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Project 23

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ARMY SERVICE FORCES
UNITED STATES ENGINEER OFFICE
MANHATTAN DISTRICT
OAK RIDGE, TENNESSEE

EIDMG-12-a
PC #13

P. O. Box E

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Subject: S-50 Product Concentration Versus Production and Material Consumption Ratio.

MEMORANDUM to Files.

1. The object of this investigation is to determine the effect on the S-50 product concentration of variations in the rate of production and the ratio of product to feed.

2. The following nomenclature is used in this memorandum:

C_f = Concentration of feed (assumed to be 0.714%)

C_p = Concentration of product

C_w = Concentration of waste

$R = T_p/T_f$ = ratio of product to feed

S = the separation factor defined as $\frac{X_p/Y_p}{X_w/Y_w}$ where X equals the composition of the light component and Y equals the composition of the heavy component and subscripts p and w refer to product and waste conditions respectively.

T_p = Weight rate of product in grams T per day

T_f = Weight rate of feed in grams T per day

H = Experimentally determined unit of production, constant for a particular column operating under a standard set of conditions (grams per column day) $H = \frac{M}{x \cdot y}$ T

v = Product rate in terms of H defined as $\frac{T_p}{H}$

y = The natural logarithm of the separation factor experimentally determined at zero production, constant for a particular column operating under a standard set of conditions.

3. This investigation is based on the following assumptions:

a. An increase in the product concentration of S-50 may be attained by either sacrificing the daily production of T per rack or decreasing the rationof product to feed.

b. Natural feed, $C_f = 0.714\%$, is used.

c. Feed, product and waste removal is continuous.

d. Operational equilibrium has been attained.

Actually assumption c does not agree with operating procedure as the operation is intermittent rather than continuous. If, however, outage time is neglected and feed is introduced and waste is removed sufficiently often, then condition c is approached. In fact in a preliminary calculation with intermittent feed and removal, Mr. Rosen has found very little difference between the results for intermittent and continuous operations, provided operational equilibrium has been attained, that is, in the case of an intermittent process, concentrations in the column, (top and bottom) do not vary from one cycle to the next. The results for the continuous process may thus be used to find the relative effect of varying production rate and material consumed for the actual operations of S-50.

4. The performance constants used in this investigation are as follows:

Present plant average value of y for S-50 = 0.35
(Value used in this investigation)

(Maximum value of y from experimental columns = 0.6)

Present S-50 columns - no outage time
H = 40 grams hex = 27 g^T per column day

(Experimental columns - no outage time
H = 100 grams hex = 67.7 g^T per column day)

5. The following formulae are based on the assumptions in Paragraph 3:

$$\frac{C_p}{C_w} = \frac{1 + v}{v + e^{-(1+v)y}}$$

probably an exponent on e

A material balance gives

$$C_f = RC_p + (1-R)\,C_w$$

so that on eliminating C_w

$$\frac{C_p}{C_f} = R + \frac{1-R}{1+v} \times \frac{v + e^{-(1+v)y}}{}$$

$$\frac{C_p}{C_w} = \frac{1 + v}{v + e^{-(1+v)y}}$$

By taking $C_f = 0.714\%$, $y = 0.35$ and $R = 0\%$, 10%, 20%, 30% up to and including 100%, a family of curves (Figure 1) is obtainte with ordinate Cp and absicissa v. These curves may be used to find any one of the quantities

$H = \frac{M}{\times y}$

C_p, V, or R when given the remaining two quantities. Figure 2 shows the rate of production in terms of H units at:

a. Twice the present feed rate per column

b. The present feed rate per column

c. One-half the present feed rate per column

Figures 1 and 2 are given in terms of H units of production so that no assumption has been made for the value of H. In both graphs the production rate of S-50 is limited to 3.35 v units, as the diffusion effect is destroyed by the turbulence caused by an excessive flow rate of the feed material.

If the concentration of the waste, C_w, is also required, its values may be found on Alignment chart No. 3.01 from the values of C_p and R. Alignment chart No. 3.02 gives the separation factor, S, in terms of C_p and C_w. Alignment chart No. 3.03 gives the separation factor, S, in terms of C_p and R.

6. The following example illustrates the use of the above mentioned figures and charts:

With C_p = 0.86% and R = 20% it is found from Figure 1 that v = 2.1, that is the production is 2.1 H units. (By alignment chart No. 3.01, C_w = 0.68%)

If the ratio of product to feed ~~were reduced to~~ is still R = 20% but production were cut in half so that v = 1.1, then the concentration of the product could be increased to C_p = 0.892%. (By alignment chart No. 3.01, C_w = 0.67%)

If the ratio of product to feed were reduced to R = 10% and at the same time production were cut in half so that v = 1.1 (this would leave the total amount of feed unaltered), then the product concentration could be increased to C_p = 0.92%. (By alignment chart No. 3.01, C_w = 0.69%)

The above results may be tabulated as follows:

C_p	R	v	C_w
0.86%	20%	2.1	0.68%
0.885%	10%	2.1	0.695%
0.892%	20%	1.1	0.67%
0.92%	10%	1.1	0.69%

/s/ Walter Bartky
WALTER BARTKY