1) Summary

Heat convection happens in three forms between fluids (gas and gas, liquid and gas, liquid and liquid), in a closed door room when cold air touches the surface of a hot solid like a radiator it gets hot and due to lower density of hot air it moves up, this process will continue to the point that all the air in the room gets same temperature. This natural flow of air is called natural convection.

The other kind of convective heat transfer is Forced convection, which happens between one solid and one moving fluid or two moving fluid with an external force. As an example wind is an external force for the outside air contacting with a hot solid surface.

2) Question

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

The thermal resistance of convection between glass and air is much bigger than the thermal resistance of the glass, and the final thermal resistance does not change considerably when the thickness of a single glass plane increases.

$$A_{glass} = 0.8 \times 1.5\text{m} = 1.2\ \text{m}^2$$

$$R_{conv1} = \frac{1}{h_1 A} = \frac{1}{10 \frac{w}{m^2 ℃} \times 1.2\ \text{m}^2} \approx 0.0833 \frac{℃}{w}$$

$$R_{conv2} = \frac{1}{h_2 A} = \frac{1}{40 \frac{w}{m^2 ℃} \times 1.2\ \text{m}^2} \approx 0.0208 \frac{℃}{w}$$

$$R_{glass} = \frac{L_g}{k_g\, A} = \frac{0.006\ m}{0.78 \frac{w}{m℃} \times 1.2\ \text{m}^2} \approx 0.0064 \frac{℃}{w}$$

$$R_{air} = \frac{L_a}{k_a\, A} = \frac{0.006\ m}{0.026 \frac{w}{m℃} \times 1.2\ \text{m}^2} \approx 0.4167 \frac{℃}{w}$$

$$R_{total} = R_{conv1} + R_{conv2} + R_{g1} + R_a + R_{g2}$$

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

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

$$\dot{Q} = \frac{T_{\infty 1 -} T_1}{R_{conv1}}$$

$$T_1 = T_{\infty 1} - \ Q \ \times \dot{R}_{conv1} \approx 20℃ - 56.2535_w \ \times 0.0833 \ \frac{℃}{w} \ \approx \mathbf{15.3}\ ℃$$