WEEK 2 weekly submission

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CONVECTIVE HEAT TRANSFER SUMMARY

Convective heat transfer or Convection, like conductive heat transfer, is the transfer of heat energy. But unlike conductive heat transfer, convection happens through the movement of fluids. It usually happens between two moving fluids, as in liquids and gases, but it can also happen between a solid and a moving fluid. To put it into architectural terms, convective heat transfer happens between the air outside and the exterior face of a wall, or the air inside and the interior face of a wall. And like the conductive heat transfer, convective heat transfer is generally from the hotter body into the cooler body. The rate of convective heat transfer depends on the temperature difference between the two bodies., the wind velocity, and the kind of liquid/gas flowing to the body.

There are two kinds of convective heat transfer: *free or natural convection*, and *forced convection.* ***Free convection*** is when the fluids move naturally and without the help of an external force. Thus, heat transfer happens as the warm liquid or gas rises and is replaced by a cooler liquid or gas. ***Forced convection*** is when the fluids move because of an external force, such as the wind.

Increasing the thickness of the glass pane does not increase the total resistance:
If you look at the computation for the total resistance, you can immediately notice that the thermal conduction resistance of the glass is significantly lower than the thermal convention resistance of the interior and exterior side of the glass. Thus, increasing the thickness of the glass is useless for decreasing the heat transfer rate because the bulk of the total resistance comes from the convection resistance between the glass and the air.

Mistakes during the last class:
On one of the exercises last week, I wasn't able to get the correct answer. And it was mainly because I made a mistake with the conversion of the units. The 8mm glass should have been 0.008m and I used 0.08m.

Example

Solve for the rate of heat transfer through a 0.8m high, 1.5m wide double pane window consisting of two 6mm thick layers of glass(k = 0.78 $\frac{W}{\text{m °C}}$) separated by a 13mm wide air gap(k = 0.026 $\frac{W}{\text{m °C}}$). Note that the convection heat transfer coefficient on the interior of the window is 10 $\frac{W}{\text{m}^2\text{ °C}}$ and on the exterior of the window is 40 $\frac{W}{\text{m}^2\text{ °C}}$.

Area
A_{glass} = 0.8m x 1.5m = 1.20m^2

Thermal resistance of convection between the air and the interior surface

$$R_{conv1} = \frac{1}{h_1 A} = \frac{1}{\frac{10W}{m^2\,°C} x\ 1.20m^2} = \mathbf{0.0833\ \frac{°C}{W}}$$

Thermal resistance of conduction within the interior glass

$$R_{wall1} = \frac{L}{k_1 A} = \frac{.006m}{\frac{0.78W}{m\,°C} x\ 1.20m^2} = \mathbf{0.0064\ \frac{°C}{W}}$$

Thermal resistance of conduction within the air gap space

$$R_{airgap} = \frac{L}{k_{airgap} A} = \frac{.013m}{\frac{0.026W}{m\,°C} x\ 1.20m^2} = \mathbf{0.4167\ \frac{°C}{W}}$$

Thermal resistance of conduction within the exterior glass

$$R_{wall2} = \frac{L}{k_2 A} = \frac{.006m}{\frac{0.78W}{m\,°C} x\ 1.20m^2} = \mathbf{0.0064\ \frac{°C}{W}}$$

Thermal resistance of convection between the air and the exterior surface

$$R_{conv2} = \frac{1}{h_2 A} = \frac{1}{\frac{40W}{m^2\,°C} x\ 1.20m^2} = \mathbf{0.0208\ \frac{°C}{W}}$$

Computation for total thermal resistance of the double pane glass window

$$R_{total} = R_{conv1} + R_{wall1} + R_{airgap} + R_{wall2} + R_{conv2}$$

$$= .0833\frac{°C}{W} + .0064\frac{°C}{W} + 0.4167\frac{°C}{W} + 0.0064\frac{°C}{W} + 0.0208\frac{°C}{W} = \mathbf{0.5336\frac{°C}{W}}$$

Computation for rate of heat transfer

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{total}} = \frac{20°C - (-10°C)}{0.5336\frac{°C}{W}} = \mathbf{56.2219\ W}$$

Computation for temperature of interior surface of window

$$\dot{Q} = \frac{T_{\infty 1} - T_1}{R_{conv1}}$$

$$T_1 = T_{\infty 1} - (\dot{Q} \times R_{conv1}) = 20°C - \left(56.2219\ W \times 0.0833\frac{°C}{W}\right) = \mathbf{15.3°C}$$

Note: We have an optimum range for the distance of the air gap space between the two glass panels because when the distance reaches a certain point and that distance allows the air inside to move, the heat transfer in the air gap shifts from conduction to convection. Thus, from that point in the optimum range, the rate of heat transfer in the double pane glass window decreases at a significant rate.