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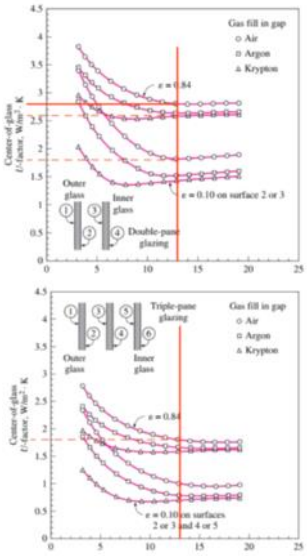
Weekly Submission 6

Tuesday, November 26, 2019 1:05 PM

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)



	BENCHMARK	1	2	3
GAP	13mm	13mm	13mm	13mm
ϵ	0.84	0.84	0.10	0.84
N Pane	2	2	2	3
Gas	Air	Krypton	Air	Air
U factor	2.8 $\frac{W}{m^2K}$	2.6$\frac{W}{m^2K}$	1.8$\frac{W}{m^2K}$	1.8$\frac{W}{m^2K}$
%	100	93	64	64

1. Based on the graph it is possible to see that by comparing the benchmark with the first case where the gas(krypton) has been changed, the Ufactor Value decreases by 7% thus improving the thermal transmittance of the window.
2. in the second comparison, using a low emissivity coating, the UFACTOR value decreases by 36% greatly improving the thermal transmittance compared to the benchmark.
3. 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 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%	99.6%			99%			0.4%		1%			
			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)

$\Delta T_{cooling} = 31.9 - 24 = 7.9\ °C$

$\Delta T_{heating} = 20 - (-4.8) = 24.8\ °C$

$DR = 11.9\ °C$

Wood Frame Section For Window 1

$A_{Window1east} = 14{,}4\ m^2$

Heating:

$U_{window1east} = 2{,}84\ \frac{W}{m^2 K}$

$HF_{window1east} = U_{Window1east} * \Delta T_{cooling} = 2.84 * 24.8 = 70.44$

$Q_{window1east} = HF_{Window1east} * A_{Window1east} = 70.44 * 14.4 =$ 1014.2 W

Cooling :

$CF_{Window1east} = U_{Window1east} * (\Delta T_{cooling} - 0.46\ DR) = 2{,}84\ (7{,}9 - 0{,}46 \cdot 11{,}9) =$ $6{,}9\ \frac{W}{m^2}$

Part for Irradiation part

$E_D = 559$ $E_d = 188$

East window of a detached house - FFS = 0.31

SHGC= 0.54

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

$CF_{Window1east} = PXI * SHGC * IAC * FF_s = 747 * 0.54 * 1 * 0.31 = 125.1$

$CF_{fenestration1east} = U_{window1east} * (\Delta T_{cooling} - 0.46\ DR) + PXI * SHGC * IAC * FF_s = 6.9 + 125.1 = 132\ \frac{W}{m^2}$

$Q_{window1east} = CF_{fenestration1east} * A_{Window1east} = 132 * 14.4 =$ 1900.8 W

Wood Frame Section For Window 2

$A_{Window2west} = 14{,}4\ m^2$

Heating :

$U_{Window2west} = 2{,}84\ \frac{W}{m^2 K}$

$HF_{Window2west} = U_{Window2west} * \Delta T_{cooling} = 2.84 * 24.8 = 70.44$

$Q_{Window2west} = HF_{Window2west} * A_{Winodw2west} = 70.44 * 14.4 =$ 1014.2 W

Cooling :

$CF_{Window2west} = U_{Winodw2west} * (\Delta T_{cooling} - 0.46\ DR) = 2{,}84\ (7{,}9 - 0{,}46 \cdot 11{,}9) =$ $6{,}9\ \frac{W}{m^2}$

$E_D = 559$

$E_d = 188$

West window of a detached house - FFS = 0.31

SHGC= 0.54

$PXI_{Window2west} = E_D + E_d = 559 + 188 = 747$

$CF_{Window2west} = PXI*SHGC*IAC*FF_s = 747*0.54*1*0.56 = 225.9$

$CF_{fenestration2west} = U_{window2west}*(\Delta T_{cooling} - 0.46\ DR) + PXI*SHGC*IAC*FF_s = 6.9 + 225.9 = 232.8\ \frac{W}{m^2}$

$Q_{Window2west} = CF_{fenestration2west} * A_{Window2west} = 232.8 * 14.4 = 3352.32\ W$

Wood Frame Section For Window 3

$A_{Window3south} = 3.6\ m^2$

Heating :

$U_{Window3south} = 2{,}84\ W/m^2\ K$

$HF_{Window3south} = U_{Window3south} * \Delta T_{cooling} = 2.84 * 24.8 = 70.44\ \frac{W}{m^2}$

$Q_{Window3south} = HF_{Window3south} * A_{Winodw3south} = 70.44 * 3.6 = 253.6\ W$

Cooling :

$CF_{Window3south} = U_{Winodw3south}*(\Delta T_{cooling} - 0.46\ DR) = 2{,}84\ (7{,}9 - 0{,}46 \cdot 11{,}9) = 6{,}9\ \frac{W}{m^2}$

$E_D = 348$

$E_d = 209$

South window of a detached house - FFS = 0.31

SHGC= 0.54

$PXI_{Window3south} = E_D + E_d = 348 + 209 = 557$

$CF_{Window3south} = PXI*SHGC*IAC*FF_s = 557*0.54*1*0.47 = 141.4$

$CF_{fenestration3south} = U_{window3south}*(\Delta T_{cooling} - 0.46\ DR) + PXI*SHGC*IAC*FF_s = 6.9 + 141.4 = 148.3\ \frac{W}{m^2}$

$Q_{window3south} = CF_{fenestration3south} * A_{Window3south} = 148.3*3.6 = 533.88\ W$

Wood Frame Section For Window 4

$A_{W4south} = 3.6\ m^2$

Heating:

$U_{Window4south} = 2{,}87\ \frac{W}{m^2 K}$

$HF_{Window4south} = U_{Window4south} * \Delta T_{cooling} = 2.87 * 24.8 = 71.17\ \frac{W}{m^2}$

$Q_{Window4south} = HF_{Window4south} * A_{Window4south} = 71.17 * 3.6 = 256.2\ W$

Cooling :

$CF_{Window4south} = U_{Window4south}*(\Delta T_{cooling} - 0.46\ DR) = 2{,}87\ (7{,}9 - 0{,}46 \cdot 11{,}9) = 6{,}96\ \frac{W}{m^2}$

$E_D = 348$

$E_d = 209$

South window of a detached house - FFS = 0.47

SHGC= 0.46

$PXI_{Window4south} = E_D + E_d = 348 + 209 = 557$

$CF_{Window4south} = PXI*SHGC*IAC*FF_s = 557*0.46*1*0.47 = 120.4$

$CF_{fenestration4south} = U_{window3south} * (\Delta T_{cooling} - 0.46DR) + PXI * SHGC * IAC * FF_s = 6.9 + 120.4 = 127.3 \frac{W}{m^2}$

$Q_{window4south} = CF_{fenestration4south} * A_{Window4south} = 127.3 * 3.6 =$ 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

Part2 / Aluminium Frame :

Aluminium Frame Section Window 1 :

$A_{window1east} = 14{,}4\ m^2$

Heating:

$U_{window1east} = 3.61 \frac{W}{m^2 K}$

$HF_{window1east} = U_{Window1east} * \Delta T_{cooling} = 3.61 * 24.8 = 89.52 \frac{W}{m^2}$

$Q_{window1east} = HF_{Window1east} * A_{Window1east} = 89.52 * 14.4 =$ 1289.1 W

Cooling :

$CF_{Window1east} = U_{Window1east} * (\Delta T_{cooling} - 0.46\ DR) = 3.61 * (7{,}9 - 0{,}46 \cdot 11{,}9) =$ $8.7 \frac{W}{m^2}$

$E_D = 559$

$E_d = 188$

East window of a detached house - FFS = 0.31

SHGC= 0.56

$PXI_{Window1east} = E_D + E_d = 559 + 188 = 747$

$CF_{Window1east} = PXI * SHGC * IAC * FF_s = 747 * 0.56 * 1 * 0.31 = 129.6$

$CF_{fenestration1east} = U_{window1east} * (\Delta T_{cooling} - 0.46\ DR) + PXI * SHGC * IAC * FF_s = 8.7 + 129.6 = 138.3 \frac{W}{m^2}$

$Q_{window1east} = CF_{fenestration1east} * A_{Window1east} = 138.3 * 14.4 =$ 1991.5 W

Aluminium Frame Section Window 2 :

$A_{Window2west} = 14{,}4\ m^2$

Heating:

$U_{Window2west} = 3.61 \frac{W}{m^2 K}$

$HF_{Window2west} = U_{Window2west} * \Delta T_{cooling} = 3.61 * 24.8 = 70.44 \frac{W}{m^2}$

$Q_{Window2west} = HF_{Window2west} * A_{Window2west} = 89.52 * 14.4 =$ 1289.1 W

Cooling :

$CF_{Window2west} = U_{Window2west} * (\Delta T_{cooling} - 0.46\ DR) = 3.61\ (7{,}9 - 0{,}46 \cdot 11{,}9) =$ $8.7 \frac{W}{m^2}$

$E_D = 559$

$E_d = 188$

West window of a detached house - FFS = 0.56

SHGC= 0.56

$PXI_{Window2west} = E_D + E_d = 559 + 188 = 747$

$CF_{Window2west}$ = PXI*SHGC*IAC*FF_s=747*0.56*1*0.56=234.26

$CF_{fenestration2west}$= $U_{window2west}$*($\Delta T_{cooling}$ – 0.46 DR) +PXI *SHGC *IAC * FF_s = 8.7+234.26=242.96 $\frac{W}{m^2}$

$Q_{Window2west}$ = $CF_{fenestration2west}$ * $A_{Window2west}$ = 242.96 * 14.4 = 3498.6 W

Aluminium Frame Section Window 3 :

$A_{Window3south}$= 3.6 m^2

Heating:

$U_{Winodw3south=}$ 3.61 $\frac{W}{m^2K}$

$HF_{Window3south=}$ $U_{Window3south}$ * $\Delta T_{cooling}$ = 3.61 *24.8 = 89.52 $\frac{W}{m^2}$

$Q_{Window3south}$= $HF_{Window3south}$ * $A_{Window3south}$ = 89.52 * 3.6 = 322.2 W

Cooling :

$CF_{Window3south}$ = $U_{Window3south}$ *($\Delta T_{cooling}$ – 0.46 DR) = 3.61 (7,9 − 0,46 · 11,9) = 8.7 $\frac{W}{m^2}$

E_D = 348

E_d= 209

South window of a detached house - FFS = 0.47

SHGC= 0.56

PXI $_{Window3south}$ = E_D + E_d = 348 + 209 = 557

CF $_{Window3south}$ = PXI*SHGC*IAC*FF_s= 557*0.56*1*0.47=146.6

$CF_{fenestration3south}$= $U_{window3south}$ *($\Delta T_{cooling}$ – 0.46 DR) +PXI *SHGC *IAC * FF_s = 8.7 +146.6=155.3 $\frac{W}{m^2}$

$Q_{window3south}$ = $CF_{fenestration3south}$ * $A_{Window3south}$ = 155.3*3.6 = 559.08 W

Aluminium Frame Section Window 4 :

$A_{Window4south}$= 3.6 m^2

Heating:

$U_{Winodw4south=}$ 4.62 $\frac{W}{m^2K}$

$HF_{Windwo4south=}$ $U_{Window4south}$ * $\Delta T_{cooling}$ = 4.62 *24.8 = 114.57 $\frac{W}{m^2}$

$Q_{Window4south}$= $HF_{Window4south}$ * $A_{Window4south}$ = 114.57 * 3.6 = 412.4 W

Cooling :

$CF_{Window4south}$ = $U_{Window4south}$ *($\Delta T_{cooling}$ – 0.46DR) = 4.62 (7,9 − 0,46 · 11,9) = 11.2 $\frac{W}{m^2}$

E_D = 348

E_d= 209

South window of a detached house - FFS = 0.47

SHGC= 0.55

PXI $_{Window4south}$ = E_D + E_d = 348 + 209 = 557

CF $_{Window4south}$ = PXI*SHGC*IAC*FF_s= 557*0.55*1*0.47=143.95

$CF_{fenestration4south}$= $U_{window3south}$ *($\Delta T_{cooling}$ – 0.46DR) +PXI *SHGC *IAC * FF_s = 11.2 +143.98=155.18 $\frac{W}{m^2}$

$Q_{window4south}$ = $CF_{fenestration4south}$ * $A_{Window4south}$ = 155.18*3.6 = 558.65 W

$Q_{\text{Total windows Cooling Aluminium frame}}$ = 1991.5+3498.6+559.08+558.65=6607.8W

$Q_{\text{Total windows Heating Aluminium frame}}$ = 1289.1+1289.1+322.2+412.4=3312.8 W

In conclusion, you requires more energy to heat or cool your place if you use aluminium frame than the wooden frame for the window .