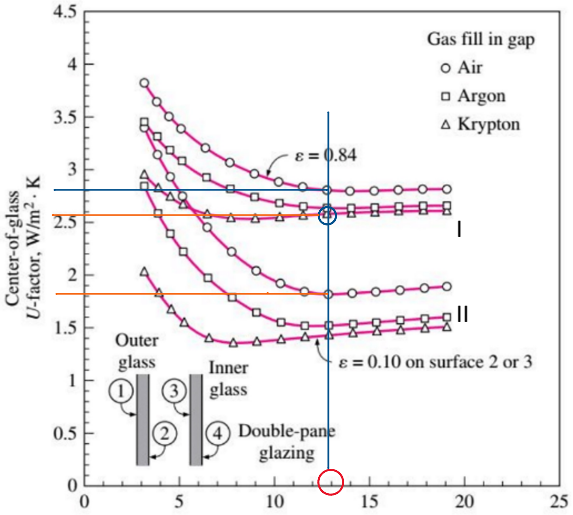
# 8th assignment

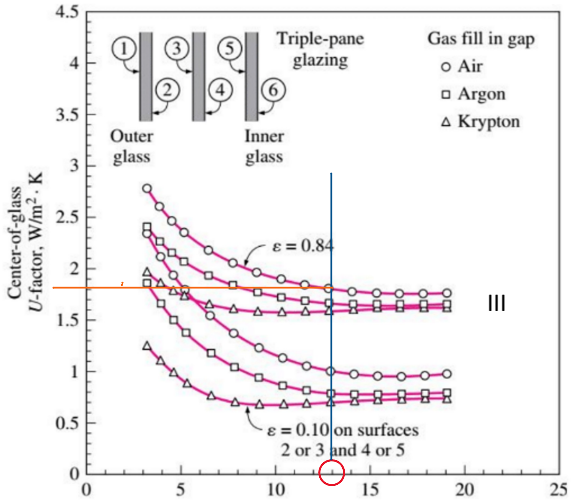
26 Kasım 2019

- 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 the double layer with air and no coating? ( keep the gap thickness to be 13 mm)

- Consider the house that we analyzed in the also 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 aluminum?

## TASK 1




| | **benchmark** | I | II | III |
|---|---|---|---|---|
| gap thickness(mm) | 13mm | 13mm | 13mm | 13mm |
| ε value | 0.84 | 0.84 | **0.10** | 0.84 |
| Gas | Air | **Kr** | Air | Air |
| -n. pane | 2 | 2 | 2 | **3** |
| u-factor value | 2.8 | 2.6 | 1.8 | 1.8 |
| Percentage(%) | %100 | %93 | %64 | %64 |

13 mm gap thickness was stabled, Gas, number of pane and ε values are changed according to the tables that were given, and these changes are observed how they are affecting % value and their results in thermal aspects.

Situation I - Air gas was changed with the krypton gas. So we observed that there is %7 loss if we calculate the equation accordingly u-factors. So that it caused to increase the transmittance of the window in the thermal aspects (u-value in inversly proportion).

Situation II - In second comparison, low ε value factor causes declination around %36 at u-value which increased the thermal transmittance.

Situation III - To add one more panel (now 3 pane) caused to %36 loss again as the previous situation, but the mutable is different. It still increases thermal ability.

# TASK 2

***Proporties of Piacenza***

Lat: 44,92 N
Long: 9,73 E
Elev :138
$T_{SUMMER}$: 24°
$T_{WINTER}$: 20°
Heating DB 99%: - 4,8
Cooling DB/MCWB 1%: 31,9
$\Delta T$cooling = 7,9 ℃
$\Delta T$heating = 24,8 ℃

$DR = 11.9\ °C$

| | | U | SHGC | area($m^2$) | $FF_s$ | IAC | $E_D$ | $E_d$ |
|---|---|---|---|---|---|---|---|---|
| Wooden Material : | West fixed | 2.84 | 0.54 | 14.4 | 0.56 | 1 | 559 | 188 |
| | South fixed | 2.84 | 0.54 | 3.6 | 0.47 | 1 | 348 | 209 |
| | South operable | 2.87 | 0.46 | 3.6 | 0.47 | 1 | 348 | 209 |

| | | | U | SHGC | area($m^2$) | $FF_s$ | IAC | $E_D$ | $E_d$ |
|---|---|---|---|---|---|---|---|---|---|
| Alumin Material | : West fixed | : | 3.61 | 0.56 | 14.4 | 0.56 | 1 | 559 | 188 |
| | South fixed | : | 3.61 | 0.56 | 3.6 | 0.47 | 1 | 348 | 209 |
| | South operable | : | 4.62 | 0.55 | 3.6 | 0.47 | 1 | 348 | 209 |

WEST FIXED WINDOW

With **wooden** window frame;

**cooling**

$$CF_{window_{west}heatTransfer} = U_{window_{west}}(\Delta T_{\boldsymbol{cooling}} - 0.46\ DR)$$

$$= 2.84\ (7.9 - 0.46 * 11.9) = \ 6.9\frac{W}{m2}$$

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

*SHGC = 0.54*
*IAC = 1 (no shader)*
*FFs = 0.56*

$$CF_{window\_{west}IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = \ 747\ * 0.54\ * 1\ * 0.56 = 225{,}8$$

$CF_{window_{west}} = CF_{window_{west}heatTransfer}C + CF_{windowo_{west}IrradiationPart} = 6.9 + 225{,}8 = 232{,}7\frac{W}{m^2}$

$Q_{window_{west}} = CF_{window_{west}} \times A_{window_{west}} = 232{,}7 * 14.4 = \mathbf{3.350\ W}$

**heating**

$U_{window_{west}} = 2.84\frac{W}{m2K}$

$HF_{window_{west}} = U_{window_{west}} \times \Delta T_{heating} = 2.84 * 24.8 = 70.4\frac{W}{m2}$
$Q_{window_{west}} = HF_{window_{west}} \times A_{window_{west}} = 70.4 * 14.4 = \mathbf{1014.2\ W}$

With **aluminium** window frame;

**cooling**

$CF_{window_{west}heatTransfer} = U_{window_{west}}(\Delta T_{cooling} - 0.46\ DR) = 3.61\ (7.9 - 0.46 * 11.9) = 8.7\frac{W}{m2}$

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

*SHGC = 0.56*
*IAC = 1 (no shader)*
*FFs = 0.56*

$CF_{window_{west}IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = 747 * 0.56 * 1 * 0.56 = 234{,}2$

$CF_{window_{west}} = CF_{window_{west}heatTransfer}C + CF_{windowo_{west}IrradiationPart} = 6.9 + 234{,}2 = 241{,}1\frac{W}{m^2}$

$Q_{window_{west}} = CF_{window_{west}} \times A_{window_{west}} = 241.1 * 14.4 = \mathbf{3.471\ W}$

**heating**

$U_{window_{west}} = 3{,}61\frac{W}{m2K}$

$HF_{window_{west}} = U_{window_{west}} \times \Delta T_{heating} = 3{,}61 * 24.8 = 89{,}5\frac{W}{m2}$
$Q_{window_{west}} = HF_{window_{west}} \times A_{window_{west}} = 70.4 * 14.4 = \mathbf{1.288{,}8\ W}$

SOUTH FIXED WINDOW

With **wooden** window frame;

**cooling**

$CF_{window_{south}heatTransfer} = U_{window_{south}}(\Delta T_{cooling} - 0.46\,DR) = 2.84\,(7.9 - 0.46 * 11.9)$
$= \ 6.9\frac{W}{m2}$

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

*SHGC = 0.54*
*IAC = 1 (no shader)*
*FFs = 0.47*

$CF_{window_{south}IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = \ 557 * 0.54 * 1 * 0.47 = 141{,}3$

$CF_{window_{south}} = CF_{window_{south}heatTransfer}C + \ CF_{windowo_{south}IrradiationPart} = \ 6.9 + 141{,}3$
$= 148{,}2\frac{W}{m^2}$

$Q_{window_{south}} = \ CF_{window_{south}} \times A_{window_{south}} = 148{,}2 * 3{,}6 = \mathbf{533,5\ W}$

**heating**

$U_{window_{south}} = 2.84\frac{W}{m2K}$

$HF_{window_{south}} = U_{window_{south}} \times \Delta T_{heating} = 2.84 * 24.8 = 70.4\frac{W}{m2}$
$Q_{window_{south}} = \ HF_{window_{south}} \times A_{window_{south}} = 70.4 * 3.6 = \mathbf{253{,}4\ W}$

With **aluminium** window frame;

**cooling**

$CF_{window_{south}heatTransfer} = U_{window_{south}}(\Delta T_{cooling} - 0.46\,DR) = 3{,}61\,(7.9 - 0.46 * 11.9)$
$= \ 8{,}7\frac{W}{m2}$

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

*SHGC = 0.56*
*IAC = 1 (no shader)*
*FFs = 0.47*

$CF_{window_{south}IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = \ 557 * 0.56 * 1 * 0.47 = 146{,}6$

$CF_{window_{south}} = CF_{window_{south}heatTransfer}C + \ CF_{windowo_{south}IrradiationPart} = \ 8{,}7 + 146{,}6$
$= 155{,}3\frac{W}{m^2}$

$Q_{window_{south}} = \ CF_{window_{south}} \times A_{window_{south}} = 155{,}3 * 3{,}6 = \mathbf{559,2\ W}$

**heating**

$U_{window_{south}} = 3{,}16 \frac{W}{m2K}$

$HF_{window_{south}} = U_{window_{south}} \times \Delta T_{heating} = 3{,}61 * 24.8 = 89.5 \frac{W}{m2}$
$Q_{window_{south}} = HF_{window_{south}} \times A_{window_{south}} = 89.5 * 3.6 =$ ***322,3 W***

SOUTH OPERABLE WINDOW

With **wooden** window frame;

**cooling**

$CF_{window_{south}heatTransfer} = U_{window_{south}}(\Delta T_{cooling} - 0.46\ DR) = 2{,}87\ (7.9 - 0.46 * 11.9)$
$= 6{,}96 \frac{W}{m2}$

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

*SHGC = 0.46*
*IAC = 1 (no shader)*
*FFS = 0.47*

$CF_{window\_{south}IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = 557 * 0.46 * 1 * 0.47 = 120{,}4$

$CF_{window\_{south}} = CF_{window_{south}heatTransfer}C + CF_{windowo_{south}IrradiationPart} = 6{,}96 + 120{,}4$
$= 127{,}36 \frac{W}{m^2}$

$Q_{window\_{south}} = CF_{window\_{south}} \times A_{window_{south}} = 127{,}36 * 3{,}6 =$ ***458,4 W***

**heating**

$U_{window_{south}} = 2{,}87 \frac{W}{m2K}$

$HF_{window_{south}} = U_{window_{south}} \times \Delta T_{heating} = 2{,}87 * 24.8 = 71{,}4 \frac{W}{m2}$
$Q_{window_{south}} = HF_{window_{south}} \times A_{window_{south}} = 71{,}4 * 3.6 =$ ***256,2 W***

With **aluminium** window frame;

**cooling**

$CF_{window_{south}heatTransfer} = U_{window_{south}}(\Delta T_{cooling} - 0.46\ DR) = 4{,}62\ (7.9 - 0.46 * 11.9)$
$= 11{,}2\ \frac{W}{m2}$

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

*SHGC = 0.55*
*IAC = 1 (no shader)*
*FFs = 0.47*

$CF_{window\_{south}IrradiationPart} = PXI \times SHGC \times IAC \times FF_S = 557 * 0.55 * 1 * 0.47 = 143{,}9$

$CF_{window\_{south}} = CF_{window_{south}heatTransfer}C + CF_{windowo_{south}IrradiationPart} = 11{,}2 + 143{,}9$
$= 155{,}18\frac{W}{m^2}$

$Q_{window\_{south}} = CF_{window\_{south}} \times A_{window_{south}} = 155{,}18 * 3{,}6 = \mathbf{558{,}6\ W}$

**heating**

$U_{window_{south}} = 4{,}62\frac{W}{m2K}$

$HF_{window_{south}} = U_{window_{south}} \times \Delta T_{heating} = 4{,}62 * 24.8 = 114{,}5\frac{W}{m2}$
$Q_{window_{south}} = HF_{window_{south}} \times A_{window_{south}} = 114{,}5 * 3.6 =$ ***412,4 W***

$3.350\ W + 533{,}5\ W + 458{,}4\ W - (3.471\ W + 558{,}6\ W + 559{,}2\ W)$

1014.2 W + 256,2 W + 253,4 W - ( 412,4 W + 322,3 W + 1.288,8 W )

*Q Total difference (cooling) between* ***wood*** *frame =* ***4342*** *W*

*Q Total difference (heating) between* ***wood*** *frame =* ***1524*** *W*

*Q Total difference (cooling) between* ***aluminium*** *frame =* ***4588,8*** *W*

*Q Total difference (heating) between* ***aluminium*** *frame =* ***2023,5****W*

**To sum up ;** $\mathbf{Q_{tot}heating_{wood} < Q_{tot}heating_{alum}}$

$\mathbf{Q_{tot}cooling_{wood} < Q_{tot}cooling_{alum}}$

From the comparison, we saw that the wooden frames are better to use than the aluminium frames in aspect of resistance both heating - cooling.