Technical Environmental System/ Dr. Behzad NAJAFi

Tuesday,November 27, 2019
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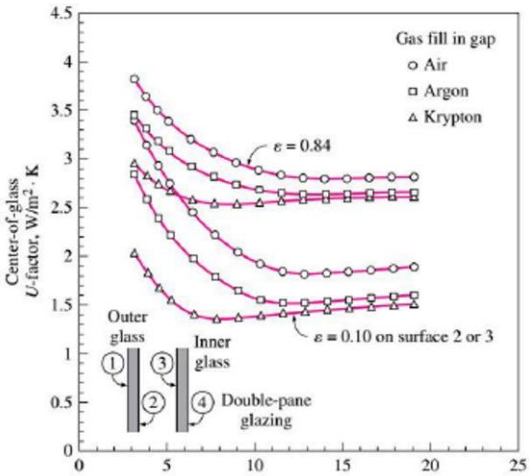
<u>TASK 1 :</u>

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 coating ? (keep the gap thickenss to be 13 mm)

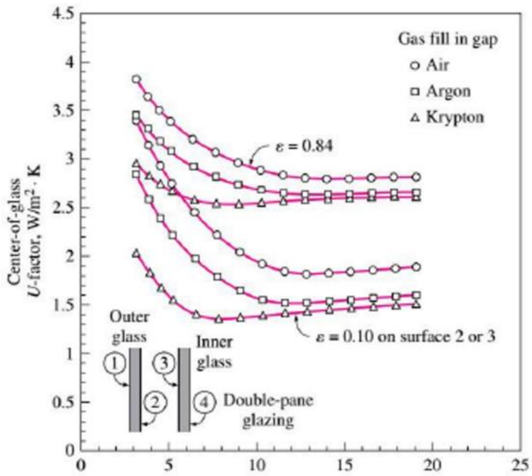
<u>CHANGING THE GAS :</u>

Changing the gas fill in the gap to argon/ krypton reduces the U-value of the centre-of-glass by 3.6% and 7.2% respectively.



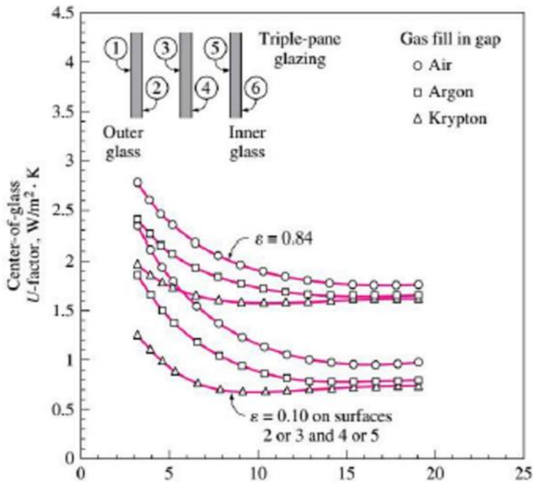
<u>ADDING AN EXTRA PANE :</u>

Adding an extra pane reduces the U-value by ~`35.7% (1/3rd)



USING A LOW EMISSIVITY COATING :

Using a low-emissivity coating on surface 2 or 3 also reduce the U-value by ~35.7% (1/3rd)



Task 2 Consider the house that we analysed in the alst two examples, calculate the heating and cooling load of the other windows which are fixed 14.4 m2 on the west, fixed 3.6 m2 on the south and an operable 3.6 m2 on the south (the same window and frame type). How much does the total value change if I change the frame of the window from wooden one to aluminium ?

The cooling design temperature $T_{cooling}$ = 24°C , and heating design temperature $T_{heating}$ = 20°C,

$\Delta T_{cooling}$ = 31.9°C - 24°C = 7.9°C =7.9K

$\Delta T_{cooling}$ = 20°C – (-4.8°C) = 24.8°C =24.8K

From the table above, DR = 11.9°C =24.8K

Calculating the cooling load of the fixed window on the west:

$Q_{\text{window west}} = A \times CF_{\text{window west}}$

$A = 14.4\ m^2$

$CF_{\text{window west}} = U_{\text{window west}} (\Delta T_{cooling} - 0.46\ DR)$

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

$U_{\text{window west}} = 2.84 \frac{W}{m^2K}$

i.e, $CF_{\text{window west}} = 2.84 \frac{W}{m^2K} \text{x} (7.9k - 0.46\text{x}11.9k) \sim 6.89 \frac{W}{m^2}$

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

SHGC = 0.54

No internal shading, so IAC = 1

FF_s = 0.56

$CF_{\text{window west}} = PXI \times SHGC \times IAC \times FF_s$

$q_{\text{window west}} = A \times CF_{\text{window west}} = A \times (CF_{\text{window west (heat transfer)}} + CF_{\text{window west (Irrigation part)}}$

$\approx 14.4 m^2 \times (6.89 + 747 \times 0.54 \times 1 \times 0.56)\frac{W}{m^2} \approx 3352.07\ W$

Calculating the heat load of the fixed window on the west :

$q_{\text{window west}} = A \times HF_{\text{window west}} = A \times U_{\text{window west}}\ \Delta T_{\text{heating}}$

$= 14.4 m^2 \times 2.84 \frac{W}{m^2K} \times 24.8\ K \approx 1014.22\ W$

When the frame were **aluminium,**

$U_{\text{window west}} = 2.84 \frac{W}{m^2K}$, HSGC = 0.56

$CF'_{\text{window west (Heat transfer)}} = U_{\text{window west}} (\Delta T_{\text{cooling}} - 0.46\ DR)$

$= 3.61 \frac{W}{m^2K} \times (7.9\ K - 0.46 \times 11.9\ k) \approx 8.76 \frac{W}{m2}$

Cooling load $q_{\text{window west}} = A \times CF'_{\text{window west}}$

$= A \times (CF'_{\text{window west (heat transfer)}} + CF'_{\text{window west (Irrigation part)}}`)$

$\approx 14.4 m^2 \times (8.76 + 747 \times 0.56 \times 1 \times 0.56)\frac{W}{m^2} \approx 3499.48\ W$

Heating load $q'_{\text{window west}} = A \times HF'_{\text{window west}} = A \times U'_{\text{window west}}\ \Delta T_{\text{heating}}$

‘ $= 14.4 m^2 \times 3.61 \frac{W}{m^2K} \times 24.8\ K \approx 1289.20\ W$

Calculating the cooling load of the fixed window on the south :

$Q_{\text{window south}} = A \times CF_{\text{window south}}$

$A = 3.6\ m^2$

$CF_{\text{window south (heat tranfer)}} = U'_{\text{window south}} (\Delta T_{\text{cooling}} - 0.46\ DR)$

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

$U_{\text{window south}} = 2.84 \frac{W}{m^2K}$

i.e, $CF_{\text{window south}} = 2.84 \frac{W}{m^2K} \times (7.9k - 0.46 \times 11.9k) \sim 6.89 \frac{W}{m^2}$

$PXI_{\text{window south}} = E_D + E_d = 348+209 = 557$

SHGC = 0.54

No internal shading, so IAC = 1

$FF_s = 0.47$

$CF_{\text{window south}} = PXI \times SHGC \times IAC \times FF_s$

$q_{\text{window south (Irrigation part)}} = A \times CF_{\text{window south}} = A \times (CF_{\text{window south (heat transfer)}} + CF_{\text{window south (Irrigation part)}}$

$$\approx 3.6\text{m}^2 \times (\,6.89 + 557 \times 0.54 \times 1 \times 0.47\,)\,\frac{W}{m^2} \approx 553.72\text{ W}$$

Calculating the heat load of the fixed window on the south :

$q_{\text{window south}} = A \times HF_{\text{window south}} = A \times U_{\text{window south}}\,\Delta T_{\text{heating}}$

$$=3.6\text{m}^2 \times 2.84\,\frac{W}{m^2K} \times 24.8\text{ K} \approx 253.56\text{ W}$$

When the frame were **aluminium,**

$U_{\text{window south}} = 3.61\,\frac{W}{m^2K}$, $HSGC = 0.56$

$CF'_{\text{window south (Heat transfer)}} = U'_{\text{window south}}\,(\Delta T_{\text{cooling}} - 0.46\text{ DR})$

$$= 3.61\,\frac{W}{m^2K} \times (7.9\text{ K} - 0.46 \times 11.9\text{ k}) \approx 8.76\,\frac{W}{m2}$$

Cooling load $q_{\text{window south}} = A \times CF'_{\text{window south}}$

$$= A \times (CF'_{\text{window south (heat transfer)}} + CF'_{\text{window south (Irrigation part)}})$$

$$\approx 3.6\text{m}^2 \times (\,8.76 + 557 \times 0.56 \times 1 \times 0.47\,)\,\frac{W}{m^2} \approx 559.30\text{ W}$$

Heating load $q'_{\text{window south}} = A \times HF'_{\text{window south}} = A \times U'_{\text{window south}}\,\Delta T_{\text{heating}}$

‘ $$=3.6\text{m}^2 \times 3.61\,\frac{W}{m^2K} \times 24.8\text{ K} \approx 322.30\text{ W}$$

Calculating the cooling load of a operable window on the south :

$q_{\text{window south}} = A \times CF_{\text{window south}}$

$A = 3.6\text{ m}^2$

$CF_{\text{window south (heat tranfer)}} = U_{\text{window south}}\,(\Delta T_{\text{cooling}} - 0.46\text{ DR})$

The window has an operable heat absorbing double layer glass with a wooden frame,

$U_{\text{window south}} = 2.87\,\frac{W}{m^2K}$

i.e, $CF_{\text{window south(heat tranfer)}} = 2.87\,\frac{W}{m^2K} \times (7.9\text{k} - 0.46 \times 11.9\text{k}) \approx 6.96\,\frac{W}{m^2}$

$PXI_{\text{window south}} = E_D + E_d = 348+209 = 557$

$SHGC = 0.46$

No internal shading, so IAC = 1

$FF_s = 0.47$

$CF_{\text{window south}} = PXI \times SHGC \times IAC \times FF_s$

$q_{\text{window south (Irrigation part)}} = A \times CF_{\text{window south}} = A \times (CF_{\text{window south (heat transfer)}} + CF_{\text{window south (Irrigation part)}}$

$$\approx 3.6\text{m}^2 \times (6.96 + 557 \times 0.46 \times 1 \times 0.47)\ \frac{W}{m^2} \approx 458.58\ \text{W}$$

<u>Calculating the heat load of operable window on the south :</u>

$q_{\text{window south}} = A \times HF_{\text{window south}} = A \times U_{\text{window south}}\ \Delta T_{\text{heating}}$

$$=3.6\text{m}^2 \times 2.84\ \frac{W}{m^2K} \times 24.8\ \text{K} \approx 253.56\ \text{W}$$

When the frame were **aluminium**,

$U_{\text{window south}} = 4.62\ \frac{W}{m^2K}$, HSGC = 0.55

$CF'_{\text{window south (Heat transfer)}} = U'_{\text{window south}}\ (\Delta T_{\text{cooling}} - 0.46\ DR)$

$$= 4.62\ \frac{W}{m^2K} \times (7.9\ \text{K} - 0.46 \times 11.9\ \text{k}) \approx 11.21 \frac{W}{m2}$$

Cooling load $q_{\text{window south}} = A \times CF'_{\text{window south}}$

$$= A \times (CF'_{\text{window south (heat transfer)}} + CF'_{\text{window south (Irrigation part)}})$$

$$\approx 3.6\text{m}^2 \times (11.21 + 557 \times 0.55 \times 1 \times 0.47)\ \frac{W}{m^2} \approx 558.70\ \text{W}$$

Heating load $q'_{\text{window south}} = A \times HF'_{\text{window south}} = A \times U'_{\text{window south}}\ \Delta T_{\text{heating}}$

$$=3.6\text{m}^2 \times 4.62\ \frac{W}{m^2K} \times 24.8\ \text{K} \approx 412.47\ \text{W}$$