Week 2 ADAMI,AMIRMOHAMMAD

Heat transfer - CONVECTION

SUMMARY

Convection is the heat conduction through a fluid in state of movement. Convective heat transfer is described by Newton's law of cooling:

$$\dot{Q}_{conv} = h\, A_{surface}\,(T_{surface} - T_{\infty})$$

In this formula, **R = 1 / (h A)** is the surface’s resistance against the heat convection. This resistance, as the one previously seen for conductive heat transfer, works similarly to the electrical resistance in a circuit.

That being said we can combine the effects of heat conduction and heat convection to describe the rate of heat transfer through different kinds of surfaces.

The Thermal Resistance Network allows us to calculate the heat loss and the temperature drop across one or more layers in contact between each other.

In architectural design this can be applied to plane walls, single pane windows, double pane windows, multi-layer plane walls and so on.

$$\dot{Q} = (T_{\infty 1} - T_{\infty 2}) / R_{tot} \quad R_{tot} = R_1 + R_2 + \ldots + R_n$$

As we previously said, thermal resistances work similarly to electrical resistances. Therefore what we have stated until now is true only for layers in series. If we start working with layers in parallel the total resistance formula must change:

$$R_{tot} = 1/R_1 + 1/R_2 + \ldots + 1/R_n$$

A generalized Thermal Resistance Network combines the effects of resistances in series and in parallel.

In architectural design this can be applied to a composite wall.

EXERCISE

Double pane window (0.8 m high – 1.5 m wide)
Two 6 mm thick glass layers (k = 0.78 W/m°C) and 13 mm thick air gap (k = 0.026 W/m°C)

Convection heat transfer coefficients: h_1 = 10 W/m^2°C (inner) h_2 = 40 W/m^2°C (outer) A = 0.8 m x 1.5 m = 1.2 m^2
R_{glass} (x 2) = L / kA = 0.006 m / (0.78 W/m°C x 1.2 m^2) = 0.0064 °C/W
R_{airgap} = 0.013 m / (0.026 W/m°C x 1.2 m^2) = 0.42 °C/W

R_{conv1} = 1 / h_1A = 1 / (10 W/m°C x 1.2 m^2) = 0.083 °C/W R_{conv2} = 1 / h_2A = 1 / (40 W/m°C x 1.2 m^2) = 0.021 °C/W

R_{tot} = 2R_{glass} + R_{airgap} + R_{conv1} + R_{conv2} = 0.54 °C/W Q. = ΔT / R_{tot} = 30 °C / 0.54 °C/W = 55.56 W
