

Homework 8

Problem 1: Phase Plane Analysis in MATLAB

Write your own code for performing phase plane analysis. Hand in the code.

Problem 2: Reactor Model

The model describes a reactor where A is converted to B. The mathematical description of the model consists of two differential equations, which represent the dynamic component (C_A) as well as temperature (T) balance:

$$\frac{dC_A}{dt} = \frac{q}{V} (C_{A,f} - C_A) - k_0 \exp\left(-\frac{E}{RT}\right) C_A \quad (1)$$

$$\frac{dT}{dt} = \frac{q}{V} (T_F - T) - \frac{\Delta H}{\rho C_p} k_0 \exp\left(-\frac{E}{RT}\right) C_A + \frac{UA}{V\rho C_p} (T_c - T) \quad (2)$$

The parameters for the process as well as the nominal operating conditions are given in the following table:

Variable	Value	Variable	Value
q	$0.1667\text{E-}2 \text{ m}^3 \text{ s}^{-1}$	E/R	8750 K
$C_{A,f}$	1000 mol m^{-3}	k_0	$1.2 \text{ E}9 \text{ s}^{-1}$
T_f	350 K	UA	$8.333\text{E}2 \text{ J (s K)}^{-1}$
V	0.1 m^3	$T_c^{nominal}$	300 K
ρ	1000 kg m^{-3}	$C_A^{nominal}$	$??? \text{ mol m}^{-3}$
C_p	$239 \text{ J (kg K)}^{-1}$	$T^{nominal}$	$??? \text{ K}$
ΔH	$-5\text{E}4 \text{ J mol}^{-1}$		

- For the nominal value of the input, $T_c^{nominal}$, determine the equilibrium point(s) of the system.
- Simulate the system for slight perturbations around the equilibrium points (by choosing initial conditions which are slightly different from the equilibrium points). Plot a few representative cases (if possible combine several simulations in the same plot).
- Perform phase plane analysis of the system. Make sure that your analysis includes the equilibrium points.

Problem 3: Phase Plane Analysis

For each of the following systems:

1) Mathematically determine the equilibrium points.

2) Plot the phase plane to include some of the equilibrium points.

a) $\frac{d^2x}{dt^2} + (x^2 - 1)\frac{dx}{dt} + x = 0$, with $x_1 = x$, $x_2 = dx/dt$

b) $\frac{dx}{dt} = \sin(x + y)$
 $\frac{dy}{dt} = \cos(xy)$