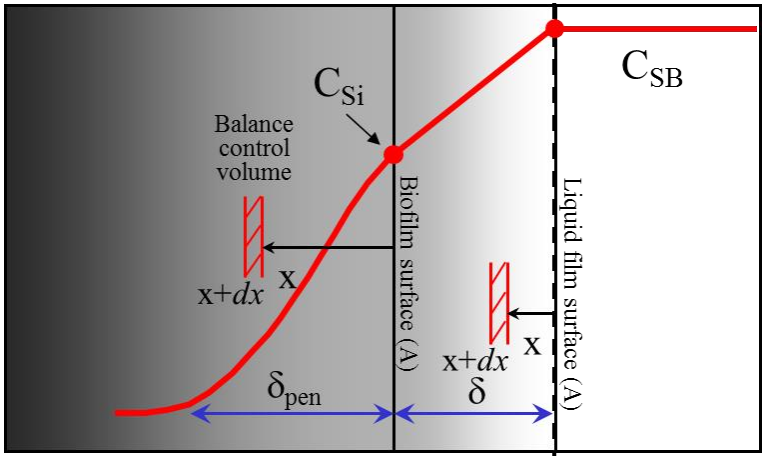
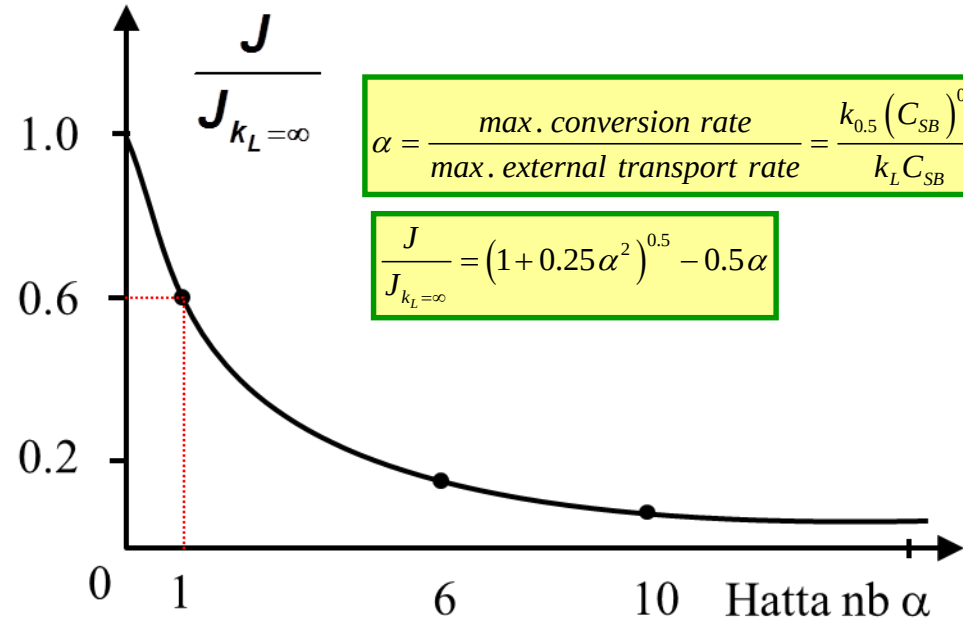
Mass transport processes in biofilms
Diffusive transport / Reaction

$$J_S = k_L (C_{SB} - C_{Si})$$

$$C_{S(x)} = \frac{C_{Si} - C_{SB}}{\delta}.x + C_{SB}$$

Boundary layer
Transport only
st.st. 10^{-1}sec





$$\alpha = \frac{max.\ conversion\ rate}{max.\ external\ transport\ rate} = \frac{k_{0.5}\left(C_{SB}\right)^{0.5}}{k_L C_{SB}}$$

$$\frac{J}{J_{k_L=\infty}} = \left(1 + 0.25\alpha^2\right)^{0.5} - 0.5\alpha$$

Biofilm Transport & Conversion
st.st. 10^{+1}sec

For Hatta number α > 1 → External mass transfer limitation is serious.

$$D.\frac{\partial^2 C_{(x)}}{\partial x^2} = q_S^{max} C_{xf}$$

$$\delta_{pen} = \left(\frac{2DC_{si}}{q_S^{max} C_{xf}}\right)^{0.5}$$

$$J_S = k_{0.5}.\left(C_{Si}\right)^{0.5} \quad with \quad k_{0.5} \overset{def}{=} \left(2.D.q_S^{max}.C_{Xf}\right)^{0.5}$$

$$J_S = \left(\frac{0.25\,k_{0.5}^4}{k_L^2} + k_{0.5}^2 C_{SB}\right)^{0.5} - 0.5\frac{k_{0.5}^2}{k_L}$$

$$C_{Si} - C_{S(x)} = \frac{q_S^{max} C_{xf} \delta_{pen}^2}{D} \cdot \left[\frac{x}{\delta_{pen}} - \frac{1}{2}\left(\frac{x}{\delta_{pen}}\right)^2\right]$$

k_L very small → External boundary layer transport limitation $C_{Si} \approx 0$
→ $J = k_L C_{SB}$

k_L very big → Mainly biofilm diffusion limitation $C_{Si} \approx C_{SB}$
→ $\mathbf{J = k_{0.5} C_{SB}^{0.5} = J_{KL=\infty}}$