Politecnico di Milano University
M.Arch Sustainable Architecture and Landscape Design
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WEEKLY SUBMISSION - TASK 02

01. 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.
02. Write an explanation about what mistakes you made in the class that resulted in wrong answers.
03. Solve the same problem as that of double pane window with the air-gap thickness of 13 mm and glass thickness of 6 mm, comment on your results and explain why we have an optimal range for the air-gap's distance.

ANSWERS:

01.

Convection, like Conduction, is a form of heat transfer from a warmer to a colder environment, but it has some distinctive features.
Convection is the transfer of heat through the movement of particles and happens in liquid or gaseous based. This temperature difference generates density difference (where the hottest particles, which are less dense, stay in suspension and the colder particles, which are denser, settle in the space below). Convection can happen in two different ways:
The first is Natural Convection: Taking as an example a house (with an internal comfortable temperature, like 23°C, and an external environment of 0°C degrees) and knowing that the warmer air is at the top and the coldest air at the bottom; We can conclude that internally natural convection will take place, where the hottest and densest particles when coming into contact with the wall that divides the internal and external environment will be cooled and will tend to descend. As these particles move in the opposite direction of the wall, they will become warmer and will suspend, creating a cyclic motion.
The second is Forced Convection: It generates the movement of particles but not due to temperature difference and density, but by external elements. If we consider an outdoor environment, this factor may be wind; and indoors, a fan.

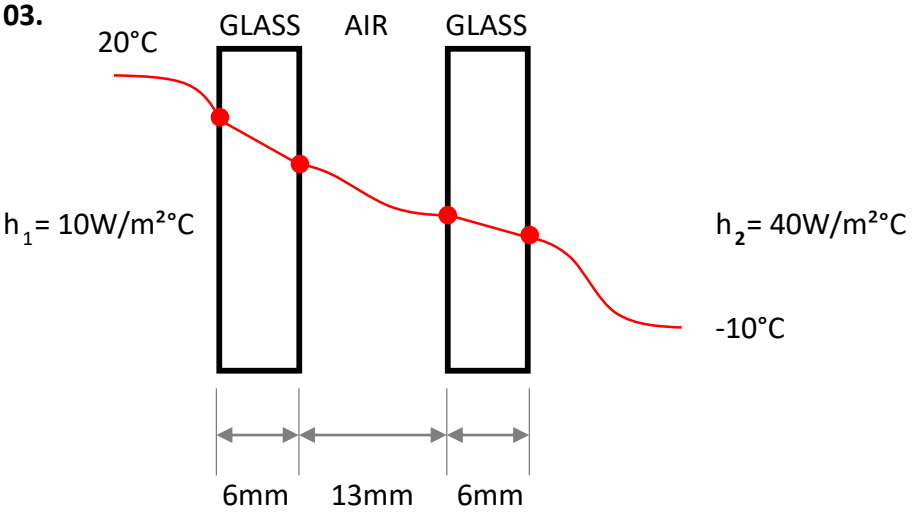
Changing the thickness of a single pane of glass in a window does not significantly contribute to heat transfer resistance because its conductivity is not too low.
Understanding the formula for calculating the resistance imposed by glass ($R = L / KA$), we can see that it is inversely proportional to K (conductivity) and A (area), so the lower the conductivity, the greater the resistance of the element.
If we compare different elements with the same area ($1.2m^2$) and thickness (6mm) as in the following exercise, the air layer will have a resistance of 0.1923W while the glass will have 0.0064W. This means that the glass would have to be thickened by about 30 times to compare the conductive efficiency of air. In addition, a very thick glass panel is extremely expensive and is too heavy to be supported by simple structures.
Thus, we can conclude that the increase in glass thickness contributes almost negligibly to the increase of the total strength of the model.

02.

The mistake I made in the first exercise in the classroom was about converting the glass unit of measurement from millimeter to meter. Where I converted 4 mm to 0.04m instead of 0.004m.

In the second exercise, the mistake was pure inattention, where I put the air space with 4mm dimension instead of 10mm as the exercise informed.

03.



Resistances:

$$R_{inside} = \frac{1}{h_1 A} = \frac{1}{10 \times 1,2} = 0,0833$$

$$R_{glass\ 1} = \frac{L}{KA} = \frac{0,006}{0,78 \times 1,2} = 0,0064$$

$$R_{air\ gap} = \frac{L}{KA} = \frac{0,013}{0,026 \times 1,2} = 0,04166$$

$$R_{glass\ 2} = \frac{L}{KA} = \frac{0,006}{0,78 \times 1,2} = 0,0064$$

$$R_{outside} = \frac{1}{h_2 A} = \frac{1}{40 \times 1,2} = 0,0208$$

R total = 0,5335 °C/W

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{total}} = \frac{20 - (-10)}{0,5335} = 56,23\ W$$

$T_1 \rightarrow \dot{Q} = h A (T_1 - T_\infty)$

$56,23 = 10 \times 1,2 (T_1 - T_\infty)$

$56,23 = 10 \times 1,2 (T_1 - 20)$

$56,23 = 12T_1 - 240 \rightarrow = 24,68°C$