BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

SECOND SEMESTER 2017-2018

CHE F418: Modeling and Simulation in Chemical Engineering

Mid Term Test Date: 08.07. 2018

Duration: 2:00 PM - 3:30 PM Maximum Marks: 60

Note: ***State your assumption clearly and also check the mathematical consistency of your model***

PART- A (Close Book)

1. Explain the following [3 x 2 = 6M]
   a. NASA polynomials
   b. Multiscale modeling and its importance
   c. Modeling approaches for chemical engineering systems
2. 1.26 kg/s of sulphuric acid of heat capacity 1500 J/kg K is to be cooled in a two stage counter-current cooler. Hot acid at 174 °C is fed to a tank where it is stirred well in contact with cooling coils. The continuous discharge from this tank at 88 ^{o}C flows to a second stirred tank and leaves at 45 ^{o}C. Cooling water at 20 ^{o}C flows into the coil of the second tank and then to the coil of the first tank. The water is at 80 °C as it leaves the coil of the hot acid tank. The heat capacity of each tank is 4500 kg of acid and flow rate of water is 0.96 kg/s. Heat transfer area of the coil in first tank and second tank is 6.28 and 8.65 m^2, respectively. The overall heat transfer coefficient for the coils in first and second tank are 1150 and 750 W/m^2 ^{o}C, respectively. Heat capacity of the water is 4200 J/kg ^{o}C.
   a. To what temperature would the contents of each tank rise if, due to trouble in the supply, the cooling water is suddenly stopped for 30 min?
   b. On restoration of the water supply, water is put on the system at the rate of 1.25 kg/s. Calculate the acid discharge temperature. [5 +5 = 10 M]
3. Develop a mathematical model for an ideal binary distillation column with N_T number of sieve trays. [12 M]
4. $A <=> B$, First order, reversible, exothermic reaction is carried out in a plug flow reactor with cooling water jacket. Develop a mathematical model of this system. [12 M]

PART- B (Open Book)

1. When cooling jackets and internal cooling coils do not give enough heat transfer area, a circulating cooling system is sometimes used. Process fluid from the reactor is pumped through an external heat exchanger and back into the reactor. Cooling water is added to the shell side of the heat exchanger at a rate F_w as set by the temperature controller. The circulation rate through the heat exchanger is constant. Assume that the shell side of the exchanger can be represented by two perfectly mixed "lumps" in series and that the process fluid flows countercurrent to the water flow, also through two perfectly mixed stages. The reaction is irreversible and fist-order in reactant A

$$A \rightarrow B$$

The contents of the tank are perfectly mixed. Neglect reactor and heat-exchanger metal. Derive a dynamic mathematical model of this system. [20 M]