BEL702: Bioprocess Plant Design

MAJOR EXAMINATION

2nd May, 2009
13.00 – 15.00 Hrs.
I – 313

Answer all questions. Maximum marks 100.

1. Product P is produced through batch fermentation of a complex media using a mold. The batch time, from inoculation to harvesting, is 24 hours. The fermented broth contains 2% (w/v) biomass. It also contains 1% P (w/v) on a biomass-free basis. P is an extra-cellular product and is miscible with water. The density of water, mold biomass and product P may all be taken as 1000 kgm^{-3} for calculation purposes. The biomass is removed from the fermented broth using a rotary vacuum filter. The filter cake contains 10% moisture. The filtrate is then concentrated to 40% of its volume by using a multiple effect evaporator. This concentrated solution is fed to a continuous crystallization unit where 80% of the product gets separated out as crystals. The crystals are washed, dried and then re-dissolved in distilled water such that the resulting solution contains 10% product. This is again taken to a multiple effect evaporator and concentrated to 40% of its volume. The concentrated solution is then taken to a crystallizer where 80% of the product gets separated as crystals, which are dried and taken to product storage. If the plant produces 100 tonnes of product per year, develop a flow-chart for the process. The number of operating days in a year may be taken as 350. Superheated steam is available such that 0.2 kg steam is required to evaporate 1.0 kg of water in the multiple-effect evaporators.

(30 marks)

2. How does a P&I diagram differ from a flow sheet? How will you decide the specifications of a pipe, to be provided in the P&I diagram, using the data available in the process flow-sheet? 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 (i) locally mounted (ii) panel mounted with parameter indication and recording facilities.

(15 marks)

3. What are the important material properties to be considered while carrying out the mechanical design of process equipment? Explain how you will decide on the suitability of a particular material for a certain application, if the input data is available to you is the form of process flow-sheet.

(15 marks)

4. (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?

(20 marks)

5. (i) How will you estimate the total equipment cost (a) while carrying out an economic feasibility study for a proposed project and (b) during detailed engineering/project implementation stage?

   (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%.

(20 marks)