Savinetti Simone 10542075 Week A. II 15.10.2019

1. **CONVECTIVE HEAT TRANSFER**

As conveniently expressed by **Newton's law of cooling**, the rate of convection heat transfer is observed to be **proportional** to the **temperature difference.** Newton's law states that:

The rate of heat loss of a body is directly proportional to the difference in the temperatures between the body and its surroundings provided the temperature difference is small and the nature of radiating surface remains same.

$$\dot{Q}_{conv} = \frac{Ts - Tx}{Rconv} \text{ [W]}$$

$$R_{conv} = \frac{1}{h * As}$$

$$\dot{Q} = h * A_s * \Delta T$$

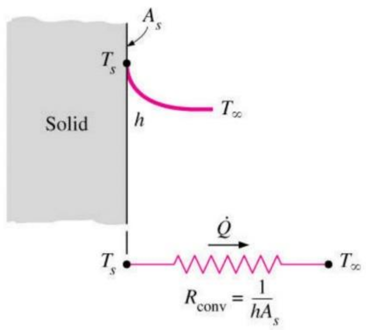
where

q is the local heat flux density [$W.m^{-2}$]

h is the heat transfer coefficient [$W.m^{-2}.K$]

ΔT is the temperature difference [K]

Note that, **ΔT** is given by the surface or **wall temperature, T_{wall}** and the **bulk temperature, T∞,** which is the temperature of the fluid sufficiently far from the surface.



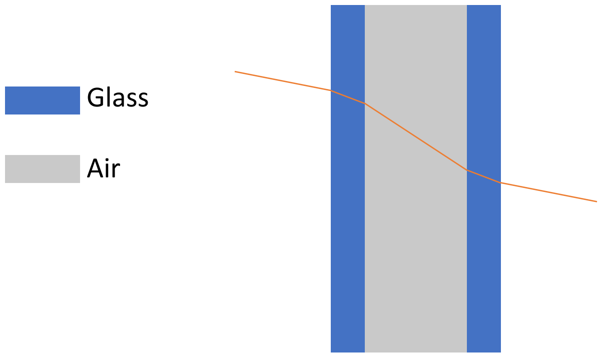
Elecrtical Analogy

$$R_{total} = R_{conv1} + R_{wall} + R_{conv2} = \frac{1}{h_{,} * A} + \frac{1}{K * A} + \frac{1}{h_{,,} * A} \qquad [°C/W]$$

According to this relation, it's possible to say that the temperature drop through a surface is proportional to its thermal resistance.

2.

2. *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. Consider a 0.8-m-high and 1.5-m-wide double-pane window consisting of two4-mm-thick layers of glass (k=0.78 W/m.°C) separated by a 10-mm-widestagnant air space (k=0.026 W/m.°C).*



$R_{conv1} = \frac{1}{H*A} = \frac{1}{10\frac{W}{m''°C}*1{,}2\ m''} = 0{,}0833°C/W$

$R_{glass\ 1,2} = \frac{l}{K*A} = \frac{0{,}006}{0{,}78\frac{W}{m''°C}*1{,}2\ m''} = 0{,}0064°C/W$

$R_{air1,2} = \frac{l}{K*A} = \frac{0{,}013}{0{,}026\frac{W}{m''°C}*1{,}2\ m''} = 0{,}416°C/W$

$R_{conv2} = \frac{1}{H*A} = \frac{1}{40\frac{W}{m''°C}*1{,}2\ m''} = 0{,}0208°C/W$

$\boldsymbol{R_{total}=R_{conv1} + R_{glass1} + R_{air} + R_{glass2} + R_{conv2}} = 0.5265°C/W$

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

$\dot{Q}_{conv} = \frac{Ts-Tx}{Rconv} = \frac{20°C-(-10),}{0{,}5265°C/W} = 56{,}98\ W$

$\dot{Q}_{conv} = \frac{Ts-Tx}{Rconv} = \frac{20°C-T,}{0{,}0833°C/W};$

$56{,}98\ W = \frac{20°C-T,}{0{,}0833°C/W};$

56,98 W * 0,0833 °C/ W = 20°C – T_1

T_1 = (20 – 4.74) °C

T_1 = 15.25 °C

$\dot{Q}_{glass1} = \frac{\mathbf{Ts-Tx}}{\boldsymbol{Rconv}} = \frac{\mathbf{15.25°C-T_{,,}}}{\mathbf{0{,}0064°}\boldsymbol{C/W}}$;

$56{,}98\ \mathrm{W} = \frac{\mathbf{15.25°C-T_{,}}}{\mathbf{0{,}0064°}\boldsymbol{C/W}}$;

56,98 W * 0,0064 °C/ W = 15,25°C – T_1

T_1 = (15,25 – 0,364) °C

T_1 = 14.89 °C

$\dot{Q}_{wall} = \frac{\mathbf{Ts-Tx}}{\boldsymbol{Rconv}} = \frac{\mathbf{14{,}89°C-T_{,,,}}}{\mathbf{0{,}416°}\boldsymbol{C/W}}$;

$56{,}98\ \mathrm{W} = \frac{\mathbf{14{,}89°C-T_{,}}}{\mathbf{0{,}416°}\boldsymbol{C/W}}$;

56,98 W * 0,416 °C/ W = 14,89°C – T_1

T_1 = (14,89 – 23,70) °C

T_1 = -8.81 °C

$\dot{Q}_{glass2} = \frac{\mathbf{Ts-Tx}}{\boldsymbol{Rconv}} = \frac{\mathbf{-8.81\ °C-T_{,,,,}}}{\mathbf{0{,}0064°}\boldsymbol{C/W}}$;

$56{,}98\ \mathrm{W} = \frac{\mathbf{-8{,}81°C-T_{,}}}{\mathbf{0{,}0064°}\boldsymbol{C/W}}$;

56,98 W * 0,0064 °C/ W = -8,81°C – T_1

T_1 = (-8,81 – 0,364) °C

T_1 = -9.17 °C