Week-2

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Task:1
Write a summary (in your own words) about the convective heat transfer (half a page) and explain why increasing the thickness of a single pane glass does not increase the total resistance.

Solution:
There are two types of Convection:

a. Natural Convection:
   Natural convention is the movement of fluids due to pressure difference and movement of molecules as hot air rises and cold air comes down, Since hot air is lighter than cold air.
b. Force Convection:
   Force Convection happens when external force is applied.

Rate of convection heat transfer depends on following factors:

a. Temperature Difference.
b. Velocity of Liquid and Gas.
c. Kind/Type of Liquid or Gas.

Conduction and Convection takes place both together.
The equation of calculating Total Resistance helps us understanding that, increasing the thickness of the glass does not help reducing the heat transfer through conduction or convection since the resistance of the glass is less than other resistances.

Instead by introducing an air-gap between two glasses will help reducing the heat transfer (which is concluded by the mathematical equation) since $\frac{L}{K*A}$.

The range of air-trap/gap should be ideally, 6mm-13mm. If it exceeds, distance will allow the air to move inside and our assumptions of air-trap will be false.

In-case of vacuum, according to theory there is no convection or conduction but in practicality it does tales place because of Radiation.

Task:2
Write and explanation about what mistakes you made in the class that resulted in wrong answers.

Solution:
While calculating the total resistance, thickness of the glass was given in millimetres and while solving the problem, millimetres was to be converted to Metres (i.e. millimetres*1000 = Metres). Which was missed by me while solving the problem.

Task:3
Consider a 0.8m high and 1.5m wide double pane window consisting of two 6mm thk. Layers of glass (k=0.78 W/m˚C) separated by a 13mm 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 coefficient on the inner and outer surface of the window to be h_1=10 W/m^2 and h_2=40 W/m^2.

Solution:
Area of the surface of the glass:
A_g=0.8*1.5=1.2m^2

Thermal Resistance of convection between inner surface and the air:

$R_{conv1} = \frac{1}{h1*A} = \frac{1}{10*1.2} = 0.0833\frac{°C}{W}$

Thermal Resistance of convection between outer surface and the air:

$R_{conv2} = \frac{1}{h2*A} = \frac{1}{40*1.2} = 0.0208\frac{°C}{W}$

Thermal Resistance of Conduction of a 6mm thk. Layer of glass:

$R_g = \frac{L\,g}{K\,g*A} = \frac{0.006}{0.78*1.2} = 0.0064\frac{°C}{W}$

Thermal Resistance of Conduction of a 13mm thk. of stagnant air space:

$R_a = \frac{L\,a}{K\,a*A} = \frac{0.013}{0.026*1.2} = 0.4167\frac{°C}{W}$

Total thermal resistance:
$R_t = R_{conv1} + R_{glass1} + R_{air} + R_{glass2} + R_{conv2}$
R_t = 0.0833+0.0064+0.4167+0.0064+0.0208
R_t= 0.5333° C/W

Steady rate of heat transfer through double pane window.

$Q = \frac{T\infty1 - T\infty2}{Rt} = \frac{20-(-10)}{0.5333} = 56.25W$

$\because Q = \frac{T\infty1 - T2}{R\,conv1}$ $\quad \therefore 56.25 = \frac{20 - T2}{0.0833}$

$\therefore T_1$= 15.32°C

$\because Q = \frac{T2 - T\infty2}{R\,conv2}$ $\quad \therefore 56.25 = \frac{T2 - (-10)}{0.0208}$

T_2= 0.117°C

Double layer glass with air-trap (range from 6-13mm wide) acts as a high resistance to the heat transfer from one point to the other.
The distance should not exceed this range , if it exceeds, it will allow the air to move and our assumption of air-trap will be false. While a single layered glass provides extremely low resistance to heat transfer.
(since $\frac{L}{K*A}$) .
Hence heat transfer is less.