Testing Accuracy of Dry Bulb and Wet Bulb Thermometer in Measuring Humidity

Dr. Deepti Rani
Associate Professor, Department of Physics, MMH College, Ghaziabad (U.P.), India

Corresponding Author: deeptirani2008@gmail.com

ABSTRACT
Another component that impacts the working environment is humidity, which must be maintained at a specified level at various locations, such as factories, hospitals, and offices. Humidity levels play a significant role in determining different weather events, including the production of clouds and precipitation. It's impossible to make accurate predictions about the weather without accurate measurements of the humidity in the air. Humidity has a significant impact on our daily lives, not just for weather forecasting, but because it can alter the entire manufacturing process. Despite the fact that humidity is a constant in the environment, the amount needed at various locations may differ.

Keywords: humidity, web bulb, dry bulb, humidity generators

I.   INTRODUCTION

Several ways of measuring humidity have been developed from time to time but the accuracy to which each of the method is appropriate has always been issue of research. Humidity is one among several factors which affects the working environment besides its specific level is required at certain places such as industries, hospitals, offices, etc. The relevance of correct measure for humidity level also arises as it determines various whether phenomena such as formation of cloud, rains, etc. Without correct measure of humidity in atmosphere, it is not possible to forecast whether conditions. Not only for whether prediction, humidity holds significance importance in our daily life as humidity of can affect complete manufacturing processes. Though , humidity is always present in the environment but the level required at different places may be different. Therefore, various humidity generators and humidity measuring appliances have been devised from time to time. The present study deals with the testing of accuracy of measuring humidity with the help of Dry and Wet bulb thermometer as it is as widely accepted method of measuring humidity and involve low cost.

II.   WORKING OF DRY AND WET BULB THERMOMETER

Dry and Wet bulb thermometer consist two identical thermometers attached in a frame in such a manner that bulb of one thermometer can be soaked through wet cotton. When the cotton rapped around the bulb is soaked and thermometers are properly ventilated, the temperature shown by wet bulb thermometer will be lower than temperature shown by dry bulb thermometer due to cooling on account of evaporation of water from the cloth. The difference in temperature shown by two thermometers will be higher when more dry air is surrounding the environment. When the stream of dry (unsaturated) air is passed over a wet surface, water of wet surface tends to evaporate from surface of air which increases moisture content of air and air become more saturated. The driving force for evaporation is a partial pressure difference between dry (unsaturated) and wet surface .Due to evaporation of water, the temperature of surface decreases and sensible heat (heat supplied from evaporation water) is supplied from air to wet surface. Thus, for a given temperature, the difference in humidity level can result in difference in the temperatures recorded in the Dry and Wet bulb thermometer. For example, if the surrounding temperature is 25 degree centigrade but the air is dry i.e. humidity is low, the difference in the temperatures would be found higher than that in the situation when humidity is high.

III.   METHODOLOGY OF THE STUDY

In order to conduct the experiment, two identical thermometers were taken and fixed on the plastic frame. The bulb of one thermometer was kept open whereas the bulb of other thermometer was covered with cotton cloth which can be soaked

with water to make it wet. The thermometers were spinned for a minute in the ventilated room and air conditioned rooms and temperatures of both the thermometers were recorded. Ten set of reading were taken at different point of time on different days. Using the difference in temperature difference of dry and wet bulb thermometer, psychometric chart showing relationship between temperature difference and dry bulb temperature was referred to find the relative humidity at given situations. The relative humidity was also measured using hygrometer device available in market which can measure temperature as well as relative humidity. The relative humidity value derived using Dry and Wet Bulb thermometer was compared against reading shown by hygrometer in the same environment and accordingly accuracy of Dry and Wet bulb thermometer was examined.

IV.   OBSERVATIONS AND READING RECORDED

First set of ten reading were taken in the ventilated room at room temperature of approximately 37 ^{0} C. The dry and wet bulb thermometer was spinned for about one minute and then reading were recorded. The process was repeated ten times and accordingly ten sets of reading were generated as shown below in table 1.

Table 1: Day I observations at Room Temperature of 37 ^{0} C

S. No.	Dry Bulb Thermometer	Wet Bulb Thermometer	Difference In reading of dry bulb and wet bulb thermometer	Humidity Calculated using Psychometric Chart	Humidity observed (as per hygrometer)
1	38	29	9	46	48.2
2	37.5	28	9.5	46	48.1
3	37	28.5	8.5	58	48
4	38.5	27.5	11	46	48.5
5	37.4	27.4	10	46	48.2
6	37.6	27.6	10	46	48.7
7	38.2	27.4	10.8	46	48.1
8	37.4	27.8	9.6	46	48.6
9	37.7	27.6	10.1	46	48.5
10	38	27.4	10.6	46	48
Average	37.73	27.82	9.91	47.2	48.2
Standard Deviation	0.44484704	0.53913511	0.788035532	3.794733192	0.260128174

Another set of observations were taken in the air conditioned room with temperature set at 25^0 C. The observations and calculated value of humidity alongwith observed humidiy is given below table 2.

Table 2: Day I observations at Air conditioned Room Temperature of 25 ^{0}C

S. No.	Dry Bulb Thermometer	Wet Bulb Thermometer	Difference In reading of dry bulb and wet bulb thermometer	Humidity Calculated using Psychometric Chart	Humidity observed (as per hygrometer)
1	24.8	21	3.8	70	72
2	26	21.2	4.8	66	70
3	25.8	21.3	4.5	66	71
4	25	21.1	3.9	70	72
5	25.3	21.3	4	70	70
6	26	21.4	4.6	66	71
7	24.8	21	3.8	70	71
8	25.1	21.1	4	70	71
9	25	21.3	3.7	70	72
10	24.9	21.5	3.4	73	72
Average	25.27	21.22	4.05	69.1	71.2
Standard Deviation	0.483160889	0.168654809	0.442844342	2.330951165	0.788810638

The process was repeater on the day when humidity was better in the external environment. The set of observations for Day 2 in an open ventilated room is given below in table 3.

Table 3: Day 2 observations at Room Temperature of 36 ^{0}C

S. No.	Dry Bulb Thermometer	Wet Bulb Thermometer	Difference In reading of dry bulb and wet bulb thermometer	Humidity Calculated using Psychometric Chart	Humidity observed (as per hygrometer)
1	36.4	31.2	5.2	69	72
2	35.3	30.4	4.9	69	72.5
3	36.2	31.3	4.9	69	72.4
4	35.6	30.6	5	69	72.5
5	36.3	31.1	5.2	69	72.2
6	35.3	30.2	5.1	69	72.3
7	35.6	30.6	5	69	72.5
8	35.7	30.6	5.1	69	72.4
9	35.9	30.6	5.3	72	72.6
10	36.2	30.9	5.3	72	72.4
Average	35.85	30.75	5.1	69.6	72.38
Standard Deviation	0.408928138	0.359783886	0.149071198	1.264911064	0.175119007

Another set of observations were taken in the air conditioned room with temperature set at 23^0 C. The observations and calculated value of humidity alongwith observed humidiy is given below table 4.

Table 4: Day 2 observations at Air Conditioned Room Temperature of 23 ^{0}C

S. No.	Dry Bulb Thermometer	Wet Bulb Thermometer	Difference In reading of dry bulb and wet bulb thermometer	Humidity Calculated using Psychometric Chart	Humidity observed (as per hygrometer)
1	23.2	20.1	3.1	76	78.4
2	22.8	20.4	2.4	80	78.3
3	22.8	20.2	2.6	80	78.4
4	22.7	20.2	2.5	80	78.6
5	22.8	20.3	2.5	80	78.6
6	22.9	20.1	2.8	76	78.2
7	23.5	20.4	3.1	76	78.4
8	22.9	20.1	2.8	76	78.6
9	22.8	20.1	2.7	80	78.2
10	23.1	20.3	2.8	76	78.6
Average	22.95	20.22	2.73	78	79
Standard Deviation	0.246080384	0.122927259	0.240601099	2.108185107	0.163639169

The difference in the calculated value of Humidity using Dry and Wet Bulb thermometer and observed value of humidity using Hygrometer were calculated by subtracting calculated value from the observed value and they have been summarized in table 5.

Table 5: Differences in Calculated value and Observed value of Humidity

Calculated Value of Humidity	Observed value of Humidity	Diff.	Calculated Value of Humidity	Observed value of Humidity	Diff.	Calculated Value of Humidity	Observed value of Humidity	Diff.	Calculated Value of Humidity	Observed value of Humidity	Diff.
46	48.2	2.2	70	72	2	69	72	3	76	78.4	2.4
46	48.1	2.1	66	70	4	69	72.5	3.5	80	78.3	-1.7
58	48	-10	66	71	5	69	72.4	3.4	80	78.4	-1.6
46	48.5	2.5	70	72	2	69	72.5	3.5	80	78.6	-1.4
46	48.2	2.2	70	70	0	69	72.2	3.2	80	78.6	-1.4
46	48.7	2.7	66	71	5	69	72.3	3.3	76	78.2	2.2
46	48.1	2.1	70	71	1	69	72.5	3.5	76	78.4	2.4
46	48.6	2.6	70	71	1	69	72.4	3.4	76	78.6	2.6
46	48.5	2.5	70	72	2	72	72.6	0.6	80	78.2	-1.8
46	48	2	73	72	-1	72	72.4	0.4	76	78.6	2.6

It can be observed that in most of the cases the difference is positive which shows that humidity observed by hygrometer is higher than humidity calculated using Dry and wet bulb thermometer.

V.   RESULT ANALYSIS

In order to analyse the result, the average value of humidity calculated using dry and wet bulb thermometer and observed value of humidity with the help of hygrometer alongwith their standard deviation is summarized below in table 6

Table 6: Summary of average and standard deviation in calculated and observed value of humidity

State of environment	Statisical value	Calculated Humidity	Observed Humidity
Day I observations at Room Temperature of 37 ^{0}C	Average	47.2	48.2
	Std dev	3.79	0.26
Day I observations at Air conditioned Room Temperature of 25 ^{0}C	Average	69.1	71.2
	Std dev	2.33	0.78
Day 2 observations at Room Temperature of 36 ^{0}C	Average	69.6	72.3
	Std dev	1.26	0.17
Day 2 observations at Air conditioned Room Temperature of 23 ^{0}C	Average	78	79
	Std dev	2.1	0.16

It can be observed from table 6 , the standard deviation in all cases of calculated value of humidity using dry and wet bulb is higher than standard deviation of observed value of humidity which shows that accuracy of humidity calculated using dry and wet bulb is subject to error to the extent of +/- 3.79 to +/-1.26 of its mean value whereas the observed value has standard deviation in the range of +/-0.78 to +/-0.16. Further, the average value of humidity observed by hygrometer is higher than average value of humidity calculated using dry and wet bulb thermometer. The less accuracy of dry and bulb thermometer can be attributed to improper soaking of cotton cloth at the bulb of wet thermometer and therefore improper evaporation which finally leads to incorrect display of temperature in the thermometer. Moreover, the psychometric chart contains values at specific intervals/range as a result of which in most of the cases the humidity has been calculated after rounding of the numbers or using approximate values.

VI.   CONCLUSION

The Dry and Wet bulb thermometer method of humidity measurement was found to be fairly accurate and can be used assuming an error in the of range of +/- 3% . The method need to be applied with caution of proper soaking the cotton rapped at the bulb of wet thermometer and spinning both the thermometer simultaneously in the air for adequate time so as to have correct difference in the temperatures of the two thermometers.

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