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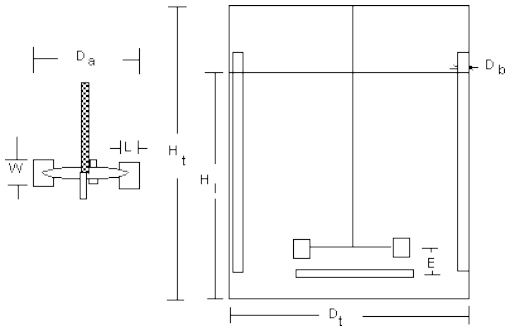
Biochemical Engineering
Exercise Session 2

1) Design aspects of a bioreactor



A stirred tank bioreactor is approximately cylindrical in shape. It has a total volume (V_t) of 100,000 liters. The geometry of the reactor is defined by the following ratios: D_t:H_t=0,5 ; D_a:D_t=0,33 ; D_b:D_t = 0,1

a) Is it an aerated system?
b) Is this type of bioreactor advantageous for mammalian cells?
c) Calculate: D_t, H_t, D_a, D_b

2) Cell concentration in aerobic culture

A strain of *Azotobacter vinelandii* is cultured in a 15m^3 stirred Fermenter for alginate production. Under current operating conditions k_La is 0.17 s^{-1}. Oxygen solubility in the broth is approx. 8 x 10^{-3} kg m^{-3}.

a) The specific rate of oxygen uptake is 12.5 mmol g^{-1} h^{-1}. What is the maximum possible cell concentration?

b) The bacteria suffer growth inhibition after copper sulphate is accidentally added to the fermentation broth. This causes a reduction in oxygen uptake rate to 3 mmol g^{-1} h^{-1}. What maximum cell concentration now be supported by the fermenter?

3) Specific oxygen uptake in *E. coli* culture

It is assumed that the specific oxygen uptake rate (q_{O2}) of *E. coli* is 5.0 mmol g^{-1} h^{-1}.

a) Which cell concentration X can be reached in a laboratory reactor with a k_La of 25 h^{-1} when C_L = 10 % C* and for the medium at 37 °C is C* = 0.17 mmol L^{-1}.

4) Oxygen consumption

Estimate how fast the dissolved oxygen concentration is consumed in a bioreactor with k_La 1000 h^{-1}, containing a 10g L^{-1} culture growing with μ = 0.5 h^{-1} if the aeration is interrupted.

a) Calculate the quasi-steady state oxygen concentration. Assume $Y_{X/O}$=1 g g^{-1} and the oxygen solubility in the medium equilibrium with C^*=7 mg L^{-1}.

b) In what time will the culture become completely anaerobic?

5) Oxygen storage capacity of fermentation broth

With a OTR (=OUR) of growing bacteria of 1 g O_2 $(L \cdot h)^{-1}$ per 1 g L^{-1} cell dry mass and approximately 100 g L^{-1} cell dry mass at the end of the growth phase, an oxygen uptake rate of 100 g $(g\ L)^{-1}$ will develop. The oxygen solubility in the fermentation broth at 28°C is calculated at 7.76 mg L^{-1}.

a) How long will the oxygen supply last?

Note: OUR per 1 g cell dry weight = q_{O2}

6) Calculating saturation concentration

Calculation of the oxygen saturation concentration at different temperatures and partial oxygen pressures using the correlation of Truesdale:

T [°C]	28	37	60	28	37	60
P_{O2} [bar]	0.2121	0.2121	0.2121	1.0133	1.0133	1.0133
$C^*_{O_2}$ [mg L^{-1}]						

7) Oxygen transfer in a sparged stirred tank bioreactor

Which of the following would have the highest oxygen transfer rate characteristics?

a) A sparged stirred tank bioreactor being stirred at 200 rpm
b) A non-sparged stirred tank bioreactor being stirred at 200 rpm
c) A shake flask being mixed at 200 rpm
d) All of the above would have equivalent oxygen transfer rate characteristics