Washer Overflow Liquor Chemistry Prediction by Using Mud Level Instrumentation

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Abstract

Maaden alumina refinery digestion alumina to caustic ratio (A/C) control is a feedback control with a lag time of 40 minutes to determine the equilibrium ratio inside digesters that adjusts the bauxite slurry required to achieve the target ratio with a margin set point (SP). Margin SP is the difference between digester equilibrium ratio and target ratio inside digesters. Digester equilibrium condition is estimated from online measurement of blow-off liquor chemistry, lab results of lead washer overflow liquor chemistry at periodic intervals and flash tanks evaporation rate. In Bayer process, clarification area uses different technologies available in the market for online measurement of interfaces and mud level in settlers and washers. Maaden uses mud level instrumentation for such purpose. Lead washer overflow (dilution) is injected to last flash tank outlet to control blow-off caustic and temperature. Lab team analyses lead washer overflow liquor chemistry at periodic intervals, and this causes multiple step changes leading to highly variable digestion target ratio control affecting digestion alumina production. This paper presents a novel approach where the online mud level instrument raw conductivity values are newly introduced to predict the liquor chemistry (alumina and caustic) in lead washer overflow using statistical method and the online values were connected to the digestion ratio control as part of digitalization projects. As a result, this improved the digestion ratio control and reduced alumina production losses by 34 000 tonnes per year (1.89 % loss avoidance yearly).

Keywords: Bayer process, Digestion ratio control, Process control and digitalization.

1. Introduction to Maaden Alumina Refinery Digestion Process

The Saudi Arabian Mining Company (Maaden) owned Maaden Aluminium complex is a largest fully integrated aluminium complex located in the minerals industrial city of Ras Al Khair on the east coast of Kingdom of Saudi Arabia. The complex consists of a bauxite mine and an alumina refinery, an aluminium smelter and a rolling mill. Maaden Alumina Refinery has been designed to produce 1.8 Mtpa alumina from bauxite and in turn will be smelted to produce 0.74 Mtpa of aluminium. Bauxite mine located at Al Baitha in north- eastern Saudi Arabia approximately 600 km north-west of Ras Al Khair supplies bauxite to alumina refinery by rail and has a production capacity of 5 Mtpa of bauxite. Key infrastructure for Maaden aluminium complex includes the port, power plant and desalination plant as well.

Maaden alumina refinery commenced operation on November 2014 with 2 digestion units and is currently operating with a capacity of 1.87 Mtpa of smelter grade alumina (SGA) (FY-2024 actual SGA Production). Bauxite handled at Maaden complex has a high boehmitic content of 32 %

approx. and so the digestion process – which extracts alumina from bauxite by contact with strong caustic liquor at high temperature and pressure – is applied with a temperature of 273 °C and a pressure of 5 200 kPa.

The digestion area receives bauxite slurry from pre-desilication tanks and strong liquor from digestion test tanks which is blended and pumped through jacketed pipe heaters to preheat the slurry to 200 °C using flash steam from digestion flash tanks. Preheated bauxite slurry is introduced into the digester vessels where it is heated to 273 °C using high pressure steam direct injection to achieve required extraction of alumina from bauxite and with required residence time.

The slurry is then cooled in a series of flash tanks, reduced to atmospheric pressure in the blow-off tank before being fed to clarifiers for solid-liquid separation. The flash vapours are used to preheat the incoming bauxite slurry in jacketed pipe heaters. Blow-off alumina to caustic ratio (A/C) and total causticity (TC) of the slurry feeding the mud settlers are in the range of 0.695–0.700 and 248–252 g/L respectively. Mud washing circuit recovers liquor rich in alumina and caustic from the mud settler underflow mud in counter current decantation method. Dilution liquor (lead washer overflow) has an alumina to caustic ratio (A/C) in the range of 0.60–0.64, total causticity (TC) at 120–135 g/L and total alkalinity (TA) 130–150 g/L respectively, and is injected into the slurry stream prior to the blow-off tank to cool down the slurry and to increase the super saturation.

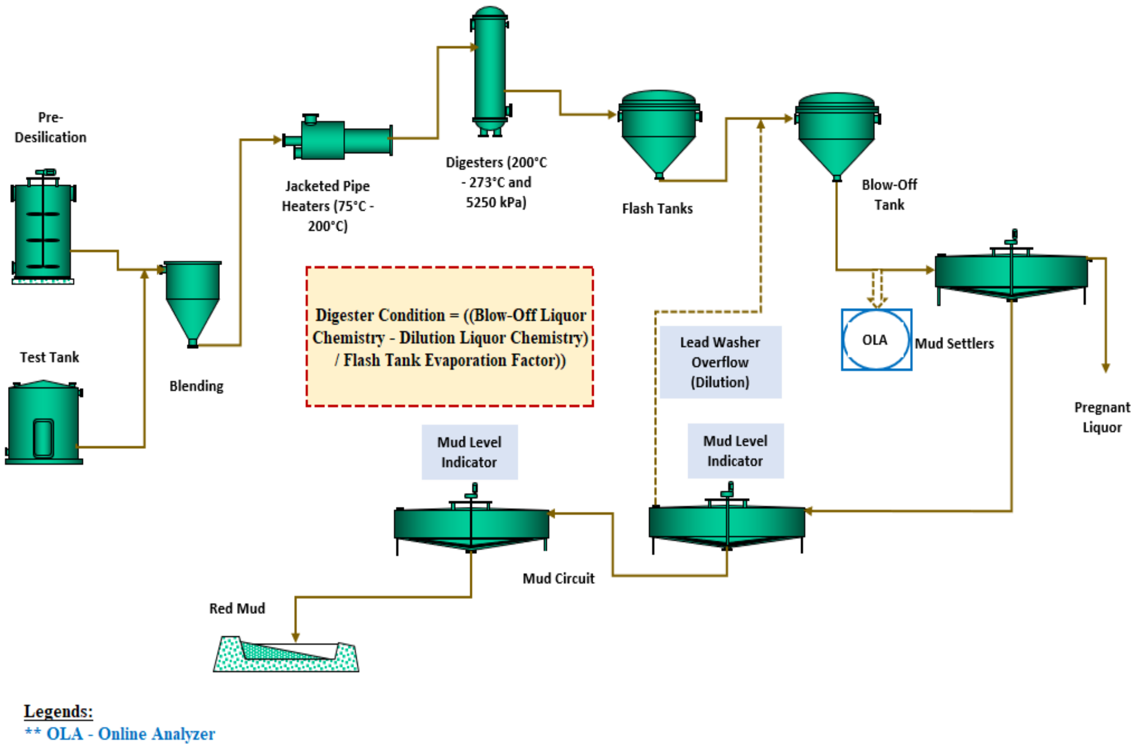

Figure 1. Maaden alumina refinery digestion process

The equilibrium ratio inside digesters is estimated from a blow-off analyser for alumina to caustic ratio (A/C) and total causticity (TC) together with laboratory analysed dilution liquor (lead washer overflow) alumina to caustic ratio (A/C) and total causticity (TC) values and evaporation factor across the flash tanks. Digester target ratio is controlled with margin SP between equilibrium ratio and actual ratio inside digesters, defined by the digestion engineer to minimize the error in the equilibrium calculation and to avoid the risk of auto precipitation. Bauxite slurry is charged accordingly to achieve digester ratio target and thereby production target with a lag time of ~40

Production gain calculation is explained in detail in Table 2.

Table 2. Production Gain Calculation.

Process Parameters	Unit	Year - 2021	Year -2024
Digestion Flow	m^3/h	2520	2494
Digester TC	g/L	181	193
Digester A/C	-	0.700	0.703
SPL A/C	-	0.331	0.323
Digester Yield (2021 Spent Liquor A/C basis)	g/L	66.9	71.7
Increase in Yield	g/L	4.8	
Overall Operation Factor Considered	-	0.926	
% Contribution Considered (More Conservative)	%	35	
Production Gain	tonnes	34 189	
Production Gain (Rounded Off)	tonnes	34 000	

Production gain is calculated based on an increase in digester yield as all actions implemented are to improve digester condition in terms of TC and A/C. Digester yield increased from 66.9 g/L to 71.7 g/L with digester TC increase from 181 g/L to 193 g/L and digester A/C increase from 0.700 to 0.703. This corresponds to 4.8 g/L increase in digestion yield.

Digester yield (g/L) = Digester TC (g/L) × (Digester A/C – Spent Liquor A/C) (4)

Production gain (t/year) = [Digestion Flow (m^3/h) × Digester Yield (g/L = kg/m^3) × 24 (h/day) × 365 (day/year) × Plant Overall Operation Factor × % Contribution assumed on a more conservative basis] / 1000 (kg/t) (5)

5. Path Forward Plan

The subjected development, “developing regression equation from online instrument continuous raw values to predict Bayer liquor chemistries using periodically analyzed lab values of the same process stream” is under transformation to other areas of refinery wherever applicable in Maaden. Currently the work is progressing to predict PGL (pregnant liquor) liquor chemistry using new installation of conductivity meters to develop a regression equation from lab values analyzed at periodic intervals to help with better process control in precipitation circuits.

These improvements will pay way more for the digitalization of process across Alumina industries as well as other industries wherever it is applicable to do.

6. References

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