B.Tech Even Semester Examination, May, 2025

Agricultural Engineering

(6th Semester)

Course No: AE-601

(Thermal Operations in Food Processing)

Full Marks: 50

Pass Marks: 25

Time: 2 hours

Note:

1. Attempt any five questions .
2. Begin each answer in a new page
3. Answer parts of a question at a place
4. Assume reasonable data wherever required
5. The figure in the right margin indicates full marks for the question
6. All the mathematical symbols and abbreviations have their usual meanings.

1. (a) Derive an expression for overall heat transfer coefficient (U) for a double pipe heat exchanger. Explain the various terms in this expression. [7]

   (b) Define the following (i) Nusselt Number (ii) Prandtl Number [3]

2. By using Newtonian cooling, derive an expression for calculating temperature of a body at any instant of time. Assume thermal resistance of body is zero. [6]

   An electric wire having a diameter of 1.5 mm and covered with a plastic insulation (thickness = 2.5 mm) is exposed to air at 300 K and h_0 = 20 W/m^2-k. The insulation has a K of 0.4 W/m-K. It is assumed that the wire surface

temperature is constant at 400 K and is not affected by covering.

(a) Calculate the value of the critical radius.

(b) Calculate the heat loss per meter of wire length with no insulation. [4]

3. (a) What is heat exchanger? Discuss different type of heat exchanger with neat sketch. [5]

(b) Hot water at 95°C is used in a plate heat exchanger for heating 2 kgs^{-1} fruit juice from 45°C to 75°C. Specific heat capacity of fruit juice is 3.7 $kJkg^{-1}K^{-1}$. Final temperature of the hot water is 70°C. Overall heat transfer coefficient is 1122 $wm^{-2}K^{-1}$. Heat transfer area is 12.75m^2. What will be the log mean temperature correction factor? [5]

4. (a) Discuss the following: (i) D-Value (ii) Z-Value [6]

(b) A suspension containing $3x10^5$ spores of organism A having a D-value of 1.5 min at 121.1^0C and $8x10^6$ spores of organism B having a D-value of 0.8 min at 121.1^0C is heated at a uniform constant temperature of 121.1^0C. Calculate the heating time for this suspension at 121.1^0C needed to obtain a probability of spoilage of 1/1000. [4]

5. (a) Discuss the following [7.5)

i. Pasteurization

ii. Sterilization

iii. Equilibrium moisture content (EMC)

iv. Falling rate drying

v. Bound moisture

(b) The F value at 121.1^0C equivalent to 99.999 % inactivation of a strain of C. Botulinum is 1.2 min. Calculate the D_0 value of this organism. [2.5]

6. (a) Explain the freeze drying process with the help of neat sketch and also mention the advantages of freeze drying system. [6]

(b) Define effectiveness of a heat exchanger. Also write the expression for effectiveness of parallel flow heat exchanger. [4]

7. (a) Define water activity. Explain the method for measurement of water activity at high moisture content. [6]

(b) An evaporator is used to concentrate orange juice. A feed of 2160 Kg/h of a solution containing 10% solids is evaporated producing 74% total solids. Calculate the weight of solution produced and amount of water removed? [4]

8. (a) Discuss the different physical and chemical properties of a solution which affect the design of evaporator. [6]

(b) Calculate the water activity of a 50 % sucrose solution. (Given: K = 2.7, Molecular weight of sucrose is 342) [4]

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