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Natural Humidity Maintaining System

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***Abstract*—Desiccant humidity control has given increasing interest in the various industries like storage industry, textile industry and air conditioning industry. Compared with conventional system desiccant humidity control system saves energy by separating humidity control from temperature control and also improves the indoor air quality as a good filter. As the first step, the adsorption mechanism is explored and desiccant material properties are obtained based on a literature review. The heat and mass transfer in the desiccant moist air system is well understood and modeled. The model provides a useful tool for two purposes; analysis of desiccant unit's performances and optimization of the design and operations of a unit. A temperature maintained strategy is proposed to improve the mass transfer efficiency. A design in which the desiccant properties are tested using the model developed before. Using the model, parametric analysis is conducted on the humidity control packed bed desiccant unit. The effect on humidity performances of processing air and thermal cycles are studied.n Three criteria are put forward to evaluate the performances of a desiccant humidity system for various applications; dry bulb temperature; wet bulb temperature and relative humidity. The systematic way is proposed to size a desiccant unit and optimize its operations. This desiccant humidity maintaining system is designed for humidity analysis and to avoid spoiling.**

***Index Terms*— Dry-and-wet bulb temperature, Dry-and-wet bulb equations, Relative humidity.**

I. INTRODUCTION

Humidity maintaining system adds or removes water vapour from indoor air to stay within proper range. Desiccant humidity control system has been increasing interest in various industries.

Desiccants are materials that upon contact with moist air at moderate temperatures exhibit a great affinity for water vapor. There are two main groups of desiccants: solids and liquids. Solid desiccants are porous materials. The water vapor molecules condense and adhere to the surface of the pores. This surface effect is called physical adsorption. Liquid desiccants incorporate the condensed water vapor molecules into their bulk. This volumetric effect is physical absorption. The term sorption has been adopted to describe both processes. Internal energy is released during the sorption process. Consequently, warm and humid air passing through desiccants becomes hot and dry.

Desiccants continue to absorb moisture as their sorption ability gradually decreases . At some point,

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desiccants become saturated to the degree required in a particular process and sorption ceases. Hot air must be brought into contact with desiccants to regenerate them. In regeneration, the moisture is transported from desiccants to regeneration air. When desiccants get dry enough, the process is switched back to dehumidification and another operation cycle starts.

Usually, the heat transfer rate between the desiccants-moist air system and the outside environment is small and can be ignored. Compared with conventional humidity control systems, desiccant humidity control system has at least two advantages.

First, desiccant humidity control system separates humidity control and temperature control. In conventional air conditioning systems, air has to be cooled to dew point to remove moisture. In some cases such as supermarkets, humid air is overcooled to achieve low humidity, which degrades the energy efficiency. Desiccant dehumidification has nothing to do with dew point. It can absorb moisture at almost any humidity level. Second, desiccants have been found to act as a good filter for contaminants [2]. In addition to removing particulate contaminants, desiccants condense vapor contaminants out of the air. Desiccants are effective in removing carbon monoxide, nitrogen dioxide and sulfur dioxide. Also, the problems, like mold, caused by using water in conventional systems do not occur in desiccant humidity control system. So, desiccant systems have a good potential to improve the indoor air quality.

II. Experimental Details

A. Selecting desiccant

Desiccant is an adsorbent (not an absorbent), that is, it attracts water vapour molecules, which adhere to its surface. Since most desiccants can hold up to a maximum 35% of their weight in moisture before losing their effectiveness, they must trap the moisture while it is still in a water vapour form, before it can condense (become liquid) and cause damage.

Some of the more common desiccants are:

(A) Silica Gel: which can be supplied in bags, bulk or desiccators is used to moderate to high humidity and/or moderate temperature (less than 125°F/52°C) environments.

(B) Molecular Sieve: crystalline metal alumina silicate, is also available in bags, bulk or desiccators. Used to create very dry environments or in high temperature (up to 400°F/204°C) applications. Available with different microscopic pore sizes, the most common being 4Å (4 angstroms).

(C) Activated Alumina: available in bulk for high moisture adsorption in high humidity environments. It is an inefficient absorber in 40% or less relative humidity (RH) environments.

(D) Montmorillonite Clay: commonly known asbentonite, normally supplied in packets, canister sand bags holding anywhere from a fraction of announce up to 5.8lbs. (80units) of desiccants. Used in moderate to high humidity and/or moderate temperature environments. It is inexpensive and used for general packaging requirements. It is not suitable for bulk desiccants applications because of its tendency to pack and restrict air flow.

B. Selection of material

Aluminum, is chemical elements in the boron group with symbol Al and atomic number 13. It is a silvery white, soft, nonmagnetic, ductile metal. Aluminum is the third most abundant element the Earth's crust. Aluminum makes up about 8% of the crust by mass. Aluminum is remarkable for the metal's low density and its ability to resist corrosion through the phenomenon of passivation.

C. Fabrication

Aluminum vessels are used to make the different chambers. Each chamber consists for specific purpose and thermodynamic cycles. The centre chamber is humidity control chamber, where required humidity range is obtained. Other chambers are fabricated for air treatment and conduction purpose.

In first chamber, silica gel is filled for air treatment, which is perforated and allows the air to pass through silica gel. This chamber filter the air, removes air contaminants and pass to next chamber.

In second chamber, conduction takes place between filtered and dry air and air inside the chamber.

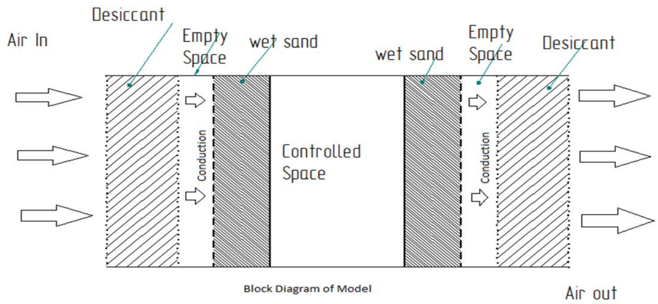

Figure 1: Block diagram of model

TABLE I: SPECIFICATION OF THE MODEL

Vessels	Height (cm)	Diameter(cm)	Thickness(cm)
1	15.5	15	0.2
2	15.5	13.5	0.2
3	14	12.5	0.2
4	11	8	0.2

Figure 2: the 2nd chamber is placed inside the air treatment chamber.

Figure 3: A view from the top.

Figure 4: The vessel carrying the food item that needs to be protected from moisture is kept inside the chamber.

Figure 5: the air treatment chamber is closed using a lid.

III. RESULTS AND DISCUSSIONS

A. Abbreviations and Acronyms

- DBT, dry bulb temperature, which is surrounding temperature.
- WBT, wet bulb temperature, temperature which is measured by putting wet cotton over mercury part of thermometer.
- H_r, Relative humidity, it indicates percentage of humidity in the air.

B. Units

- SI unit meter (M), meter is used to measure the dimensions of model such as diameter, length, thickness, and depth.
- SI unit degree Celsius℃, which is used to measure temperature outside and inside temperature.
- Mill bar, mb, which is used to measure the atmospheric pressure, 1013.2502mb.

C. Equations

The principle of psychometric hygrometry is that the humidity is calculated by the dry-and-wet bulb equation according to dry-bulb and wet-bulb temperatures. The dry-and-wet bulb equation is:

$$H_r = \frac{e_w - A \times P \times \Delta t}{e_d} \times 100 \qquad (1)$$

where,

H_r= The relative humidity.

e_w= The saturation vapor pressure in the wet bulb temp.

e_d = The saturation vapor pressure in the dry bulb temp.

A= The measuring humidity coefficient.

P= The mean atmospheric pressure.

Δt= The difference between the dry bulb temperature and wet bulb temperature.

According to formula (1), we can note that: The keys to getting relative humidity are e_w, e_d and A. In this study, we use the Buck formula (Buck, 1981) to calculate e_w and e_d. Compared with the saturation vapor pressure formula which is proposed by Coff in 1965, the Buck formula is simpler and easier.

The Buck formula is as follows:

$$E=6.112\times e^{\frac{17.502\times t}{240.97+t}} \qquad (2)$$

According to formula (2), we can get e_w and e_d.

They are:

$$e_w = 6.112 \times e^{\frac{17.502\times T_w}{240.97+T_w}} \qquad (3)$$

$$e_d = 6.112 \times e^{\frac{17.502\times T_d}{240.97+T_d}} \qquad (4)$$

A is the conversion factor which can be calculated by

Empirical formula:

$$A = 0.00066 \times (1 + 0.00115 \times T_w) \qquad (5)$$

TABLE II: THE OBSERVATIONS AFTER TAKING TRIALS AT 4 DIFFERENT TIMES BETWEEN 12-6PM. DAY 1

Serial no (time)	DBT (℃)	WBT (℃)	RH of outside (%)	RH of inside chamber (%)
1(12:00pm)	35	23	35	-
2(12:15pm)	33	29.5	-	77.12
3(4:00pm)	36	23.5	34.25	-
4(6:00pm)	29	25	-	72.20

TABLE III: THE OBSERVATION AFTER TAKING TRIALS AT 4 DIFFERENT TIMES BETWEEN 11AM-4PM. DAY 2

Serial no (time)	DBT (℃)	WBT (℃)	RH of outside (%)	RH of inside chamber (%)
1(11:00am)	32	21	36.43	-
2(11:30am)	29	25	-	72.18
3(2:00pm)	33	21	34.55	-
4(4:00pm)	30	25.5	-	70

III. CONCLUSION

From the project work undertaken, it can be concluded that, this study tries to measure the humidity based on the dry-bulb and wet bulb temperatures. And a theoretical formula is deduced for the calculation of relative humidity from dry-bulb and wet-bulb temperatures on the basis of accurately determining the empirical formulas of measuring humidity coefficient and saturation vapor pressure. A method is proposed to maintain humidity by combining the layers of thermodynamic process, which is suitable for rapid control of humidity. Experimental data shows that, the proposed method is not only simple and fast but also has high veracity. And its relative error is less than 4%. Therefore, the proposed method has certain value for humidity control in industrial control process.

REFERENCES

[1] Buck, A.L., 1981. New Equations For Computing Vapor Pressure And Enhancement Factor. J. Appl. Meteorol., 20(12): 1527-1532.

[2] Butler, C.J. And García-Suárez, 2012. Relative Humidity At Armagh Observatory 1838-2008. Int. J. Climatol., 32(2012): 657-668.

[3] Jun, L., 2008. Research Of The Theory And Factors Of Humidity Measuring In Damp Bulb Method. China Metrol., 10(2008): 80-81, (In Chinese).

[4] K.C. Ng, H.T. Chua, C.Y. Chung, C.H. Loke, T. Kashiwagi, A. Akisawa, B.B. Shaha., " Experimental Investigation Of The Silica Gel-Water

[5] Adsorption Isotherm Characteristics", Applied Thermal Engineering , Vol. 21, Pp. 1631-1642, 2001.

[6] K. Daou, R.Z. Wang, Z.Z. Xia," Desiccant Cooling Air Conditioning: A Review", Renewable And Sustainable Energy Review, Vol. 10, Pp. 55-77,

[7] 2006.

[8] Environmental Standards Committee Working Group, 1986. GB6999-1986, Relative Humidity Tables For Environmental Test, General Administration Of Quality Supervision. Inspection And Quarantine Of The People's Republic Of China.

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