CAPE Laboratory

Assignment - 5

1. Stiff ODE

Solve the following system of Ordinary Differential Equations (van der Pol ODE) using both ode45 and ode15s.

$$dy_1/dt = y_2$$
$$dy_2/dt = 1000(1-y_1^2)y_2 - y_1$$

$y_1(0) = 2$
$y_2(0) = 0$
$tspan = [0, 3000]$

(a) Comment on the efficiency of `ode45` and `ode15s` in solving this system.
(b) Plot y_1 and y_2 as a function of time.

2. Modelling and Simulation of a Binary Distillation Column

Consider the binary distillation column as shown in the figure. Liquid hold-up at each tray is constant and assume constant molar overflow in the column. The following data are given.

Nomenclature: Consider Condenser as Tray-1, Reboiler as Tray-10

Number of trays = 10, Relative volatility (α) is constant

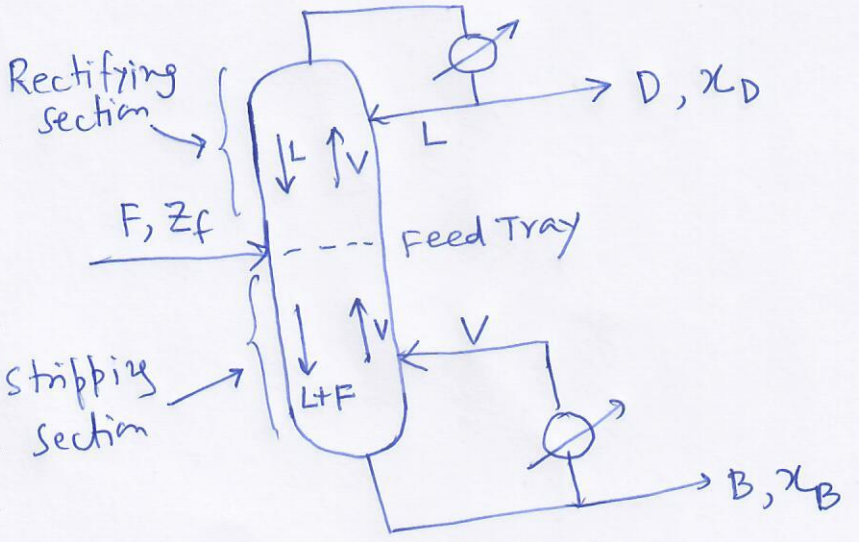
F = 50 mol/s, D = 25 mol/s, z_f = 0.5, V = 60 mol/s

Hold-up: For tray, M = 400 mol, Condenser, M_C = 4000 mol, Reboiler, M_R = 4000 mol

Initial condition: Compositions in all trays, x_f = 0.5

(a) Solve the dynamic equations to find steady state compositions when feed enters at Tray-4, Tray-5, and Tray-6. Assume α = 2.5

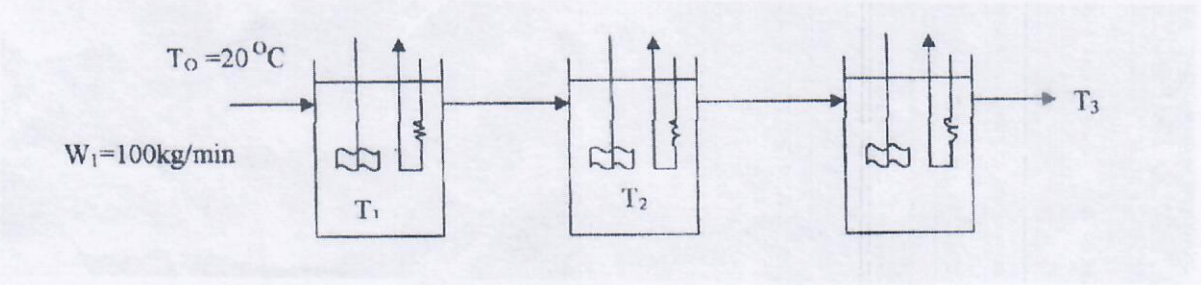
(b) Consider feed enters at Tray-5. Find the steady state compositions at each tray for α = 1.5, 3, and 4. Explain the effect of magnitude of relative volatility on separation.



$$y_i = \frac{\alpha x_i}{1+(\alpha-1)x_i}$$

3) **Dynamic Simulation of stirred tank heater**

There are three stirred tanks with internal heating arrangement connected in series. Each tank is initially filled with 100kg of oil at 50°C. Saturated steam at 250°C condenses inside heating coil immersed in each tank. The oil fed into first tank at the rate of 1 OOkg/min and overflows into 2nd and 3rd tank at same flow rate. The temperature of oil fed to first tank is 20 °c. The CP of the oil is 2KJ/kg^{0}c. For each tank, rate of heat transfer may be assumed as UA= 10 K.J/min°c.



a. Develop the dynamic model equations.

b. Determine the steady state temperature in all 3 tanks.

c. What time interval will be required for T3 to reach 99% of steady state value during start up?

d. Show the "step response" of all the temperature till the new steady state, if the T_0 is suddenly increased by 50% from its original value.

2+3+2+3=10