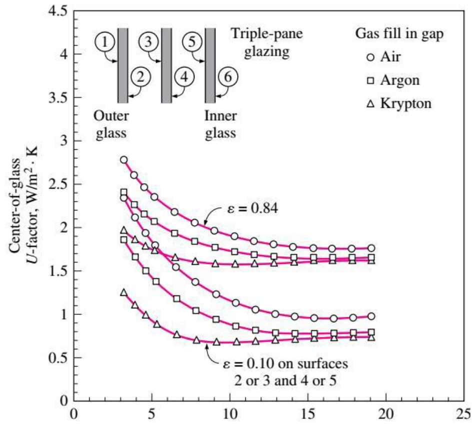
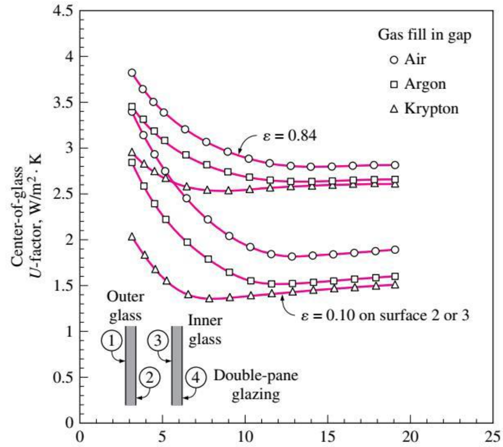
Week 8

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)





To calculate U value of a window

$$U_{window} = \frac{U_{center}A_{center} + U_{edge}A_{edge} + U_{fram}A_{fram}}{A\,window}$$

If its double glazed window, the thermal resistance of the glass layer can be disregared,

$$\frac{1}{U\;double\;panel(center\;region)} \approx \frac{1}{h1} + \frac{1}{hspace} + \frac{1}{h0}$$

$H_{space} = h_{rad,\,space} + h_{conv,\,space}$

The h space depends on the type of gas that fills the gap

From the diagram:

- When the gape is 13mm, and altering the gas that fills the gaps from air into argon, the U-value of the glass centre decreases from 2.8 to 2.65w/m²k, which is about 6.43%
- When the gape is 13mm, and altering the gas that fills the gaps from air into Krypton, the U-value of the glass center decreases from 2.8 to 2.6w/m²k, which is about 7.14%

In addition, the h space in U centre depends also on the amount of panel.

From the diagram:

- When the gape is 13mm, the gas in the gap is air, by adding an extra panel, the U-value of the center decreases from 2.8to 1.8 w/m²k, hence that U-value decreased with 55.6%.

Another way to alternate the U centre, is to coat the glass with surfaces that has a low emissivity.

From the diagram:

When the gape is 13mm, and the gap is filled with air,

By coating the glass surface with a material with emissivity of 0.1, the u value of the centre of glass decreases from 2.8 to 1.8, hence, the its decreased with 55.6%.

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 ?

PIACENZA, Italy WMO#: **160840**

Lat: **44.92N** Long: **9.73E** Elev: **138** StdP: **99.68** Time Zone: **1.00 (EUW)** Period: **89-10** 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	**-6.2**	**-4.8**	**-11.6**	**1.4**	**3.1**	**-8.8**	**1.8**	**1.8**	**8.8**	**5.6**	**7.7**	**6.2**	**2.1**	**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)	
8	**11.9**	**33.1**	**22.7**	**31.9**	**22.4**	**30.3**	**21.8**	**24.6**	**30.2**	**23.7**	**29.2**	**22.9**	**28.3**	**2.4**	**90**	(2)

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
δTcooling = 31,9 − 24 = 7,9 °C
δTheating= 20 − (−4,8) = 24,8 °C
building east side is
45° latitude
no internal shading – aic = 1
Dr = 11,9

Table 10 Peak Irradiance, W/m²

Exposure		20°	25°	30°	35°	40°	45°	50°	55°	60°
North	E_D	125	106	92	84	81	85	96	112	136
	E_d	128	115	103	93	84	76	69	62	55
	E_t	253	221	195	177	166	162	164	174	191
Northeast/Northwest	E_D	460	449	437	425	412	399	386	374	361
	E_d	177	169	162	156	151	147	143	140	137
	E_t	637	618	599	581	563	546	529	513	498
East/West	E_D	530	543	552	558	560	559	555	547	537
	E_d	200	196	193	190	189	188	187	187	187
	E_t	730	739	745	748	749	747	742	734	724
Southeast/Southwest	E_D	282	328	369	405	436	463	485	503	517
	E_d	204	203	203	204	205	207	210	212	215
	E_t	485	531	572	609	641	670	695	715	732
South	E_D	0	60	139	214	283	348	408	464	515
	E_d	166	193	196	200	204	209	214	219	225
	E_t	166	253	335	414	487	557	622	683	740
Horizontal	E_D	845	840	827	806	776	738	691	637	574
	E_d	170	170	170	170	170	170	170	170	170
	E_t	1015	1010	997	976	946	908	861	807	744

Table 13 Fenestration Solar Load Factors FF_s

Exposure	Single Family Detached	Multifamily
North	0.44	0.27
Northeast	0.21	0.43
East	0.31	0.56
Southeast	0.37	0.54
South	0.47	0.53
Southwest	0.58	0.61
West	0.56	0.65
Northwest	0.46	0.57
Horizontal	0.58	0.73

Calculating the cooling load of the fixed west window:

$q_{\text{window west}}$ =A X CFwindow west

A=14.4m²

$CF_{\text{window west(heat transfer part)}}$ =U window west(ΔTcooling-0.46DR)

The window is double glazed fixed with wooden frame

∴ U window west=2.84 w/m²k

$CF_{\text{window west(heat transfer part)}}$ = 2.84w/m²Kx(7.9k-0.46x11.9K)≈ 6.89w/m²

$PXI_{\text{window west}}$ =ED+Ed=559+188=747

SHGC=0.54

No internal shading,so IAC=1

FFs=0.56

$CF_{\text{window west(irradiation part)}}$ = PXI X SHGC X IAC X FFS

$q_{\text{window west}}$=A X ($CF_{\text{window west(heat transfer part)}}$ + $CF_{\text{window west(irradiation part)}}$)

≈14.4m²x(6.89+747x0.54x1x0.56)w/m²

≈3352.07W

Calculating the heating load of the fixed west window:

$q_{\text{window west}}$ =A x HFwindow west

= A x $U_{\text{window west}}$ x ΔT heating

= 14.4x 2.84x 24.8≈ 1014.22W

<u>Changing the frame from wood to aluminium</u>,

$U_{\text{window west}}$= 3.61w/m²K , HSGC=0.56

$CF'_{\text{window west(heat transfer part)}}$=$U'_{\text{window west}}$(ΔTcooling – 0.46DR)

= 3.61x(7.9-0.46x11.9) ≈ 8.76w/m²

Cooling load $q'_{\text{window west}}$ = Ax$CF'_{\text{window west}}$

= Ax($CF'_{\text{window west(heat transfer part)}}$ + $CF'_{\text{window west(irradiation part)}}$)

=14.4x(8.76+747x0.56x1x0.56) ≈3499.48w

Heating load $q'_{\text{window west}}$ =A x HFwindow west

= A x $U_{\text{window west}}$ x ΔT heating

= 14.4x 3.61x 24.8≈ 1289.20W

Calculating the cooling load of the fixed south window:

$q_{\text{window south}} = A \times CF_{\text{window south}}$

$A = 3.6m^2$

$CF_{\text{window south(heat transfer part)}} = U_{\text{window south}} (\Delta T_{cooling} - 0.46DR)$

The window is double glazed fixed with wooden frame

$\therefore U_{\text{window south}} = 2.84 \, w/m^2k$

$CF_{\text{window south (heat transfer part)}} = 2.84 \times (7.9 - 0.46 \times 11.9) \approx 6.89 w/m^2$

$PXI_{\text{window south}} = ED + Ed = 348 + 209 = 557$

SHGC=0.55

No internal shading,so IAC=1

FFs=0.47

$CF_{\text{window south (irradiation part)}} = PXI \times SHGC \times IAC \times FFS$

$q_{\text{window south}} = A \times (CF_{\text{window south (heat transfer part)}} + CF_{\text{window south (irradiation part)}})$

$\approx 3.6m^2 \times (6.89 + 557 \times 0.54 \times 1 \times 0.47) w/m^2$

$\approx 553.72W$

Calculating the heating load of the fixed south window:

$q_{\text{window south}} = A \times HF_{\text{window south}}$

$= A \times U_{\text{window south}} \times \Delta T_{heating}$

$= 3.6 \times 2.84 \times 24.8 \approx 253.56W$

Changing the frame from wood to aluminium,

$U_{\text{window south}} = 3.61 w/m^2K$, HSGC=0.56

$CF'_{\text{window south (heat transfer part)}} = U'_{\text{window south}} (\Delta T_{cooling} – 0.46DR)$

$= 3.61 \times (7.9 - 0.46 \times 11.9) \approx 8.76 w/m^2$

Cooling load $q'_{\text{window south}} = A \times CF'_{\text{window south}}$

$= A \times (CF'_{\text{window south (heat transfer part)}} + CF'_{\text{window south (irradiation part)}})$

$= 3.6 \times (8.76 + 557 \times 0.56 \times 1 \times 0.47) \approx 559.30w$

Heating load $q'_{\text{window south}} = A \times HF_{\text{window south}}$

$= A \times U_{\text{window south}} \times \Delta T_{heating}$

$= 3.6 \times 3.61 \times 24.8 \approx 322.30w$

Calculating the cooling load of the operable south window:

$q_{\text{window south}} = A \times CF_{\text{window south}}$

$A = 3.6 m^2$

$CF_{\text{window south(heat transfer part)}} = U_{\text{window south}} (\Delta T_{cooling} - 0.46 DR)$

The window is double glazed fixed with wooden frame

$\therefore U_{\text{window south}} = 2.87\ w/m^2k$

$CF_{\text{window south (heat transfer part)}} = 2.87 \times (7.9 - 0.46 \times 11.9) \approx 6.96 w/m^2$

$PXI_{\text{window south}} = ED + Ed = 348 + 209 = 557$

SHGC=0.46

No internal shading,so IAC=1

FFs=0.47

$CF_{\text{window south (irradiation part)}} = PXI \times SHGC \times IAC \times FFS$

$q_{\text{window south}} = A \times (CF_{\text{window south (heat transfer part)}} + CF_{\text{window south (irradiation part)}})$

$\approx 3.6 m^2 \times (6.96 + 557 \times 0.54 \times 1 \times 0.47) w/m^2$

$\approx 553.98W$

Calculating the heating load of the fixed $_{\text{south}}$ window:

$q_{\text{window south}} = A \times HF_{\text{window south}}$

$= A \times U_{\text{window south}} \times \Delta T_{heating}$

$= 3.6 \times 2.87 \times 24.8 \approx 256.23W$

Changing the frame from wood to aluminium,

$U_{\text{window south}} = 4.62 w/m^2K$, HSGC=0.55

$CF'_{\text{window south (heat transfer part)}} = U'_{\text{window south}} (\Delta T_{cooling} - 0.46DR)$

$= 4.62 \times (7.9 - 0.46 \times 11.9) \approx 11.21 w/m^2$

Cooling load $q'_{\text{window south}} = A \times CF'_{\text{window south}}$

$= A \times (CF'_{\text{window south (heat transfer part)}} + CF'_{\text{window south (irradiation part)}})$

$= 3.6 \times (11.21 + 557 \times 0.55 \times 1 \times 0.47) \approx 558.70w$

Heating load $q'_{\text{window south}} = A \times HF_{\text{window south}}$

$= A \times U_{\text{window south}} \times \Delta T_{heating}$

$= 3.6 \times 4.62 \times 24.8 \approx 412.47w$