Week 8
Assignment 8
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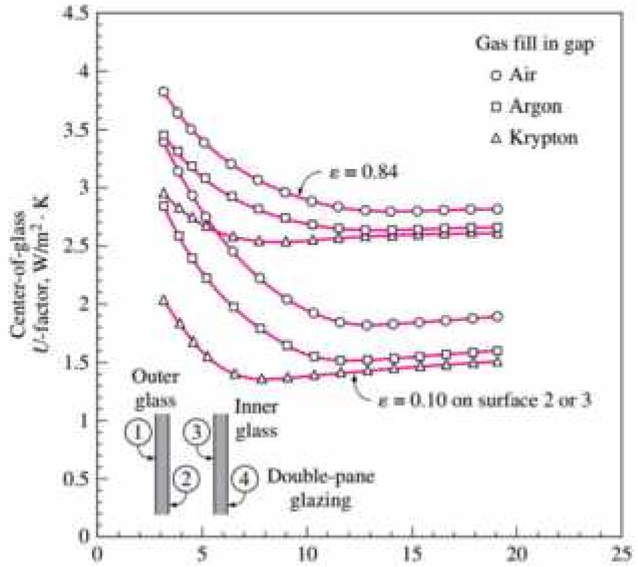
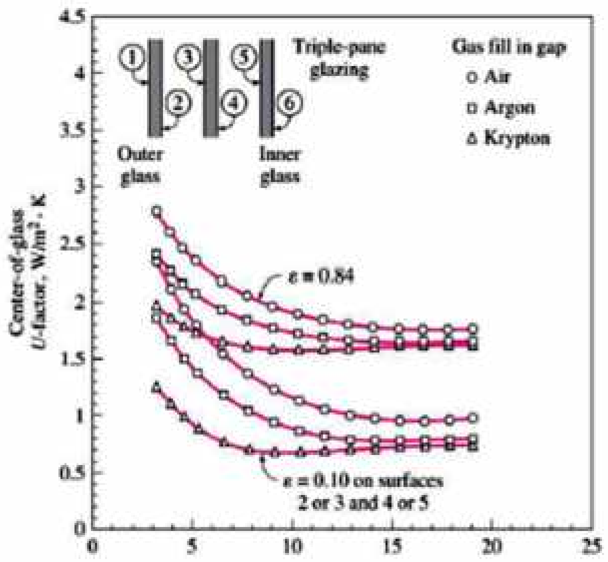
Task 1 Using the diagrams given in the presentation calculate how much (%) is the effect of applying different modifications (changing the gas, adding an extra pane, using a low emissivity coating) on the U value with respect to a benchmark case of double layer with air and no coating ? (keep the gap thickenss to be 13 mm)





Emissivity is 0.84
U = 2.8 w/m^{2}k

According to the graph:

- Argon: U value =2.65 W/m²k (5% less than that of air)
- Krypton, the U value will be 2.6 W/m²k (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/m²k 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/m²k.

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

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 ?

BRINDISI, Italy WMO#: 163200

Lat: 40.65N Long: 17.95E Elev: 10 StdP: 101.2 Time Zone: 1.00 (EUW) Period: 86-10 WBAN: 99999

Annual Heating and Humidification Design Conditions

	Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		
				99.6%			99%			0.4%		1%				
		99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	
(1)	2	2.9	4.1	-5.1	2.5	7.2	-3.0	3.0	7.4	13.4	10.2	12.4	10.6	3.4	250	(1)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

	Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB		
			0.4%		1%		2%		0.4%		1%		2%				
			DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(2)	8	7.1	32.8	23.6	31.1	24.3	29.9	24.3	27.2	29.7	26.3	29.0	25.6	28.3	4.2	180	(2)

	Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Hours 8 to 4 & 12.8/20.6	
	0.4%			1%			2%			0.4%		1%		2%			
	DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB		
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(3)	26.3	21.8	29.2	25.4	20.7	28.5	24.7	19.7	27.9	86.0	30.1	82.2	29.1	78.5	28.3	1236	(3)

Extreme Annual Design Conditions

	Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB								
					Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years		
	1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(4)	11.3	9.9	8.7	31.4	0.4	37.3	1.4	3.0	-0.6	39.4	-1.4	41.1	-2.2	42.8	-3.2	44.9	(4)

HEATING DB 99%: - 4,8
COOLING DB/MCWB 1%: 31,9
$\Delta T = 31{,}9 - 24 = 7{,}9\ °C$
$\Delta T = 20 - (-4{,}8) = 24{,}8\ °C$

DR = 11,9

Fixed Wooden frame on the west side

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

HEATING:

$U_{\text{window\_west}}$ = 2.84 W/m²k

$HF_{\text{window\_west}}$ = U. $\Delta T_{\text{cooling}}$ = 2.84 x 24.8 = 70.44 W/m²

$Q_{\text{window\_west}} = HF$ = 70,44·14,4 = 1014,2 W/m²

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/m² k

Irradiation:

E_D = 559

E_d = 188

SHGC = 0.56

West window cf a detached house - FF_S = 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

$CF_{\text{fenestration\_west}}$ = U ($\Delta T_{\text{cooling}}$ – 0.46 DR) + PXI . SHG . IAC . FF_S = 138.3 w/m²

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

Fixed window in the south
Aluminum frame

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

HEATING:

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

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

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

COOLING:

Heat transfer:

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

Irradiation:

$E_D = 348$

$E_d = 209$

$SHGC = 0.56$

South window of a detached house - FFS = 0.47

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

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

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

$\dot{Q} = CF \cdot A = 155.3 \times 3.6 = 559.08\ W$

Operable window with aluminum frame

HEATING:

$U_{window\_south} = 4.62\ w/m^2\ k$

$HF_{window\_south} = U . \Delta T_{cooling} = 4.62 \times 24.8 = 114.57\ w/m^2\ k$

$Q = HF . A = 114.57 \times 3.6 = 412.4\ W$

COOLING:

Heat transfer:

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

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

Observation

Wooden frames are better in resisting through cooling and heating while aluminum frames have a smaller resistance.

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

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

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