Summary about the convective heat transfer

Heat can travel from one place to another in three ways: *Conduction, **Convection** and Radiation.*

Convective heat transfer is a heat transfer phenomenon that occurs as a result of the movement of fluid (liquid-liquid, liquid-gas, gas-gas) or takes between a solid and gas. For example- heat transfer between a solid wall and air.

Convection is caused due to density differences caused by temperature variations in the fluids or solid and fluid. At heating the density changes, cause the fluid to rise and be replaced by cooler fluid that also will heat and rise. This continues phenomena is called convection.
Conduction and convection is a combined process.

Heat transfer usually takes place in two methods :

1. Natural convection- It is a method of heat transfer, in which the fluid motion is generated by density differences in the fluid occurring due to temperature difference without external force.
2. Forced convection- It is a method of heat transfer, in which fluid motion is generated by an external source (like a pump, fan, etc.).

Rate of convection heat transfer depends on:

1. Variation of temperature
2. Velocity of liquid or gas
3. Kind of liquid or gas

Why increasing the thickness of a single panel glass does not increase the total resistance?

The thermal resistance of single panel glass is relatively less in caparison to thermal resistance of convection between glass and air, so increasing the thickness of single glass can increase the thermal resistance of glass, but it will have negligible effect on the total thermal resistance.

Write an explanation about what mistakes you made in the class that resulted in wrong answers.

Conversion and calculation mistakes - concept is clear.

Consider a 0.8-m-high and 1.5-m-wide double-pane window consisting of two 6-mm-thick layers of glass (k= 0.78 W/m°C) separated by a 13-mm-wide stagnant air space (k= 0.026 W/m°C). Determine the steady rate of heat transfer through this double-pane window and the temperature of its inner surface.
Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be h1= 10 W/m2°C and h2=40 W/m2°C, which includes the effects of radiation.

Comment on your results and explain why we have an optimal range for the air-gap's distance

We should first calculate the total resistance :

The area of surface
$A = 0.8 * 1.5 = 1.2\ m^2$

The thermal resistance of the conduction of 6mm glass

$$R_{g1} = R_{g2} = \frac{L_g}{k_g \times A} = \frac{0.006}{0.78\frac{W}{m^{\circ}C} * 1.2\ m^2} = 0.0064^{\circ}\frac{C}{W}$$

The thermal resistance of the convection between inner surface and air

$$R_{conv1} = \frac{1}{h_1 \times A} = \frac{1}{\frac{10W}{m^{\circ}C} * 1.2\ m^2} = 0.0833^{\circ}\frac{C}{W}$$

The thermal resistance of the convection between outer surface and air

$$R_{conv2} = \frac{1}{h_2 \times A} = \frac{1}{\frac{40W}{m^{\circ}C} * 1.2\ m^2} = 0.0208^{\circ}\frac{C}{W}$$

The thermal resistance of the conduction of 13mm glass

$$R_{air} = \frac{L_{air}}{k_{air} \times A} = \frac{0.013}{0.026\frac{W}{m^{\circ}C} * 1.2\ m^2} = 0.4167^{\circ}\frac{C}{W}$$

Total thermal resistance of the window

$$R_{tot} = R_{conv1} + 2 \times R_{glass} + R_{Gap} + R_{conv2} = 0.0833 + 2 * 0.0064 + 0.0208 + 0.4167 = 0.5333^{\circ}\frac{C}{W}$$

Total the steady rate of heat transfer through this double-pane window

$$\dot{Q} = \frac{(\Delta T)}{R_{tot}} = \frac{T_{inff1} - T_{inff_2}}{R_{tot}} = \frac{20 - (-10)}{0.5333^{\circ}\frac{C}{W}} = 56.25\ W$$

The temperature of its inner surface

$$\dot{Q} = \frac{T_{inff1} - T_1}{R_1} \rightarrow$$

$$T_1 = T_{inff1} - \dot{Q} * R_{conv1} = 20^{\circ}C - 56.25\ W * 0.0833^{\circ}\frac{C}{W}$$

=15.3℃

In case of single layered glass, resistance to heat transfer is low while in the case of double layered glass with air trap (ranges from 6mm-13mm) acts as a resistance towards the heat transfer from one point to other.

We have an optimal range (6mm-13mm) for the air-gap's distance because the excess distance allows the air to move and our assumptions of trap air will be false.