where $q_o n$ is the rate of oxygen Consumption.

when $C_{AL} = \bar{C}_{AL}$, $\frac{dC_{AL}}{dt} = 0$

↓

final steady state

$$q_o n = K_L A [C_{ALi} - \bar{C}_{AL}]$$

So, $$\frac{dC_{AL}}{dt} = K_L A [\bar{C}_{AL} - C_{AL}]$$

$$K_L A = \frac{\ln\left[\frac{\bar{C}_{AL} - C_{AL1}}{\bar{C}_{AL} - C_{AL2}}\right]}{t_2 - t_1}$$

Chapter 9 Design and Analysis of biological reactors

1. Fed-Batch Reactors:-

$F(t)$ = Volumetric flow rate of entering feed stream at time t.

$C_{if}(t)$ = Conc. of Component i in entering stream.

after Material balance,

$$\frac{d}{dt}\left[V_R \cdot c_i\right] = V_R \cdot \gamma_{f_1} + F(t) \cdot c_{if} \quad \text{--- } 1$$

total mass balance on the reactor

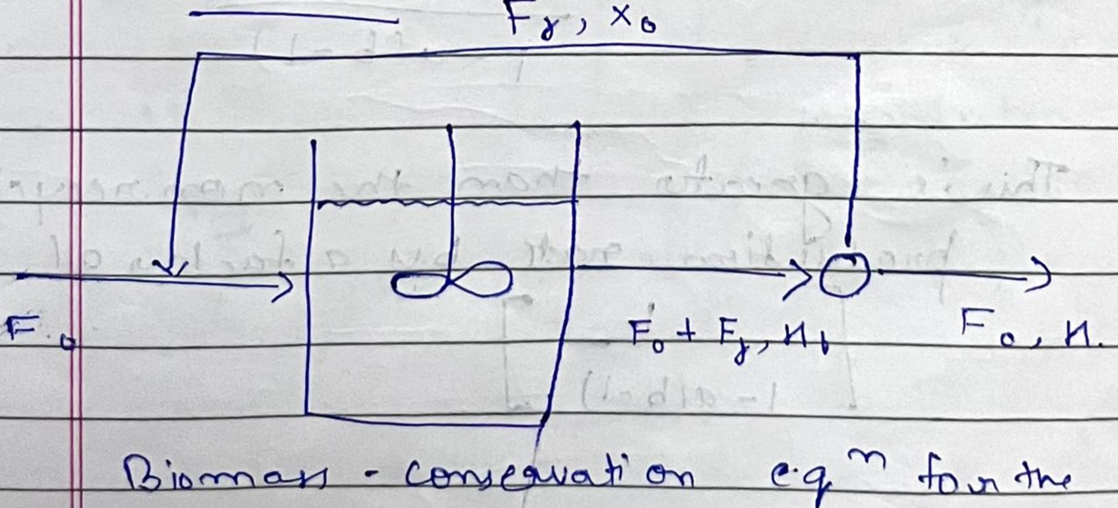
$$\frac{d}{dt}\left[\rho \cdot V_R\right] = \rho \cdot F(t)$$

$$\frac{dV_R}{dt} = F(t) \quad \text{--- } 2$$

from 1 and 2

$$\frac{dc_i}{dt} = \frac{F(t)}{V_R}\left[c_{if} - c_i\right] + \gamma_{fi}$$

2. CSTR



Biomass - conservation eq^n for the recycle system

$$F_\gamma x_0 + \mu x_1 V_R - (F_0 + F_\gamma) x_1 = 0.$$

With $a = \frac{F_r}{F_0}$, $b = \frac{x_0}{x_1}$

$$\Rightarrow \frac{F_r}{F_0} \cdot \frac{x_0}{x_1} + \frac{\mu V_R}{F_0} - \left(1 + \frac{F_r}{F_0}\right) = 0$$

$$\Rightarrow ab + \frac{\mu}{D} = 1 + a$$

$$\Rightarrow \frac{\mu}{D} = 1 + a(1-b)$$

$$\Rightarrow D = \frac{\mu}{1 - a(b-1)}$$

Substrate balance,

$$D[S_0 - S] - \frac{\mu x_1}{Y} = 0$$

$Y \longrightarrow$ yild

$$\Rightarrow \mu x_1 = \frac{\mu Y (S_0 - S)}{1 - a(b-1)}$$

This is greater than the non recycle production rate by a factor of

$$\left[\frac{1}{1 - a(b-1)}\right]$$

⇒ if we assume that cells on the film at the vessel wall have conc. x_f which is constant.

in such situation continous - reactor mass balance takes general form,

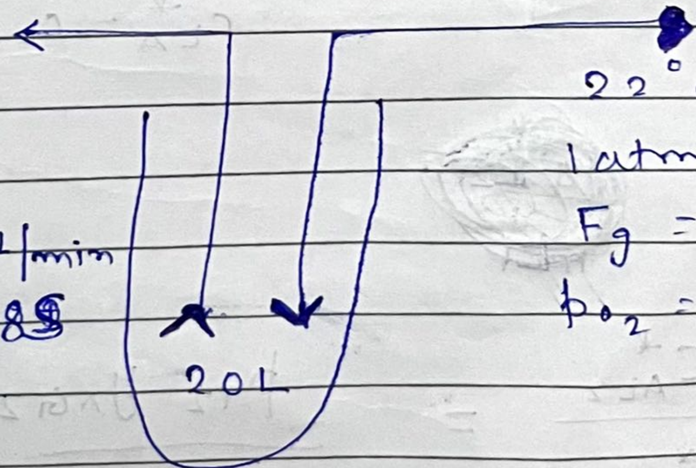
$$Dx = \mu x + \mu_f x_f$$

$$D(S_0 - S) = \frac{1}{Y}\mu x + \frac{1}{Y_f}\mu_f x_f.$$

Y_f → yild factor in the film

μ_f → Specific growth rate in the film.

1. 30°C
150 KPa
$F_g = 8.9$ L/min
$p_{O_2} = 0.2985$ atm



22°C
1 atm
$F_g = 0.23$ L/s
$p_{O_2} = 0.2099$ atm

$R = 0.082$ L atm K^{-1}

$$N_A = \frac{1}{RV_R}\left[\left[\frac{F_g P_{O_2}}{T_{O_2}}\right]_i - \left[\frac{F_g P_{O_2}}{T_{O_2}}\right]_o\right]$$

⇒ if we assume that cells on the film at the vessel wall have conc. x_f which is constant.

in such situation continuous-reactor mass balance takes general form,

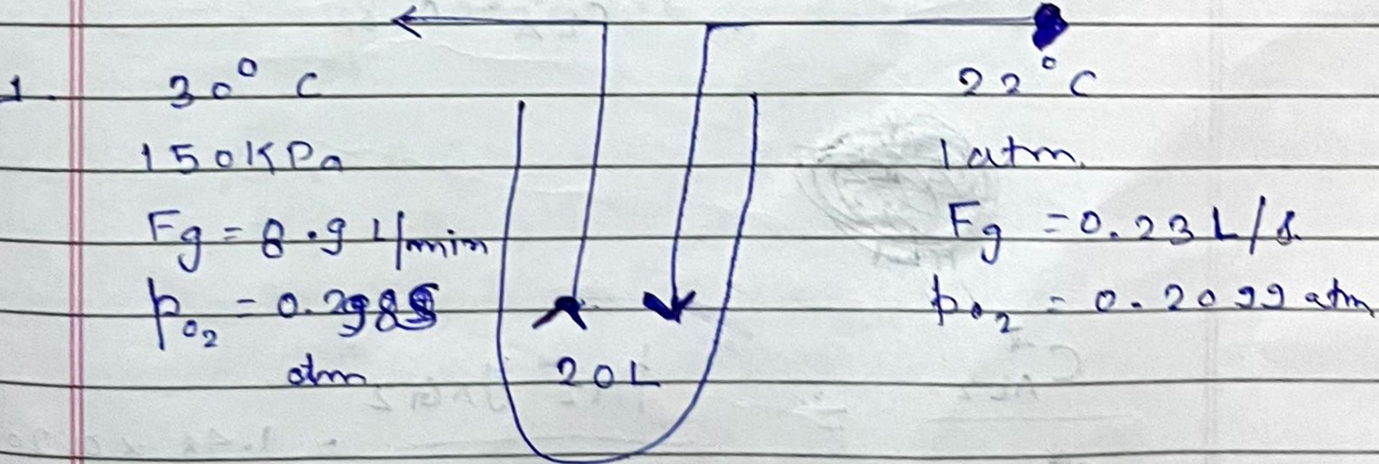
$$Dx = \mu x + \mu_f x_f$$

$$D(S_0 - S) = \frac{1}{Y}\mu x + \frac{1}{Y_f}\mu_f x_f.$$

yield factor in the film

specific growth rate in the film.

1.



$$R = 0.082 \text{ L atm K}^{-1}$$

$$N_A = \frac{1}{RV_R}\left[\left[\frac{F_g p_{O_2}}{T_{O_2}}\right]_i - \left[\frac{F_g p_{O_2}}{T_{O_2}}\right]_o\right]$$

$$N_A = \frac{1}{0.082\times 20}\left[\frac{0.23\times 0.2099}{22+273.15} - \frac{8.9\times 0.2985}{60\times(30+273.15)}\right]$$

$$= \frac{1}{1.64}\left[0.00016356 - 0.00014605\right]$$

$$= \frac{0.00001751}{1.64}$$

$$= \frac{1.751}{1.64}\times 10^{-5}$$

$$N_A = 1.06\times 10^{-5} \ \frac{\text{gmol}}{\text{L sec}}$$

Given,

$$C^*_{AL1} = 8.05\times 10^{-3} \ \text{g/L}$$

$$N_A = K_{LA}\left[C^*_{A2} - C_{LA}\right]$$

$$\Rightarrow K_{LA} = \frac{N_A}{C^*_{LA} - C_{LA}}$$

$$\frac{C^*_{AL2}}{C^*_{AL1}} = \frac{p_{T2}\, y_{AG2}}{p_{T1}\, y_{AG1}} = \frac{1.48\times 0.201}{1\times 0.2099}$$

$$\Rightarrow C^*_{AL2} = 1.4172\times 8.05\times 10^{-3}$$

$$= 0.0114 \ \text{g}l^{-1}$$

$C_{AL} = p_T \, C^*_{AL1}$

$C_{AL} = \frac{0.82 \times 1.48}{1} \times 8.05 \times 10^{-3}$

$= 9.77 \times 10^{-3} \, g \, L^{-1}$

$K_{LA} = \frac{1.06 \times 10^{-5} \times 32}{0.0114 - 9.77 \times 10^{-3} \, g \, L^{-1}}$

$= \frac{1.06 \times 32 \times 10^{-5}}{0.00163}$

$= 0.2 \, s^{-1}$

2. Fed batch operating with intermittent addition of glucose solution, values of the following parameters are given at $t = 2h$, when the system is quasi steady state

$V = 1000 \, mL$, $S_0 = 100 \, g/L$

$F = \frac{dV}{dt} = 200 \, mL/h$, $x_0 = 30 \, g/L$

$\mu_m = 0.3 \, h^{-1}$ $\quad Y_{X/S} = 0.5$ gdw cells/gS

$K_S = 0.1 \, g/L$

a. initial volume of culture

$\therefore \frac{dV}{dt} = 200 \, mL/h$

$\Rightarrow V - V_0 = 200t$

$\Rightarrow V = 1000 - 200 \times 2$

$= 600 \, mL$