Accepted Manuscript

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PII: S1026-9185(16)30082-8
DOI: 10.1016/j.sajce.2017.05.004
Reference: SAJCE 33

To appear in: *South African Journal of Chemical Engineering*

Received Date: 16 November 2016
Revised Date: 24 May 2017
Accepted Date: 25 May 2017

ANALYSIS OF POTASSIUM NITRATE PURIFICATION WITH RECOVERY OF SOLVENT THROUGH SINGLE EFFECT MECHANICAL VAPOR COMPRESSION

Abstract

Analysis of purification of potassium nitrate with incorporation of single effect mechanical vapor compressor for solvent recovery was done. Analysis focused on the effect of concentration and temperature of mother liquor on the energy efficiency of the process and the amount of recovered solvent. Performance coefficient of mechanical vapor compressor ranged between 1.5 and 7.5 depending primarily on the temperature of mother liquor. It was found that with increase in temperature of mother liquor through pre-heating, the power of the compressor, compression ratio and amount of heat supplied to the evaporator decrease. For a 40% concentrated feed solution and mother liquor temperature above 80°C, performance coefficient is higher than 4. It is therefore concluded that preheating mother liquor and reduction of the effect of concentration of both mother liquor and concentrated waste stream through other methods reduces the power consumption of purification process.

Keywords: performance coefficient, mother liquor, concentrated solution, recovered solvent, boiling point elevation, mechanical vapor compressor.

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1. Introduction

Potassium nitrate (KNO_3) is used as a food preservative, fertilizer and heat transfer agent in chemical industries. KNO_3 is also essential in the production of explosives, glass and steel [1-3]. The only known ore of KNO_3 is caliche mined in Chile [2, 4]. Potassium chloride (KCl), also known as potash, is another mined compound of potassium. To meet the high demand of KNO_3, the mineral deposits are supplemented with the manufactured compound. The following chemical processes have been developed for its production:

(i) Reaction of potassium chloride with nitric acid at elevated temperatures (equation 1) [1, 2].

$$3KCl + 4HNO_3 \xrightarrow{100℃} 3KNO_3 + Cl_2 + NOCl + 2H_2O \qquad (1)$$

(ii) Potassium chloride react with hot aqueous sodium nitrate to produce sodium chloride (NaCl) and potassium nitrate (equation 2) [3]. NaCl is less soluble at elevated temperatures and thus crystallizes out of the hot solution rich in KNO_3 [1-3].

$$NaNO_3(aq) + KCl\,(s) \rightarrow NaCl\,(s) + KNO_3\,(aq) \qquad (2)$$

(iii) Nitric acid is reacted with potassium chloride to produce potassium nitrate and hydrochloric acid which is extracted with an organic solvent (equation 3) [2, 5].

$$HNO_3 + KCl \rightarrow HCl + KNO_3 \qquad (3)$$

(iv) Electrodialysis – cation exchange membranes (CEM) and anion exchange membranes (AEM) alternate in a compartment with external electric field. The ion exchange membranes keep ions of the same charge but allow ions of opposite charge to pass through [3, 6]. Jaroszek, et al. [3] fed K_2SO_4 into the two outermost cells in a four cell compartment and $NaNO_3$ in the