Summary:

Convective heat transfer is a phenomenon of heat transfer that occurs during the flow of a fluid. is mainly due to movement of the mass position, tending to equalize temperature. Although the primary means of heat transfer in liquids and gases is convective heat transfer, it is often accompanied by heat transfer. Usually due to different reasons, there are two kinds of natural and forced convection. The flow state can be divided into layers and turbulent convection heat transfer. Are often encountered in the chemical industry convective heat transfer, the heat is transferred to the fluid by the solid wall , like near the hot fluid side of the container wall or catheter wall, or a fluid passing around a solid wall , near the cold fluid one side wall of the conduit . This fluid transmitted by the wall surface or the reverse process, commonly referred to heat.

Question:

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

Answer: The thermal resistance of glass is a quite small value compared to the thermal resistance of convection between glass and air. Increasing the thickness of a single glass can increase the thermal resistance of the glass, but it does not significantly increase the total thermal resistance.

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 =0.78 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$\frac{W}{m^2℃}$ and h2=40$\frac{W}{m^2℃}$, which includes the effects of radiation.

Answer: The area of the surface: A_{glass}=0.8m*1.5m=1.2m^2

The thermal resistance of the convection between inner surface and the air:

$R_{conv,1}=\frac{1}{h_1A}=\frac{1}{\frac{10W}{m^2℃}*1.2m^2}\approx 0.0833\frac{℃}{W}$

The thermal resistance of the convection between outer surface and the air:

$R_{conv,2}=\frac{1}{h_2A}=\frac{1}{\frac{40W}{m^2℃}*1.2m^2}\approx 0.0208\frac{℃}{W}$

The thermal resistance of the conduction of a 6-mm-thick layers of glass:

$R_{glass}=\frac{L_{glass}}{k_{glass}A}=\frac{0.006m}{0.78\frac{W}{m℃}*1.2m^2}\approx 0.0064\frac{℃}{W}$

The thermal resistance of the conduction of a 13-mm-wide stagnant air space:

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

Total thermal resistance of the window:

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

$\approx 0.0833\frac{℃}{W}+0.0064\frac{℃}{W}+0.4167\frac{℃}{W}+0.0064\frac{℃}{W}+0.0208\frac{℃}{W}=0.5333\frac{℃}{W}$

And the steady rate of heat transfer through this double−pane window is:

$\dot{Q}=\frac{T_{\infty 1}-T_{\infty 2}}{R_{total}}\approx\frac{20℃-(-10℃)}{0.5333\frac{℃}{W}}\approx 56.2535W$

$\because \dot{Q}=\frac{T_{\infty 1}-T_1}{R_{conv,1}}$

∴The temperature of the inner surface of the window is:

$T_1=T_{\infty 1}-\dot{Q}*R_{conv,1}\approx 20℃-56.2535W*0.0833\frac{℃}{W}\approx 15.3℃$