TES Week 9

03 December 2019 23:13

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Task 1
Use a weather forecast website, and utilize the psychrometric chart and the formula we went through in the class to determine the absolute humidity, the wet-bulb temperature and the mass of water vapour in the air in Classroom A (Aula A) of Piacenza campus in the moment that you are solving this exercise (provide the inputs that you utilized)

Umidità: Relative humidity, Pressione atmosferica: Air total pressure (1 hPa: 0.1 kPa), Temperatura effettiva: temperature to be utilized.

From <https://github.com/bnajafi/TES_2019-2020_weeklySubmissions/tree/master/Week%209>

Answer task 1

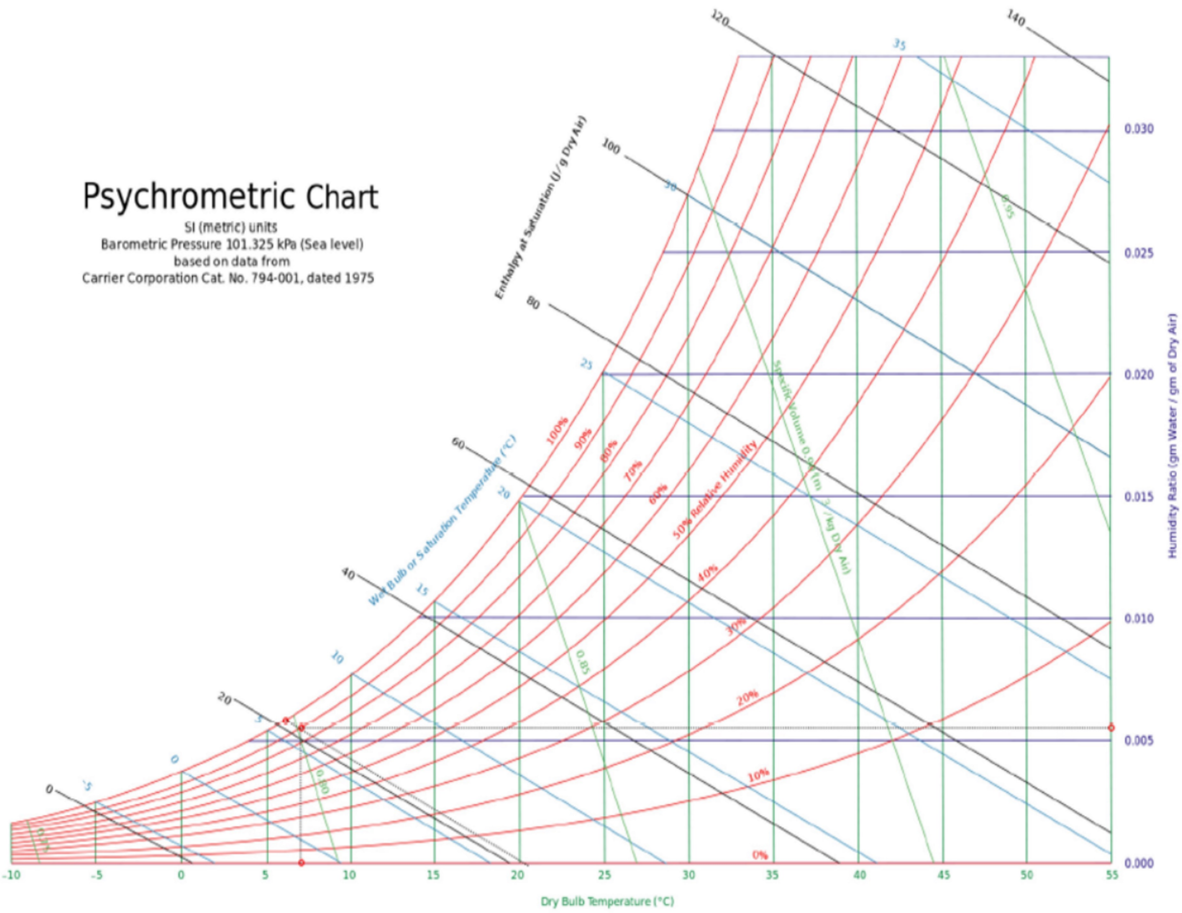
Weather data 2 December 2019, 20:00
Website: https://www.meteooggi.it/italia/regione-emilia-romagna/tempo-piacenza/

Il tempo oggi in Piacenza
Lunedi, 02 Dicembre 2019

	13:00	14:00	16:00	18:00	20:00	21:00	22:00
	PartlyCloud	PartlyCloud	LightCloud	LightCloud	PartlyCloud	Cloud	PartlyCloud
Temperatura effettiva	10°C	10°C	9°C	6°C	7°C	7°C	8°C
Temperatura percepita	10°C	10°C	8°C	5°C	7°C	6°C	7°C
Precipitazioni	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm
Umidità	79 %	77 %	89 %	90 %	90 %	92 %	91 %
Pressione atmosferica	1016 hPa	1015 hPa	1016 hPa	1017 hPa	1019 hPa	1019 hPa	1020 hPa

Relative humidity: 90%
Total air pressure P=101.9 kPa
Utilized temperature: 7°C, in Kelvin scale: T=230°K

Using psychometric chart to determine wet bulb temperature, mass of water vapour



At 7°C, with relative humidity 90%
-> the absolute humidity ω=0.0055
-> wet bulb temperature T_{wb}=6°C

If
$\omega = 0.622P_v/P_a$
$= 0.622P_v/ P - P_v = 0.0055$

and
$P = 101.9$ kPa
$\therefore P_v = 0.893$kPa

$\Phi = m_v/m_g = 90\%$
For ideal gas, $m = PV/R_{sp}T$

It is known that $R_{sp} = 0.4615$
Meanwhile $P_v = 0.893$ kPa
With the volume of aula A symbolised as V

$\therefore m_v = 0.893V/0.4615*230$
$= 8.41 \times 10^{-3}V$

Where $\Phi = m_v/m_g$
$m_g = m_v/90\% = 934$ x 10-3V

Task 2 Utilize the same methodology we went through in the class and determine the sensible and latent load corresponding to internal gains, the ventilation, and the infiltration in a house with a *good* construction quality and with the same geometry as that of the example which is located in Brindisi, Italy.

From <https://github.com/bnajafi/TES_2019-2020_weeklySubmissions/tree/master/Week%209>

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)

Answer Task 2

Internal gains

1. Sensible cooling load from internal gains:
   $Q_{ig,s} = 136 + 2.2A_{cf} + 22N_{oc} = 136 + (2.2 * 200) + (22 *2) = 620$ W

2. Latent cooling load from internal gains:
   $Q_{ig,l} = 20 + 0.22A_{cf} + 12N_{oc} = 20 + (0.22 * 200) + (12 *2) = 88$ W

Infiltration

For a house with good construction quality, unit leakage area $A_{ul} = 1.4$ cm^2/m^2

∴ exposed surface $A_{es} = A_{wall} + A_{roof} = 200 + 144 = 344$ m^2

$A_L = A_{es} * A_{ul} = 344 * 1.4 = 481.6$ cm^2

- Heating and cooling rate

It is known: $T_{cooling} = 24^oC$
$T_{heating} = 20^oC$

Case in Brindisi:
$\Delta T_{cooling} = 31.1^oC - 24^oC = 7.1^oC = 7.1K$
$\Delta T_{heating} = 20^oC - (-4.1^oC) = 24.1^oC = 24.1K$

$DR = 7.1^oC = 7.1K$

- Infiltration airflow rate

$IDF_{heating} = 0.073$ $L/s*cm^2$
$IDF_{cooling} = 0.033$ $L/s*cm^2$

$Q_{i,heating} = A_L * IDF_{heating} = 481.6 * 0.073 = 35.1568$ L/s
$Q_{i,heating} = A_L * IDF_{cooling} = 481.6 *0.033 = 15.8928$ L/s

The required minimum whole building ventilation rate:
$Q_v = 0.05A_{cf} + 3.5(N_{br} + 1) = 0.05 * 200 + 3.5 * (1 + 1) = 17$ L/s

Thus

$Q_{i\text{-}v,\ heating} = Q_{i,\ heating} + Q_v = 35.1568 + 17 = 52.1568$ L/s

$Q_{i\text{-}v,\ cooling} = Q_{i,\ cooling} + Q_v = 15.8928 + 17 = 32.8928$ L/s

Using the given values:
$C_{sensible} = 1.23$
$C_{latent} = 2010$
$\Delta\omega_{cooling} = 0.0039$

$Q_{inf\text{-}ventilation\_cooling\_sensible} = C_{sensible} * Q_{i\text{-}v,cooling} * \Delta T_{cooling} = 1.23 * 32.893 * 7.1 = 287.2546$ W

$Q_{inf\text{-}ventilation\_cooling\_latent} = C_{sensible} * Q_{i\text{-}v,cooling} * \Delta\omega_{cooling} = 3010 * 32.893 * 0.0039 = 386.1309$ W

$Q_{inf\text{-}ventilation\_cooling\_sensible} = C_{sensible} * Q_{i\text{-}v,cooling} * \Delta T_{heating} = 1.23 * 52.157 * 24.1 = 1{,}546.09$ W