WEEK 2

2019年10月14日　　0:59

QUESTIONS:

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

2. write an explanation about what mistakes you made in the class that resulted in wrong answers !

3. solve the same probelm as that of double pane window with the air-gap thickness of 13 mm and glass thickness of 6 mm, commment on your results and explain why we have an optimal range for the air-gap's distance !

ANSWERS:

1. 1) SUMMARY:

- Outdoor space: When outdoor air flows against the warm wall, the temperature around the exterior surface of the wall is cool down by cold air.
  Indoor space: because of the air has different pressure on different temperature, the warm air tends to flow up while the cold air goes down inside the house, thus it occurs wind motions.
  The indoor warm air continues to heat the inner surface of the wall.
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- There are two types of convection--
  forced convection: A type of heat transfer when the fluids are forced to move. The force can be strong wind, suction device, a pump, etc.
  natural convection: A type of motion of fluids without forces, but only flowing by the impact of the gravity--because of the differences of pressure.

- Definition of convective heat transfer:
  The rate of thermal energy transferred from the surface of solid area to the central zone (where the temperature is steady) of the fluid, or reverse pocess, due to the different temperatures when the fluid flows past the surface of solid substance.

- The convective heat transfer depends on the speed of fluid motion, material of fluid, the temperature differences between fluid and solid and also superfacial area of solid object.
  (But not the material of solid object!)

2) INCREASING TOTAL RESISTANCE:

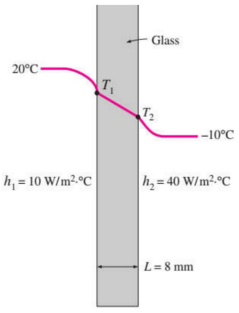
- According to the exercise we have seen in the class.

$$R_{total} = R_{conv,1} + R_{glass} + R_{conv,2}$$

$$R_{conv,1} = \frac{1}{h_1 A} = \frac{1}{10 * 0.8 * 1.5} \approx 0.083 \quad (°C/W)$$

$$R_{glass} = \frac{L}{kA} = \frac{0.008}{0.78 * 0.8 * 1.5} \approx 0.0085 \quad (°C/W)$$

$$R_{conv,2} = \frac{1}{h_2 A} = \frac{1}{40 * 0.8 * 1.5} \approx 0.02 \quad (°C/W)$$



❖Consider a 0.8 m high and 1.5 m wide glass window, shown above with a thermal conductivity of k =0.78 W/m·°C. Determine the steady rate of heat transfer through this glass window and the temperature of its inner surface

- It's very clear that the resistance of convective heat transfers is about twice to tenfold the resistance of the single pane glass, and a reasonable thickness of glass can only increases finitely, which means the magnitude of glass thickness change is too small to dedicate total resistance increase.

2. None

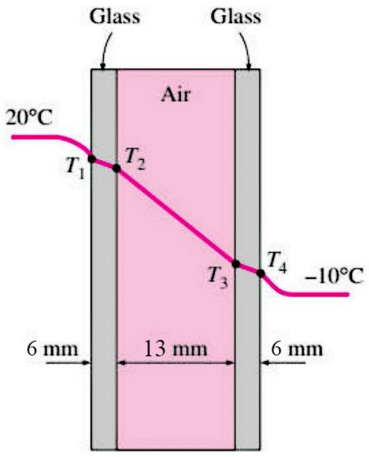
3. ❖ Consider a 0.8-m-high and 1.5-m-wide double-pane window consisting of two 6-mm-thick layers of glass (k= 0.78 W/m.°C) separated by a 13-mm-wide stagnant air space (k= 0.026 W/m.°C). Determine the steady rate of heat transfer through this double-pane window and the temperature of its inner surface.

✓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.

$$R_{total} = R_{conv,1} + R_{glass1} + R_{airgap} + R_{glass2} + R_{conv,2}$$
$$= \frac{1}{h_1 A} + \frac{L_1}{k_1 A} + \frac{L_{gap}}{k_{gap} A} + \frac{L_1}{k_1 A} + \frac{1}{h_2 A}$$
$$= \frac{1}{10*0.8*1.5} + \frac{2*6*0.001}{0.78*0.8*1.5} + \frac{13*0.001}{0.026*0.8*1.5} + \frac{1}{40*0.8*1.5}$$
$$\approx 0.0833 + 0.0128 + 0.4167 + 0.0208$$
$$\approx 0.5336\ (°C/W)$$

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{total}} = \frac{20 + 10}{0.5336} \approx 56.22\ (W)$$

$$T_1 = T_{\infty 1} - \dot{Q} * R_{conv,1} = 20 - 56.22 * 0.0833 \approx 15.32\ (°C)$$



- Becauese the k_{air} *is* around 30 times smaller than k_{glass}, so when the magnitudes of thickness are almost the same, R_{air} is much largger than R_{glass} *a*nd also than other resistances, therefore increasing the thickness of air-gap can increase apparently total resistance.
- When the distance of air-gap is quite short, we can suppose this air-gap with only effect of conduction. However too much thickness increase can cause convection which accelerates heat transfer in the air-gap.