WEEK 8_ ROJER

TASK 1

Using the diagrams given in the presentation calculate how much (%) is the effect of applying different modifications (changing the gas, adding an extra pane, using a low emissivity coating) on the U value with respect to a benchmark case of double layer with air and no coting? (Keep the gap thickness to be 13 mm)

$$U_{window} = \frac{U_{center}A_{center} + U_{edge}A_{edge} + U_{frame}A_{frame}}{A_{window}}$$

If we have a double pane window:

$$\frac{1}{U_{double\text{-}pane(center\ region)}} \simeq \frac{1}{h_i} + \frac{1}{h_{space}} + \frac{1}{h_o}, \quad h_{space} =$$

$$= h_{rad,space} + h_{conv,space}$$

- The U_{center}, or h_{space}, changes by changing the gas that fills the gap
When the gap thickness is 13 mm: by changing the gas that fills the gap from air to argon, the U value of the glass center decreases from 2,8 W/m^2K to 2,65 W/m^2K, which means the U value decreases 6,43% ca. From air to Krypton, U value decrease to 2,6 W/m^2K, 7,14% ca.
- When the U_{center} changes by adding an extra pane, U value decreases from 2,8 W/m^2K to 1,8 W/m^2K, so 35,6 % ca.
- When the U_{center} changes coating the glass surfaces with a film that has a low emissivity, for instance emissivity = 0,1, the U value of the center of the glass decreases from 2,8 W/m^2K to 1,8 W/m^2K

TASK 2:

Consider the house that we analysed in the last two examples, calculate the heating and cooling load of the other windows which are fixed 14,4 m^2 at the west, fixed 3,6 m^2 on the south and an operable 3,6 m^2 on the south (the same window and frame type). How much does the total value chang the frame of the window from wooden one to aluminium?

1 The net area of walls (excluding doors and windows) of a building located in Piacenza is 105,8 m^2, the calculated U value is 0,438 W/m^2K for the winter and 0,435 W/m^2K for the summer. Find the corresponding heating and cooling load

2 A fixed heat absorbing double layer glass (with a wooden frame) window at the east side of a building located in Piacenza has a surface of 14,4 m^2. In case there are no internal and external shading factors. Calculate the heating and cooling load of the corresponding to that window)

$T_{cooling} = 24°C$ $T_{heating} = 20°C$

$\Delta T_{cooling} = 31,9°C - 24°C = 7,9°C = 7,9K$

$\Delta T_{heating} = 20°C - (-4,8°C) = 24,8°C$

$DR = 11,9°C$

$\dot{Q}_{window,west} = A \cdot CF_{window,west}$

$A = 14,4 m^2$

$CF_{window,west} = U_{window\ west} (\Delta T_{cooling} - 0,46\ DR)$

heat transfer part

The window has a fixed heat absorbing double layer glass with a wooden frame:

$U_{window\,west} = 2{,}84\ W/m^2K$

$CF_{window\,west} = 2{,}84\ W/m^2K\,(7{,}9K - 0{,}46 \cdot 11{,}9K)$
$\simeq 6{,}89\ W/m^2$

$PXI_{window,west} = E_D + E_d = 559 + 188 = 747$

$SHGC = 0{,}54$

No internal shading, so $IAC = 1$

$FF_S = 0{,}56$

irradiation part

$CF_{window\,west} = PXI \cdot SHGC \cdot IAC \cdot FF_S$

$\Phi_{window\,west} = A \cdot CF_{window\,west} =$
$= A \cdot CF_{window,west\,(heat\,transf.part)} + CF_{window,w\,(irradiation\,part)}$
$\simeq 14{,}4\,m^2 \cdot (6{,}89 + 747 \cdot 0{,}54 \cdot 1 \cdot 0{,}56)\,\frac{W}{m^2} \simeq 3352{,}07\,W$

Heat load of the fixed window on the west:

$\Phi_{window\,west} = A \cdot HF_{window\,west} = A \cdot U_{window\,west}\,\Delta T_{heating}$
$= 14{,}4\,m^2 \cdot 2{,}84\,\frac{W}{m^2K} \cdot 24{,}8K \simeq 1014{,}22\,W$

When we have aluminium:

$U_{window\,west} = 3{,}61\,\frac{W}{m^2K}$, $HSGC = 0{,}56$

$CF'_{window\,west\,(heat\,transf.\,part)} = U'_{window\,west}\,(\Delta T_{cooling} - 0{,}46\,DR) = 3{,}61\,\frac{W}{m^2K} \cdot (7{,}9K - 0{,}46 \cdot 11{,}9K) \simeq 8{,}76\,\frac{W}{m^2}$

Cooling load $\Phi'_{window\,west} = A \cdot CF'_{window\,west}$
$= A \cdot (CF'_{window\,w.\,(heat.\,tr.\,part)} + CF'_{wind.w.\,(irradiation\,part)}) =$

$\simeq 14{,}4\,m^2 \cdot (8{,}76 + 747 \cdot 0{,}56 \cdot 1 \cdot 0{,}56)\frac{W}{m^2} \cong 3499{,}48\,W$

Heating load $\Phi'_{window\,west} = A \cdot HF'_{window\,west} =$

$= A \cdot U'_{wind.w.} \Delta T_{heating}$

$= 14{,}4\,m^2 \cdot 3{,}61\frac{W}{m^2K} \cdot 24{,}8\,K \simeq 1289{,}20\,W$

Cooling load of the fixed window on the south:

$\Phi_{window_{south}} = A \cdot CF_{wind.south}$ $\quad A = 3{,}6\,m^2$

$CF_{wind.south\,(heat\,tr.part)} = U_{wind.south}(\Delta T_{cooling} - 0{,}46DR)$

- double layer glass with wooden frame:

$U_{window_{south}} = 2{,}84\frac{W}{m^2K}$

$CF_{wind.south\,(h.tr.p.)} = 2{,}84\frac{W}{m^2K} \cdot (7{,}9K - 0{,}46 \cdot 11{,}9K)$

$\simeq 6{,}89\frac{W}{m^2}$

$PXI_{wind.south} = E_D + E_d = 348 + 209 = 557$

$SHGC = 0{,}56$

No internal shading, so $IAC = 1$

$FF_S = 0{,}47$

$CF_{wind.south\,(irradiation\,part)} = PXI \cdot SHGC \cdot IAC \cdot FF_S$

$\Phi_{wind.south} = A \cdot CF_{wind.south} = A \cdot (CF_{(h.tr.part)} + CF_{(irrad.part)})$

$\simeq 3{,}6\,m^2 \cdot 2{,}84\frac{W}{m^2K} \cdot 24{,}8\,K \simeq 253{,}56\,W$

When we have aluminium:

$U_{wind.south} = 3{,}61\frac{W}{m^2K}$, $SHGC = 0{,}56$

$CF'_{wind.south\,(heat\,tr.p.)} = U'_{wind.south}(\Delta T_{cooling} - 0{,}46\,DR)$

$= 36,1 \frac{W}{m^2K} \cdot (7,9K - 0,46 \cdot 11,9K) \approx 8,76 \frac{W}{m^2}$

Cooling load $\varphi'_{window_{south}} = A \cdot CF_{wind.south}$

$= 3,6 m^2 \cdot (8,76 + 557 \cdot 0,86 \cdot 1 \cdot 0,47) \frac{W}{m^2} \approx 559,30 W$

Heating load $\varphi'_{wind.south} = A \cdot HF'_{wind.south} =$

$\approx 3,6 m^2 \cdot 3,61 \frac{W}{m^2K} \cdot 24,8K \approx 322,30 W$

- Cooling load of the operable window on the south:

$\varphi_{window\,south} = A \cdot CF_{wind.south}$ $A = 3,6 m^2$

$CF_{wind.south\,(h.tr.p.)} = U_{w.s.} (\Delta T_{cooling} - 0,46\,DR)$

$U_{w.west} = 2,87 \frac{W}{m^2K}$ (wooden frames)

$CF_{w.s.} = 2,87 \frac{W}{m^2K} \cdot (7,9K - 0,46 \cdot 11,9K) \approx 6,96 \frac{W}{m^2}$

$PXI_{wind.s.} = E_D + E_d = 348 + 209 = 557$

$SHGC = 0,46$; No internal shading $\rightarrow IAC = 1$

$FF_S = 0,47$

$CF_{w.s\,(irradiation\,part)} = PXI \cdot SHGC \cdot IAC \cdot FF_S$

$\varphi_{w.s.} = A \cdot CF_{w.s.} = 3,6 m^2 \cdot (6,96 + 557 \cdot 0,24 \cdot 1 \cdot 0,47) \frac{W}{m^2}$

$\approx 553,98 W$

Heat load of the fixed window on the south:

$\varphi_{wind.s.} = A \cdot HF_{w.s} = 3,6 m^2 \cdot 2,87 \frac{W}{m^2K} \cdot 24,8K \approx 256,23 W$

When we have aluminium:

$U_{w.s.} = 4,62 \frac{W}{m^2K}$ $SHGC = 0,55$

$$CF'_{w.s.(\text{heat tr. p.})} = U'_{w.s.} \cdot (\Delta T_{Cooling} - 0{,}46 \cdot DR)$$

$$= 4{,}62 \frac{W}{m^2K} \cdot (7{,}9K - 0{,}46 \cdot 11{,}9K) \simeq 11{,}21 \frac{W}{m^2}$$

$$\text{Cooling load } \Phi'_{w.s.} = A \cdot CF'_{w.s.}$$

$$\simeq 3{,}6 m^2 \cdot (11{,}21 + 257 \cdot 0{,}55 \cdot 1 \cdot 0{,}47) \frac{W}{m^2} =$$

$$\simeq 558{,}70\ W$$

$$\text{Heating load } \Phi'_{w.s.} = A \cdot HF'_{w.s.}$$

$$= 3{,}6 m^2 \cdot 4{,}62 \frac{W}{m^2K} \cdot 24{,}8K \simeq 412{,}47 W$$