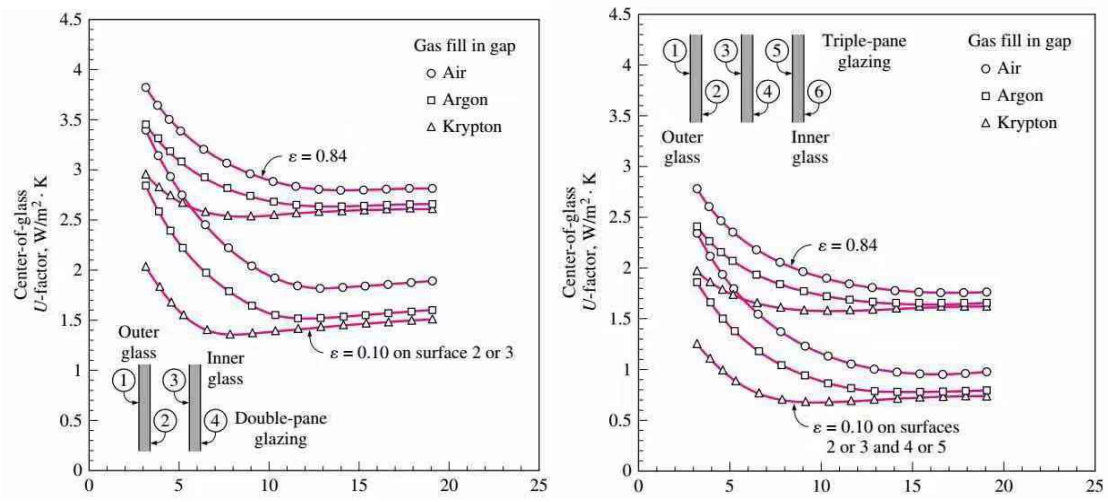
Week8 Assignment

Task1：

Using the diagram 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 thickness to be 13 mm)

Answer:



1、From the diagram, when we change the gas from air to argon, we can find that the U-factor from 2.8W/㎡ • K to 2.6W/㎡ • K. The U-factor value decreases 7%.
2、When we use a low emissivity coating, the emissivity changes from 0.84 to 0.1, the U-factor changes from 2.8W/㎡ • K to 1.8W/㎡ • K, decreasing 36%.
3、 If we add an extra pane, the U-factor changes from 2.8W/㎡ • K to 1.8W/㎡ • K, decreasing 36%.
By comparing all the results, we can find that using a low emissivity coating and adding an extra pane both can improve the thermal transmittance of the window.

Task2：

Create 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 ㎡ on the west, fixed 3.6 ㎡ on the south and an operable 3.6 ㎡ 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?

Answer:4

Creating a house in Piacenza, define the T_{summer} is 24℃， T_{winter} is 20℃,

$$\Delta T_{cooling} = 31.9 - 24 = 7.9℃$$

$$\Delta T_{heating} = 20 - (-4.8) = 24.8℃$$

DR=11.9K

Window on the east:

Heating:

$$U_{window-east} = 2.84 W/m^2 \cdot K$$

$$HF_{window-east} = U_{window-east} \cdot \Delta T_{cooling} = 2.84 \times 24.8 = 70.44 W/m^2$$

$$Q_{window-east} = HF_{window-east} \cdot A_{window-east} = 70.44 \times 24.8 = 1014.34 W$$

Heat transfer :

$$CF_{window-east} = U_{window-east} \cdot (\Delta T_{cooling} - 0.46 \cdot DR)$$
$$= 2.84 \times (7.9 - 0.46 \times 11.9) = 6.89 W/m^2$$

Irradiation:

E_D=559, E_d=188,

$$PXI_{window-east} = E_D + E_d = 559 + 188 = 747$$

SHGC=0.54,

$$CF_{window-east} = PXI \cdot SHGC \cdot IAC \cdot FF_S$$
$$= 747 \times 0.54 \times 1 \times 0.31 = 125.05$$

$$Q_{window-east} = A \times HF_{window-east} = 14.4 \times (6.89 + 125.05) = 1899.94 W$$

Change the frame of the window with aluminium:

Heating:

$$U_{window-east} = 3.61 W/m^2 \cdot K$$

$$HF_{window-east} = U_{window-east} \cdot \Delta T_{cooling} = 3.61 \times 24.8 = 89.53 W/m^2$$

$$Q_{window-east} = HF_{window-east} \cdot A_{window-east} = 89.53 \times 14.4 = 1289.23 W$$

Heat transfer :

$$CF_{window-east} = U_{window-east} \cdot (\Delta T_{cooling} - 0.46 \cdot DR)$$
$$= 3.61 \times (7.9 - 0.46 \times 11.9) = 8.76 W/m^2$$

Irradiation:

E_D=559, E_d=188,

$$PXI_{window-east} = E_D + E_d = 559 + 188 = 747$$

SHGC=0.56,

$$CF_{window-east} = PXI \cdot SHGC \cdot IAC \cdot FF_S$$
$$= 747 \times 0.56 \times 1 \times 0.31 = 129.68$$
$$Q_{window-east} = A \times HF_{window-east} = 14.4 \times (8.76 + 129.68) = 1993.54\ W$$

Window on the west:
Heating:

$$U_{window-west} = 2.84 W / m^2 \cdot K$$

$$HF_{window-west} = U_{window-west} \cdot \Delta T_{cooling} = 2.84 \times 24.8 = 70.44 W / m^2$$

$$Q_{window-west} = HF_{window-west} \cdot A_{window-west} = 70.44 \times 24.8 = 1014.34\ W$$

Heat transfer :

$$CF_{window-west} = U_{window-west} \cdot (\Delta T_{cooling} - 0.46 \cdot DR)$$
$$= 2.84 \times (7.9 - 0.46 \times 11.9) = 6.89\ W / m^2$$

Irradiation:

E_D=559, E_d=188,

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

SHGC=0.54,

$$CF_{window-west} = PXI \cdot SHGC \cdot IAC \cdot FF_S$$
$$= 747 \times 0.54 \times 1 \times 0.56 = 225.89$$
$$Q_{window-west} = A \times HF_{window-west} = 14.4 \times (6.89 + 225.89) = 3352.03\ W$$

Change the frame of the window with aluminium:
Heating:

$$U_{window-west} = 3.61 W / m^2 \cdot K$$

$$HF_{window-west} = U_{window-west} \cdot \Delta T_{cooling} = 3.61 \times 24.8 = 89.53 W / m^2$$

$$Q_{window-west} = HF_{window-west} \cdot A_{window-west} = 89.53 \times 14.4 = 1289.23\ W$$

Heat transfer :

$$CF_{window-west} = U_{window-west} \cdot (\Delta T_{cooling} - 0.46 \cdot DR)$$
$$= 3.61 \times (7.9 - 0.46 \times 11.9) = 8.76\ W/m^2$$

Irradiation:

E_D=559, E_d=188,

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

SHGC=0.56,

$$CF_{window-west} = PXI \cdot SHGC \cdot IAC \cdot FF_S$$
$$= 747 \times 0.56 \times 1 \times 0.56 = 234.26$$
$$Q_{window-west} = A \times HF_{window-west} = 14.4 \times (8.76 + 234.26) = 3499.49\ W$$

Window on the south:
Heating:

$$U_{window-south} = 2.84 W/m^2 \cdot K$$

$$HF_{window-south} = U_{window-south} \cdot \Delta T_{cooling} = 2.84 \times 24.8 = 70.44 W/m^2$$

$$Q_{window-south} = HF_{window-south} \cdot A_{window-south} = 70.44 \times 3.6 = 253.58\ W$$

Heat transfer :

$$CF_{window-south} = U_{window-south} \cdot (\Delta T_{cooling} - 0.46 \cdot DR)$$
$$= 2.84 \times (7.9 - 0.46 \times 11.9) = 6.89\ W/m^2$$

Irradiation:

E_D=348, E_d=209,

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

SHGC=0.54,

$$CF_{window-south} = PXI \cdot SHGC \cdot IAC \cdot FF_S$$
$$= 557 \times 0.54 \times 1 \times 0.47 = 141.37$$
$$Q_{window-south} = A \times HF_{window-south} = 3.6 \times (6.89 + 141.37) = 533.74\ W$$

Change the frame of the window with aluminium:
Heating:

$$U_{window-south} = 3.61 W/m^2 \cdot K$$

$$HF_{window-south} = U_{window-south} \cdot \Delta T_{cooling} = 3.61 \times 24.8 = 89.53 W/m^2$$

$$Q_{window-south} = HF_{window-south} \cdot A_{window-south} = 89.53 \times 3.6 = 322.31 W$$

Heat transfer :

$$CF_{window-south} = U_{window-south} \cdot (\Delta T_{cooling} - 0.46 \cdot DR)$$
$$= 3.61 \times (7.9 - 0.46 \times 11.9) = 8.76 W/m^2$$

Irradiation:

E_D=348, E_d=209,

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

SHGC=0.56,

$$CF_{window-south} = PXI \cdot SHGC \cdot IAC \cdot FF_S$$
$$= 557 \times 0.56 \times 1 \times 0.47 = 146.6$$

$$Q_{window-south} = A \times HF_{window-south} = 3.6 \times (8.76 + 146.6) = 559.30 W$$

Window on the north:

Heating:

$$U_{window-north} = 2.87 W/m^2 \cdot K$$

$$HF_{window-north} = U_{window-north} \cdot \Delta T_{cooling} = 2.87 \times 24.8 = 71.18 W/m^2$$

$$Q_{window-north} = HF_{window-north} \cdot A_{window-north} = 71.18 \times 3.6 = 256.25 W$$

Heat transfer :

$$CF_{window-north} = U_{window-north} \cdot (\Delta T_{cooling} - 0.46 \cdot DR)$$
$$= 2.87 \times (7.9 - 0.46 \times 11.9) = 6.96 W/m^2$$

Irradiation:

E_D=348, E_d=209,

$$PXI_{window-north} = E_D + E_d = 348 + 209 = 557$$

SHGC=0.46,

$$CF_{window-north} = PXI \cdot SHGC \cdot IAC \cdot FF_S$$
$$= 557 \times 0.46 \times 1 \times 0.47 = 120.42$$

$$Q_{window-north} = A \times HF_{window-north} = 3.6 \times (6.96 + 120.42) = 458.58\ W$$

Change the frame of the window with aluminium:

Heating:

$$U_{window-north} = 4.62 W / m^2 \cdot K$$

$$HF_{window-north} = U_{window-north} \cdot \Delta T_{cooling} = 4.62 \times 24.8 = 114.58\ W / m^2$$

$$Q_{window-north} = HF_{window-north} \cdot A_{window-north} = 114.58 \times 3.6 = 412.49\ W$$

Heat transfer :

$$CF_{window-north} = U_{window-north} \cdot (\Delta T_{cooling} - 0.46 \cdot DR)$$
$$= 4.62 \times (7.9 - 0.46 \times 11.9) = 11.21\ W / m^2$$

Irradiation:

E_D=348, E_d=209,

$$PXI_{window-north} = E_D + E_d = 348 + 209 = 557$$

SHGC=0.55,

$$CF_{window-north} = PXI \cdot SHGC \cdot IAC \cdot FF_S$$
$$= 557 \times 0.55 \times 1 \times 0.47 = 143.98$$
$$Q_{window-north} = A \times HF_{window-north} = 3.6 \times (11.21 + 143.98) = 558.68\ W$$

$$Q_{Total-window-wood} = Q_{window-east} + Q_{window-west}$$
$$+ Q_{window-south} + Q_{window-north}$$
$$= 1899.94 + 3352.03 + 533.74 + 458.58 = 6244.29\ W$$

$$Q_{Total-window-aluminium} = Q_{window-east} + Q_{window-west}$$
$$+ Q_{window-south} + Q_{window-north}$$
$$= 1993.54 + 3499.49 + 559.30 + 558.68 = 6611.01 W$$

$$\Delta Q_{Total-window} = Q_{Total-window-wood} - Q_{Total-window-aluminium}$$
$$= 6244.29 - 6611.01 = 366.72 W$$