APPENDIX C2. DESIGN OF AN ION EXCHANGE COLUMN

Problem Formulation

Figure C2.1 illustrates the equilibrium data for protein uptake by a cellulose ion exchanger.

Waste water with a protein concentration of 200 mg / l is considered.

The break-point will be considered as the time at which the effluent has a protein concentration of 20 mg / l and the bed will be considered exhausted when the effluent has a protein concentration of 180 mg/l.

$H_t = 0.05$ m

The depth of the ion exchange bed is 0.5 m.

Find Z_a and the saturation in percentage.

Solution

The equilibrium data as indicated above are plotted in Fig. C2.1.. Table C2.1 lists the value of Y on the operating line between Y_B and Y_E, and the corresponding value of Y+.

In Table 7.3 1/(Y-Y+) has been computed. Column 4 in the table is based on Fig. C2.2. and column 5 indicates the corresponding values of $(W-W_B)/W_A$.

By means of column 6, which shows Y/Y_0, Fig. C2.3 is plotted. The total number of transferred units is found in Table C2.1 to be 4.23. It is now possible by use of Fig. C2.3. to find f, as: 0.64.

$$Z_a = N * H_t = 4.23 * 0.05 = 0.21 \text{ m}$$

$$\text{Saturation (\%)} = \left(\frac{Z - (1 - f) Z_a}{Z}\right)100 = \frac{(0.5 - (1 - 0.64) * 0.21)\,100}{0.5} = 85\%$$

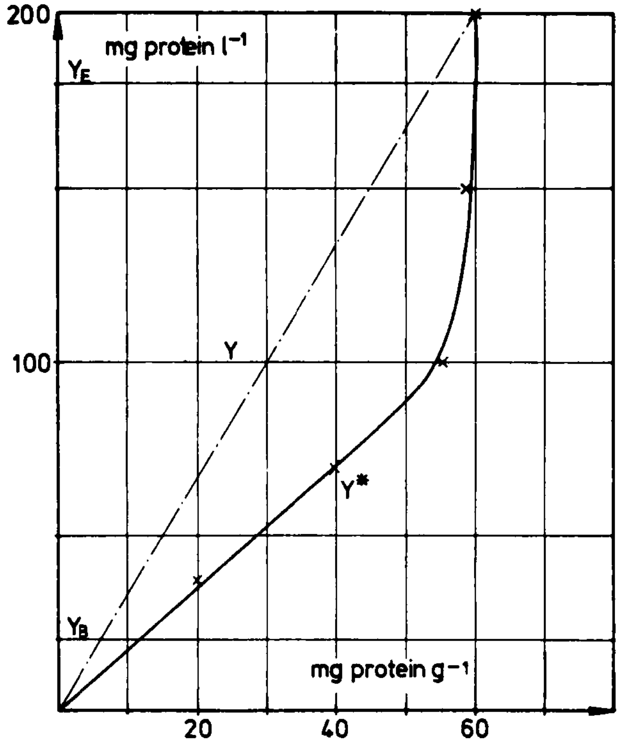

Figure C2.1. Equilibrium line and operation line.

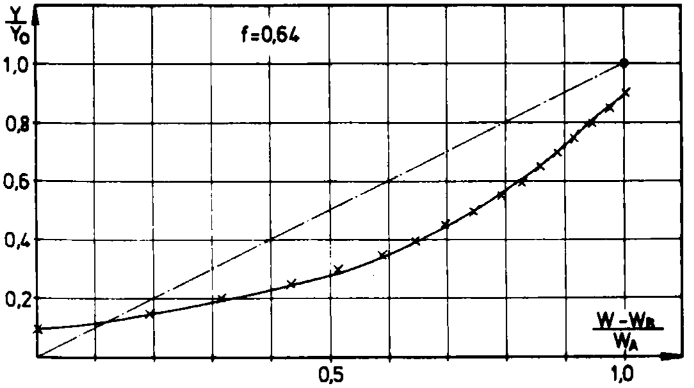

Figure C2.2. (W - WB) / WA = f (Y / Yo). f can be found to 0.64.

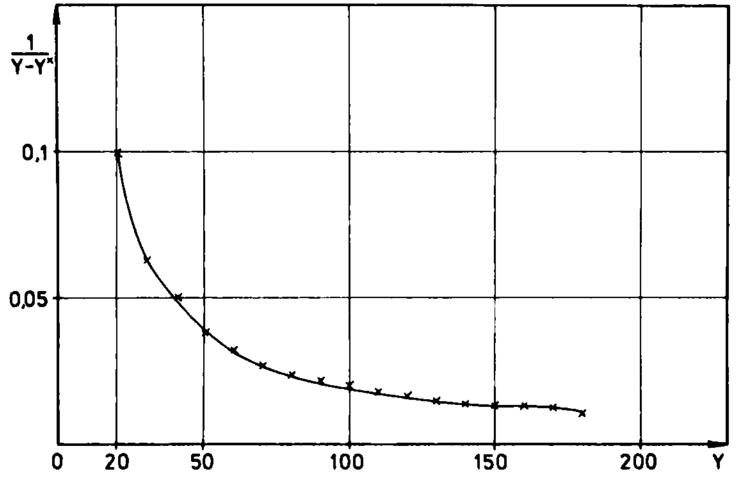

Figure C2.3. $Y = f\left(\dfrac{1}{Y - Yx}\right)$

Table C2.1

Theoretical column calculations

Y	Y^*	$\frac{1}{Y - Y^*}$	$\frac{dY}{Y - Y^*}$	$\frac{W - W_B}{W_A}$	$\frac{Y}{Y_0}$
20	10	0.100	0	0	0.1
30	14	0.063	0.8	0.189	0.15
40	20	0.050	1.35	0.319	0.20
50	24	0.038	1.81	0.428	0.25
60	29	0.032	2.16	0.510	0.30
70	33	0.027	2.47	0.584	0.35
80	39	0.024	2.72	0.643	0.40
90	44	0.022	2.94	0.695	0.45
100	49	0.020	3.14	0.742	0.50
110	53	0.018	3.32	0.785	0.55
120	58	0.016	3.48	0.823	0.60
130	64	0.015	3.63	0.858	0.65
140	68	0.014	3.74	0.884	0.70
150	74	0.013	3.87	0.915	0.75
160	80	0.013	4.00	0.946	0.80
170	85	0.012	4.12	0.974	0.85
180	93	0.010	4.23	1.000	0.90