CE 329, Fall 2015

Assignment 22

Problem Statement

An acid, A, is to be hydrolyzed using an adiabatic CSTR according to the reaction A + W → P, where W represents water and P, the product. When the reactor is first started up, it is filled with water at 90 ºC. The acid is then fed at 10 kg/s and water is fed at 30 kg/s; the feed temperature is 90 ºC. The fluid volume of the CSTR is 0.5 m^3. The rate expression is given in equation (1), with the rate coefficient given in equation (2) and the equilibrium constant in equation (3). The heat of reaction is -86,000 kJ/kmol at 298K. The fluid density is constant and equal to 992 kg/m^3. The heat capacities of A, W, and P are 2.9, 4.2, and 3.2 kJ/(kg K), respectively, and may be taken to be independent of temperature. The molecular weight of A is 142. Plot the outlet concentration of P and temperature from the time the feed flow starts until the reactor appears to be approaching steady state.

$$r_1 = kC_A C_W \left[1 - \frac{C_P}{KC_A C_W} \right] \tag{1}$$

$$k = \left(1.2 \times 10^{12} \text{ m}^3 \text{ kmol}^{-1} \text{ s}^{-1} \right) \exp\left\{ \frac{-13000K}{T} \right\} \tag{2}$$

$$K = \left(4.2 \times 10^{-15} \text{ m}^3 \text{ kmol}^{-1} \right) \exp\left\{ \frac{11300K}{T} \right\} \tag{3}$$