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APPENDICES

Appendix A

Table A.1

Analysis of Permeate from RO plant

Ca^{++} Hardness (mg/l)	0.63
Mg^{++} Hardness (mg/l)	1.25
Total Hardness (mg/l)	1.88
Phenolphthalene	0
Methyl Orange	0
Chlorine, Cl^-	0
pH	4.2

Table A.2

Analysis of concentrate from RO

Acidity (ppm as $CaCO_3$)	6375
COD (ppm)	4,640,000
pH	4.05
Total sugar (%) g/ml	24.2
Reducing sugar (%)	19.38

Table A.3

Analysis of Concentrate from UF

	%
Moisture	98.98
Fat	trace
Ash	0.1049
Protein	0.155
Crude Fibre	0.037

Table A.4

Analysis of pineapple juice

Acidity (ppm as $CaCO_3$)	2,400
COD (ppm)	900,000
pH	4.05
Total solid (ppm)	69,647.2
Total dissolved solid (ppm)	59,825
Total sugar % (gm/ml)	9.0
Reducing sugar % (gm/ml)	3.46
Turbidity (JTU)	350
Total Nitrogen (ppm)	118.8
Cl^- (ppm)	10,500

Table A.5

Proximate analysis of Hawaiian beverage pineapple juice

Moistrue (by drying)	84.7 %
Protein (N x 6.25)	0.3
Fat (ether extract)	trace
Crude Fiber	0.1
Titratable acidity (as anhydrous citric)	0.6
Ash	0.3
Total carbohydrates ether than crude fiber and acid by difference	14.0
Total sugar as invert	13.9
pH	3.7
Calories (per gm)	0.6
Calories (per ounce)	16.9

Table A.6

Osmotic pressures of aqueous sucrose solution

°Brix	Osmotic Pressure (atm) 0°	20°	40°	60°
1.8	2.46	2.59	2.66	2.72
3.6	4.72	5.06	5.16	5.44
5.4	7.09	7.61	7.84	8.14
7.2	9.44	10.41	10.60	10.87
9.0	11.90	12.75	13.36	13.67
10.8	14.38	15.39	16.15	16.54
12.6	16.89	18.13	18.93	19.40
14.4	19.48	20.91	21.80	22.33
16.2	22.12	23.72	24.74	25.27
18.0	24.83	26.64	27.70	28.37

Appendix B

Sample of Calculation

(1) Calculation of Energy required by Evaporaion ;

At pressure 1 atm. $212^{o}F$ (From ref.)

Latent heat of evaporation of water = 970.3 Btu/lb_m

$\therefore$ The energy required for evaporating 110 kg. of water

= (970.3)(110)(2.205)

= 2.353×10^5 Btu

(2) Calculation of Energy required by Reverse Osmosis ;

E_1 = (Pressure lose)(Volume of permeate)

= (59)(110) = 6,490 litre.Bar

= (6,490)(0.9869) = 6,404.98 litre-atmosphere

= $\frac{(6,404.98)}{(10.409)}$ = 615.33 Btu

E_2 = (Total pressure drop across module)(Total volume)

Total pressure drop across module = (pressure drop per pass) x (no. of pazs)

Flow rate of pump = 720 litre/hr or 12 litre/min.

From graph B.2 , we obtain :

Pressure drop per module per pass = 1.2 kg/cm^2

= (1.2)(0.9807) = 1.18 Bar

No. of pass obtained from graphical integration in graph shows :

$$\text{No. of pass} = \int_{T_o}^{T_f} \frac{F\,dT}{V(T)} = F\int_{T_o}^{T_f} \frac{dT}{V(T)}$$

where ; F : Flow rate of pump (litre/hr)

V : Volume in Feed tank (litre)

T : Time (hr)

∴ No. of pass = (720)(0.101) = 72.72

∴ Total pressure drop across module

= (72.72)(1.18) = 85.81 Bar

E_2 = (85.81)(120) = 10,297.2 litre-Bar

= (10,297.2)(0.9869) = 10,162.31 litre-atm.

$= \frac{(10,162.31)}{(10.409)} = 976.30$ Btu

∴ Total Energy required for Reverse Osmosis :

$= E_1 + E_2 = 615.33$

= 615.33 + 976.30 = 1,591.63 Btu

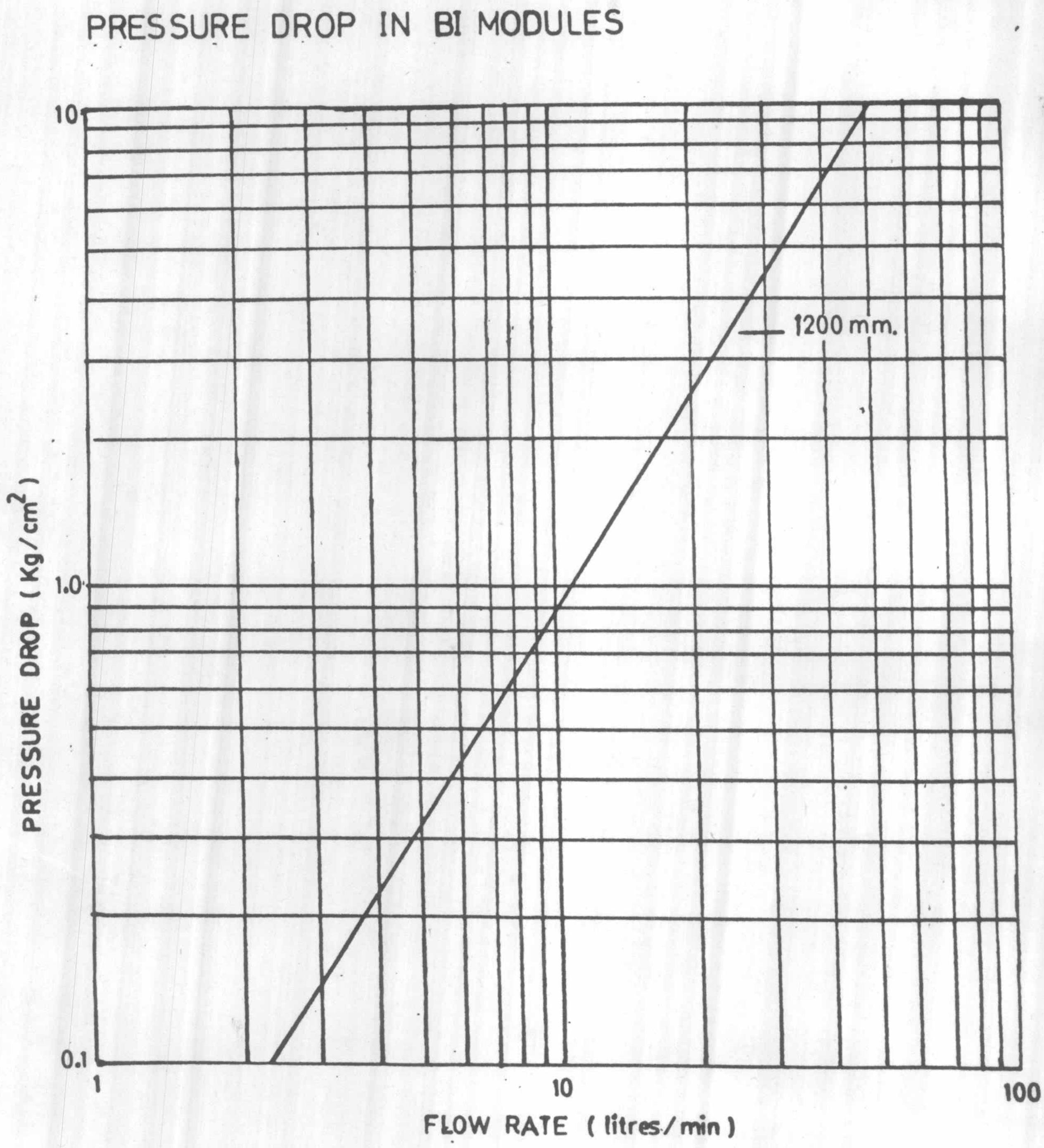

Figure B.1 Flow rate vs Pressure Drop

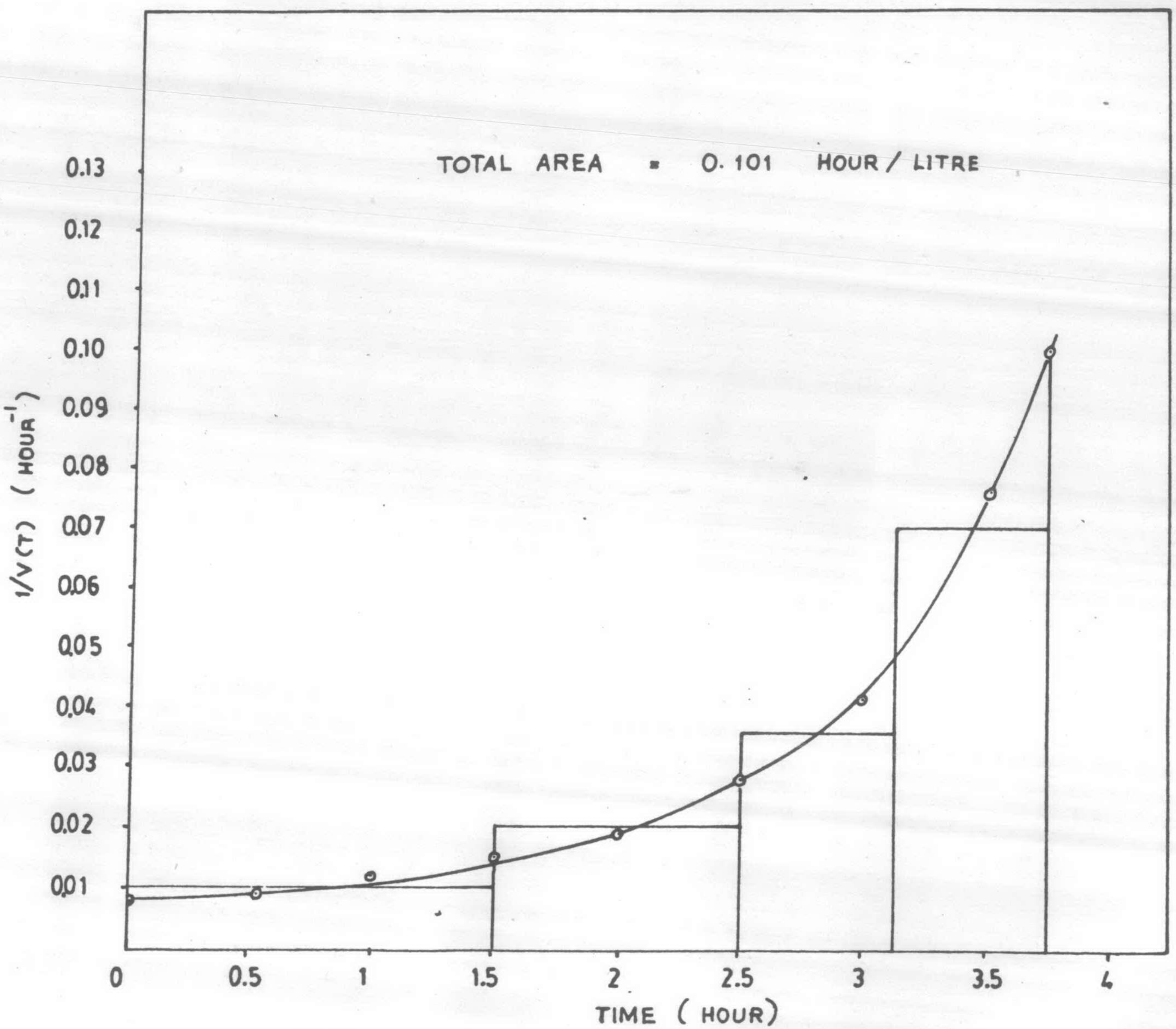

FIGURE B.2 GRAPHICAL INTEGRATION

Appendix C

NOMENCLATURE

A_m = membrane area

C = solute concentration

$C_{b,g,m,p,w}$ = conc. in bulk, gel, membrane, permeate, at wall

d_e = hydraulic diameter

D, D_m = solute diffusivity, in membrane

J_1 = solvent flux

J_2 = solute flux

k = solute mass transfer coefficient

Q_o = vol. feed rate to system

$P_{1,N}$ = permeate flow rate from stage 1, N ect.

ΔP = transmembrane pressure drop

ΔP_c = pressure drop along channel

r = stirred cell radius

$R_{b,m,g}$ = resistance due to boundary layer, membrane, gel

t = time

U = fluid (cross-flow) velocity

V = volume

Δx = concentration boundary layer thickness

x = characteristic length

x_A = fraction of active membrane area (eqn.16)

α = fraction of solvent passing through pores capable of allowidng solute passage

$\dot{\gamma}$ = fluid shear rate

ν = kinematic viscosity

σ = measured rejection coefficient

σ_i = intrinsic rejection coefficient

ω = angular velocity

R_o = Overall resistance

R_f = Fouling resistance

R_d = Dynamic resistance

R_m = Membrane resistance

VITA

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