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A Paper on Experimental Investigation of Forced Convection Desiccant Integrated Phase Change Material Regenerated Dryer

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Abstract— There are hot and humid environment present in many parts of India. It is necessary to produce the dry air for such environment. Beside refrigeration, vapour compression system is also used to produce dry air but it leads to the environmental issues. For many domestic and industrial purposes, dry air is produced by using solid desiccants like silica gel, activated alumina and activated charcoal. These methods have low operating and maintenance cost and also these methods are environment friendly. For using these desiccants again, we have to regenerate them. In this review paper the methods have been studied to regenerate the desiccants for further use.
[10pt Bold, Italic]

Keywords— Desiccant; Dry air; Regeneration; Forced convection; Silica gel; Humidity

I. INTRODUCTION

For many industrial and domestic purposes, dry air is produced by using solid desiccants. These desiccants can be used once or more. For using these desiccants again, these should be regenerated. Regeneration can be done by using conventional method such as heater and vapour compression system. But these methods consume high grade energy and also lead to the environmental issue. The regeneration of desiccants can also be done using low grade energy such as solar energy [1-5] which will help in producing the dry air. Dry air plays a vital role for improving the product, process or condition in many industries such as pharmaceutical production, chemical industries, food production [6-7]. Dry air is also required in hygroscopic raw material storage, packaging equipment rooms, organic plant dehydration and inorganic products.

Humidity control plays a vital role for drying of any food article. Humidity control is also related with the growth of bacteria and fungi which causes spoilage of product and affect the health of living being. The simple and effective way of producing the dry air is by using chemical dehumidification process using solid desiccants. These desiccants attract moisture due to difference in vapour pressure without undergoing any change in their physical and chemical composition. The amount of vapour absorbed is directly proportional to the surface area of the desiccants [8]. After some time desiccants is saturated. For the reuse of desiccants it must be regenerated. The saturated desiccants can be regenerated by passing hot air through it. Various solid desiccants can be used such as silica gel, zeolite, activated charcoal and activated alumina [9].

II. CHEMICAL DEHUMIDIFICATION PROCESS

It is the process in which the air is passed over chemicals which have an affinity for moisture. As the air comes in contact with these chemicals, the moisture gets condensed out of air and gives up its latent heat. Because of condensation, the specific humidity decreases and the heat of condensation supplies sensible heat for heating the air and thus dry bulb temperature is increased. The path followed during this process is along the constant enthalpy line or constant wet bulb temperature line [10]. Two types of chemicals used for dehumidification are absorbents and adsorbents [10]. The absorbents are substances which can take up moisture from air and during process change it chemically, physically or in both respects. These include water solutions or brines of calcium chloride, lithium chloride, lithium bromide and ethylene glycol. These are used as air dehydrators by spraying or otherwise exposing a large surface of solution in the air stream. The adsorbents are substances in solid state which can take up moisture from the air and during the process do not change it chemically or physically. These include silica gel (which is a form of silicon dioxide prepared by mixing fused sodium silicate and sulphuric acid) and activated alumina (which is a porous amorphous form of aluminum oxide).

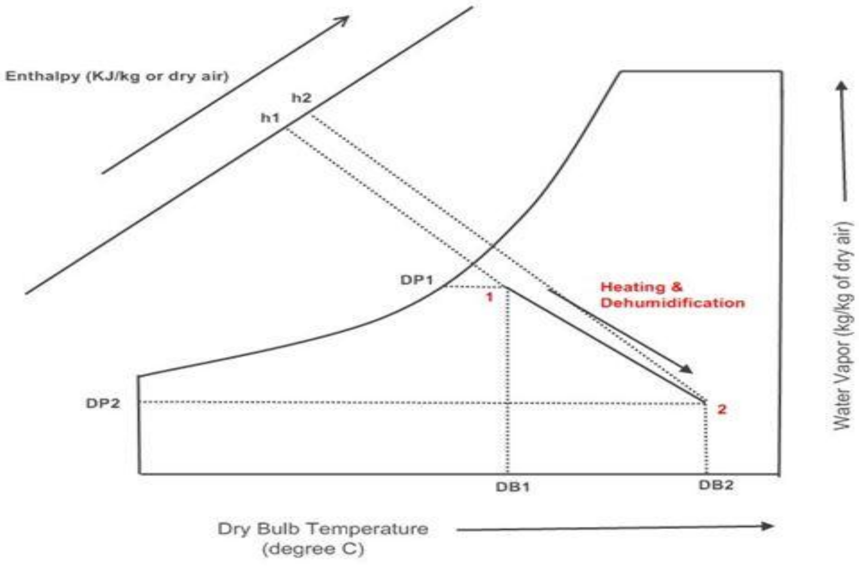

Fig. 1 Chemical Dehumidification Process

II. REGENERATION OF SOLID DESICCANTS

In chemical dehumidification process air passes through desiccants and it will humidify the solid desiccants. After some time desiccants will get saturated. Due to saturation, the color of desiccants changes; for example in case of silica gel, its color changes from dark blue to purplish pink after saturation. For reuse of desiccants it must be regenerated or reactivated. This can be done by driving of the moisture from desiccant. For this process source of energy is required. This source can be electricity, waste heat, natural energy or solar energy. Regeneration of the solid desiccants have been done by different researcher in the following manner Dunkle(1965) presented the alternative method where regeneration of desiccants was done by using solar energy. Mohammed M. Farid , Amar M. Khudhair, Siddique Ali K. Razack, Said Al-Hallaj(2003) studied on phase change energy storage: materials and applications[12]. Latent heat storage is one of the most efficient ways of storing thermal energy. Unlike the sensible heat storage method, the latent heat storage method provides much higher storage density, with a smaller temperature difference between storing and releasing heat. This paper reviews previous work on latent heat storage and provides an insight to recent efforts to develop new classes of phase change materials (PCMs) for use in energy storage. Three aspects have been the focus of this review: PCM materials, encapsulation and applications. There are large numbers of phase change materials that melt and solidify at a wide range of temperatures, making them attractive in a number of applications. Paraffin waxes are cheap and have moderate thermal energy storage density but low thermal conductivity and, hence, require large surface area. Hydrated salts have larger energy storage density and higher thermal conductivity but experience super cooling and phase segregation, and hence, their application requires the use of some nucleating and thickening agents. The main advantages of PCM encapsulation are providing large heat transfer area, reduction of the PCMs reactivity towards the outside environment and controlling the changes in volume of the storage materials as phase change occurs. The different applications in which the phase change method of heat storage can be applied are also reviewed in this paper. Kodama et al.(2005) carried out experiments on desiccant cooling process where regeneration was done at low temperature i.e. 60 degree centigrade and heat was obtained from low grade energy such as waste heat or solar heat. Various solid desiccants like silica gel, activated alumina, activated charcoal and zeolite can be regenerated at low temperature by using solar energy which can be easily collected by simple flat plate and evacuated tube solar air collector.[13] V.Shanmugam, E.Natarajan(2005) have done experimental investigation of forced convection and desiccant integrated solar dryer[14].An indirect forced convection and desiccant integrated solar dryer was designed and fabricated to investigate its performance under hot and humid environment of Chennai, India. The system consists of a flat plate solar air collector, drying chamber and a desiccant unit. The system pickup efficiency, specific moisture extraction rate, dimensionless mass loss, mass shrinkage ratio and drying rate were discussed in this paper. Wisut Chramsa-ard , Sirinuch Jindaruksa , Chatchai Sirisumpunwong , and Sorawit Sonsaree(2012) studied performance of desiccant bed solar dryer[15].Desiccant bed solar dryer is a solar dryer that has dehumidification system used for decreasing drying air humidity by installing silica gel beds (SGB) for continuously drying process. Each SGB has width of 0.55 m, length of 0.95 m. and thickness of 0.01 m. The collector area was 2.5 m2 with 17 degree tilted angles. From the experiments we can conclude that the top SGB has highest adsorption rate, average 0.073 kg water/hr, the west SGB has lower adsorption rate, average 0.062 kg water/hr, and the east SGB has lowest adsorption rate, average 0.032 kg water/hr. The parameters that effects to adsorption rate are air temperature and humidity ratio of humid air. The results shows that with-load test, the conditions that suitable for drying chili are 0.08 kg/s mass flow rate and 60 degree centigrade drying temperature, drying chili 8 kg from initial moisture content 82% wb to final moisture content 13% wb. The experiments were carried out by continuously operated and divided into two parts, with-dehumidification system and without-dehumidification system. The drying time of with dehumidification system is shorter than without-dehumidification system by 20.83 %. Avadhesh Yadav and V. K. Bajpai (2012) compared various solid desiccants for regeneration by evacuated solar air collector and air dehumidification[14].The air needed for a regeneration was heated in an evacuated tube solar collector with a surface area of 4.44 m2. The desiccants were regenerated at temperature in the range of 54.3-68.3 degree centigrade.

Fig. 2 Silica gel before regeneration

Fig. 3 Silica gel after saturation

Fig. 4 Silica gel after regeneration

II. CONCLUSIONS

Following conclusion can be determined from the previous research; Latent heat storage is one of the most efficient ways of storing thermal energy hence it is quite useful method for regenerating the desiccants. Unlike the sensible heat storage method, the latent heat storage method provide much higher storage density, with a smaller temperature difference between storing and releasing heat. The integration of desiccant unit with solar drying continues the drying product in the off-sunshine hours and improves the quality of drying product. The structural integrity and the characteristics of the desiccant have been found to be stable even after a long time. It is found from the study, in the climate of India silica gel is the best desiccant for adsorption. The drying with regeneration of desiccants is quite reduced.

REFERENCES

[1] Saito Y. Regeneration of adsorbent in the integrate desiccant/ collector. J Sol Engg. 1993; 115:169–75.
[2] Techajunta S, Chirarattananon S, Exell RHB. Experiments in a solar simulator on solid desiccant regeneration and air dehumidification for air conditioning in a tropical humid climate. Renew Energy ,1999;17:549–68.
[3] Techajunta S. A study of solar regenerated solid desiccant for air conditioning In a tropical humid climate, Dissertation No.ET-99-2, Asian Institute of Technology, Pathumthanee, Thailand, 1999.
[4] Singh S, Singh PP. Regeneration of silica gel in multi-shelf regenerator. Renew Energy, 1998;13(1):105–19.
[5] Pawar RS, Takwale MG, Bhide VG. Solar drying of custard powder.Energy Conversion Management, 1995; 36:1085– 96.
[6] Garg HP, Sharma VK, Mahajan RB, Bhargave AK. Experimental study of an inexpensive solar collector cum storage system for agricultural uses. Solar Energy, 1985;35:321–31.
[7] Niles PW, Carnegie EG, Pohl JG, Cherne JM. Design and performance of an air collector for industrial crop dehydration. Solar Energy, 1978;20:19–23.
[8] George W.Scherer, Effect of drying properties of silica gel, 1997.
[9] Avadhesh Yadav and V.K.Bajpai, Experimental comparision of various solid desiccants for regeneration by evacuated solar air collector and air dehumidification, 2012.
[10] V. Shanmugam and E. Natrajan, Experimental investigation of forced convection and desiccant integrated solar dryer, 2005.
[11] Mohammed M. Farid , Amar M. Khudhair, Siddique Ali K. Razack, Said Al-Hallaj, Phase change energy storage: materials and applications, 2003.
[12] Kodama,A;Ohkura,M.;Hirose,t.;Goto,M.;Okano,H. Experimental study on process design for adsorption desiccant cooling driven with a low temperature heat, 2005.
[13] Wisut Chramsa-ard , Sirinuch Jindaruksa , Chatchai Sirisumpunwong , and Sorawit Sonsaree ,Performance of desiccant bed solar dryer, 2012.
[14] Air research manufacturing company of California. Developement of solar desiccant humidifier,technical press report no. 78-14957-1;Air research manufacturing company of California;Los Angeles,CA , 1978.
[15] Garg HP, Prakash J. Solar energy fundamentals and applications. 1st ed. New Delhi: Tata McGraw-Hill, 2000.
[16] ASHRAE. 2009 A Fundamental Handbook. (404) 636-8400.

