BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

FIRST SEMESTER 2016-2017

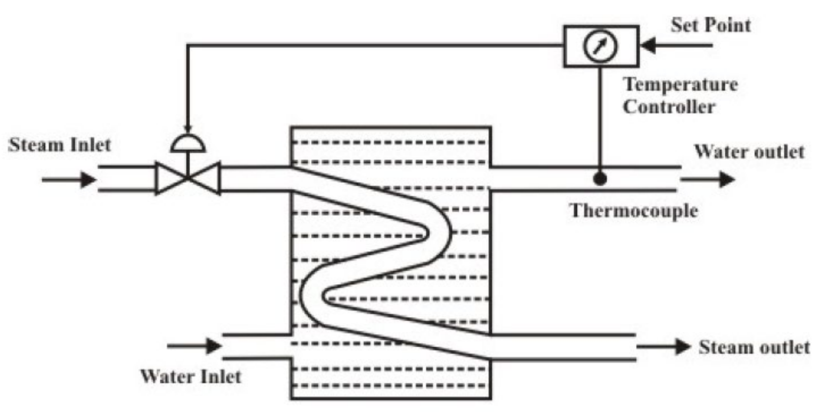
CHE F471: Advance Process Control   Mid Term Test ***(Close Book)***   Date: 09.10. 2017

Time : 90 Min.   Max. Marks: 30

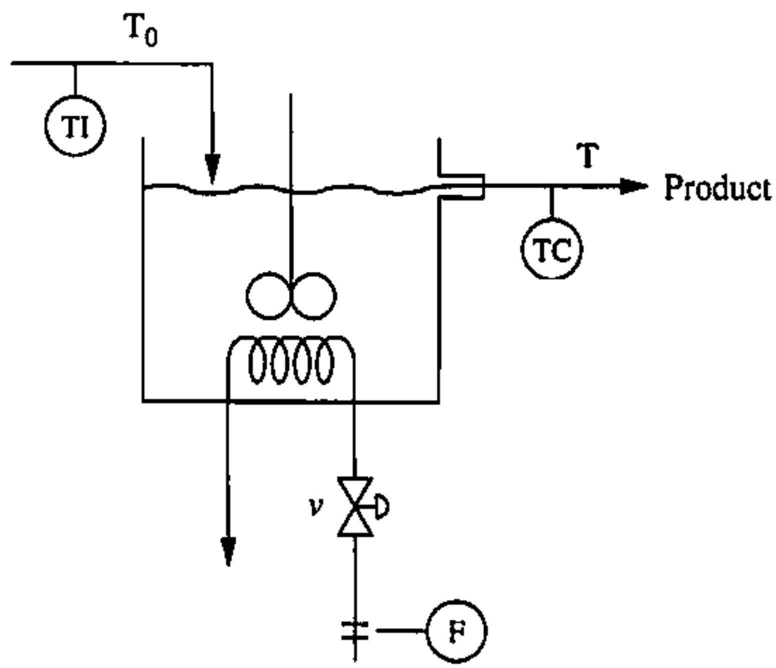
Note: ***Please take the proper assumptions whenever it is necessary***

Section- 1   **5 x 2 = 10 M**

1. Algorithm for solving the following equation in MATLAB
   $x^2y^1 = y \ln y - y^1$,y(0) = 2
2. Show the SIMULINK block for solving the following
   $$\frac{dy}{dt} = \frac{2}{t}y, where\ y(0) = 1.$$
3. Define Integration windup and Bumpless transfer
4. The figure shown below is used to control the exit temperature measured by thermocouple. Suppose that the single loop controller does not provide adequate control performance and that the most significant disturbance is the steam flow rate to the heating coil. Design a cascade control strategy for this process using the sensors and manipulated variables given and also suggest a suitable control valve for steam controlling.



5. The figure shown below, suggest the combination of feedback and feedforward control strategies. Explain the input and output signals in each controller with the help of block diagram. (TC- temperature controller, F – flow, T_0 and T_1 are inlet and exit temperatures, respectively.)



Section- 2 **5 x 4 = 20 M**

6. A first order irreversible reaction ($A \rightarrow B$) takes place in an isothermal CSTR. If the concentration is controlled by a PI controller. Develop an algorithm for solving reactant outlet concentration by Euler method.

7. You need to control the fuel to air ratio for a packed bed reactor in which partial oxidation of methane reaction takes place. You should always maintain the excess fuel to the reactor to avoid the total oxidation reactions. Suggest a best strategy based on two control schemes (with a neat sketch).

8. Consider the following first order process:

$$g_p(s) = \frac{2}{3\,S + 1}$$

If the desired closed loop response to a set-point change is second order with the following transfer function,

$$g_{CL}(s) = \frac{\alpha s + 1}{(\lambda s + 1)^2}$$

Find the feedback controller required, where α and λ are adjustable tuning parameters (they are both positive). What type of controller is this? If the controller is PID form (perhaps with a lag), find each of the tuning parameters (kc, τ_I, τ_D, τ_F). Show that $\lambda > 0.5\,\alpha$ is required for the controller to be stable.

9. Consider the closed-loop response for IMC when the model is *not* perfect. Show that there is no offset for a set-point change for the following process model and actual process transfer functions. Also, find the minimum value of λ that assures closed-loop stability for this system. (Hint: use the Routh test)

$$g_p(s) = \frac{2}{5s+1}$$

$$g_p(s) = \frac{1.5\,(-s+1)}{(s+1)(4s+1)}$$

10. Consider the following process model with a RHP zero

$$g_p(s) = \frac{k\,(-\beta s+1)}{s}$$

Use the IMC-based PID design procedure to find a PI controller. Assume that an all-pass factorization is used for the RHP zero. Also, assume that $q(s)$ is semiproper. Use an IMC filter with the form

$$\frac{\gamma s+1}{(\lambda s+1)^n}$$

and solve for γ to give exactly a PI controller (no other terms).

Find the proportional gain and integral time as a function of the model parameters (k, β) and λ.