20 October 2019 20:26

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Task 1:

In this week's assignment you should first finalize the composite wall question by finding the heat transfer rate, and then solve the same question while the thickness of the brick is increased to 32 cm and comment on the results.

Heat loss through composite wall
A 3Meter high and 5Meter wide wall consists of long 32cm*22cm cross section of horizontal bricks (k=0.72 W/m° C. on the inner side of the wall. The indoor and the outdoor temperatures are 20° C and -10° C. The convection heat transfer coefficient on the inner and outer sides are h_1=10 W/m^2 ° C and h_2 =10 W/m^2 ° C respectively. Assuming the one dimensional heat transfer and disregarding radiation, determine the rate of the heat transfer through the wall.

Answer:

Total resistance= $h_{1\ conv.} + R_{1\ foam} + R_{plaster\ A} + [R_{plaster1} + R_{brick} + R_{plaster2}] + R_{plaster\ B} + R_{2\ conv.}$

$$h_{1\ conv.} = \frac{1}{h1*A} = \frac{1}{10*(0.25*1)} = 0.4\ \frac{°C}{W}$$

$$R_{1\ foam} = \frac{L\ f}{k\ f\ *A} = \frac{0.03}{0.026*(0.25*1)} = 4.615\ \frac{°C}{W}$$

$$R_{plaster\ A} = R_{plaster\ B} = \frac{L\ p}{k\ p*A} = \frac{0.02}{0.022*(0.25*1)} = 0.363\ \frac{°C}{W}$$

$R_{Total\text{-}parallel} = R_{plaster1} + R_{brick} + R_{plaster2}$

$$R_{plaster1} = R_{plaster2} = \frac{L\ p}{k\ p*A} = \frac{0.32}{0.22*(0.015*1)} = 96.97\ \frac{°C}{W}$$

$$R_{brick} = \frac{L\ b}{k\ b*A} = \frac{0.32}{0.72*(0.22*1)} = 2.02\ \frac{°C}{W}$$

$$R_{Total\text{-}parallel} = R_{plaster1} + R_{brick} + R_{plaster2} = \frac{1}{96.97} + \frac{1}{2.02} + \frac{1}{96.97} = 0.516\ \frac{W}{°C}$$

$$R_{Total\text{-}parallel} = \frac{1}{0.516} = 1.94\ \frac{°C}{W}$$

$$R_{2\ conv.} = \frac{1}{h2*A} = \frac{1}{40*(0.25*1)} = 0.1\ \frac{°C}{W}$$

Total resistance= $h_{1\ conv.} + R_{1\ foam} + R_{plaster\ A} + R_{Total\text{-}parallel} + R_{plaster\ B} + R_{2\ conv.}$

=0.4+4.615+0.363+1.94+0.36+0.1+7.781

The Heat transfer rate is,

$$\dot{Q} = \frac{T\infty1 - T\infty2}{Rt} = \frac{20-(-10)}{7.781} = 3.86W$$

In the previous sum we have calculated the $R_{wall\ total}$ while the thickness of the brick in composite wall is 16mm,

$R_{wall\ total} = 6.81 \frac{^{\circ}C}{W}$

In this condition, the rate of heat transfer is,

$Q = \frac{T\infty 1 - T\infty 2}{Rt} = \frac{20-(-10)}{6.81} = 4.41\ W$

By comparing these two results, we can conclude that,

Foam provides maximum resistance. More the thickness of the foam = Less the heat transfer. Increasing the thickness of the brick wall, does not increases the thermal resistance of the entire wall.

Task 2:

A wood frame wall that is built around 38mm-90mm wood studs with a centre to centre distance of 400mm. The 90mm wide cavity between the studs is filled with urethane rigid foam insulation. Inside is finished with 13mm gypsum constitutes 75 % of heat transmission area while the studs, plate and sills constitute 21 percent. The headers constitute 4 % of the area and they can be treated as studs. Find the two R_{unit} values.

Answer:

	Wood	**Insulation**
Outside Air	0.03	0.03
Wood Bevel (13mm*200mm)	0.14	0.14
Plywood (13mm)	0.11	0.11
Urethane Rigid foam Ins (90mm)	No	9=0.98*(90/25)=3.528
Wood studs (90mm)	0.63	No
Gypsum Board (13mm)	0.079	0.079
Inside Surface	0.12	0.12

$R'_{with\ wood}$ = 0.03+0.14+0.11+0.63+0.079+0.12 $m^2\ \frac{^{\circ}C}{W} = 1.109\ m^2\ \frac{^{\circ}C}{W}$

$R'_{with\ insulation}$= 0.03+0.14+0.11+3.528+0.079+0.12 $m^2\ \frac{^{\circ}C}{W} = 4.007\ m^2\ \frac{^{\circ}C}{W}$