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DEW POINT CALCULATION IN CASE OF TWO PRESSURE HUMIDITY GENERATION AND ITS RELATIONSHIP WITH AIR TEMPERATURE AND OTHER VARIABLES

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Abstract

Dew point temperature is an important measure associated with relative humidity and temperature as it helps to make projections about condensation, formation of mist, rainfall ,etc. The present study aims to examine it relationship with various parameters such as chamber pressure, saturation pressure , temperature which determines the value of relative humidity in case of Two pressure Humidity generator.

Key words: *Dew point , Two Pressure humidity generator, Chamber pressure, Correlation*

Introduction

Dew point, as commonly known, is related to Relative humidity and temperature at constant pressure. Dew point temperature is a measure of humidity. If air is cooled eventually enough energy will be removed for water vapor to begin to condense. As we know that the water vapor is originally liquid water and to get it to evaporated we have to add energy. As long as it has sufficient energy it will remain vapor, but as we cool it at some point condensation will occur. The temperature where condensation begins is the dew point temperature. In terms of relative humidity, as the parcel of air is cooled, the relative humidity increases, when the relative humidity reaches 100%, the air parcel has cooled to the dew point temperature. Unlike relative humidity if dew point increases, it is only because the amount of moisture increases. If relative humidity changes it can be because of temperature changes or moisture changes, or both.

Objective of the study

The present study aims to calculate dew point with the help relative humidity generated using two pressure technique of humidity generation and thereafter examine its relationship with temperature and other factors determining its evaluation.

Experimental set up for the study

The model for generating relative humidity using two pressure, at National Physical Lab where the experiment was conducted, was connected with required devices and equipment for conducting the study. The gas is passed through regulators and flow control valve. Flowmeter has been used to monitor the flow rate. The gas was passed through a heat exchanger known as saturator. The saturation pressure Ps and saturation temperature Ts of the gas were measured at the point of final solution before gas leaves the heat exchanger. Then the gas passes through expansion devices where it was expanded to a lower pressure in desired test chamber. The final pressure Pc and temperature Tc of the gas were measured with the test chamber. From the test chamber the gas is exhausted to the atmosphere at an ambient pressure. For measuring pressure & temperature of the gas in the saturator and test chamber, precise pressure and temperature transduces were used. The humidity at chamber pressure ,when the temperature of the gas is held constant during pressure reduction, may then be approximated as the ratio of the two absolute pressure and the relationship is given in equation (1), below:

$\%R.H. = [\ [P_c/P_s] \times 100$ …… (1)

Where

P_c = the absolute pressure in the chamber

P_s = the absolute pressure in the saturator

Under the dynamic conditions where some slight temperature difference exist, the relative humidity formula for ideal gas may then be expressed in the form of equation (2)

$\%R.H. = [\ e_w(T_s)/\ e_w(T_C)] \times [P_c/P_s] \times 100$ …… (2)

Where

$e_w(T_s)$ = Saturation vapour pressure at saturation temperature Ts

$e_w(T_c)$ = Saturation vapour pressure at saturation temperature Tc

P_c = the absolute pressure in the chamber

P_s = the absolute pressure in the saturator

The schematic diagram of the experimental set up is shown in Figure 1.

SCHEMATIC DIAGRAM OF THE EXPERIMENTAL SET UP

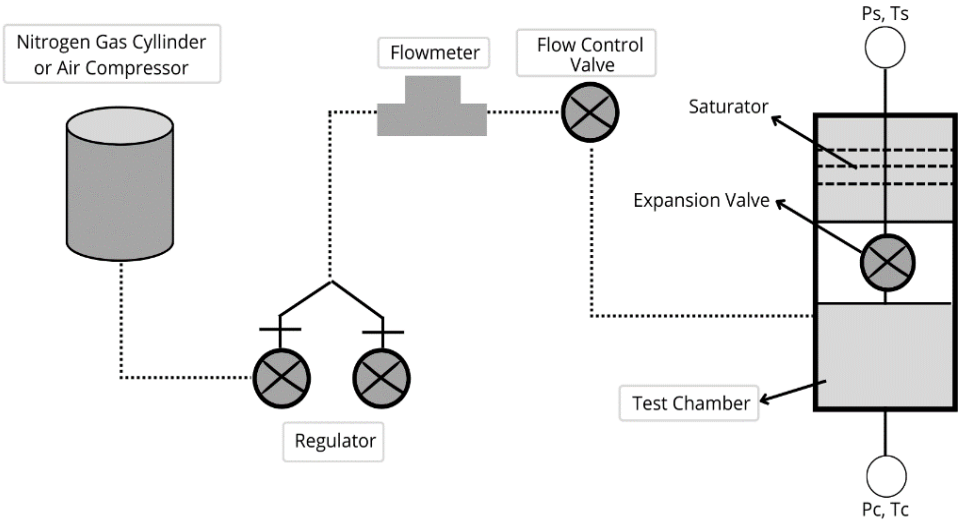

Figure 1

Dewpoint can be calculated with the help of Relative humidity and temperature

The steps for the same are given below

Step I Obtain the saturation vapor pressure (Es) when air temperature is known by using the following formula

Es=6.11*10.0**(7.5*Tc/(237.7+Tc))

Step II Use the saturation vapor pressure and the relative humidity to compute the actual vapor pressure (E) of the air. This can be done with the following formula.

$E = (RH \ X \ E_S)/100$

Where RH relative humidity of air expressed as a percent.

Now we can obtain the dewpoint temperature (T_dC) using the formula given below:

Dew Point temperature T_dC = (-430.22+237.7 x ln (E)) / (-In (E) +19.08)

Note:

Ln( ) means to take the natural log of the variable in the parentheses .

If we wish to convert the Celsius Dew point into the Fahrenheit scale, we can use the following formula:

$T_dF = (9.0/5.0) \ x \ T_dC + 32$

Observations and Readings

In the present study, dew point has been calculated at different level of pressure, temperature and relative humidity. The values are summarized in table 1.

S.No.	Time (in min)	Saturation Pressure (bar)	Chamber Pressure (bar)	Temperature (degree celcius)	Relative humidity (%)	DEW POINT
1	2	2.28	1.01	22.1	48.6	10.77
2	4	2.41	1.01	22.4	45.4	10.03
3	6	2.98	1.02	22.7	39	8.04
4	8	3.01	1.02	22.8	36.8	7.28
5	10	3.04	1.02	22.6	36	6.87
6	12	3.9	1.03	22.5	29.1	3.63
7	14	5.13	1.07	22.4	23.9	0.7727
8	16	1.62	0.99	23.6	62.7	16.07
9	18	1.53	0.99	24.2	66.5	17.57
10	20	1.56	0.99	24.3	67.2	17.83
11	22	1.44	0.97	24.5	68.3	18.28
12	24	1.42	0.97	24.4	71.1	18.82
13	26	1.36	0.99	24.2	74	19.27
14	28	1.32	0.99	24.1	75.1	19.41
15	30	1.29	0.99	24.1	75.4	19.48
16	32	1.38	0.98	24.1	75.6	19.52
17	34	1.7	1	24.2	61.5	16.33
18	36	1.73	1	24.2	56.4	14.98
19	38	1.75	1	24.2	55.8	14.82
20	40	2.28	1.01	22.9	45	10.34
21	42	2.35	1.01	23.1	40.9	9.1
22	44	2.41	1.01	23.1	40	8.77
23	46	2.34	0.99	22.1	50	11.2
24	48	4.01	1.01	22.1	25	1.15
25	50	6.48	1.05	21.8	16	-5.16
26	52	7.74	1.08	21.8	13.9	-7.02
27	54	8.4	1.1	21.8	13	-7.92
28	56	8.44	1.1	21.8	12.5	-7.47
29	58	9.17	1.12	21.8	11.6	-9.37
30	60	9.65	1.14	21.8	11	-10.05
	Correlation with Dew point	-0.961687242	-0.935637068	0.89410797	0.981034721	

Table 1 : Calculated value of Dew Point for different values of chamber pressure, saturated pressure, temperature and Relative humidity alongwith degree of correlation

In order to examine relationship between Dew point and each of its determining variable , its degree of correlation was calculated so as to find its behavior with respect to

change in value of the measuring variable. The relationship has also been exhibited with the help of figure 1 containing four charts shown below

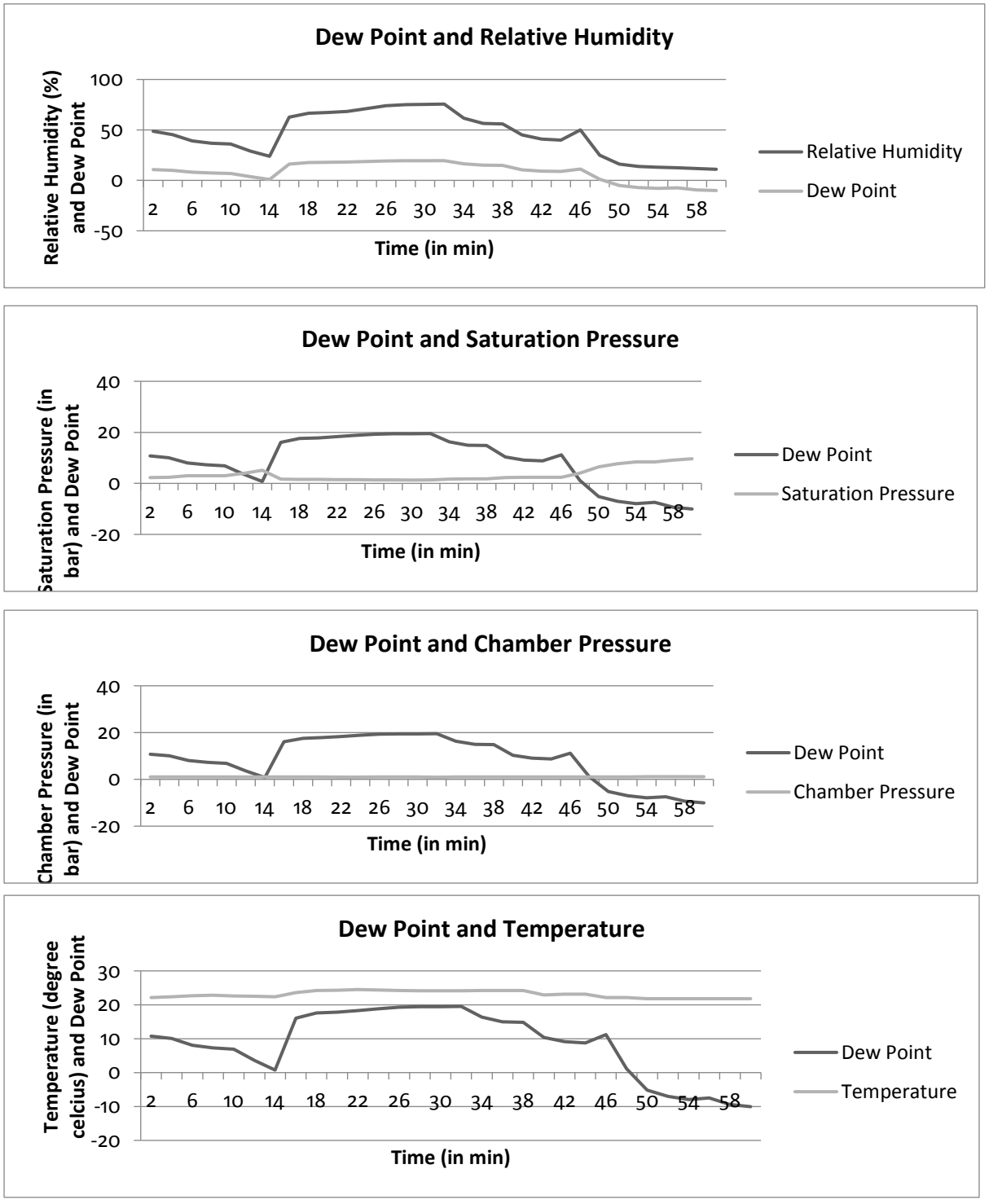

Figure 1 : Charts showing relationship between Dew Point and all its determining variables in the study.

Following observations were made:

1. There is positive correlation between Dew point and Temperature as well as Relative humidity, The degree of positive correlation was observed to be high in case of relative humidity than temperature. This implies as the air temperature will increase , dew point will also increase and similarly for relative humidity.
2. There is negative correlation between Dew point and both chamber as well as saturated pressure. As the pressure increases , dew point decreases.
3. The dew point has exhibited behavior with time also , initially it tend to increase but after 46 minutes, it fell down sharply because of gradual significant increase in saturation pressure as most of the other variables were changed insignificantly. Thus, saturation pressure has higher tendency of reducing dew point.
4. The movement of Relative humidity curve was observed in direct proportion to the movement of dew point curve.
5. Temperature was observed to have positive correlation with Dew point and had little impact when the saturated pressure was increase significantly.

The relationship between Relative Humidity and Dew Point at constant temperature was examined and the following values were observed (table 2)

S.No.	Temperature	Relative Humidity	Dew Point
1	24	45	11.3
2	24	50	12.9
3	24	55	14.4
4	24	60	15.7
5	24	65	17

Table 2: Variation of Dew Point with changes in Relative Humidity

At a given temperature, the dew point increases with the increase in relative humidity.

The relationship between temperature and Dew Point at constant relative humidity was examined and the following values were observed.(Table 3)

S.No.	Temperature	Relative Humidity	Dew Point
1	22	60	13.9
2	24	60	15.7
3	26	60	17.6
4	28	60	19.5
5	30	60	21.4

Table 3: Variation of Dew Point with changes in Temperature

It can be observed that for a given value of relative humidity , there is direct relationship between temperature and dew point so long other parameters are not significantly changed.

Conclusion of the study

In case of humidity generated using Two Pressure technique, Dew point is a function of four variables – temperature, relative humidity , saturated pressure and chamber pressure. Dew point is positively related to temperature but negatively related to saturated pressure (keeping other variables in almost constant range). For the given range to temperature, saturated pressure has tendency to reduced dew point to a negative level as well.

References

Chabane, F., Moummia, N. and Brima, A. (2018) Forecast of Relationship between a Relative Humidity and a Dew Point Temperature. Journal of Power Technologies, 98, 183-187

Gornicki, K., Winiczenko, R., Kaleta, A. and Choinska, A. (2017) Evaluation of Models for the Dew Point Temperature Determination: Technical Sciences, 20, 241-257. https://doi.org/10.31648/ts.5425

Lawrence, Mark. (2005). The Relationship between Relative Humidity and the Dewpoint Temperature in Moist Air: A Simple Conversion and Applications. Bulletin of the American Meteorological Society, v.86, 225-233 (2005). 86. 10.1175/BAMS-86-2-225.

Mohamed, Doaa & Mahmoud, Essam. (2016). NIS two-pressure humidity generator. International Journal of Metrology and Quality Engineering. 7. 303. 10.1051/ijmaqe/2016012.

R. E. Bentley, Temperature and Humidity Measurement, vol. 1, Springer, 1998.

Tawhida, A.Y. and Hisham, M.M.T. (2013) The Relationship between Relative Humidity and the Dew point Temperature in Khartoum State, Sudan. Journal of Applied and Industrial Sciences, 1, 20-23.