BEL 702: Bioprocess Plant Design

Major Examination

4th May, 2007
13.00 – 15.00 Hrs.
11 – LT2

Maximum marks 100. All questions carry equal marks.

1. (i) What are the major differences between a process flow-sheet and its piping and instrumentation diagram with respect to the information they contain? Explain.
   (ii) What are the broad objectives of the control and instrumentation loops provided in a process plant? Sketch the control and instrumentation loops for control of pressure, temperature, flow and level as it appears in a typical P&I diagram for the case where the controller is (a) loeally mounted (b) panel mounted with parameter indication and recording facilities.

2. (i) You have been retained as the technical consultant by a biochemical industry which produees product P. The company is in the process of developing the detailed engineering documents for a new plant for the product P, but with a new technology. The downstream process in this new teehnology involves extracting the product P using an organic solvent B. The relative volatility of the mixture of P and B are such that they can be effectively separated using distillation. Explain in detail how you will proceed to develop the detailed engineering for a distillation column to separate P and B.
   (ii) After making the detailed engineering drawings, you approaehed a fabricator. When you explainecl the scope of work to the fabricator, he unfoldcd a strange story. They (fabricator) had undertaken a similar job about a couple of ycars ago. Thcy had done the fabrication of the bubble cap plates made of copper as stipulated in the design document. These plates were then attaehed to the inside surface of the column shell using 10 mm thick rings using galvanized steel rivets. The plant was commissioned and ran smoothly for the first year. But then the plant started

developing problems, with the product quality deteriorating rapidly. The company blamed the fabricator for poor quality of the job, but the fabricator is confident about the excellent quality of the job he had executed. The fabricator is willing to take up your job only if you are able to ensure that such a problem will not repeat. Can you do that? How? Explain.

3. (i) In a fermentation industry, the continuous fermentation operation is being carried out using a mechanically agitated bioreactor operating at a dilution rate of 0.8 d^{-1}. The feed is being sterilized using a continuous sterilizer and comes out at a temperature of 80°C. This needs to be cooled to 30°C by using cooling water available at 20°C. If the fermenter has a working volume of 200,000 litres, explain how you will design a shell and tube type of heat exchanger to cool down the sterile feed.
   (ii) What are the major advantages and disadvantages of plate-type heat exchangers?

4. (i) How will you estimate the total capital investment for a project with accuracy sufficient enough for budget authorization?
   (ii) What is depreciation? Why is it shown as an expenditure?
   (iii) A fermenter was purchased at a total cost of Rs 4,500,000. It has an estimated life of 12 years, at the end of which it could fetch a maximum of Rs 100,000 through sale as scrap. What will be the depreciation cost for the first three years for this piece of equipment if depreciation calculations follow (i) straight line method (ii) declining balance method (iii) sinking fund method. Which method would you prefer if you were the owner of the equipment? Why? Interest rate may be taken as 8%.

5. (i) What are the major mechanical and process design challenges one would face in developing the mechanical agitation system for a bioreactor having a total volume of 100,000 litres and a height-to-diameter ratio of 18 ? What are the potential solutions?
   (ii) What are the major safety concerns in a typical biochemical/biologieal manufacturing facility? How will you address them as the design engineer in eharge of developing the detailed engineering for the plant?