Project 4

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Design of controller for CSTR

Date : April 10th 2006, Due date : April 28th 2006

Objective

The purpose of this project is to set up a dynamic simulator for a chemical reactor and to design and tune a control system.

Compile a comprehensive report and analyze your finding in detail. The report will be graded for contents and organization. Include your abstract, outline, methods, graphs, tables, conclusions and reference in your report.

Reactor with Fast Heat Transfer

Consider the continuously stirred tank reactor (CSTR) with heating coil. Reactant A is fed at a flow rate F_A, molar concentration C_{A0}, and temperature T_A to the reactor, where the irreversible exothermic reaction A->B occurs.

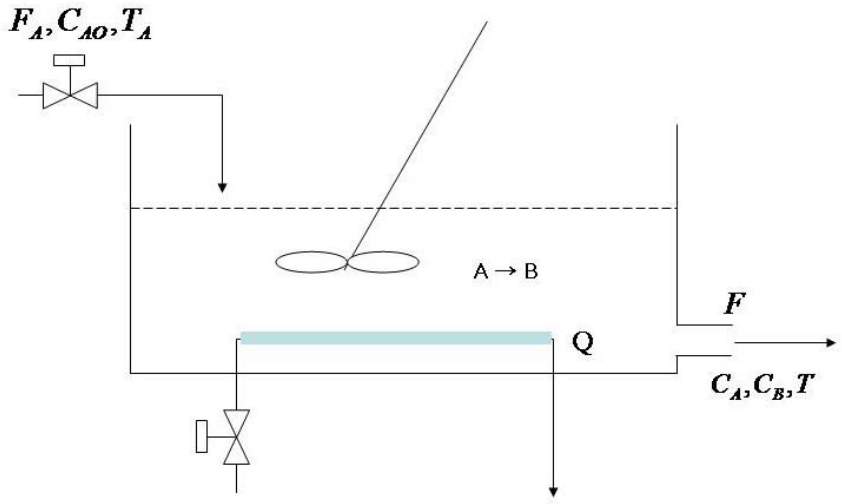

Fig 1 CSTR open loop

The rate of reaction is,

$$R_A = k_o \, \mathrm{e}^{-\frac{E}{RT}} C_A \qquad \textbf{(1)}$$

Where C_A is the molar concentration of A and T is the reactor temperature. The product stream is withdrawn at a flow F and heat is provided to the reactor through the coil. The detail model of process is

given by the following ODE system.

$$\frac{dC_A}{dt} = \frac{F_A}{V}\left(C_{A0} - C_A\right) - k_o e^{-E/RT} C_A \quad \textbf{(2)}$$

$$\frac{dC_B}{dt} = -\frac{F_A}{V} C_B + k_o e^{-E/RT} C_A \quad \textbf{(3)}$$

$$\frac{dT}{dt} = \frac{F_A}{V}\left(T_A - T\right) - k_o e^{-E/RT} C_A \frac{\Delta H}{\rho c_p} + Q \quad \textbf{(4)}$$

The description of variables and nominal values are in Table 1.

Variable	Description	Nominal value
C_{A0}	Feed reactant concentration	**10.0 (*mol/l)***
C_A	Reactant concentration in reactor	---
C_B	Product concentration in reactor	----
c_P	Specific heat capacity	6.0 (J/gK)
E	Activation energy	50000(J/mol K)
F_A	Inflow rate into reactor	3.0 (l/min)
k_o	Pre-exponential factor in reaction rate	1.0*10^9 (l/mol min)
T_A	Feed reactant temperature	250 (K)
T	Reactor temperature	---
V	Reactor volume	10.0 (l)
ρ	Liquid density	600 (g/l)
ΔH_r	Heat of reaction	-200 (J/mol)
Q	Heat input	10(J/mol)

Table 1 Nominal values of variables for CSTR

Task 1 Steady state value and dynamic model

Solve ODE systems (2),(3),(4) numerically and plot the graph ,t vs C_A, C_B, T. What are values of C_A, C_B, T when it goes to steady-state? Set up dynamic simulations and create realistic loop scenarios to characteristic the dynamics of system.

Task 2 Loop 1-Concentration control

We want to keep concentration of C_B at set point using the feedback control system. Manipulated variable is $C_{Ao.}$ The values of Set pints are in the appendix. Discuss performance of set up point tracking and disturbance rejection.

Task 3 Loop2 -Temperature control

In this time, we want to keep temperature of reactor at some set point by manipulating Q. The values of

Set up points are in the appendix. Discuss results like Task 2

Task 4 **Multiple inputs and multiple outputs system**

Switch both loops on and execute system. Discuss dynamics of multiple reactor control system..

Appendix

Group	Set point for product concentration B	Set point for Reactor temperature
A	**7**	**300**
B	**7.5**	**255**
C	**8**	**260**
D	**8.5**	**265**
E	**9**	**270**
F	**9.5**	**275**
G	**5**	**280**
H	**5.5**	**285**
I	**6**	**290**
J	**6.5**	**295**