

https://dspace.org/

Application of process synthesis for the recovery of valuable chemicals from an industrial waste stream

Molote, Moratwe

2018

https://hdl.handle.net/10539/26034

Molote, Moratwe Emmanuel, (2018) Application of process synthesus for the recovery of valuable chemicals from an industrial waste stream, University of the Witwatersrand, Johannesburg, https://hdl.handle.net/10539/26034

Downloaded from a DSpace repository. https://dspace.org/

Abstract

This work aims at designing and simulating on Aspen Plus process simulator a process that can recover valuable chemicals from a High Organic Waste (HOW) stream produced at Sasol Secunda plant, South Africa. The waste is made up of low boiling point organic components such as pyridine, acetonitrile and Methyl Ethyl Ketone and water. Currently, the waste is incinerated without energy recovery. This practice serves to exacerbate the already high greenhouse gases emissions from the plant, but more importantly, it results in the missed opportunity to maximize revenues through resale of recycled valuable chemicals. The recovery of valuable chemicals from the HOW is made difficult by the formations of azeotrope between organic components and water; at least 6 azeotropes exist in the HOW stream. In this work the emphasis is on pyridine because of its established market value and demand. Pyridine market size is about 400 million USD in 2017 and is expected to increase to over 600 million USD by 2021 mainly due to increased usage in the agrochemical industry. Water integration strategy was also assessed demand because of the reported need to improve water utilization efficiency at Sasol Secunda plant.

The recovery was achieved in 2 separate steps: 1) water-pyridine mixture was separated from the rest of the HOW stream using fractional distillation and 2) pyridine enrichment section which was designed using thermodynamic tools such as residue curve maps and isovolatility curves. The rest of the HOW stream (light fractions) was sent to the currently used incinerator. Liquid-liquid extraction and azeotropic distillation were considered for the pyridine enrichment step. Results showed that the combination of liquid-liquid extraction and distillation offered the benefit of a lower entrainer to azeotropic mixture ratio (EA) compared to azeotropic distillation. This gave the lowest recorded EA at 0.320:1. The comparison between the proposed process and the incineration of the whole HOW stream showed that the implementation of the process proposed reduced the incineration load by 60wt% and CO and CO_2 emissions by 50%. Dividing Wall column process integration technique was implemented to reduce the number of distillation columns in the proposed process and 10% reduction in the

reboiler and condenser duties was observed. Implementation of DWC further improved the purity of the recovered pyridine from 96mol% to over 99.9mol%. Preliminary economic evaluation carried out on Aspen Plus showed that the proposed recovery process was profitable with an Internal Rate of Return (IRR) of 20% and a payback period of 4.5 years.