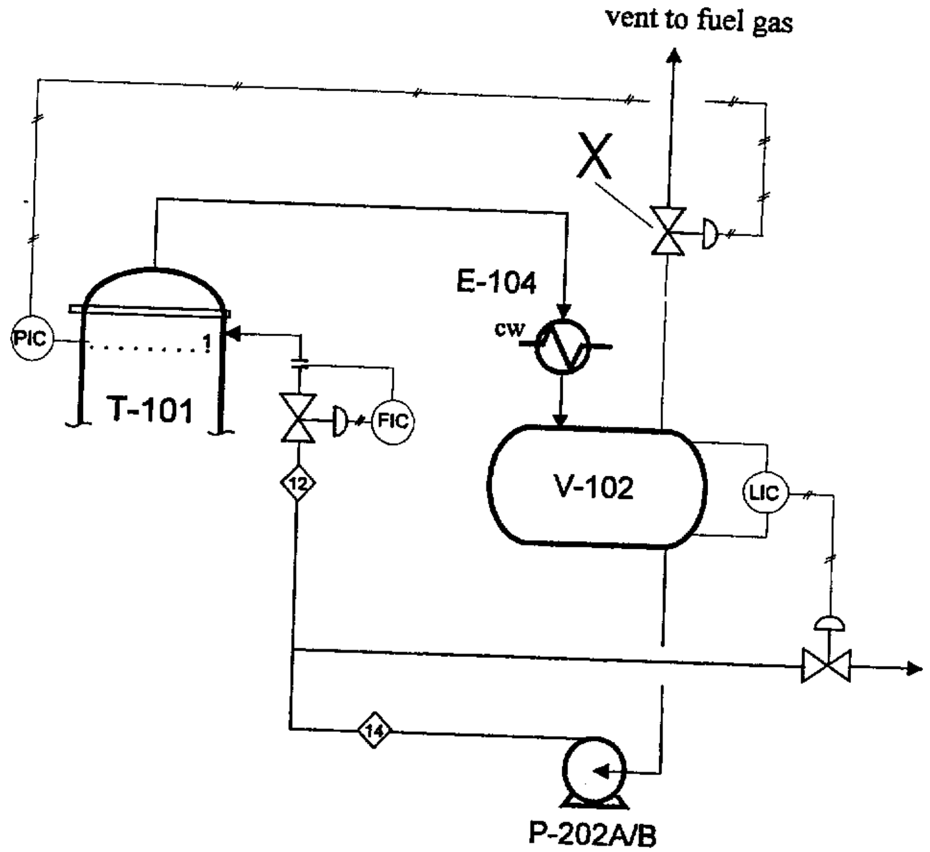
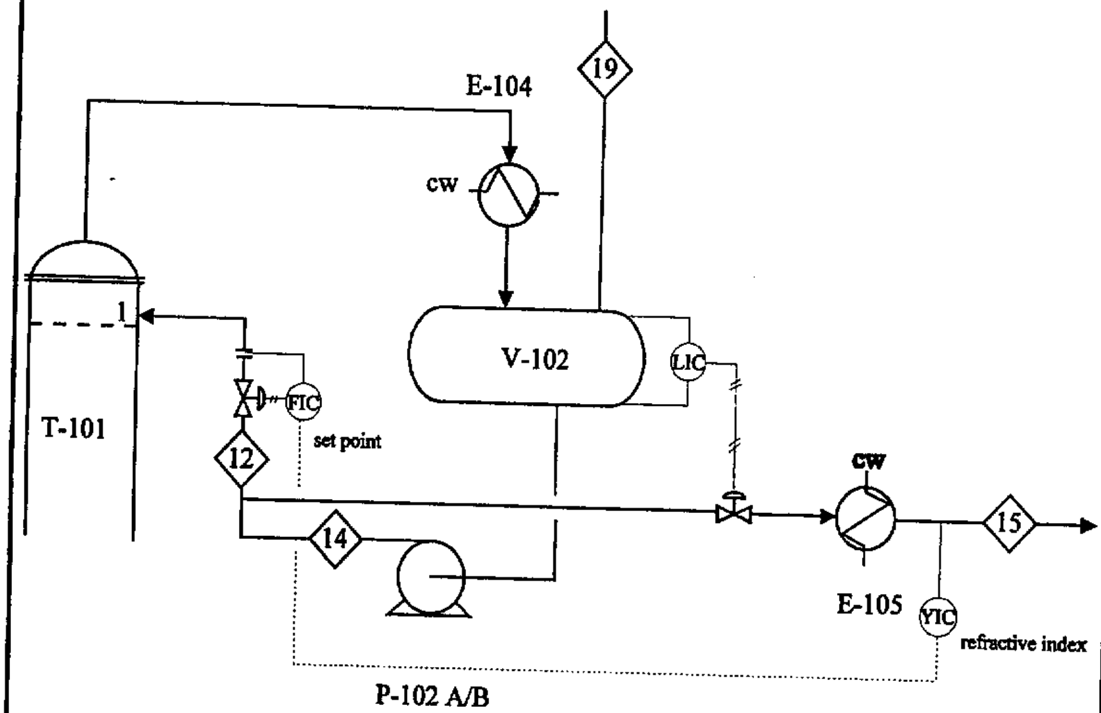
15.2 The overhead system for T-101 is shown in the sketch below.



a. As the column pressure begins to drop, a signal is sent to control valve X to close slightly. This in turn causes the flow of non-condensables going to fuel gas to drop. This means that the non-condensables start to build up in the reflux drum, V-102, and the pressure in the drum starts to increase. As the pressure in V-102 increases this causes the pressure in the column, T-101, to increase. Thus the desired control action is achieved.

b. If the amount of non-condensables fed to the column suddenly increases then there will be an increase in the amount of non-condensables in V-102. With no control action the valve X would not change position and the non-condensables would build up in V-102 causing the pressure to rise in V-102, E-104, and T-101. Because of the control loop, as the pressure in T-101 starts to increase a signal is sent to open valve X, which in turn allows more flow to the fuel gas and hence reduces the pressure in V-102. Thus the desired control action is achieved.

15.5 Regulation of overhead product purity of Benzene Tower, T-101



a. The purity of the overhead product stream is controlled by a refractive index monitor which adjusts the set point of the flow controller on the reflux line. Thus the reflux ratio is adjusted (up or down) depending on the purity of Stream 15, as inferred by the refractive index of this stream.

b. This type of control system is an example of a cascade control system.

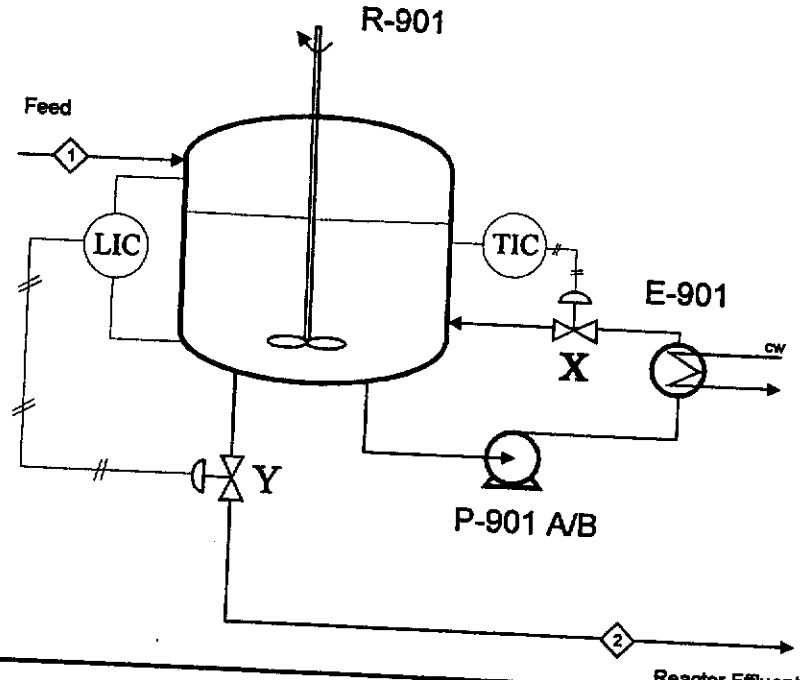
15.8 a. Regulate the temperature of the reactor

This is easily accomplished by placing a control valve (X) on the discharge of pump, P-901, and using a temperature indicator controller (TIC) placed either in the reactor or in Stream 2 to adjust the setting of the valve. For example, if the temperature in the reactor was too high, then the TIC would cause the control valve X to open causing more fluid to circulate through E-901 and hence increasing the heat removal from the reactor - causing the reactor temperature to drop. This control loop is shown in the diagram below.

b. Regulate the inventory of the reactor

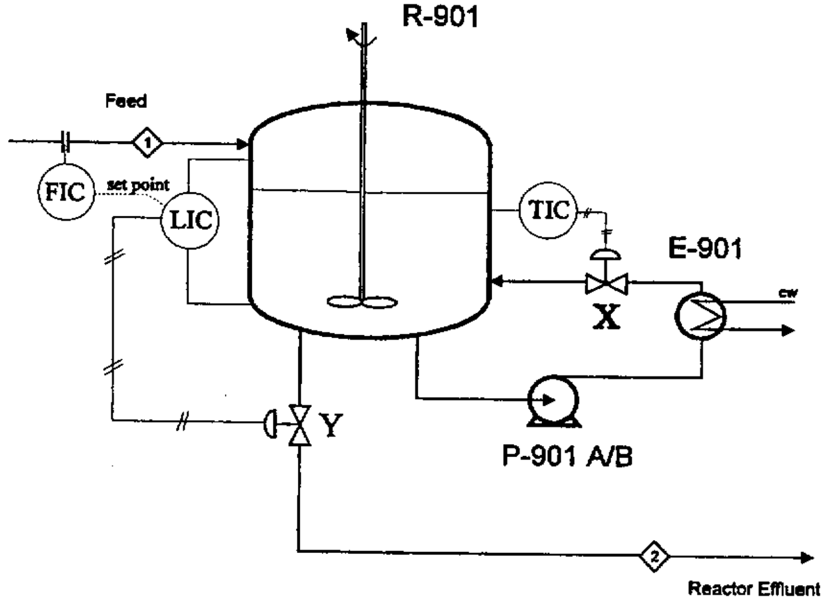
Again this can be easily accomplished by using a liquid level controller (LIC) in the reactor to adjust the setting of a control valve (Y) in the exit line from the reactor, Stream 2. If a change in flowrate of Stream 1 were to take place, say a decrease in flow. Then the level in the reactor would start to drop, the LIC would sense this change and close the control valve Y. This in turn would reduce the flow of liquid from the reactor thus allowing the level in the reactor to increase back to its original level. This control loop is shown in the diagram below.

Note that the rate at which fluid is circulated through the external heat removal loop (P-901 and E-901) does not affect the level in the reactor.



Maintaining constant conversion/residence time

One simple way of maintaining a constant residence time in the reactor would be to use a feed forward signal from a flow element placed in the feed line, Stream 1, to adjust the set point of the level controller. Thus if the flow of Stream 1 were to drop, the level would be lowered to compensate and if the flow were to increase then the reverse action would be initiated.

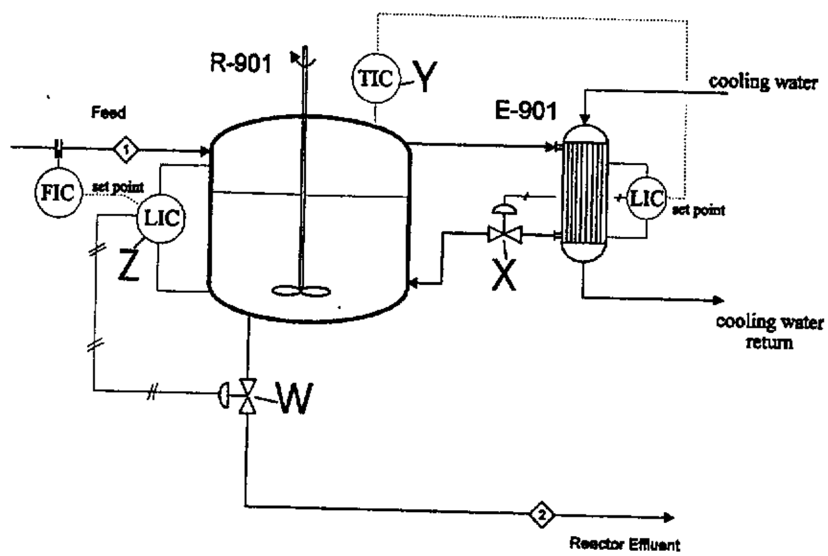


15.9. Control of the temperature in the reactor

We will assume that the external heat exchanger, E-901, condenses the vapor in the shell side of the heat exchanger and that the level of condensate in the exchanger can be measured. The control strategy is to adjust the level of condensate in E-901 to expose more or less heat transfer area to the vapor. Since it is necessary to control the level of condensate, a material balance control loop is required. The control valve X is adjusted with the signal from the level controller (LIC) on the condensate level in E-901. A temperature control then adjusts the set point of the level indicator to respond to changes in the reactor temperature. For example, if the reactor temperature were to increase, then a signal would be sent from the temperature sensing element, Y, to the set point of the level controller. The level set point would be decreased so that more exchanger surface area is exposed to condensing vapor and hence more condensation can take place. This would cause the temperature of the reactor to drop. This control scheme is shown in the diagram below.

b. Control of the reactor residence time

In order to maintain a constant inventory in the reactor a feedback material balance control loop is provided for the reactor. A level indicator controller, Z, controls the position of the control valve, W. In order to maintain a constant residence time the level in the reactor must change in sympathy with the changing feed flow rate. Therefore, a feedforward control loop is added which senses the flow of Stream 1 and adjusts the level in the reactor by changing the level set point, Z. These loops are shown in the diagram below.



c. Explain how this system responds to an increase in flow of Stream 1

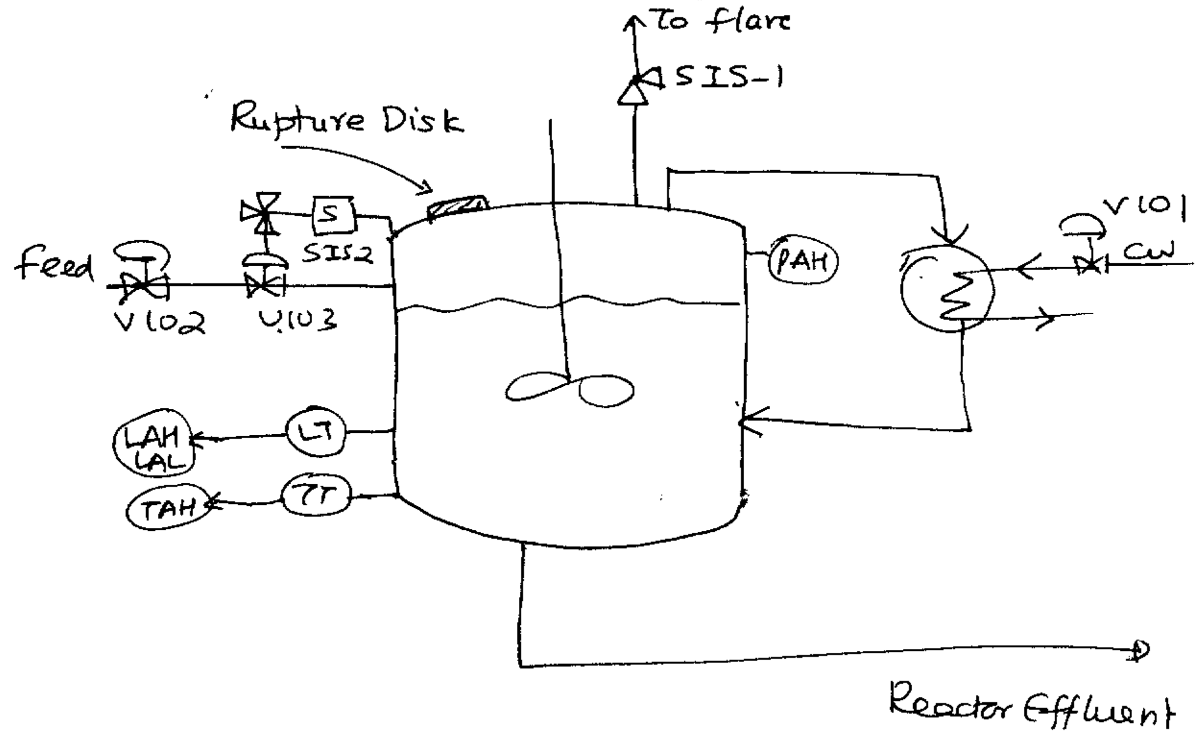
As Stream 1 increases, the flowrate controller sends a signal to the level indicator to increase the level set point. Initially, the control valve (W) on the liquid exit line from the reactor will not change position and the level slowly rises. When the level in the reactor rises above the new set point, the material balance control loop comes into play and the control valve (W) starts to open and eventually a new steady state will be reached. Note that at steady state the liquid feed into and out of the reactor must be the same - all that has happened is that the level in the reactor, i.e., the liquid inventory, has increased thus maintaining the residence time of the liquid in the reactor.

d. Explain how this system responds to fouling of the tubes on the cw side of E-901

As the heat exchange tubes in E-901 begin to foul the amount of heat transfer taking place will decrease (for a given condensate level in the exchanger). This means that the temperature and pressure in the reactor will start to rise since not enough heat is being removed from the reactor system. As the temperature in the reactor rises the TIC (Y) sends a signal to adjust the set point of the condensate level in the exchanger. The level set point is decreased. This means that more tube area is exposed to condensing vapor and more condensation can occur. As more condensation occurs the temperature and pressure in the reactor decreases.

B. Joseph | PS #8, ChE471 | Oct 17, 2000

Problems 15.9e (Safety Issues)



① Rupture Disk will open if pressure exceeds max allowable

② SIS-1. Safety Interlock Switch will open and vent reactor contents to flare if pressure builds up

③ SIS-2 : will cut off ~~feed~~ flow if temp exceeds a certain limit. V-103 is used for this purpose (a solenoid on/off type valve)

④ ~~V-101~~ PAH, LAH, TAH, LAL are high/low ~~level~~ alarm switches to alert operator if exceptions occur in system

⑤ V-101 is air-to-close. will open if power fails
V-102 is air-to-open, will close " "