-Free Cleaning Challenges with MVR Evaporator-Crystalliser

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Abstract

ALTEO's Gardanne refinery has faced significant operational challenges following its rapid transition from bauxite feed to alumina trihydrate (ATH) feed, which has eliminated the need for caustic soda. Key issues include the descaling of existing refinery tanks without fresh caustic, as well as managing sodium carbonate (Na_2CO_3) levels in the liquor, now that desilication product (DSP) and carbonate causticisation no longer provide a removal pathway. Additionally, ALTEO is committed to achieving net-zero CO_2 emissions by 2050 and eliminating process water discharge to the environment by 2030.

To address these challenges, ALTEO requires a sustainable method for producing caustic cleaning liquor without relying on fresh caustic soda. The proposed solution is a Mechanical Vapour Recompression (MVR) forced circulation evaporator-crystalliser to produce of strong caustic liquor for effective descaling, which offers multiple advantages: i) it operates on France's low-carbon electricity; ii) it provides high energy efficiency; iii) it crystallises Na_2CO_3 for separation.

GEA is supporting ALTEO with its expertise in MVR evaporation and liquor concentration, delivering a tailored design to meet strict capital cost constraints. The system features a compact, skid-mounted configuration for ease of installation, optimised delivery timelines, and energy-efficient operation. The MVR evaporator-crystalliser will contribute to balancing water use, reducing environmental impact, and maintaining operational efficiency within ALTEO's broader refinery transformation. The remaining challenges and future optimisation strategies will also be presented.

Keywords: Strong Liquor, Caustic Descaling, Mechanical Vapour Recompression MVR, Energy consumption, CO_2 emission.

1. Introduction

ALTEO Gardanne, a specialty alumina refinery in France, has strategically transitioned from bauxite feed to alumina trihydrate (ATH) feed [1]. This change, while environmentally beneficial, introduces several new operational challenges. Notably, the transition eliminates the net consumption of caustic soda, which historically played a crucial role in refinery descaling and impurity control. In parallel, ALTEO is pursuing ambitious environmental objectives, including net-zero CO_2 emissions by 2050 and zero process water discharge by 2030.

The design and implementation of the transition from bauxite feed to ATH feed was completed in an exceedingly short time: about 12 months to update the refinery's P&IDs (process and instrumentation diagrams) and make the necessary design changes, scope the physical changes, and 3 weeks to shut down and implement those changes.

This paper presents the rationale, design, and implementation strategy for a 3 t/h Mechanical Vapour Recompression (MVR) evaporator-crystalliser ("MVR Concentrator") supplied by GEA. This will serve both as an immediate operational solution and a low-risk pilot for future full-scale deployment of MVR Evaporation.

2. Challenges Created by the Transition to Alumina Trihydrate

The elimination of net caustic consumption has created two significant challenges:

- **Descaling**: Without fresh caustic addition, the refinery lacks a direct source of strong liquor for cleaning tanks and process lines from hydrate scale.
- **Impurity Management**: Sodium carbonate (Na_2CO_3), previously removed via desilication product (DSP) formation, now accumulates in the liquor, affecting process chemistry.

These technical hurdles are compounded by tight regulatory requirements and the alumina industry's historical aversion to technology risk – a cautious stance rooted in past experiences with costly and disruptive innovations.

3. Short-Term Strategy Post Transition to Alumina Trihydrate

The short-term strategy was to find the most straightforward, most expedient solutions.

Descaling of Whiteside precipitators, tanks, pipes, and seed filters was performed using cleaning liquor prepared with spent liquor and purchased fresh caustic. This was not sustainable, as this would add to the caustic inventory of the refinery. If necessary, a standby digestion unit could have been put online to evaporate spent liquor and produce a caustic cleaning liquor. Again, not ideal as the energy efficiency or coefficient of performance (CoP) would have been exceedingly low, less than 0.5 kJ of evaporation / kJ of steam supplied.

The increase in sodium carbonate concentration in the refinery liquor due to carbonation from atmospheric carbon dioxide was minimised by reducing or eliminating air ingress into the refinery liquor from drops of liquor and slurries entering tanks. However, despite these improvements, carbonate concentrations were still slowly rising by around 0.5 to 1.0 % of total soda per year.

4. ALTEO's Long-Term Strategy for Refinery Transformation

It is crucial to ALTEO's future that it retain mastery of the quality of its hydrate while respecting commitments to Net Zero by 2050 and zero process water discharge by 2030. So as part of its step-wise transformation roadmap, ALTEO plans to replace its current digestion system with a more energy-efficient alternative. This new flowsheet will require integrated systems for caustic recovery, impurity control, and water management. Electrification and modularity are key design drivers to ensure compatibility with short-term and long-term decarbonisation goals. The water management would likely include installing an evaporator, as the new digestion envisaged would not remove water from the refinery.

However, in the short to medium term, we still need to produce a strong cleaning liquor from spent liquor without adding fresh caustic. Ideally, it would be preferable to first install an evaporator required to meet the refinery's net-zero process water discharge by 2030, and then feed the concentrated product to a small evaporator-crystalliser to produce caustic cleaning liquor.

14. References

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