Problem 4.1.

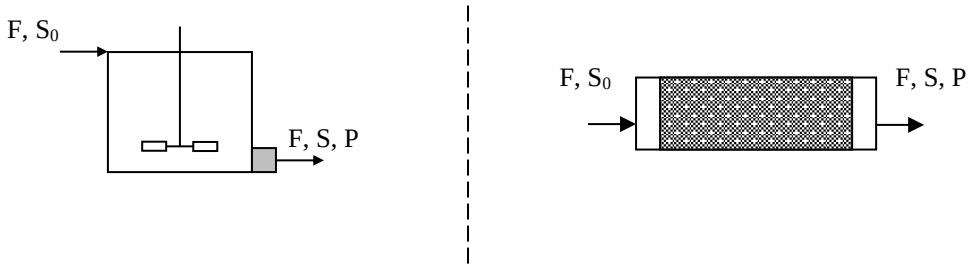
Consider a cell culture with negligible growth ($\mu \approx 0$) characterized by the following biological reaction:

Reaction: $S \xrightarrow{X} P\ (+ X)$

Kinetic: $v_s = \frac{v_{s,max} S}{K_S + S}$

$v_{s,max}$=0.6 g-subs g-cel^{-1} h^{-1}, K_S=0.01 g/L Y'_{sp}=0.2 g-prod/g-subs (negligible maintenance)

Consider the Bioreactors indicated in the figure. In the case of the CSTR, a filter in the output current prevents the Bioreactor from being washed. In the case of PFR, cells are immobilized on a solid support without diffusional limitations for the transport of 'S' and 'P'. In either case the cells are evenly distributed with concentration X=12.1 g/l.



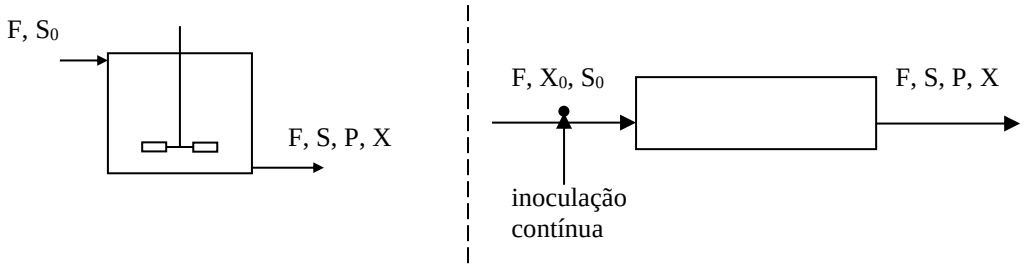
a) Size the Bioreactors indicated in the figure for a productivity of 60 g product/h knowing that the input current has a substrate concentration So=13.2 g/l and that its conversion is 95%. Consider that the substrate is in large excess in each of the reactors and that consequently the kinetics is of order 0.

b) Size the reactors for the same conditions as in point a) considering that the saturation constant is K_s= 25 g/l, S_0=2.5 g/l and X=1.21 g/l.

c) Comment on the results obtained in a) and b)

Problem 4.2.

Consider the following Bioreactors



in which the following biological reaction occurs

Reaction: $S \xrightarrow{X} P + X$

Cinética: $\mu = \frac{\mu_{max} S}{K_S + S}$

μ_{max}=0.3 h^{-1}, K_S=0.01 g/L Y'_{xs}=0.5 g cell/g subs
Y'_{xp}=4.3 g cell/g prod (negligible maintenance)

It is intended to dimension each one of the Bioreactors to treat a stream with S_0=150 g/l and to convert 90% of substrate into product and cells. The size of the reactor must be such that the absolute productivity is 1 kg of product per hour.

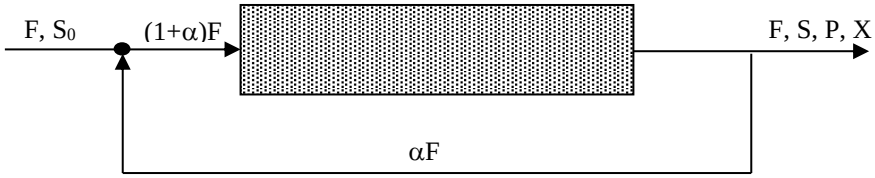
a) Size a CSTR for the specified conditions knowing that the reactor is initially inoculated with 1 g/l of cells after which the process converges to steady state.

b) Size a PFR for the same conditions but with continuous inoculation with X_0= 1 g/l. Compare the result with the one obtained in point a) and comment.

c) Determine the length and diameter of the PFR from point b). Consider that the physical properties of the culture medium are similar to those of water.

Problem 4.3.

Consider a piston Bioreactor with backflow from the outlet to the inlet as indicated in the figure



with α the ratio (reflow flow)/(inflow flow). The input current has S_0=100g/l and the flow through the system is F=10 l/h. The intended conversion is 90% of the input substrate. Consider that the Bioreactor is always operated with a large excess of substrate so $\mu=\mu max=0.3\ h^{-1}$. The yields are Y'x/s=0.5 and Y'x/p=7.1 (negligible maintenance).

a) Calculate the concentrations of S, P and X at the exit of the system.

b) If you choose α =0.1, what volume is needed to achieve the desired conversion?

c) If you choose α =2 what volume is needed to achieve the desired conversion?

d) Compare and comment on the results of b) and c)