Part A

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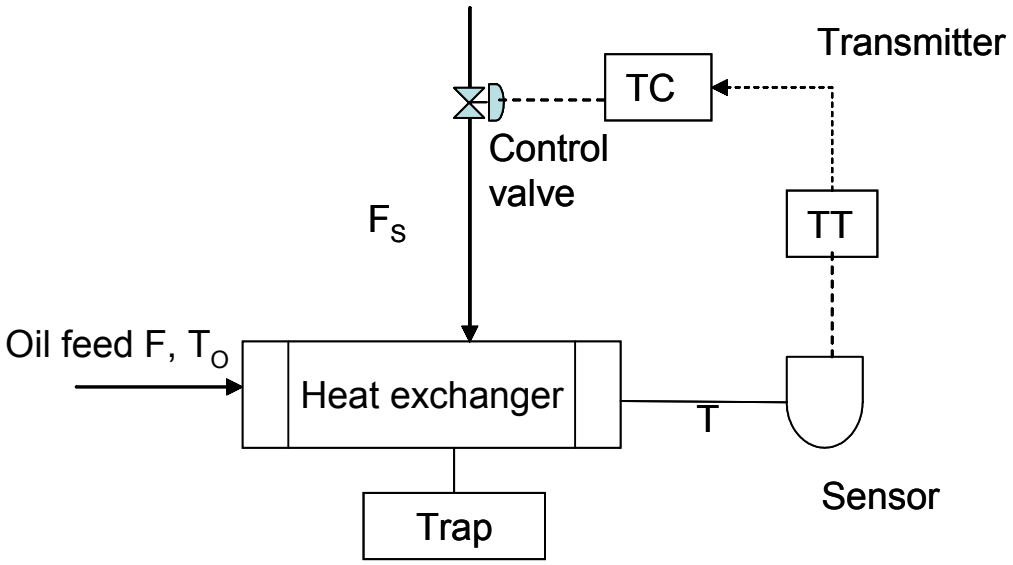
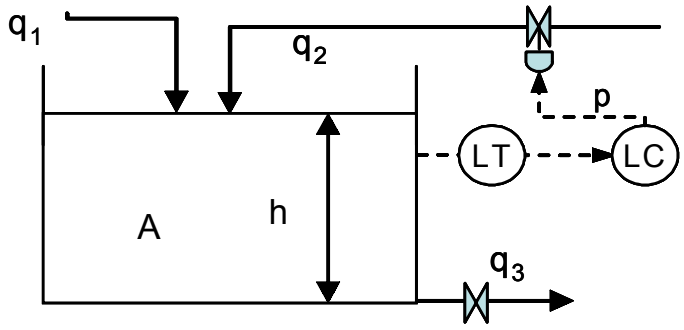


1.1) What are load disturbance(s), manipulated variable(s) and control variable(s)? **[10]**

1.2) Show the block diagram and the transfer function of a process (Use G_p , G_v, G_m, G_c for the transfer functions of a process, final control element, measurement and controller, respectively) **[10]**

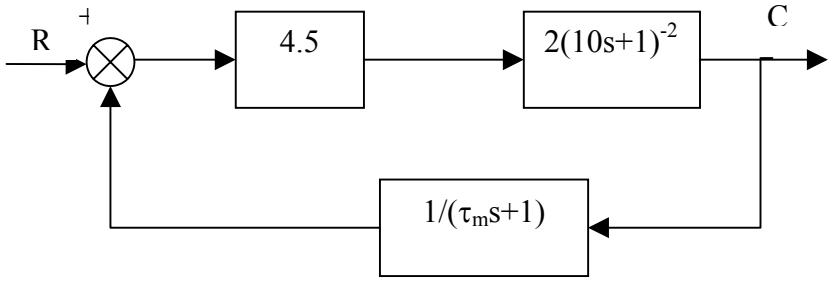


Consider the liquid-level, PI control system as shown in a Figure with the following parameter values A=2 ft^2, R =1.0 min/ft^2, K_v = 0.2 cfm/psi, K_m = 2 psi/ft, K_c =5 and τ_I =120 seconds.

2.1) Show the block diagram and the characteristic equations for set point change**. [10]**

2.2) Suppose that the system is initially at the nominal steady state with a liquid level of 2 ft . If the set point is suddenly changed from 2 to 3 ft, how long will it take the system to reach (a) 30 inches, and (b) =3 ft.
[20]

3 A second-order process with measuring element is controlled by proportional controller as shown in the drawing.



3.1) Find ranges of τ_m that make system stable by using Routh stability criterion. **[15]**
3.2) What is the appropriate ranges that we will use in this process? And why do you select that range? **[10]**
3.3) If a PD controller with $\tau_D=\tau_m$ is used instead of using P-only controller, what should be the range of all time constants? How different of this answer and the answer in part A) are? **[15]**

4 Consider a process whose transfer function is given by

$$g(s) = \frac{1}{(s+1)(5s+1)(0.5s+1)}$$

4.1) Roughly, sketch Bode diagram of this process transfer function. **[20]**

4.2) Calculate the value of a proportional controller gain (K_c) that gives phase margin of 45^o **[20]**

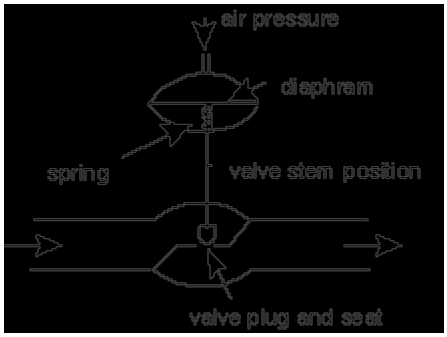
4.3) Calculate the Ziegler-Nichols controller setting for the process with P, PI and PID controller. **[20]**

Part B Select or give the right answers of each problem [30]

1 Which of these control loop elements are typically very fast and very accurate? (x-mark all right answers)

A) electrical transmitter B) signal conversion C) pneumatic transmitter
D) process E) controller F) final control element, valve
G) sensor

2 The following statements are true or false? If it is incorrect, give the reason why?



A) The control valve always remains within its limits when used for control; it is never fully closed or open.

B) Most control signals are transmitted 50 meters or less

C) The selection of which valve to manipulate influences the behavior of the controlled variable

3 Which of the following criteria are required for a manipulated variable? (Distinguish criteria that are (i) required, (ii) desirable, and (ii) not relevant.) (x-mark all right answers)

A) The ability to compensate for large disturbances

B) Automated valve to influence the selected flow

C) Causal relationship between the valve and the controlled variable

D) The ability to adjust the manipulated variable rapidly and with little upset to the remainder of the plant.

4. The behavior of the controlled variable, CV, is important because...

A) It was selected to achieve one or more of the 7 control objectives.

B) The sensor measures this value.

C) Large fluctuations create messy trend plots.

5 Is it possible to measure the temperature, pressure and flow of highly corrosive materials, like acid, why?

6 Closed loop stability can be determined from the frequency response plot of the total open loop transfer function or total closed loop transfer function of the system? Show examples of frequency response plot.

7 Is it true that process open loop unstable can be closed loop stable?, why?

8 A control valve % opening is usually changed by adjusting an electric motor that moves the stem position, isn't it? Why?

9 Is it true that control engineers do not need to know how the processes work before they control those processes? Why?

10 If you want to fine the transfer function of the liquid level in a tank, how do you design for the experiment and how do you get the transfer function from the experiment.

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