Gazi University
Department of Chemical Engineering
CHE321 Heat Transfer

25.10.2021

PROBLEM SET 1

1. A plastic panel of a area of 0.30 m^2 and thickness of 0.64 cm was found to conduct heat rate of 3 W at steady state with temperature of 24 °C and 26 °C on the two main surfaces. What is the thermal conductivity of plastic at 25 °C.
2. A refrigeration room has a cork board wall that is 6.1 m long, 5.5 m high and 0.46 m thick. The outside wall temperature is 20 °C and inside wall temperature -7.8 °C. The rate of heat flow through the wall is 105.48 W. Find the thermal conductivity of this material.
3. A heated sphere of diameter D is placed in a large amount of stagnant fluid. Consider the heat conduction in a fluid surrounding the sphere in the absence of convection. The thermal conductivity k of the fluid may be considered constant. The temperature at the sphere surface is Ts and the temperature far away from the sphere is Ta.
   a) Establish an expression for the temperature T in the surrounding fluid as a function of r , the distance from the center of the sphere.
   b) If h is the heat transfer coefficient, then show that the Nusselt number (dimensionless heat transfer coefficient) is given by
   c) Nu= hD/k =2
4. The wall of a furnace comprises three layers as shown in the Figure. The first layer is refractory (whose maximum allowable temperature is 1400 °C) while the second layer is insulation (whose maximum allowable temperature is 1093 °C). The third layer is a plate of 6.35 mm thickness of steel [thermal conductivity =45 W/(m K)]. Assume the layers to be in very good thermal contact.

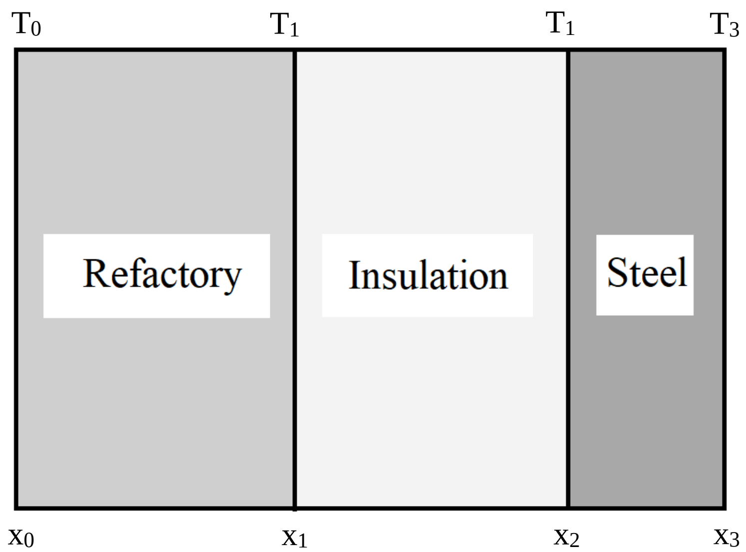

Figure. Layers in a composite furnace wall.

The temperature T_0 on the inside of the refractory is 1370 °C, while the temperature T_3 on the outside of the steel plate is 37.8 °C. The heat loss through the furnace wall is expected to be 15800 W/m^2. Determine the thickness of refractory and insulation that results in the minimum total thickness of the wall. Given thermal conductivities in W/(m K).

Layer	k at 37.8 °C	k at 1093 °C
Refractory	3.12	6.23
Insulation	1.56	3.12

5. A cylinder of radius ro, length L, and thermal conductivity k is immersed in a fluid of convection coefficient h and unknown temperature $T\infty$. At a certain instant the temperature distribution in the cylinder is $T(r)=a + br^2$, where a and b are constants. Obtain expressions for the heat transfer rate at ro and the fluid temperature.

6. At a given instant of time, the temperature distribution within an infinite homogeneous body is given by the function $T(x,y,z) = x^2 – 2y^2 + z^2 –xy + 2yz$. Assuming constant properties and no internal heat generation, determine the regions where the temperature changes with time.

7. The steady-state temperature distribution in a one-dimensional wall of thermal conductivity 50 W/mK and thickness 50 mm is observed to be $T(^oC) = a + bx^2$ where $a = 200^oC$, $b= -2000^oC/m^2$ and x is in meters. (a) What is the heat generation rate in the wall? (b) Determine the heat fluxes at the two wall faces. In what manner are these heat fluxes related to the heat generation rate?

8. One-dimensional, steady state conduction with no energy generation is occurring in a cylindrical shell of inner radius r_1 and outer radius r_2. Under what condition is the linear temperature distribution shown possible?