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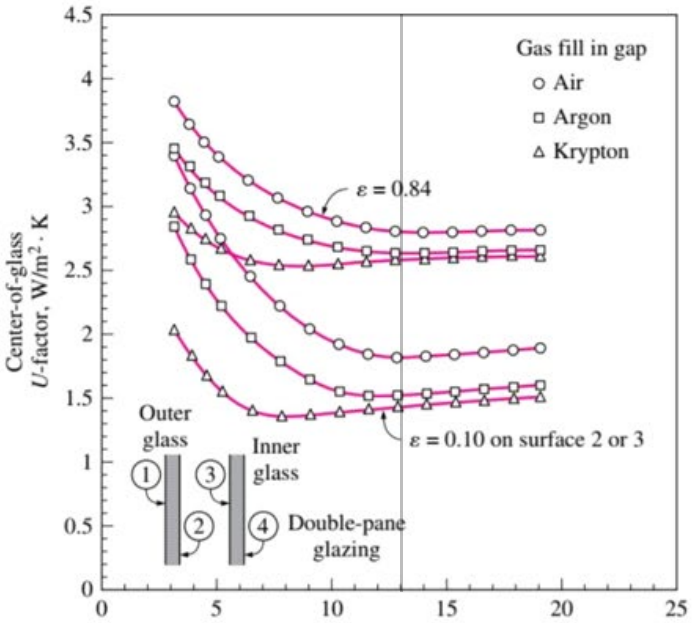
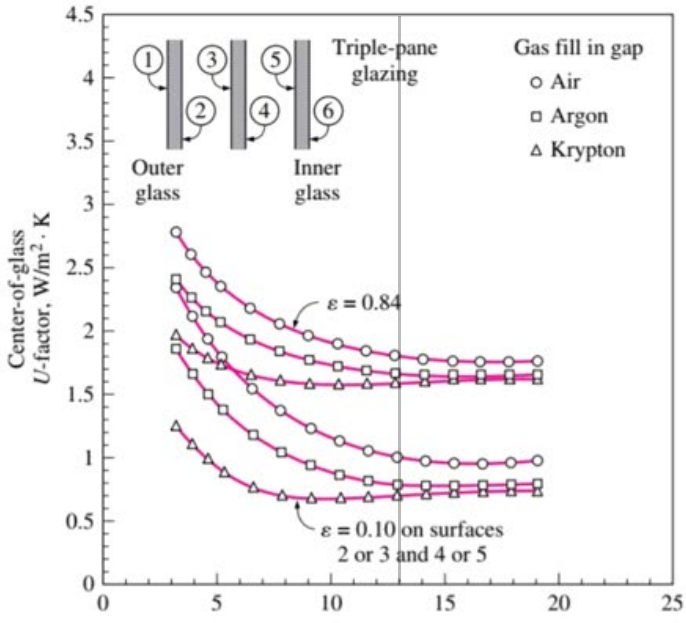
Task 1

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

Double pane glazing:
ε=0.84/ thickness :13mm
If we change the gap from air to argon the U value of the glass drop from 2.8 w/m^2 to 2.65 w/m^2 , it means, we have 5.357% decrease. While in comparison air to krypton we have 7.142% decease in U value

In the second comparison, using a low emissivity coating, the UFACTOR value decreases by 36%, greatly improving the thermal transmittance compared to the benchmark.
In the last comparison, adding an extra pane, the UFACTOR value, still decreases by 36%, proving a great improvement in the thermal efficiency of the window





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 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?

PIACENZA
LAT: 44,92 N
LONG: 9,73 E
ELEV :138
TSUMMER: 24°
TWINTER: 20°
HEATING DB 99%: - 4,8
COOLING DB/MCWB 1%: 31,9
$\Delta T_{cooling} = 31,9 - 24 = 7,9$ C
$\Delta T_{heating} = 20 - (-4,8) = 24,8$ C
EAST SIDE OF THE BUILDING
45° LATITUDE
No internal shading – AIC = 1
DR = 11,9

Wood Frame Section
WINDOW 1
AW1east= 14,4 m2
EAST
FIXED
WOOD FRAME
Heating:
Uw1east= 2,84 W/m2 K
$HF_{w1east} = UW1east * \Delta T_{cooling} = 2.84 * 24.8 = 70.44$
$Q_{w1east} = HFW1east * AW1east = 70.44 * 14.4 = 1014.2$ W

Cooling
Part for Heat transfer
$CFW1east = UW1east * (\Delta T_{cooling} - 0.46 * DR) = 2,84\ (7,9 - 0,46\ .\ 11,9) = 6,9$ W/m2
Part for Irradiation part
ED = 559

Ed= 188
East window of a detached house - FFS = 0.31
SHGC= 0.54
PXIW1east = ED + Ed = 559 + 188 = 747
CFW1east = PXI*SHGC*IAC*FFs= 747*0.54*1*0.31=125.1

$CFfenestration1east = Uw1east * (\Delta T_{cooling} - 0.46 * DR) + PXI * SHGC * IAC * FFs = 6.9 + 125.1 = 132$ W/m2
$\dot{Q}_{w1east} = CFfenestration1east * AW1east = 132 * 14.4 = 1900.8$ W
WINDOW 2
AW2west= 14,4 m2
WEST
FIXED
WOOD FRAME

Heating:
UW2west= 2,84 W/m2 K
HFW2west= UW2west * ΔTcooling = 2.84 *24.8 = 70.44
QW2west= HFW2west * AW2west = 70.44 * 14.4 = 1014.2 W

Cooling
Part for Heat transfer

CFW2west = UW2west *(ΔTcooling – 0.46 * DR) = 2,84 (7,9 – 0,46 . 11,9) = 6,9 W/m2
ED = 559
Ed= 188
West window of a detached house - FFS = 0.31
SHGC= 0.54
PXIW2west = ED + Ed = 559 + 188 = 747
CFW2west = PXI*SHGC*IAC*FFs=747*0.54*1*0.56=225.9
CFfenestration2west= Uw2west*(ΔTcooling – 0.46 * DR) +PXI *SHGC *IAC * FFs = 6.9+225.9=232.8 W/m2
Q_{W2west} = CFfenestration2west * AW2west = 232.8 * 14.4 = 3352.32 W

WINDOW 3
AW3south= 3.6 m2
SOUTH
FIXED
WOOD FRAME

Heating:
UW3south= 2,84 W/m2 K
HFW3south= UW3south * ΔTcooling = 2.84 *24.8 = 70.44 W/ m2
QW3south= HFW3south * AW3south = 70.44 * 3.6 = 253.6 W

Cooling
Heat transfer part
CFW3south = UW3south *(ΔTcooling – 0.46 * DR) = 2,84 (7,9 – 0,46 . 11,9) = 6,9 W/m2
Part for Irradiation part
ED = 348
Ed= 209
South window of a detached house - FFS = 0.31
SHGC= 0.54
PXI W3south = ED + Ed = 348 + 209 = 557
CF W3south = PXI*SHGC*IAC*FFs= 557*0.54*1*0.47=141.4

CFfenestration3south= Uw3south *(ΔTcooling – 0.46 * DR) +PXI *SHGC *IAC * FFs = 6.9 +141.4=148.3 W/ m2
$Q_{w3south}$ = CFfenestration3south * AW3south = 148.3*3.6 = 533.88 W

WINDOW 4
AW4south= 3.6 m2
SOUTH
OPERABLE
WOOD FRAME

Heating:
UW4south= 2,87 W/m2 K
HFW4south= UW4south * ΔTcooling = 2.87 *24.8 = 71.17 W/ m2
QW4south= HFW4south * AW4south = 71.17 * 3.6 = 256.2 W

Cooling
Heat transfer part
CFW4south = UW4south *(ΔTcooling – 0.46 * DR) = 2,87 (7,9 – 0,46 . 11,9) = 6,96 W/m2
Part for Irradiation part
ED = 348
Ed= 209
South window of a detached house - FFS = 0.47
SHGC= 0.46
PXI W4south = ED + Ed = 348 + 209 = 557
CF W4south = PXI*SHGC*IAC*FFs= 557*0.46*1*0.47=120.4

CFfenestration4south= Uw3south *(ΔTcooling – 0.46 * DR) +PXI *SHGC *IAC * FFs = 6.9 +120.4=127.3 W/m2
$Q_{w4south}$ = CFfenestration4south * AW4south = 127.3*3.6 = 458.28 W

$Q_{Total\ windows\ Cooling\ wood\ frame}$ = 1900,.8 + 3352.32 + 533.88 + 458.28 = 6245.3 W
$Q_{Total\ windows\ Heating\ wood\ frame}$ = 1014.2+1014.2+253.6+256.2=2538.2 W

Aluminium Frame Section

Window 1

AW1east= 14,4 m2
EAST
FIXED
Aluminium FRAME
Heating:
Uw1east= 3.61 W/m2 K
HFw1east= UW1east * ΔTcooling = 3.61 *24.8 = 89.52 W/m2
Qw1east= HFW1east * AW1east = 89.52 * 14.4 = 1289.1 W

Cooling
Part for Heat transfer
CFW1east = UW1east *(ΔTcooling – 0.46 * DR) = 3.61* (7,9 – 0,46 11,9) = 8.7 W/m2
Part for Irradiation part
ED = 559
Ed= 188
East window of a detached house - FFS = 0.31
SHGC= 0.56
PXIW1east = ED + Ed = 559 + 188 = 747
CFW1east = PXI*SHGC*IAC*FFs= 747*0.56*1*0.31=129.6

CFfenestration1east= Uw1east*(ΔTcooling – 0.46 * DR) +PXI *SHGC *IAC * FFs = 8.7 +129.6 =138.3 W/m2
Q_{w1east} = CFfenestration1east * AW1east = 138.3*14.4 = 1991.5 W

WINDOW 2
AW2west= 14,4 m2
WEST
FIXED
Aluminium FRAME

Heating:
UW2west= 3.61 W/m2 K
HFW2west= UW2west * ΔTcooling = 3.61 *24.8 = 70.44
QW2west= HFW2west * AW2west = 89.52 * 14.4 = 1289.1 W

Cooling
Part for Heat transfer
CFW2west = UW2west *(ΔTcooling – 0.46 * DR) = 3.61 (7,9 – 0,46 . 11,9) = 8.7 W/m2
ED = 559
Ed= 188
West window of a detached house - FFS = 0.56
SHGC= 0.56
PXIW2west = ED + Ed = 559 + 188 = 747
CFW2west = PXI*SHGC*IAC*FFs=747*0.56*1*0.56=234.26
CFfenestration2west= Uw2west*(ΔTcooling – 0.46 * DR) +PXI *SHGC *IAC * FFs = 8.7+234.26=242.96 W/ m2
Q_{W2west} = CFfenestration2west * AW2west = 242.96 * 14.4 = 3498.6 W

WINDOW 3
AW3south= 3.6 m2
SOUTH
FIXED
ALUMINIUM FRAME

Heating:
UW3south= 3.61 W/m2 K
HFW3south= UW3south * ΔTcooling = 3.61 *24.8 = 89.52 W/ m2
QW3south= HFW3south * AW3south = 89.52 * 3.6 = 322.2 W

Cooling
Heat transfer part
CFW3south = UW3south *(ΔTcooling – 0.46 * DR) = 3.61 (7,9 – 0,46 . 11,9) = 8.7 W/m2
Part for Irradiation part
ED = 348
Ed= 209
South window of a detached house - FFS = 0.47
SHGC= 0.56
PXI W3south = ED + Ed = 348 + 209 = 557
CF W3south = PXI*SHGC*IAC*FFs= 557*0.56*1*0.47=146.6

CFfenestration3south= Uw3south *(ΔTcooling – 0.46 * DR) +PXI *SHGC *IAC * FFs = 8.7 +146.6=155.3 W/ m2
$\dot{Q}_{w3south}$ = CFfenestration3south * AW3south = 155.3*3.6 = 559.08 W

WINDOW 4
AW4south= 3.6 m2
SOUTH
OPERABLE
ALUMINIUM FRAME

Heating:
UW4south= 4.62 W/m2 K
HFW4south= UW4south * ΔTcooling = 4.62 *24.8 = 114.57 W/ m2
QW4south= HFW4south * AW4south = 114.57 * 3.6 = 412.4 W

Cooling
Heat transfer part
CFW4south = UW4south *(ΔTcooling – 0.46 * DR) = 4.62 (7,9 – 0,46 . 11,9) = 11.2 W/m2
Part for Irradiation part
ED = 348
Ed= 209
South window of a detached house - FFS = 0.47
SHGC= 0.55
PXI W4south = ED + Ed = 348 + 209 = 557

CF W4south = PXI*SHGC*IAC*FFs= 557*0.55*1*0.47=143.95

CFfenestration4south= Uw3south *(ΔTcooling – 0.46 * DR) +PXI *SHGC *IAC * FFs = 11.2 +143.98=155.18 W/m2
$\dot{Q}_{w4south}$ = CFfenestration4south * AW4south = 155.18*3.6 = 558.65 W

$\dot{Q}_{\text{Total windows Cooling Aluminium frame}}$ = 1991.5 + 3498.6 + 559.08 + 558.65 = 6607.8 W
$\dot{Q}_{\text{Total windows Heating Aluminium frame}}$ = 1289.1 + 1289.1 + 322.2 + 412.4 = 3312.8 W

Conclusion

$\dot{Q}_{\text{Total windows Cooling Aluminium frame}}$ (6607 W) > $\dot{Q}$Total windows Cooling wood frame (6245.3 W)

$\dot{Q}_{\text{Total windows Heating Aluminium frame}}$ (3312.8 W) > $\dot{Q}$Total windows Heating wood frame (2538.2 W)