Week2 Assignment

Summary：

Convection refers to the process of the transfer of heat from one place to another by the movement of fluids. Convection is usually the dominant form of heat transfer in liquids and gases. Since the various part of the fluid are in contact with each other, in addition to the thermal convection caused by the overall movement of the fluid, heat conduction(due to the movement of the microscopic particles of the fluid) is also involved.

In the main body of the glass, since the fluid mass is drastically violent, the temperature difference of the fluid is extremely small in the heat transfer direction, the temperature is basically the same everywhere, and the heat transfer mainly depends on the convection, the conduction plays little role. In the transition layer, the temperature of the fluid changes slowly and conduction and convection simultaneously act. In the air layer, the fluid flows only in parallel along the wall surface, there is no particle displacement in the heat transfer direction, so the heat transfer mainly depends on conduction. Since the thermal conductivity of the fluid is small, the heat resistance in the air layer is large. Therefore, the temperature difference of the fluid in the layer is large. In convection heat transfer, the thermal resistance is mainly concentrated in the air layer. It is an important way to enhance the convective heat transfer by thinning the thickness of the air layer.

Explanation about the mistakes：

I did the class assignment correctly in the class.

Question：

Consider a 0.8-m-high and 1.5-m-wide double-pane window consisting of two 6-mm-thick layers of glass（k=0.78W/m.℃）separated by a 13-mm-wide stagnant air space （k=0.026W/m.℃） .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=10W/㎡ •℃and h2=40W/㎡ •℃，which includes the effects of radiation.Comment on your results and explain why we have an optimal range for the air-gap’s distance!

Solution:

$$R_{conv.1} = \frac{1}{h_1 A} = \frac{1}{10 \times 1.2} \approx 0.0833(°C/W)$$

$$R_{conv.2} = \frac{1}{h_2 A} = \frac{1}{40 \times 1.2} \approx 0.0208(°C/W)$$

$$R_{\text{glass}} = \frac{L}{KA} = \frac{0.006}{0.78 \times 1.2} \approx 0.0064(°C/W)$$

$$R_{air} = \frac{L}{KA} = \frac{0.013}{0.026 \times 1.2} \approx 0.4167(°C/W)$$

$$R_{total} = R_{conv.1} + R_{glass1} + R_{air} + R_{glass2} + R_{conv.2} = 0.0833 + 0.0064 + 0.4167 + 0.0064 + 0.0208 = 0.5336(°C/W)$$

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

$$\dot{Q} = \frac{T_{\infty 1} - T_{1}}{\mathrm{R_{conv.1}}}$$

$$\mathrm{T_1} = \mathrm{T_{\infty 1}} - \dot{Q} * R_{conv.1} = 20 - 56.2219 * 0.0833 \approx 15.32℃$$

When the air-gap's distance gets larger，it will have heat transfer. When the air-gap's distance is in an optimal range, the air can be considered to be static. So there will only have conduction and the resistance will get smaller.