WEEK_8 Againi

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)

TASK1

	U	DIFFERENCE	%
2 Parallel plans with air	2,8 W/m2		
2 Parallel plans with gas	2,6 W/m2	0,2 W/m2	7,14
2 Parallel plans with air and coating	1,8 W/m2	1,0 W/m2	35,71
2 Parallel plans with gas and coating	1,5 W/m2	1,3 W/m2	46,42
3 Parallel plans with air	1,8 W/m2	1,0 W/m2	35,71
3 Parallel plans with gas	1,6 W/m2	1,2 W/m2	42,85
3 Parallel plans with air and coating	1,0 W/m2	1,8 W/m2	64,28
3 Parallel plans with gas and coating	0,75 W/m2	2,05 W/m2	73,21

Consider the house that we analyzed 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 aluminum ?

TASK2

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)

Temperature difference calculation

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

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

DR = 11.9 °C

WEST WINDOW (FIXED)

Cooling Load: Wooden Frame

$\dot{q}_{windowwest} = A \times CF_{windowwest}$

A = 14.4 m^2

$CF_{windowwest} = CF_{windowwest,heattransfer} + CF_{windowwest,irridiation}$

$CF_{windowwest} = U(\Delta T - 0.46DR) + PXI \times SHGC \times IAC \times FF_s$

$CF_{windowwest_{\downarrow}heattransfer} = U(\Delta T - 0.46DR)$
U = 2.84
$CF_{windowwest_{\downarrow}heattransfer} = 2.84\ (7.9 - (0.46)(11.9)) = 6.89\ \frac{W}{m^2}$
$CF_{windowwest_{\downarrow}irridiation} = PXI \times SHGC \times IAC \times FF_s$
$PXI = E_D - E_d = 559 + 188 = 747$
SHGC = 0.54
IAC = 1
$FF_s = 0.56$
$CF_{windowwest_{\downarrow}irridiation} = 747 \times 0.54 \times 1 \times 0.56 = 225.89\ \frac{W}{m^2}$
$CF_{windowwest} = CF_{windowwest_{\downarrow}heattransfer} + CF_{windowwest_{\downarrow}irridiation}$
$CF_{windowwest} = 6.89 + 225.89 = 232.78\ \frac{W}{m^2}$
$\dot{q}_{windowwest} = A \times CF_{windowwest} = 14.4 \times 232.78 = 3352.07\ W$

Cooling Load: Aluminum Frame

$\dot{q}_{windowwest} = A \times CF_{windowwest}$
$A = 14.4\ m^2$
$CF_{windowwest} = CF_{windowwest_{\downarrow}heattransfer} + CF_{windowwest_{\downarrow}irridiation}$
$CF_{windowwest} = U(\Delta T - 0.46DR) + PXI \times SHGC \times IAC \times FF_s$
$CF_{windowwest_{\downarrow}heattransfer} = U(\Delta T - 0.46DR)$
U = 3.61
$CF_{windowwest_{\downarrow}heattransfer} = 3.61\ (7.9 - (0.46)(11.9)) = 8.76\ \frac{W}{m^2}$
$CF_{windowwest_{\downarrow}irridiation} = PXI \times SHGC \times IAC \times FF_s$
$PXI = E_D - E_d = 559 + 188 = 747$
SHGC = 0.56
IAC = 1
$FF_s = 0.56$
$CF_{windowwest_{\downarrow}irridiation} = 747 \times 0.56 \times 1 \times 0.56 = 234.26\ \frac{W}{m^2}$
$CF_{windowwest} = 8.76 + 234.26 = 243.02\ \frac{W}{m^2}$
$\dot{q}_{windowwest} = A \times CF_{windowwest} = 14.4 \times 243.02 = 3499.47\ W$

Heating Load: Wooden Frame

$\dot{q}_{windowwest} = A \times HF_{windowwest}$
$A = 14.4\ m^2$
$HF_{windowwest} = U_{windowwest} \times \Delta T_{heating}$
$U = 2.84$
$HF_{windowwest} = 2.84 \times 24.8 = 70.43\ \frac{W}{m^2}$
$\dot{q}_{windowwest} = A \times HF_{windowwest} = 14.4 \times 70.43 = 1014.22\ W$

Heating Load: Aluminum Frame

$\dot{q}_{windowwest} = A \times HF_{windowwest}$
$A = 14.4\ m^2$
$HF_{windowwest} = U_{windowwest} \times \Delta T_{heating}$
$U = 3.61$
$HF_{windowwest} = 3.61 \times 24.8 = 89.53\ \frac{W}{m^2}$
$\dot{q}_{windowwest} = A \times HF_{windowwest} = 14.4 \times 89.53 = 1289.20\ W$

Difference:
Cooling Load = 147.4 W
Heating Load = 274.98 W

SOUTH WINDOW (FIXED)

Cooling Load: Wooden Frame

$\dot{q}_{windowsouth} = A \times CF_{windowsouth}$

$A = 3.6\ m^2$

$CF_{windowsouth} = CF_{windowsouth,heattransfer} + CF_{windowsouth,irridiation}$

$CF_{windowsouth} = U(\Delta T - 0.46DR) + PXI \times SHGC \times IAC \times FF_s$

$CF_{windowsouth,heattransfer} = U(\Delta T - 0.46DR)$

$U = 2.84$

$CF_{windowsouth,heattransfer} = 2.84\ (7.9 - (0.46)(11.9)) = 6.89\ \frac{W}{m^2}$

$CF_{windowsouth,irridiation} = PXI \times SHGC \times IAC \times FF_s$

$PXI = E_D - E_d = 348 + 209 = 557$

$SHGC = 0.54$

$IAC = 1$

$FF_s = 0.47$

$CF_{windowsouth,irridiation} = 557 \times 0.54 \times 1 \times 0.47 = 141.37\ \frac{W}{m^2}$

$CF_{windowsouth} = CF_{windowsouth,heattransfer} + CF_{windowsouth,irridiation}$

$CF_{windowsouth} = 6.89 + 141.37 = 148.26\ \frac{W}{m^2}$

$\dot{q}_{windowsouth} = A \times CF_{windowsouth} = 3.6 \times 148.26 = 533.74\ W$

Cooling Load: Aluminum Frame

$\dot{q}_{windowsouth} = A \times CF_{windowsouth}$

$A = 3.6\ m^2$

$CF_{windowsouth} = CF_{windowsouth,heattransfer} + CF_{windowsouth,irridiation}$

$CF_{windowsouth} = U(\Delta T - 0.46DR) + PXI \times SHGC \times IAC \times FF_s$

$CF_{windowsouth,heattransfer} = U(\Delta T - 0.46DR)$

$U = 3.61$

$CF_{windowsouth,heattransfer} = 3.61\ (7.9 - (0.46)(11.9)) = 8.76\ \frac{W}{m^2}$

$CF_{windowsouth,irridiation} = PXI \times SHGC \times IAC \times FF_s$

$PXI = E_D - E_d = 348 + 209 = 557$

$SHGC = 0.56$

$IAC = 1$

$FF_s = 0.47$

$CF_{windowsouth,irridiation} = 557 \times 0.56 \times 1 \times 0.47 = 146.60\ \frac{W}{m^2}$

$CF_{windowsouth} = 8.76 + 146.60 = 155.36\ \frac{W}{m^2}$

$\dot{q}_{windowsouth} = A \times CF_{windowsouth} = 3.6 \times 155.36 = 559.30\ W$

Heating Load: Wooden Frame

$\dot{q}_{windowsouth} = A \times HF_{windowsouth}$

$A = 3.6\ m^2$

$HF_{windowsouth} = U_{windowsouth} \times \Delta T_{heating}$

$U = 2.84$

$HF_{windowsouth} = 2.84 \times 24.8 = 70.43\ \frac{W}{m^2}$

$\dot{q}_{windowsouth} = A \times HF_{windowsouth} = 3.6 \times 70.43 = 253.08\ W$

Heating Load: Aluminum Frame

$\dot{q}_{windowsouth} = A \times HF_{windowsouth}$

$A = 3.6\ m^2$

$HF_{windowsouth} = U_{windowsouth} \times \Delta T_{heating}$

$U = 3.61$

$HF_{windowsouth} = 3.61 \times 24.8 = 89.53\ \frac{W}{m^2}$

$\dot{q}_{windowsouth} = A \times HF_{windowsouth} = 3.6 \times 89.53 = 322.31\ W$

Difference:
Cooling Load = 25.56 W
Heating Load = 69.23 W

SOUTH WINDOW (OPERABLE)

Cooling Load: Wooden Frame

$\dot{q}_{windowsouth} = A \times CF_{windowsouth}$

A = 3.6 m^2

$CF_{windowsouth} = CF_{windowsouth,heattransfer} + CF_{windowsouth,irridiation}$

$CF_{windowsouth} = U(\Delta T - 0.46DR) + PXI \times SHGC \times IAC \times FF_s$

$CF_{windowsouth,heattransfer} = U(\Delta T - 0.46DR)$

U = 2.87

$CF_{windowsouth\downarrow heattransfer} = 2.87\ (7.9 - (0.46)(11.9)) = 6.96\ \frac{W}{m^2}$

$CF_{windowsouth,irridiation} = PXI \times SHGC \times IAC \times FF_s$

$PXI = E_D - E_d = 348 + 209 = 557$

SHGC = 0.46

IAC = 1

$FF_s = 0.47$

$CF_{windowsouth\downarrow irridiation} = 557 \times 0.46 \times 1 \times 0.47 = 120.42\ \frac{W}{m^2}$

$CF_{windowsouth} = CF_{windowsouth,heattransfer} + CF_{windowsouth,irridiation}$

$CF_{windowsouth} = 6.96 + 120.42 = 127.38\ \frac{W}{m^2}$

$\dot{q}_{windowsouth} = A \times CF_{windowsouth} = 3.6 \times 127.38 = 458.57\ W$

Cooling Load: Aluminum Frame

$\dot{q}_{windowsouth} = A \times CF_{windowsouth}$

A = 3.6 m^2

$CF_{windowsouth} = CF_{windowsouth,heattransfer} + CF_{windowsouth,irridiation}$

$CF_{windowsouth} = U(\Delta T - 0.46DR) + PXI \times SHGC \times IAC \times FF_s$

$CF_{windowsouth,heattransfer} = U(\Delta T - 0.46DR)$

U = 4.62

$CF_{windowsouth\downarrow heattransfer} = 4.62\ (7.9 - (0.46)(11.9)) = 11.21\ \frac{W}{m^2}$

$CF_{windowsouth,irridiation} = PXI \times SHGC \times IAC \times FF_s$

$PXI = E_D - E_d = 348 + 209 = 557$

SHGC = 0.55

IAC = 1

$FF_s = 0.47$

$CF_{windowsouth\downarrow irridiation} = 557 \times 0.55 \times 1 \times 0.47 = 143.98\ \frac{W}{m^2}$

$CF_{windowsouth} = 11.21 + 143.98 = 155.19\ \frac{W}{m^2}$

$\dot{q}_{windowsouth} = A \times CF_{windowsouth} = 3.6 \times 155.19 = 558.68\ W$

Heating Load: Wooden Frame

$\dot{q}_{windowsouth} = A \times HF_{windowsouth}$

A = 3.6 m^2

$HF_{windowsouth} = U_{windowsouth} \times \Delta T_{heating}$

U = 2.87

$HF_{windowsouth} = 2.87 \times 24.8 = 71.18\ \frac{W}{m^2}$

$\dot{q}_{windowsouth} = A \times HF_{windowsouth} = 3.6 \times 71.18 = 256.23\ W$

Heating Load: Aluminum Frame

$\dot{q}_{windowsouth} = A \times HF_{windowsouth}$

A = 3.6 m^2

$HF_{windowsouth} = U_{windowsouth}$ x $\Delta T_{heating}$

U = 4.62

$HF_{windowsouth} = 4.62$ x $24.8 = 114.58 \frac{W}{m^2}$

$\dot{q}_{windowsouth} = A$ x $HF_{windowsouth} = 3.6$ x $114.58 = 412.47$ W

Difference:

Cooling Load = 100.11 W

Heating Load = 156.24 W