Light Metals 2013

ALUMINA AND BAUXITE

Precipitation and Calcination

SESSION CHAIR

Everett C. Phillips
Nalco Company
Batavia, IL USA

ENVIRONMENTALLY SAFE OPERATION OF BAROMETRIC CONDENSERS

Matthew Jacobs[1]
[1]Alcoa – Point Comfort Operations; State Hwy 35; Point Comfort; TX; 77978; USA

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Abstract

Refining alumina from bauxite via the Bayer Process can create environmental liabilities. Many refineries rely on barometric condensers for key unit operations. While barometric condensers offer simple, efficient, and reliable cooling options, they have the ability to discharge contaminated water back to the cooling water source. With tightening environmental regulations worldwide, developing reliable barometric condensers that operate without discharging high pH water is critical to sustaining condenser operations. Alcoa has devised a method to prevent high pH excursions from barometric condenser discharge that has been 100% effective.

Introduction

In 1959, Alcoa began construction of its Point Comfort, Texas alumina refinery. The plant was built as a four unit low temperature digester plant to support the already existent smelting operation. The engineering design for Point Comfort Operations (PTC) consisted of three barometric condensers in Precipitation for trim cooling of green liquor coming from Building 40 – Heat Interchange (Figure 1). The plant was later expanded to its current capacity, 6,300 MT/day, and installed a fourth barometric condenser to achieve the required cooling duty into Precipitation. Barometric condensers operate by using water as a heat sink to control flash cooling from a paired flash tank. Point Comfort Operations uses a cooling lake located at the residue storage area to provide the required water to operate the barometric condensers. A myriad of upset conditions could lead to liquor carry over from the flash tank into the barometric condenser. As part of Alcoa's core values, particularly environmental sustainability, Point Comfort Operations devised a method to upgrade its barometric condensers to operate safely without risk of liquor carryover that could result in contamination of the cooling lake.

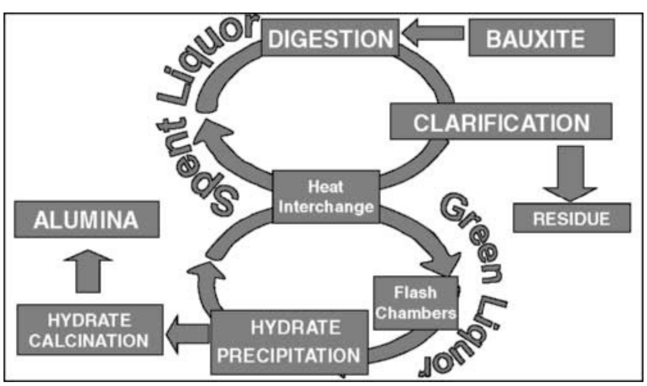

Figure 1: PTC Bayer Process Flow Path Overview

Operation of Equipment Prior to Upgrade

At Point Comfort Operations, Clarification thickener overflow is cleaned of any remaining solids through a bank of Kelly Presses. The Kelly Press filtrate discharges to a number of filtrate tanks that provide feed to Heat Interchange. Hot green liquor passes through a series of flash tanks to exchange heat with spent liquor returning to Digestion. Each heat interchange unit discharges into a seal tank that transfers the cooled green liquor to Precipitation. All of the green liquor lines from Heat Interchange enter a common feed header to distribute green liquor to any number of flash chambers that are in service (Figure 2). The green liquor travels up the feed riser to a junction with two valves. The first valve is a positive seat manual blocking valve that allows green liquor to flow through the green liquor bypass to feed the green liquor stock tanks directly. The second valve is also a positive seat manual blocking valve that allows flow to feed its respective flash chamber. Vacuum pumps are used to pull initial vacuum on the flash chambers through the barometric condensers to remove any non-condensable vapor (Figure 3).

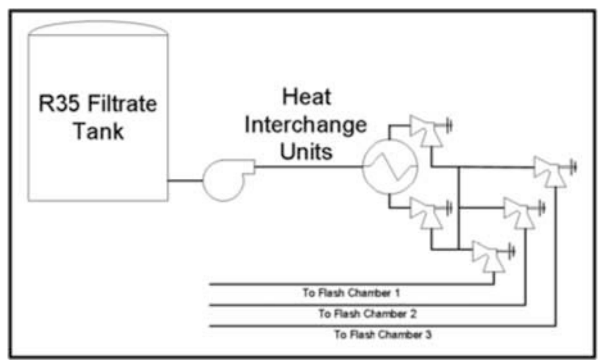

Figure 2: Flash Chamber Feed Header Arrangement

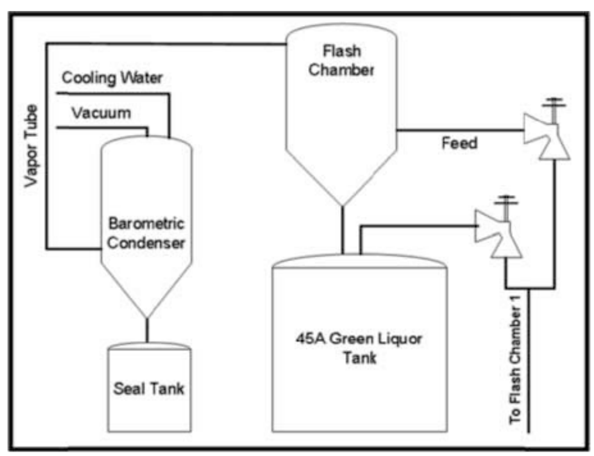

Figure 3: Flash Chambers Pre Upgrade

Once vacuum is established, the manual blocking valve on the bypass line is closed to send green liquor to the flash chamber. Green liquor that enters the flash chamber flashes off steam vapor while under vacuum. The steam vapor travels through a vapor tube into the barometric condenser where it mixes with cooling lake water. The amount of water flowing through the barometric condenser is varied to adjust the apparent vacuum and flashing to achieve the target green liquor fill temperature requested by the area process engineer. When the flash chambers provide more cooling than required, the manual bypass valve is partially opened to regulate the amount of bypass flow around the flash chamber to achieve the desired fill temperature result. The water discharging the barometric condenser collects in a seal tank where it is pumped back to the cooling water lake. The conductivity of the water feeding the barometric condenser and discharging the seal tank is monitored to determine if any liquor discharges with the cooling water. If liquor is detected in the effluent, the control operator will open the manual bypass valve until the flash over event ceases.

Methods of Liquor Carryover

PTC identified three mechanisms of liquor carryover for flash chambers that can lead to contamination of barometric condenser effluent. The first two are related to liquor/vapor turbulence within the flash chamber. The first method of carryover occurs when the seal tanks in Heat Interchange pump nearly empty. When the liquor level in the seal tank drops below the top of the pump suction nozzle, air is entrained with the liquor going through the pump. Because air is compressible, the pump generates a compressed air bubble that travels with the green liquor to Precipitation. Once the compressed bubble enters the flash chamber, it rapidly expands due to the flash chamber operating under vacuum, acting like a miniature explosion within the flash tank. The violent nature of this reaction entrains liquor droplets in the steam vapor that exits the flash chamber via its vapor tube, resulting in liquor contamination of the effluent. The same effect occurs when the liquor level within the flash chamber rises above the level of the liquor feed pipe. Flashing begins to occur below the surface of the liquor as the feed enters below the liquor level. As the steam bubbles rise through the liquor, droplets are entrained in the steam as it passes to the barometric condenser (Figure 4).

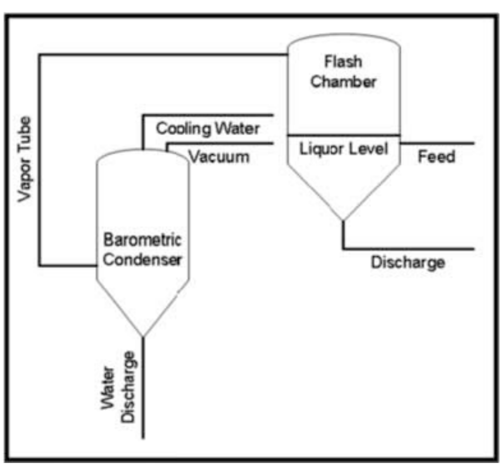

Figure 4: Flash Chamber Arrangement

The final method of failure is total failure of the flash chamber discharge line due to scale fracture. If green liquor scale dislodges from the wall of a dirty flash chamber before it comes out for routine cleaning, the discharge to the green liquor tank becomes plugged. The green liquor level in the flash chamber will climb until a total carryover of liquor to the barometric condenser occurs. The conductivity meter would detect the event after a full carryover has already occurred because the original flash chamber design did not include level indication. The flash chamber would then require operator interaction to be bypassed to halt the carryover event. The lack of controls with the original Point Comfort Operations flash chamber and barometric condenser design allows flash over events to occur without warning and last longer than desired (Figure 4).

Equipment Upgrades and Operation Post Upgrade

The first issue addressed in the flash chamber and barometric condenser upgrade was the lack of control over the flash chamber feed. Air actuated butterfly valves were installed downstream of the manual green liquor bypass blocking valve. This allows the control operator to instantly adjust the flash chamber as required from the control room. To prevent failure of the butterfly valve in green liquor service, the valve has been coated with an Alcoa anti-scale coating and is automatically exercised by the control system four times per day. Differential pressure level indication was also added to the flash chamber to allow for continuous level monitoring of the flash tank. Logic was added to automatically bypass the flash chambers if the level of the Heat Interchange seal tanks becomes low enough to cause air entrainment. Automated vacuum breakers were also added to the flash chamber to mitigate any flash over event as soon as possible (Figure 5). The original conductivity monitoring system is used to detect any amount of liquor carryover from the flash chamber. Conductivity was chosen as a first method of detection due to its higher sensitivity to changes in the effluent water than conventional pH meters. A pH meter was installed on the discharge of the lake water return pumps as a last layer of protection to prevent the contamination of the cooling lake should the conductivity monitoring fail.

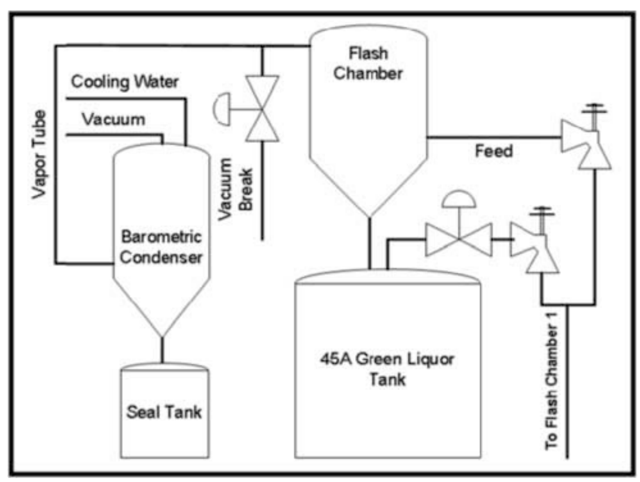

Figure 5: Flash Chambers Post Upgrade

To operate the flash chambers and barometric condensers post upgrade, the vacuum breakers are first closed. After vacuum builds to target, the bypass control valves are closed while controlling the level in the flash tank below the level of the feed pipe. The water flow on the barometric condenser is then regulated by the control software to maintain the target fill temperature. If the control system detects the Heat Interchange seal tank levels, flash chamber level, effluent conductivity, or effluent pH go into alarm, the system is immediately bypassed and shut down until the alarm condition is cleared. This prevents any contamination of the cooling lake return water.

Results and Conclusions

Point Comfort Operations has experienced a number of events that could have resulted in liquor contaminated cooling water being returned to the cooling lake since the upgrade of the flash chambers and barometric condensers. None of them have resulted in a liquor carryover to the cooling lake. There has been a 100% success rate with the new system. This has proven to be an effective way to retrofit old cooling technology with modern controls to prevent contaminating our environment.