Načini obratovanja bioreaktorjev

Kontinuirni bioproces

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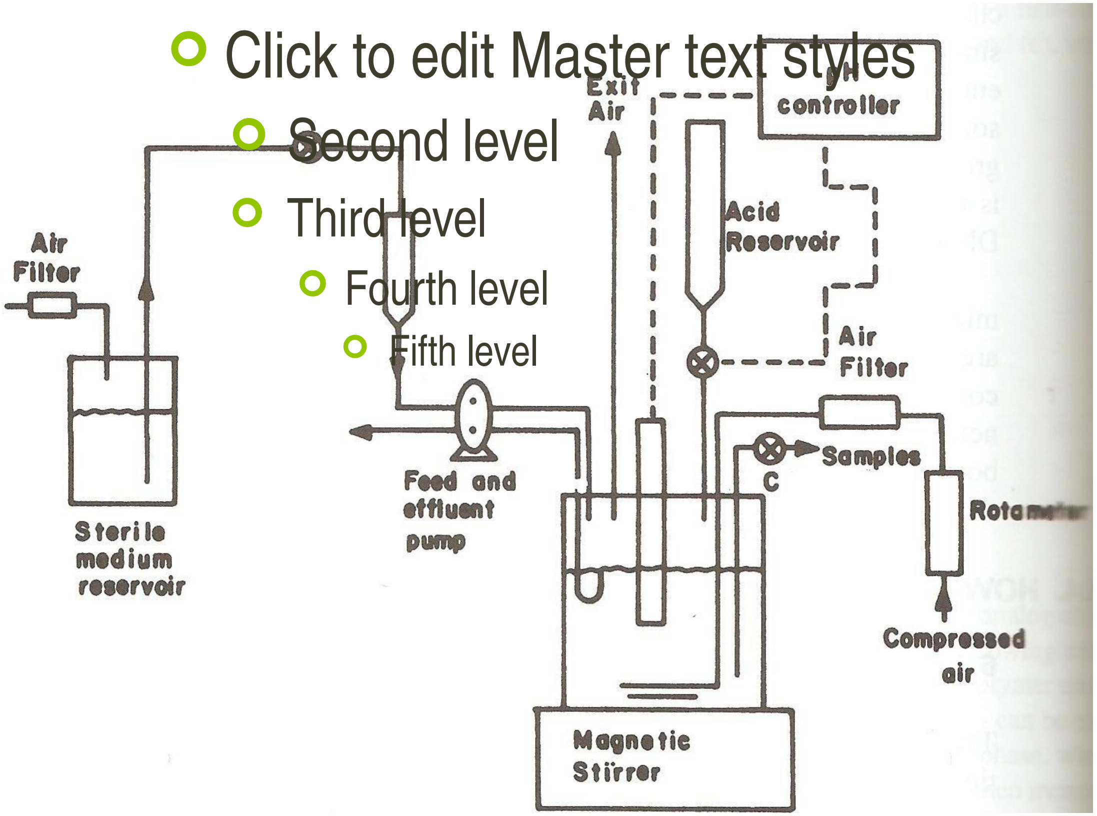


Tipi kontinuirnih obratovanj

Glede na metodo nadzora:

- • Kemostat - reguliran na osnovi nadzora koncentracije limitnega hranila
- • Turbidostat - reguliran na osnovi nadzora biomase z uporabo optične gostote (fotoelektrična celica)
- • Biostat - reguliran na osnovi sistema za nadzor biomase, ki ne temelji na optični gostoti (npr. proizvodnja CO_2)

Uporaba kontinuirnih procesov

- **Industrija**
- Biološke čistilne naprave
- Proizvodnja „single-cell“ proteinov
- Kontinuirna proizvodnja piva
- Kontinuirna proizvodnja amino kislin
- Kontinuirna proizvodnja organskih kislin
- Kontinuirna proizvodnja etanola

Uporaba kontinuirnih procesov

- **Raziskave**
- Fiziološke in biokemijske študije za nadzor hitrosti rasti
  - Vpliv dejavnikov okolja/ procesnih parametrov na rast in tvorbo produkta

    Indukcija, represija, hitrost rasti, vpliv temperature, pH itd.

- Mikrobna ekologija
  - Izbor populacij, ki rastejo počasi
  - Interakcije žrtev-plenilec
  - Kompetitivnost (npr. plasmidi +/-)

- Kinetične študije

  Izračun rastnih konstant, podatki o fermentacijah

Snovne bilance – kontinuirni proces

- za biomaso (X):

$$\frac{dX}{dt} = \mu X - \frac{FX}{V} = \mu X - DX$$

- za substrat (S):

$$\frac{dS}{dt} = \frac{F S_V}{V} + r_S - \frac{FS}{V} = D(S_V - S) + r_S$$

- za produkt (P):

$$\frac{dP}{dt} = r_P - \frac{FP}{V} = r_P - DP$$

Kemostat

- Stacionarno stanje
- Biomasa:

$$0 = \mu X - D X$$

$$\mu = D$$

- Substrat:

$$0 = D(S_V - S) + r_S$$

$$X = Y_{X/S}(S_V - S)$$

$$S = \frac{\mu K_s}{\mu_{max} - \mu}$$

$$S = \frac{D K_s}{\mu_{max} - D}$$

Kemostat – tvorba produkta

$$D\left(P_F - P\right) + Y_{P/X} \cdot \mu \cdot X = 0$$

Če je PF =0

$$P = \frac{Y_{P/X}\,\mu X}{D}$$

Uporaba kontinuirnih procesov

$$V_R \cdot \frac{dS}{dt} = F \cdot S_F - F \cdot S - V_R \cdot \mu_g \cdot X \cdot \frac{1}{Y^M_{x/S}} - V_R \cdot q_P \cdot X \cdot \frac{1}{Y_{P/S}}$$

$Y^M_{x/S}$ ...maksimalni izkoristek X/S

Če ni tvorbe produkta + stacionarno stanje:

$$D \cdot (S_F - S) = \mu_g \cdot X \cdot \frac{1}{Y^M_{x/S}}$$

$$D = \mu_g - k_d = \mu$$

$$D \cdot (S_F - S) - (D + k_d) \cdot X \cdot \frac{1}{Y^M_{X/S}} = 0 \quad / : X$$

$$D\left(\frac{S_F - S}{X}\right) - \frac{D}{Y^M_{X/S}} - \frac{k_d}{Y^M_{X/S}} = 0 \quad / : D$$

$$\frac{1}{Y^{AP}_{X/S}} = \frac{1}{Y^M_{X/S}} + \frac{k_d}{Y^M_{X/S} \cdot D} = \frac{1}{Y^M_{X/S}} + \frac{m_S}{D}$$

$$m_S = \frac{k_d}{Y^M_{X/S}}$$

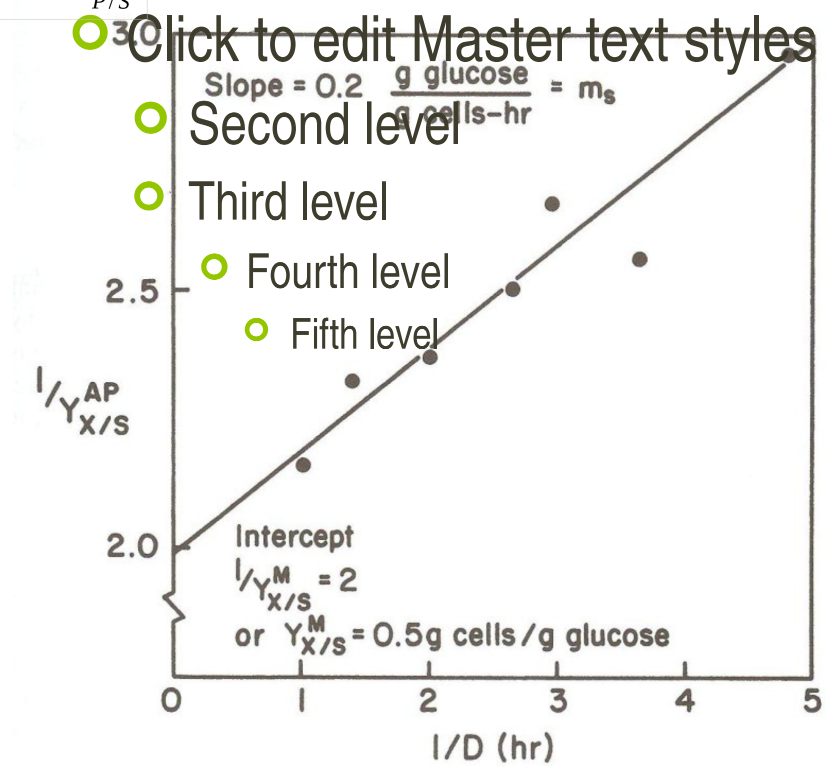
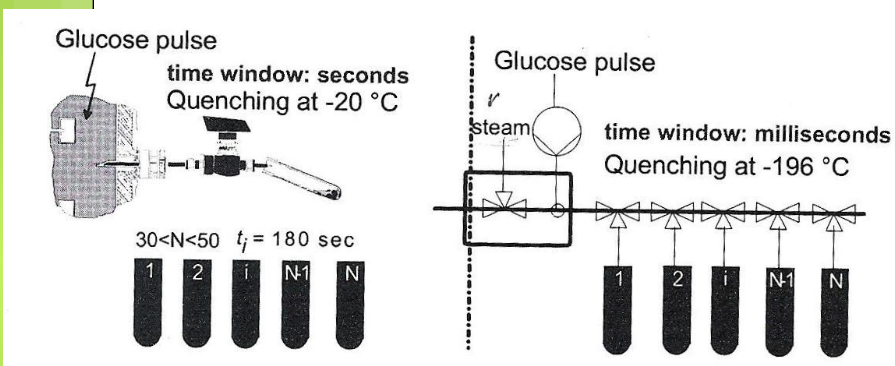


Figure 6.19. Graphical approach to estimating $Y^M_{X/S}$ and m_s for chemostat data for *E. coli* growing on glucose as the limiting nutrient.

Uporaba kontinuirnih procesov



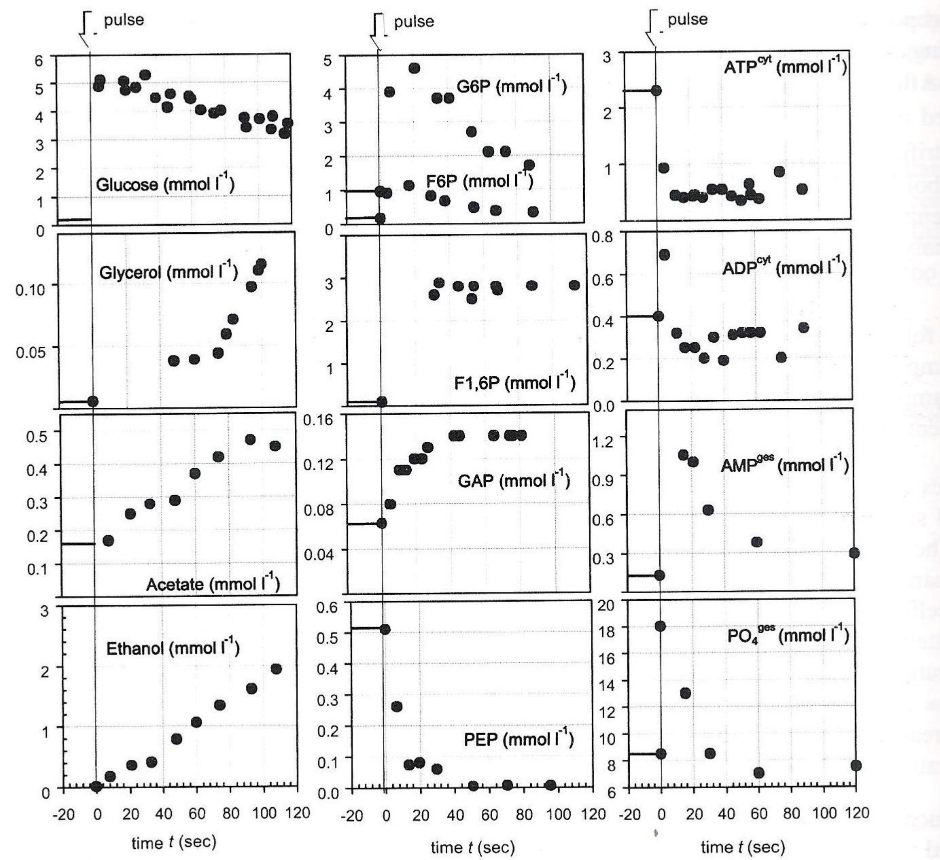
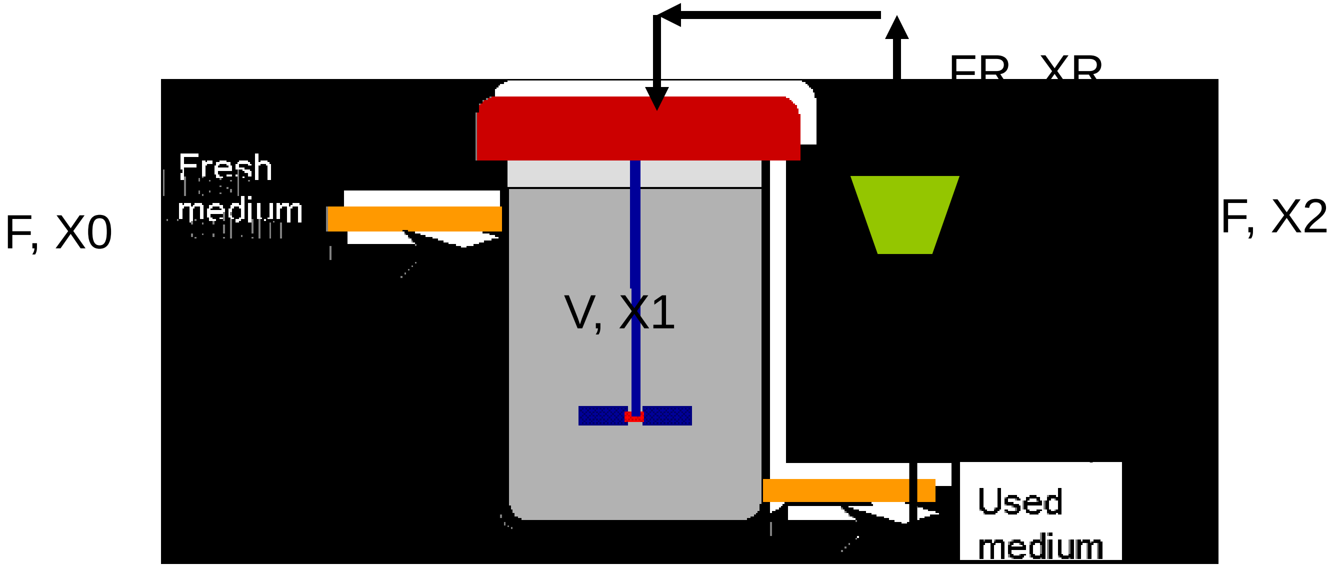


Figure 4. Changes in the concentration of extracellular products and substrates (lef side), intracellular metabolites (middle) and intracellular co-metabolites (right hand sid a glucose pulse at t=0 sec.

Kemostat z reciklom celic



F – pretok napajalne raztopine

V – volumen reaktorja

X1 – koncentracija biomase v reaktorju

X2 - koncentracija biomase v iztoku

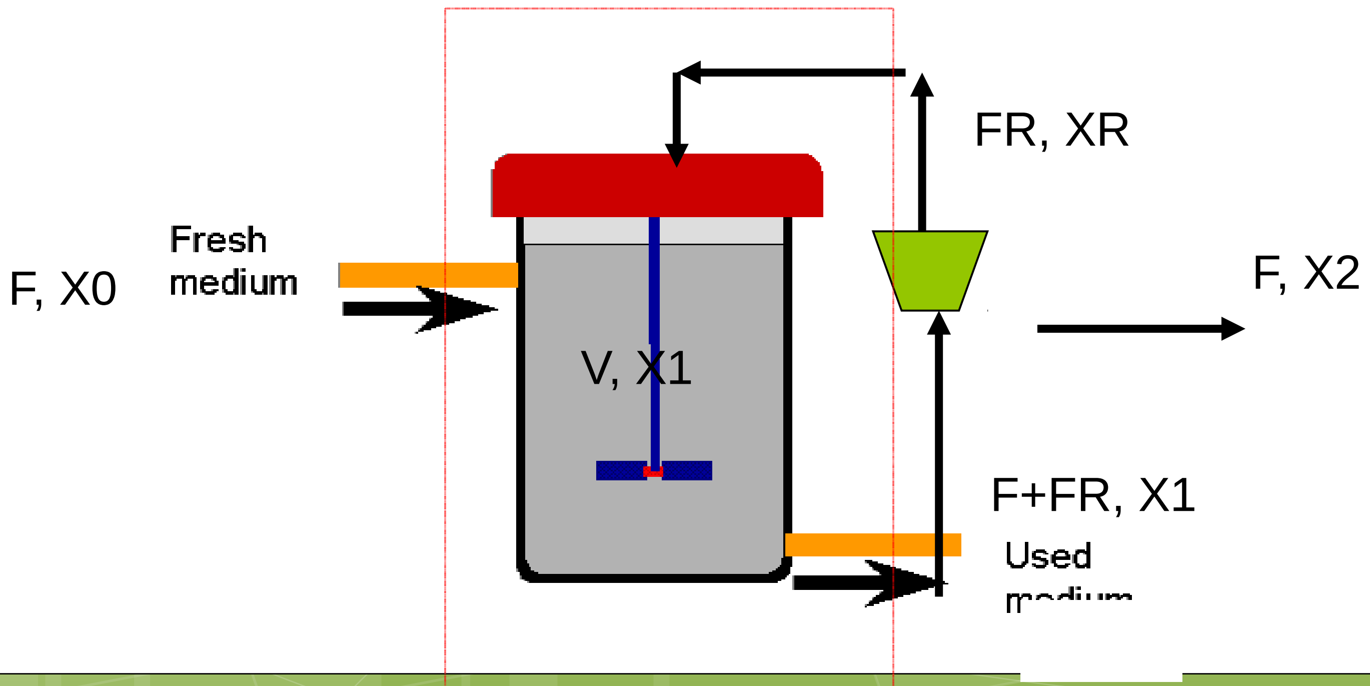
XR - koncentracija biomase v reciklu

FR – pretok recikla

Kemostat z reciklom celic

Snovna bilanca za biomaso:

$$F X0 + FR XR - (F + FR) X1 + V\mu X1 \frac{dX}{dt} V$$



Kemostat z reciklom celic

Definicije

$\alpha = FR/F$

$C = XR / X1$

Izpeljava

- $F + FR = (1 + \alpha)F$
- FRXR   len

  $FR = F\alpha$

  $XR = CX1$

  $FRXR = \alpha CFX1$

$$F\,X0 + FR\,XR - (F + FR)\,X1 + V\mu X1 = \frac{dX_1}{dt}\,V$$

$$F\,X0 + \alpha CFX1 - (1 + \alpha)F\,X1 + V\mu X1 = \frac{dX_1}{dt}\,V$$

Kemostat z reciklom celic

- Predpostavke
  - Stacionarno stanje: $\frac{dX_1}{dt} = 0$
  - Sterilni vtok: X0 = 0

$(\alpha C - 1 - \alpha)F + V\mu = 0$

e je D = F/V, velja za recikel:

$\mu = D(1 + \alpha(1 - C))$

e je C > 1 (konc. celic), potem je $\alpha(1 - C) < 0$

in je $\mu < D$

Kemostat z reciklom lahko deluje pri D > μmax

Bilanca za substrat- Recikel

$$FS_0 + \alpha FS - V\frac{\mu X_1}{Y_{X/S}} - (1+\alpha)FS = V\frac{dS}{dt}$$

- V stacionarnem stanju in menjavi D za μ:

$$X_1 = \frac{D}{\mu} Y_{X/S}(S_0 - S) = \frac{Y_{X/S}(S_0 - S)}{(1+\alpha-\alpha C)}$$

Bilanca za substrat- Recikel

- Upoštevamo kinetiko Monoda

$$S = \frac{K_S D(1+\alpha-\alpha C)}{\mu_{\max} - D(1+\alpha-\alpha C)}$$

$$X_1 = \frac{Y_{X/S}}{(1+\alpha-\alpha C)}\left[S_0 - \frac{K_S D(1+\alpha-\alpha C)}{\mu_{\max} - D(1+\alpha-\alpha C)}\right]$$

Šaržni proces z dohranjevanjem

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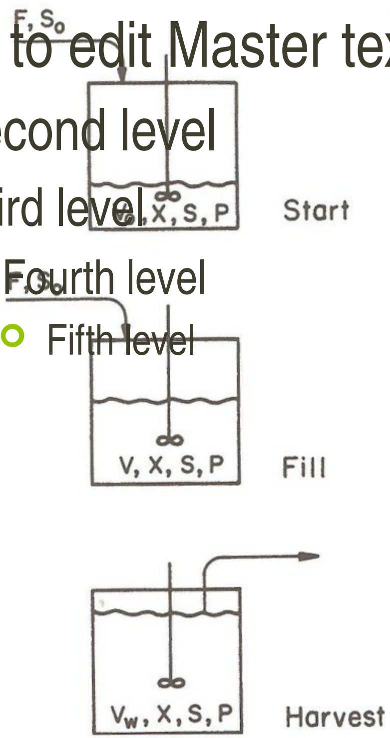

$$\frac{d(CV)}{dt} = V\frac{dC}{dt} + C\frac{dV}{dt} = V\frac{dC}{dt} + CF_V(t)$$

$$\frac{F_V(t)}{V(t)} = D$$

$$\frac{d(XV)}{dt} = \mu X V$$

$$\frac{d(SV)}{dt} = F\,SV + rs\,V$$

$$\frac{d(PV)}{dt} = rp\,V$$