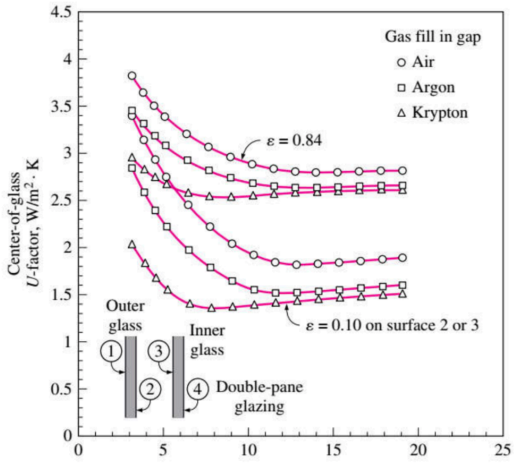
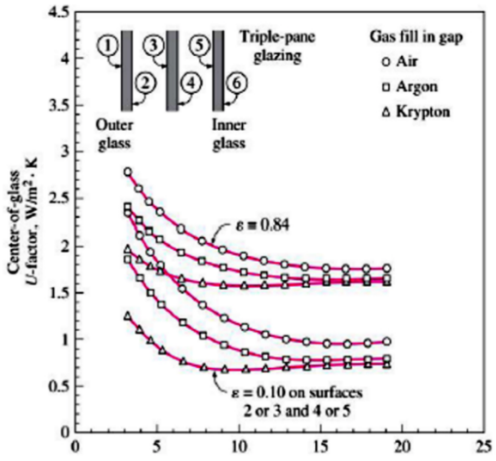
Week 8

Task 1:

Benchmark is a double-pane window with 13 mm air-filled gap
Emissivity is 0.84
U = 2.8 w/m^2k





According to the graph:

- If we changed the air with Argon, the U value will be 2.65 W/m^2k which is 5% less than that of air.
- If we changed the air with Krypton, the U value will be 2.6 W/m^2k which is 7% less than that with air.

Both gases will decrease the heat transmissivity which improves the thermal characteristics of the window.

- If there was a third pane, the U value will be 1.8 W/m^2k which is 36% less than that of double-pane window.
- If we add a coating with emissivity of 0.1, the U value will decrease to 1 W/m^2k.

So, adding a third pane with a coating of low emissivity decreases the heat transfer as well.

Task 2:

HEATING DB 99%: - 4,8
COOLING DB/MCWB 1%: 31,9
ΔT = 31,9 – 24 = 7,9 °C
ΔT = 20 – (–4,8) = 24,8 °C
DR = 11,9

WINDOW 1

$A_{\text{window\_west}}$ =14,4 m^2

Fixed Wooden frame on the west side

HEATING:

$U_{\text{window\_west}}$ = 2.84 W/m^{2}k

$HF_{\text{window\_west}}$ = U. $\Delta T_{\text{cooling}}$ = 2.84 x 24.8 = 70.44 W/m^2

$Q_{\text{window\_west}}$ = HF = 70,44 · 14,4 = 1014,2 W/m^2

COOLING:

Heat transfer:

$CF_{\text{window\_west}}$ = $U_{\text{window\_west}}$ ($\Delta T_{\text{cooling}}$ – 0.46 DR) = 2.84 (7.9 – 0.46 x 11.9) = 6.9 w/m^2 k

Irradiation:

E_D = 559

E_d = 188

SHGC = 0.56

West window of a detached house - FFS = 0,31

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

$CF = PXI \cdot SHGC \cdot IAC \cdot FF_s$ = 747 x 0.56 x 1 0.31 = 129.6

$CF_{fenestration\_west} = U\ (\Delta T_{cooling} - 0.46\ DR) + PXI\ .\ SHG\ .\ IAC\ .\ FF_s = 138.3\ w/m^2$

$Q = CF.\ A_{window} = 138.3\ x\ 14.4 = 1991.5\ W$

Window 3

$A_{window} = 3.6\ m^2$

Fixed window in the south
Aluminum frame

HEATING:

$U_{window\_south} = 3.61\ w/m^2\ k$

$HF_{window\_south} = U_{window\_south}\ .\ (\Delta T_{cooling} - 0.46\ DR) = 3{,}61 \cdot 24{,}8 = 89{,}52\ w/m^2\ k$

$Q = HF \cdot A = 89.52\ x\ 3.6 = 322.2\ W$

COOLING:

Heat transfer:

$CF_{window\_south} = U_{window\_south} = 3.61\ (7.9 - 0.46\ x\ 11.9) = 8{,}7\ w/m^2\ k$

Irradiation:

$E_D = 348$

$E_d = 209$

$SHGC = 0.56$

South window of a detached house - FFS = 0.47

$PXI_{window\_south} = E_D + E_d = 559 + 188 = 557$

$CF = PXI \cdot SHGC \cdot IAC \cdot FF_s = 557\ x\ 0.56\ x\ 1\ x\ 0.47 = 146.6$

$CF_{fenestration\_south} = U\ (\Delta T_{cooling} - 0.46\ DR) + PXI \cdot SHGC \cdot IAC \cdot FFs = 8.7 + 146.6 = 155.3\ w/m^2\ k$

$Q = CF \cdot A = 155.3\ x\ 3.6 = 559.08\ W$

Window 4

Operable window with aluminum frame

HEATING:

$U_{\text{window\_south}}$ = 4.62 w/m^2 k
$HF_{\text{window\_south}} = U.\ \Delta T_{\text{cooling}}$ = 4.62 x 24.8 = 114.57 w/m^2 k
$Q = HF.$ A = 114.57 x 3.6 = 412.4 W

COOLING:

Heat transfer:

$CF = U\ (\Delta T_{\text{cooling}}$ – 0.46 DR) = 4.62 (7.9 – 0.46 x 11.9) = 11.2 w/m^2 k

Irradiation:
E_D = 348
E_d = 209
$SHGC$ = 0.55
South window of a detached house – FF_s = 0.47
$PXI = E_D + E_d$ = 559 + 188 = 557
$CF = PXI \cdot SHGC \cdot IAC \cdot FF_s$ = 557 x 0.55 x 1 x 0.47 = 143.98
$CF_{\text{fenestration\_south}} = U\ (\Delta T_{\text{cooling}}$ – 0.46 DR) + $PXI \cdot SHGC \cdot IAC \cdot FF_s$ = 11.2 + 143.98 = 155.18 w/m^2 k
$Q = CF_{\text{fenestration\_south}} \cdot A$ = 558.65 W
$\dot{Q}_{\text{Total cooling(aluminum)}}$ = 1991.5 + 3498.6 + 559.08 + 558.65 = 6607.8 W
$\dot{Q}_{\text{Total heating(aluminum)}}$ = 1289.1 + 1289.1 + 322.2 + 412.4 = 3312.8 W

Conclusion:

$\dot{Q}_{\text{Total cooling(wood)}}$ = 6245.3 W
$\dot{Q}_{\text{Total cooling(aluminum)}}$ = 6607.8 W
$\Delta\ Q_{\text{cooling}}$ = 6607.8 – 6245.3 = 362.5 W

$\dot{Q}_{\text{Total heating(wood)}}$ = 2538.2 W
$\dot{Q}_{\text{Total heating(aluminum)}}$ = 3312.8 W

$\Delta Q_{\text{heating}}$ = 3312.8 – 2538.2 = 774.6 W

The results show that a window with a wooden frame has a greater resistance in cooling and heating than a window with an aluminum frame.