Ex/ChE/T/322/2017

Bachelor of Chemical Engineering Part-I Examination 2017– 2nd Semester

PROCESS DYNAMICS AND CONTROL

Time: Three hours; Full Marks = 100

Answer any four questions. All questions carry equal marks

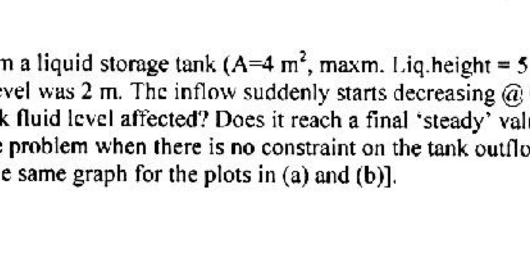
1. For a liquid mixing tank (A= 7 m^2) at steady state the liq. Level (h) is 7 m and inflow(q_i) and outflow (q) rates are 100 m^3 h^{-1}. Predict the final level for a step change of -10 m^3 h^{-1} in inflow rate for two cases, viz.
(a).assuming a linear flow-head relationship, and
(b).a relationship of the form $q=C_V h^{0.5}$

2. (a) Examine the effect of controller dynamics on overall process dynamics with regard to order of dynamics of the controlled process and speed of controlled response by considering a second-order process and Proportional, Integral and Derivative modes of control action separately.
(b) Define 'offset' for both set point and load changes. For a first-order process, show that whereas offset is inevitable with a 'P'

3. (a). The liquid level in a two-tanks-in-series system is to be controlled using a simple proportional controller. Both tanks have unity gain with time constants 1 min. and ½ min. respectively. The liquid level measuring device that provides feedback to the controller is also unity gain with time-constant 1/3 min. Draw a block diagram of the control system. Using the Routh test, find the range of values of controller gain K_c, for which the control system is stable.
(b). A temperature sensor with heat transfer area = 1x10^{-5} m^2, mass = 1x10^{-4} kg. and sp. heat capacity = 504 J/kg K: is used to measure the temperature of a gas stream flowing through a conduit. After having remained unchanged at 200°C for a long time, the gas stream temperature suddenly jumps to 210°C due to some disturbance in the source of flow. 4.8 minutes after this instant, the sensor shows a reading of 209.8°C. Estimate the film coefficient of heat transfer (W/m^2 K). State necessary assumptions.

4. Consider two overflow-type constant volume isothermal CSTRs in series in which the 1st-order liquid phase reaction A → products (k=1min^{-1}) takes place. Volume of each reactor = 5 m^3 and constant volumetric flow rate through the system = 5 m^3/min. A feedback PI controller is used to manipulate the flow of reactant. Further, the sensor (for measuring concentration) and the control valve (i.e. the final control element) are both assumed fast, unity-gain elements. It is also known that a dead time of 1 min exists in series with the process. Determine, using frequency response and the Ziegler-Nichols' tuning relations (i.e. K_C=0.45K_U; τ_I=P_U/1.2), the optimum PI controller settings for this system.

5. A fluid of constant density ρ is pumped, at a volumetric flow rate F_0 into an inverted cone-shaped tank of total volume $H \pi R^2 / 3$. The volumetric flow rate out of the bottom of the tank, F, is proportional to the square root of the height *h* of liquid in the tank. Derive a linear model for liquid level h, as the output variable and F_0 as input.



6. The outflow from a liquid storage tank (A=4 m^2, maxm. Liq.height = 5 m) is forcibly constrained at 0.02 m^3/s. At a certain "steady state", tank fluid level was 2 m. The inflow suddenly starts decreasing @ 0.002 m^3/s^2 for 5 s and then stops changing further.
(a) How is the tank fluid level affected? Does it reach a final 'steady' value? Answer with the help of a plot.
(b) Redo the above problem when there is no constraint on the tank outflow.;
[N.B. Try to use the same graph for the plots in (a) and (b)].