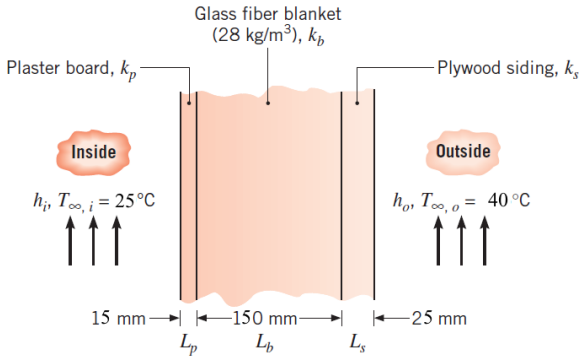
King Abdulaziz University
Faculty of Engineering
Mechanical Engineering

MEP 460
Heat Exchanger Design
Spring 2022
HW. # 01

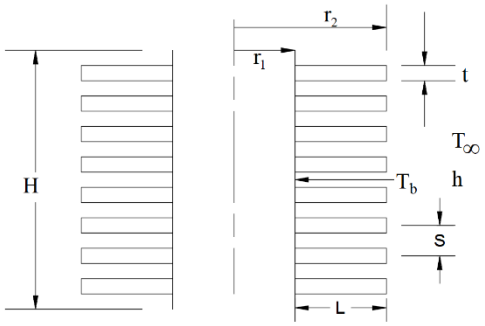
1-A wall of a house is made of three layers starting from outside to inside: a plywood of thickness 25 mm, Glass fiber (28 kg/m^3), and a plaster board. The inside temperature is 25°C and the outside temperature is 40° C. Draw the representative resistance circuit of the wall and find the total resistance. The wall area is 250 m^2. The convection heat transfer coefficients are: h_o= **50** W/m^2 K and h_i= **5** W/m^2 K



a) Calculate the heat transfer rate into the house
b) Which of the thermal resistance is the dominant one?
c) If in a windy condition the convective heat transfer on the outside wall is increased to **90** W/m^2.K, calculate the heat into the house

2-A stainless steel (AISI 304) tube used to transport a chilled pharmaceutical has an inner diameter of **30** mm and a wall thickness of **4** mm. The pharmaceutical and ambient air are at temperatures of 6°C and 23°C, respectively, while the corresponding inner and outer convection coefficients are **500** W/m^{2}K and **5** W/m^{2}K, respectively.
(a) What is the heat gain per unit tube length?
(b) What is the heat gain per unit length if a **25**-mm thick layer of calcium silicate insulation (k_{ins}= 0.050 W/m.K) is applied to the tube?

3-Consider a hallow cylinder with outer radius of r_1=25 mm exposed to air at T_∞=300 K with convective heat transfer h of **70** W/m^2.K. The cylinder height H is 0.15 m.



a) Calculate the heat transfer from the external wall of the cylinder assuming the outer surface of the cylinder is at T_b=500K.
b) Assume **10** circular fins were added to the outer surface of the cylinder. The fin thickness t is **5** mm, the fin length **L=30** mm as shown in the figure. Assume the fin material has a thermal conductivity of **60** W/m.K. Calculate the suface overall efficiency and the heat rate.

4-A pipe made of commercial steel of length **23** meters and inside diameter of **3.0** cm has four 90° elbows (k_{elbow}**=0.85**) Take the entrance friction coefficient $k_{enterance}$ to be 0.5 . The water velocity inside the pipe is 2 m/s, and the water can be considered to be at 30 °C. Calculate the pressure drop due to major and minor losses in the pipe. Repeat if the pipe diameter is changed to 2 cm, assuming the same flow rate in both cases.

5-A tube bank uses in-lined arrangement with **25** mm outside diameter tube, S_T=50 mm, S_L=**50** mm, and a tube length of 1 m. There are 10 tube rows in the flow direction (i.e. N_L=10) and 7 tubes per row (i.e. N_T=7). Air at T_i=27 ºC and velocity V=15 m/s is moving across the tubes while the wall temperature of the tubes is kept at T_s=100 ºC. Determine
a) Air outlet temperature T_o

b) Air pressure drop through the tube bank
c) Fan power needed to force the air across the tubes

You may use the following relation (Equation 7.63 Incropera 7th edition) to find the outlet temperature of the air

$$\frac{T_s - T_o}{T_s - T_i} = exp\left(-\frac{\pi DNh}{\rho C_p V N_T S_T}\right)$$

where N is the total number of tubes i.e. $N=N_T*N_L$