Immobilized Enzyme on a (CSTR) Reactor Surface with Product Inhibition --- Vary F, solve 1 eqn.
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Operating parameters:

$F := 0\cdot cm^3\cdot sec^{-1}, 0.5\cdot cm^3\cdot sec^{-1} .. 10\cdot cm^3\cdot sec^{-1}$ ... volumetric flow rate

$A := 100\cdot cm^2$ ... surface area of immobilized enzyme

$s_f := 10\cdot g\cdot liter^{-1}$ ... feed substrate concentration

$k_L := 0.01\cdot cm\cdot sec^{-1}$ ... mass transfer coefficient

Reaction rate parameters:

$v_m := 0.0001\cdot g\cdot sec^{-1}\cdot cm^{-2}$ ... maximum reaction rate

$K_m := 1\cdot g\cdot liter^{-1}$ ... Michaelis-Menten constant

$K_p := 1$ ... product inhibition constant

Non-dimensionalized equations to be solved:

$K := \frac{K_m}{s_f}$ $\beta(F) := \frac{F\cdot s_f}{v_m\cdot A}$ $\Gamma(F) := \frac{F}{k_L\cdot A}$ $\alpha(F) := \frac{\beta(F)}{1+\Gamma(F)}$

$f(x,F) := \alpha(F)\cdot(1-x) - \frac{x}{K + K_p + \left(1-K_p\right)\cdot x}$ = 0

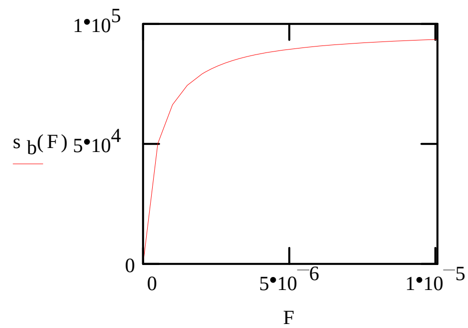
Solution:

$x := 1$ ... provide initial guess

$x(F) := \mathrm{root}(f(x,F),x)$ ... find the solution

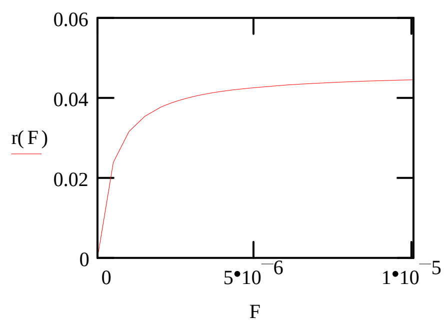
Substrate concentration in the bulk or reactor exit

$$s_b(F) := \frac{\Gamma(F)\cdot s_f + x(F)\cdot s_f}{1 + \Gamma(F)}$$



Rate of conversion (productivity)

$$r(F) := F\cdot\left(s_f - s_b(F)\right)$$

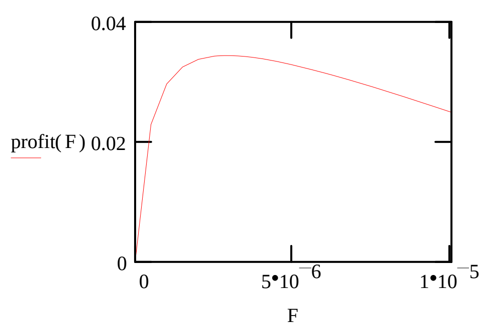


Profitability

$relative\_price := 0.02$ ... (substrate price)/(product price)

$material\_cost(F) := relative\_price\cdot F\cdot s_f$

$profit(F) := r(F) - material\_cost(F)$



In practice, there usually exists an optimal operating point where profit is maximized.