THE CONVECTIVE HEAT TRANSFER

The **Thermal Convection** is the transmission of the heat that takes place in a solid, liquid or aeriform medium.

There are two types of thermal convection:
- Natural convection: the movement of the fluid is induced by internal forces to the fluid itself
- Forced convection: the movement of the fluid is induced by external forces

$$\dot{Q}_{conv} = h\,A_s\,(T_{surface} - T_{\infty}) = \frac{Tsurface - T\infty}{R\ conv} \quad [\,W]$$

$$R_{conv} = \frac{1}{h\ As} \quad [\frac{°C}{W}]$$

$\dot{Q}$ is proportional to the Convective coefficient (h), that doesn't depend on the physical characteristics of the material $[\frac{W}{m^2 °C}]$ or $[\frac{W}{m^2 K}]$

$\dot{Q}$ is proportional to the Area of the surface [m^2]

$\dot{Q}$ is proportional to the Difference of Temperature [°C] or [K]

R is inversely proportional to the Area of the surface, so that higher is A, less resistance it has

When I have to calculate the heat loss through a single pane window (without considering the radiation), I'm dealing with three different resistances: two are about the convection in the inner and outer ($R_{conv} = \frac{1}{h\ As}$), and one is about the conduction through the glass ($R_{cond} = \frac{L}{kA}$).
Comparing the resistance values, I can see that the resistance of the glass (conduction) is lower than the resistance of conduction. So, thick glass is useless to have good resistance.
To obtain a higher glass resistance I should increase "L" a lot. But doing so, besides spending a lot of money, I would still not get a resistance so significant as to increase the total resistance.

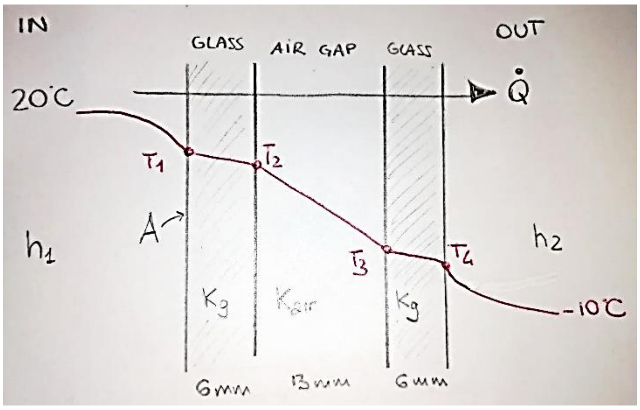
In the exercises carried out in class, the mistakes I had made were due to a distraction error in performing the calculation of the area and subsequently in transcribing the result.

Exercise 1

Consider a 0,8m high and 1,5m wide double-pane window; considering of 2 6mm thick layers of glass ($K_{glass} = 0.78\ [\frac{W}{m°C}]$) separated by 13mm stagnant air space ($K_{air} = 0.026\ [\frac{W}{m°C}]$).
Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be $h_1 = 10\ [\frac{W}{m^2°C}]$ and $h_2 = 0.78\ [\frac{W}{m^2°C}]$, which includes the effects of radiation.

Determine the steady rate of heat transfer through this double pane windows and the temperature of its inner surface

Solving:



$A_{tot} = 0,8 * 1,5 = 1,2\ m^2$ Total Area

$$R_{CONV\,1} = \frac{1}{h1*A} = \frac{1}{10*1,2} = 0,0833\ \frac{°C}{W}$$

$$R_{CONV\,2} = \frac{1}{h2*A} = \frac{1}{40*1,2} = 0,0208\ \frac{°C}{W}$$

$$R_{COND\,glass1} = R_{COND\,glass2} = \frac{L}{k*A} = \frac{0.006}{0.78*1,2} = 0.0064\ \frac{°C}{W}$$

$$R_{COND\,air\,gap} = \frac{L}{k*A} = \frac{0.013}{0.026*1,2} = 0.4167\ \frac{°C}{W}$$

$$R_{tot} = R_{CONV\,1} + R_{CONV\,2} + R_{COND\,glass1} + R_{COND\,glass2} + R_{COND\,air\,gap} = 0,52716\ \frac{°C}{W}$$ Total Resistance

$$\dot{Q} = \frac{\Delta T}{R\ tot} = \frac{20+10}{0.52716} = 56,9087\ W$$ Heat Transfer through the window

$$\dot{Q} = \frac{T\infty1 - Ts1}{R\ conv1} \Rightarrow T_{s1} = T_{\infty1} - \dot{Q} * R_{CONV\,1} = 20 - 56,9087 * 0,0833$$

$T_{s1} = 15,26\ °C$ Temperature of the Inner Surface

Compared to the exercises done in the classroom, the first with only one 8mm thick glass, and the second in which we had two 4mm thick glasses separated by 10mm of air-gap, now, here, I have obtained a better $\dot{Q}$.
In fact, the $\dot{Q}$ has drastically decreased from 266.4W to 69.26W to 56,91W, inserting only a layer of air-gap and increasing its widths.