KERALA AGRICULTURAL UNIVERSITY
B.Tech.(Food Technology) 2020 Admission
III Semester Final Examination –March 2022

Pafe.2115 **Heat and Mass Transfer in Food Processing (2+1)** **Marks: 50**
Time: 2 hours

I **State True or False** **(10x1=10)**

1. One dimensional, steady-state heat equation for sphere with no heat generation is given as $\frac{1}{r}\frac{d}{dr}\left(r\frac{dT}{dr}\right)=0$
2. Chilling effect of cold wind on a warm body is an example of steady-state heat transfer.
3. Large number of thin fins are better than large number of thick fins in order achieve more effective heat transfer from a given surface.
4. Ice is considered to be a Gray body.
5. Grashof number is a key parameter in the study of force convection.
6. Uniform Heat generation takes place in symmetric slab such that the heat flows towards the both sides where the wall is in contact with fluid. The zero temperature gradient will occur at the left end of slab.
7. Nusselt number is defined as non-dimensional temperature gradient normal to surface.

Answer the Following

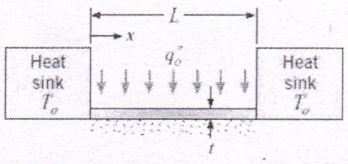
8. What is a contact resistance? What are its units for an interface of prescribed area?
9. Write the mode of heat conduction between two horizontal plates separated by distance h from each other in a gravitation field. Note that the temperature of top plate is twice to that of bottom one.
10. Define thermal time constant. State how solid responds to its thermal environment with the increase or decrease in thermal time constant.

II **Write short notes on ANY FIVE of the following** **(5x2=10)**

1. Draw temperature profile for following cases in plane wall with uniform heat generation per unit volume and constant thermal conductivity.
   (a) Convective heat transfer coefficients on both sides are same.
   (b) Convective heat transfer coefficients of one side is two times of that other side.
2. A hemispherical bowl is closed with flat lid at bottom. If bowl is surface-1 and lid is surface-2. What is the value of shape factor F21 ?
3. 'N' numbers of identical radiation shield(s) is/are kept between the source and environment. 75 percent reduction in heat transfer value is required. Value of N is?
4. Temperature of solid surface changes from 60 to 650 degree Celsius. What will be the ratio of emissive power?
5. Discuss about non-dimensional numbers on which convective heat transfer depends.
6. Define fouling factor observed in heat exchanger.
7. What are the characteristics of a blackbody? Does such a thing actually exist in nature?

III **Answer ANY FIVE of the following** **(5x4=20)**

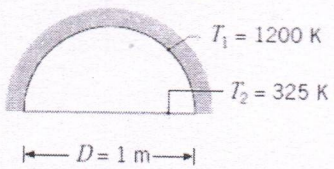
1. A thin flat plate of length L, thickness t, and width W >> L is thermally joined to two large heat sinks that are maintained at a temperature To. The bottom of the plate is well insulated, while the net heat flux to the top surface of the plate is known to have a uniform value of q_o''.



   (a) Derive the differential equation that determines the steady-state temperature distribution T(x) in the plate.
   (b) Solve the foregoing equation for the temperature distribution, and obtain an expression for the rate of heat transfer from the plate to the heat sinks.
2. Steel balls 10 mm in diameter are annealed by heating to 1200 K and then slowly cooling to 400 K in an air environment for which T□ = 300 K and h =20 W/m2-K. Assuming the properties of the steel to be k = 40 W/m-K, ρ = 7800 kg/m3, and c = 600 J/kg-K, estimate the time required for the cooling process.
3. The temperature distribution across a large concrete slab is given by equation T = 70 60x+23x2+30x3-25x4, where x in meters and T is in degree Celsius. Consider an area of 5 m2 and thickness of slab is 50 cm. Find the location (x) where rate of cooling or heating is maximum.
4. A wire of diameter 1mm is proposed to be coated with paint having thermal conductivity 0.1 W/m-K to increase the heat transfer. Find the optimal thickness of paint if outer side has the heat transfer coefficient as 100 W/m2 K.
5. Steam at 100 degree Celsius enters in heat exchanger on outside of the tube. Cold fluid enters and exit the tube at 20 and 50 degree Celsius respectively. What is the value of log mean temperature deference in degree Celsius?
6. Derive axial temperature variations for heat transfer in a tube supplied with constant surface heat flux.
7. Draw axial temperature variation of hot and cold fluid in heat exchanger for different combinations of heat capacity rate i.e.
   (a) heat capacity rate of hot fluid is greater than that of cold (Ch >> Cc)
   (b) heat capacity rate of hot fluid is smaller than that of cold (Ch << Cc)
   (c) heat capacity rate of hot fluid is equal to that of cold (Ch = Cc)

IV **Write an essay on ANY ONE of the following** **(1x10=10)**

1. A drying oven consists of a long semicircular duct of diameter D=1 m. Materials to be dried cover the base of the oven while the wall is maintained at 1200 K. What is the drying rate per unit length of the oven (kg/s-m) if a water coated layer of material is maintained at 325K during the drying process? Blackbody behavior may be assumed for the water surface and the oven wall.
   (Latent heat of evaporation = hfg =2.378 x10^6 J/kg)



2. Discuss the types of heat exchangers. What are the design parameters to be considered in heat exchanger design?

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