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EXAMPLE AND SUMMARY

Finalize the answer by determining the heat transfer rate of the composite wall question done in the classwork.

$$\dot{Q} = \frac{\Delta T}{R_{Tot}} = \frac{T_{\infty 1}-T_{\infty 2}}{R_{Tot}} = \frac{20-(-10)}{6.813} = \mathbf{4.403\ W}$$

Example 1

A 3 m high and 5 m wide wall consists of long 32 cm 22 cm cross section horizontal bricks (k =0.72 W/m · °C) separated by 3 cm thick plaster layers (k =0.22 W/m · °C). There are also 2 cm thick plaster layers on each side of the brick and a 3-cm-thick rigid foam (k 0.026 W/m · °C) on the inner side of the wall. The indoor and the outdoor temperatures are 20°C and 10°C, and the convection heat transfer coefficients on the inner and the outer sides are h1=10 W/m2 · °C and h2 =40 W/m2 · °C, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.

$$R_i = \frac{1}{h_1 \times A_i} = \frac{1}{10 * (0.015 + 0.22 + 0.015) * 1} = 0.4\,°\frac{C}{W}$$

$$R_f = \frac{L_f}{(K_f \times A_f)} = \frac{0.03}{0.026 * (0.015 + 0.22 + 0.015) * 1} = 4.615\,°\frac{C}{W}$$

$$R_{p-up} = R_{p-down} = \frac{L_{p-up}}{(K_{p-up} \times A_{p-up})} = \frac{0.32}{0.22 * 0.015 * 1} = 96.97\,°\frac{C}{W}$$

$$R_b = \frac{L_b}{(K_b \times A_b)} = \frac{0.32}{0.72 * 0.22 * 1} = 2.02\,°\frac{C}{W}$$

$$\therefore \frac{1}{R_{total-parallal}} = \frac{1}{R_b} + \frac{1}{R_{p-up}} + \frac{1}{R_{p-down}} = \frac{1}{2.02} + \frac{1}{96.97} + \frac{1}{96.97} = 0.516\,°\frac{W}{C}$$

$$\therefore R_{total-parallal} = 1.94\,°\frac{C}{W}$$

Now,

$$R_{p1} = R_{p2} = \frac{L_{p1}}{(K_{p1} \times A_{p1})} = \frac{0.02}{0.22 * 0.25 * 1} = 0.364\,°\frac{C}{W}$$

$$R_o = \frac{1}{h_2 \times A_o} = \frac{1}{40 * (0.015 + 0.22 + 0.015) * 1} = 0.1\ ^\circ\frac{C}{W}$$

$$\therefore\ R_{total} = R_i + R_f + R_b + R_{total-parallal} + R_{p1} + R_{p2} + R_o$$

$$= 0.4+4.615+1.94+0.364+0.364+0.1 = 7.783\ ^\circ\frac{C}{W}$$

Heat transfer rate,

$$\dot{Q} = \frac{\Delta T}{R_{Tot}} = \frac{T_{\infty 1}-T_{\infty 2}}{R_{Tot}} = \frac{20-(-10)}{7.783} = \mathbf{3.855\ W}$$

Comparing both of the heat transfer rate results:

Varying the brick thickness shows us that, the thickness of the brick has very minimal effect on the heat transfer rate. It does not increase the total resistance of the wall in a significant amount so that the change in heat transfer rate is also very insignificant. Whereas, the use of foam with brick makes an alteration. So, it is advisable to use foam as an insulator rather than changing the brick thickness.

Example 2

Determine the overall unit thermal resistance (the R value) and the overall heat transfer coefficient (the U-factor) of a wood frame wall that is built around 38-mm 90-mm wood studs with a center-to-center distance of 400 mm. The 90-mm-wide cavity between the studs is filled with urethane rigid foam insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13-mm plywood and 13-mm 200-mm wood bevel lapped siding. The insulated cavity constitutes 75 percent of the heat transmission area while the studs, plates, and sills constitute 21 percent. The headers constitute 4 percent of the area, and they can be treated as studs. Also, determine the rate of heat loss through the walls of a house whose perimeter is 50 m and wall height is 2.5 m in Las Vegas, Nevada, whose winter design temperature is -2 C. Take the indoor design temperature to be 22 C and assume 20 percent of the wall area is occupied by glazing.

	Wood	Insulation
Outside air	0.03	0.03
Wood stud - 90mm	0.63	NO

Urethane rigid foam insulation-90 mm	NO	$0.98 * \frac{90}{25} = 3.528$
Gypsum wallboard- 13 mm	0.079	0.079
Plywood- 13mm	0.11	0.11
Wood bevel- 13*200mm	0.14	0.14
Inside surface	0.12	0.12

$$R_{withwood} = 0.03 + 0.63 + 0.079 + 0.11 + 0.14 + 0.12 = 1.109\ m^2 \circ \frac{W}{C}$$

$$R_{withinsulation} = 0.03 + 3.528 + 0.079 + 0.11 + 0.14 + 0.12 = 4.007\ m^2 \circ \frac{W}{C}$$