

## Week 3-Assignment

1. Finalize the composite wall question by finding the heat transfer rate  $\dot{Q}$ :

Indoor Temperature = 20

Outdoor Temperature = -10

$R_{\text{total}} = 6.8164$

$$= 20 - (-10) = 30$$

$$= (T_{\text{indoor}} - T_{\text{outdoor}}) / R_{\text{total}} = 30 / 6.8134 = 4.4031 \text{ W}$$

2) Solve the same question while the thickness of the brick is increased to 32 cm and comment on the results:

A 3 m high and 5 m wide wall consists of long 32 cm 22 cm section horizontal bricks ( $k = 0.72 \text{ W/m} \cdot ^\circ\text{C}$ ) separated by 3 cm thick plaster layers ( $k = 0.22 \text{ W/m} \cdot ^\circ\text{C}$ ).

There are also 2 cm thick plaster layers on each side of the wall and a 3-cm-thick rigid foam ( $k = 0.026 \text{ W/m} \cdot ^\circ\text{C}$ ) on the inner side of the wall.

The indoor and the outdoor temperatures are  $20^\circ\text{C}$  and  $-10^\circ\text{C}$ , and the convection heat transfer coefficients on the inner and outer sides are  $h_1 = 10 \text{ W/m}^2 \cdot ^\circ\text{C}$  and  $h_2 = 25 \text{ W/m}^2 \cdot ^\circ\text{C}$ , respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

$$R_{\text{conv } 1} = 1 / h_1 \cdot A = 1 / (10 \times 0.25) = 0.4$$

$$R_{\text{conv } 2} = 1 / h_2 \cdot A = 1 / (25 \times 0.25) = 0.16$$

R conduction in series

$$R_{\text{cond. Foam}} = L / (k_f \cdot A) = 0.03 / (0.026 \times 0.25) = 4.6154$$

$$R_{\text{plaster } 1} = R_{\text{plaster } 2} = L / (k \cdot A) = 0.02 / (0.22 \times 0.25) = 0.3636$$

### R conduction in parallel

$$R_{pc1} = R_{pc2} = L/K.A = 0.32/(0.22 \times 0.015) = 96.9697$$

$$R_{brick} = L/K.A = 0.32/(0.72 \times 0.22) = 2.0202$$

$$\begin{aligned} 1/R_{total} &= 1/R_{pc1} + 1/R_{brick} + 1/R_{pc2} = 1/96.9697 + 1/2.0202 + \\ 1/96.9697 &= 0.5156 \quad R_{total} = 1/0.5156 = 1.9395 \end{aligned}$$

$$\begin{aligned} \underline{R_{total}} &= R_{conv. 1} + R_{cond. foam} + R_{pc1} + R_{pc2} + R_{total parallel} + R_{conv. 2} = \\ &= 0.4 + 4.6154 + 0.3636 + 1.9395 + 0.3636 + 0.1 = 7.7821 \end{aligned}$$

$$\text{Heat Transfer} = (T_{ind} - T_{out}) / R_{tot} = (20 - (-10)) / 7.7821 = 3.855 \text{ W}$$

### Comparing :

$$(16 \text{ cm brick}) = 4.4031 \text{ W}$$

$$(32 \text{ cm brick}) = 3.8550 \text{ W}$$

Thermal resistance of the brick has approximately doubled by doubling the thickness of the brick. Also, the heat transfer rate  $\dot{Q}$  for the new brick thickness of 32 cm has decreased as well from 4.4031 W to 3.8550 W. However, the decrease is not enough compared to the cost that was probably paid. The investment should be in the foam insulation layer, by making it thicker for example.

3) Solve again the simplified wall calculation procedure replacing the glass fiber one with urethane rigid foam and while replacing the fiber board with plywood and find the two R values.

	Wood (A	Insulation (B
Outside	0.03	0.03
Wood bevel	0.14	0.14
Plywood	0.11	0.11
Urethane rigid	no	$0.98 \times (90/25) = 3.528$
Wood Studs	0.63	no
Gypsum board	0.079	0.079
Inside Surface	0.12	0.12

R with wood (section A) =  $0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109 \text{ (m}^2 \cdot \text{)}/\text{W}$

R with insulation (section B) =  $0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007 \text{ (m}^2 \cdot \text{)}/\text{W}$

