H.T.U. and N.T.U. for Amalgam Decomposition Tower

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The required volume, SH, the overall coefficient for mass transfer, K, and the driving force, E_h , are respectively represented as following equations in our previous papers^{1),2)}.

$$\frac{SH}{M} = - \int_{y_0}^{y_1} \frac{dy}{KE_h} \dots\dots\dots (1)$$

$$\frac{1}{K} = \frac{1}{k_A Y} + \frac{1}{k_H} + \frac{1}{k_F \kappa} \div \frac{1}{k_H} + \frac{1}{k_F \kappa} \dots\dots\dots (2)$$

$$E_h = \alpha x + \beta_1 y + \beta_2 y^2 + \gamma \dots\dots\dots (3)$$

When many conditions, such as the concentration of amalgam, and caustic soda, the fluxes of mercury and water, and temperature, are known, the amalgam decomposition tower can be designed. But eq.(1) does not represent individually S and H. Therefore, H.T.U. and N.T.U. for amalgam decomposition tower were determined in order to calculate S and H.

The righthand side of eq.(1) has the same means as N.T.U. of packed tower, then, the function

$$\frac{H}{n} = H \left| - \int_{y_0}^{y_1} \frac{dy}{E_h} \right| \dots\dots\dots (4)$$

is the same as H.T.U. in absorption tower.

However, the dimensions of these numbers are not the same as in common cases, but for convenience sake, we call $\int_{y_0}^{y_1} \frac{dy}{E_h}$ and H/n the N.T.U. and H.T.U. for amalgam decomposition tower, respectively. And these dimensions are (1/volt) and (volt. m).

I. H.T.U. of Amalgam Decomposition Tower.

H.T.U. and K have the following relation³⁾:

Fig. 1 Amalgam decomposition packed tower for H.T.U.
(for $M/S < 350 \text{ kg-mol/h/m}^2$)

Fig. 2 Electroconductivity of NaOH.

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$$K = \frac{1}{\text{H.T.U.}} \cdot \frac{M}{S} \dots\dots\dots (5)$$

Therefore, H.T.U. becomes constant under constant temperature and constant concentration of caustic soda.

H.T.U. is shown in Fig. 1. The conductivity of caustic soda at various conditions, were determined as shown in Fig. 2 and used for the above calculation.

II. *N.T.U. of Amalgam Decomposition Tower*

N.T.U. is presented as the area under $1/E_h$ - y curve among the arguments y_1 and y_0 . Figs. 3-8 are the $1/E_h$ - y relations at different temperatures.

For example, we may calculate the decomposition tower under the following conditions :

concentration of caustic soda	40%
concentration of amalgam : top	0.20%
bottom	0.002%
temperature	50~90°C

(i*) At 50°C :

H.T.U.=17.5 (volt·m) from Fig. 1

Fig. 3 Amalgam decomposition packed tower for N.T.U.

Fig. 4 Amalgam decomposition packed tower for N.T.U.

Fig. 5 Amalgam decomposition packed tower for N.T.U.

Fig. 7 Amalgam decomposition packed tower for N.T.U.

Fig. 6 Amalgam decomposition packed tower for N.T.U.

Fig. 8 Amalgam decomposition packed tower for N.T.U.

$$N.T.U. = 6.3 \times 10^{-2} \text{ (1/volt) from Fig. 3}$$

$$H = 1.11 \text{ (m)}$$

(ii) At 90°C :

$$H.T.U. = 10.2 \text{ (volt} \cdot \text{m) from Fig. 1}$$

$$N.T.U. = 3.9 \times 10^{-2} \text{ (1/volt) from Fig. 7}$$

$$H = 0.40 \text{ (m)}$$

III. Influence of Operating Temperature

It is understood that the required volume of the packed tower is considerably affected by the temperature during operation.

Therefore the coefficients k_H and k_F are independent with temperature, and the correlative factor concerning temperature is only the conductivity of caustic soda κ , and it becomes large according to temperature rises⁵⁾⁻⁷⁾. Therefore, H.T.U. becomes smaller.

N.T.U. is shown as follows :

$$n = - \int_{y_0}^{y_1} \frac{dy}{E_h} \dots\dots\dots (6)$$

Therefore E_h in this equation is the larger for higher temperature, that N.T.U. takes small value at high temperature, and then, the required height needs not be so high in such case. These facts are much important for the designing of decomposition tower.

Symbols :

S : Sectional area of tower (m)

H : Height (m²)

K : Overall coefficient for mass transfer (kg-mol/volt $\cdot$ m³ $\cdot$ hr)

E_h : Practical driving force ($E - \pi_h^0$) (volt)

E : E.M.F. of local cell (volt)

π_h^0 : Intersection of hydrogen overpotential diagram (volt)

Y : Activity of sodium in amalgam (kg-mol/m³)

κ : Conductivity of caustic soda (mho/m)

x : Number of kg-mol of caustic soda per 1 kg-mol of water

y : Number of kg-mol of sodium per 1 kg-mol of mercury

k_A : Coefficient for mass transfer at amalgam side (1/volt $\cdot$ hr)

k_H : Coefficient for mass transfer at graphite side (kg-mol/volt $\cdot$ m³ $\cdot$ hr)

k_F : Coefficient for mass transfer at solution (kg-mol/amp $\cdot$ m² $\cdot$ hr)

[H.T.U.] : (volt $\cdot$ m)

[N.T.U.] : (1/volt)

Suffixes 0 and 1 represent the top and the bottom of the packed tower, respectively.

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