8. BINARY BATCH DISTILLATION

8.1 Numerical Methods

Solution of a system of equations comprised of ordinary differential equations and nonlinear algebraic equations.

8.2 Concepts Utilized

Batch distillation of an ideal binary mixture.

8.3 Course Useage

Separation Processes.

8.4 Problem Statement

For a binary batch distillation process involving two components designated 1 and 2, the moles of liquid remaining, L, as a function of the mole fraction of the component 2, x_2, can be expressed by the following equation

$$\frac{dL}{dx_2} = \frac{L}{x_2(k_2 - 1)} \tag{27}$$

where k_2 is the vapor liquid equilibrium ratio for component 2. If the system may be considered ideal, the vapor liquid equilibrium ratio can be calculated from $k_i = P_i / P$ where P_i is the vapor pressure of component i and P is the total pressure.

A common vapor pressure model is the Antoine equation which utilizes three parameters A, B, and C for component i as given below where T is the temperature in °C.

$$P_i = 10^{\left(A - \frac{B}{T + C}\right)} \tag{28}$$

The temperature in the batch still follow the bubble point curve. The bubble point temperature is defined by the implicit algebraic equation which can be written using the vapor liquid equilibrium ratios as

$$k_1 x_1 + k_2 x_2 = 1 \tag{29}$$

Consider a binary mixture of benzene (component 1) and toluene (component 2) which is to be considered as ideal. The Antoine equation constants for benzene are A_1 = 6.90565, B_1 = 1211.033 and C_1 = 220.79. For toluene A_2 = 6.95464, B_2 = 1344.8 and C_2 = 219.482 (Dean[1]). P is the pressure in mm

Hg and T the temperature in °C.

The batch distillation of benzene (component 1) and toluene (component 2) mixture is being carried out at a pressure of 1.2 atm. Initially, there are 100 moles of liquid in the still, comprised of 60% benzene and 40% toluene (mole fraction basis). Calculate the amount of liquid remaining in the still when concentration of toluene reaches 80%.