Drivers for seawater neutralisation of bauxite residue

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Abstract

Proponents and designers of greenfield alumina refineries face many constraints when planning new refinery projects, and the need for environmentally sustainable residue management practises is chief among them. Regulators, local communities, and project owners are increasingly demanding solutions that minimise the long term environmental liabilities of an alumina refinery and its associated bauxite residue disposal area. The seawater neutralisation of bauxite residue is one way to achieve this, however there is only a handful of refineries in the world today that have adopted the practice. This paper discusses the drivers and enablers for implementing sea water neutralisation of alumina refinery residues, with an emphasis on greenfield projects. It reviews benefits of a non-hazardous residue, competing treatment options, and implications of site selection on residue treatment.

Keywords: Seawater neutralization; bauxite residue.

1. Introduction

The global inventory of bauxite residue is estimated to be in the order of 4 Gt as of 2015 and increasing at a rate of ~ 170 Mtpa at current global alumina production rates. Analysts have predicted that alumina production will increase at a rate of 3.1 % p.a. over the next 5 years to 2019 [1]. Based on the current world production of ~ 108 Mt of alumina, this means that an additional 14 Mtpa of new capacity is predicted to come on-line in the next 5 years.

It is becoming increasingly important that the bauxite residue management practises adopted for these new projects are environmentally sustainable, and do not leave an enduring legacy to be managed long after the bauxite reserve is depleted and the refinery decommissioned. The strategy for achieving this should be two fold: firstly, to maximise the amount of residue that is re-used, and secondly, to eliminate the need for active ongoing management of the residue storage facility after closure so as to permit transfer of ownership and alternative land use.

When the project conditions are conducive, seawater neutralisation may be one way to achieve this; however only a handful of refineries in the world today have adopted the practise. This paper considers the drivers and requirements for a seawater neutralisation process so that informed process selections can be made during the early development phases of greenfield projects.

2. Environmental Considerations

Environmental issues weigh heavily in the selection of a residue disposal strategy and whether or not neutralisation should be adopted. Sea water neutralisation is differentiated in the following areas which are discussed below:

- Post closure ground water management
- Seawater discharge
- Dust
- Hazardous Material classification
- Water balance management
- Re-vegetation potential

- Improved properties for re-use

2.1. Post closure ground water management

Bauxite residue disposal areas continue to yield leachate and seepage long after their closure due to infiltration of water and further consolidation of the residue. To prevent ground water contamination this water will usually need to be recovered via a basal drainage system. How the recovered water is managed after the refinery is decommissioned is a significant issue, as it is generally not suitable for direct discharge to the environment. There is much uncertainty about how this effluent should be managed; it will require active treatment for many years and without the revenue from a refinery to pay for this treatment it will be a legacy burden either for the former operator of the refinery (as long as they remain in business) or for the state. The timeframe over which this can be expected to occur is in the order of many decades [2].

The challenge for new projects is to design a residue disposal system that does not result in a long lasting legacy requiring ongoing management after refinery closure. If the residue can be treated so that its leachate is non-hazardous to the surrounding environment, then this can be achieved. Sea water neutralisation is therefore of particular benefit where the residue disposal area can be located in a saline ground water environment. In this case, a low permeability liner may not be required (subject to assessment of groundwater impacts) and the enduring requirement for collection and treatment of basal drainage water may be reduced or eliminated. Queensland Alumina in Australia is an example where this applies [3], [4] – and similar opportunities may exist for new refinery developments in the Middle East where there are extensive areas of hypersaline ground water.

2.2. Seawater discharge

In the seawater neutralisation process large volumes of effluent must be discharged to the marine environment. This discharge is most often a point of contention when deciding whether or not to adopt seawater neutralisation for a new project. This is because of the risk of harm to the marine environment. However, this risk can be effectively managed providing sufficient seawater is always made available with adequate Mg^{2+} and Ca^{2+} ions available.

Studies at Queensland Alumina have shown that the seawater discharge has very low impact on the receiving environment. The trace element concentrations in the sediments, waters, mangroves, and oysters near the outfall site, as well as a survey on benthic fauna, showed no significant differences when compared to pristine control sites [5]. Concentrations of signature species Al, V, Ga, and Mo were all below ANZECC/ARMCANZ guidelines and the discharge waters were not toxic [6]. Similar results have been repeated in other toxicological studies [7], [8]. This low impact is thought to be due to the capacity of the neutralised residue to trap metal ions. When the neutralisation reaction takes place in the presence of the residue solids, the efficiency of metal removal is increased. This is because heavy metals are adsorbed by the solids and prevented from being discharged in the supernatant liquor [9], [10]. The residue also helps bind the hydrotalcite precipitate and improve dewatering/clarification of the discharge waters. These aspects highlight the importance of the presence of the residue solids in the neutralisation process – neutralisation of decant liquor alone does not achieve the same results.

Dissolved oxygen levels, turbidity, concentration and temperature are also important considerations for the discharge water. Where these parameters differ greatly from the receiving environment there is potential for impacts on benthic flora and fauna. The design of a sea water neutralisation system may need controls built in to ensure that these parameters are within the required levels. Specialist design of a sub-sea diffuser may also be required if there are buoyancy differences to ensure good mixing of the discharge with the receiving waters.

6. References

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