DESICCANT EVAPORATIVE COOLING SYSTEM

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***ABSTRACT*: Desiccant evaporative cooling basically absorb the latent heat in the air i.e. reduces the humidity of the air. This property of desiccants is due to its low vapor pressure. In cooling systems a solid desiccant or a liquid desiccant solution can be used to assist in the cooling process. Desiccant has a property of regeneration so it can be recirculated and reused. In this cooling system we use liquid CO2/dry ice to achieve the sensible heat reduction while using silica gel (desiccant) to absorb moisture and decrease latent heat.**

INTRODUCTION

Desiccant cooling systems process water vapor in the earth's atmosphere to produce cooling. Since mass transfer occur between the system and its environment they are referred to as open-cycle system. These systems all use a liquid solution or solid material called a desiccant to remove water vapor from the air.The process by which moisture is removed is most often adsorption on solid desiccant and absorption in liquid desiccant.

Desiccant systems are presently used in industrial air drying applications. The solid desiccant silica gel is impregnated in the wheel material or encapsulated as a packed bed. Air to be tried flows through one side of the wheel while the desiccant on the other side of the wheel is being dried by an extremely heated air stream. This air stream must be kept physically separated in order to maintain the distinctly separate function.

Selecting high performance desiccant materials is of the pivotal factors in the design of desiccant air conditioning unit. Mesoporous silica plays a powerful candidate for the system due to its unique characteristics of quick adsorption and with a specific range of humidity enhancing the operation speed and its high water storage capacity.

In the last 10 years desiccant and evaporative cooling technology for air conditioning systems has increased as alternative to the conventional vapor compression system(VCR). Typical systems combine a dehumidification that uses a rotary desiccant wheel with direct and indirect evaporative systems, allowing filtered and cool air supplying temperature, humidity and speed condition that propitiate environmental thermal comfort, even in equatorial and tropical climate.

Advantages and Disadvantages

Advantages	Disadvantages
Improved air quality in interiors	High initial setup of the system
Less electricity consumption as alternative sources can be used	Experienced professionals are required to construct, install and service such systems
CFC, HFC, HCFC refrigerants are not used. Hence these systems are environment friendly	Liquid desiccants could be corrosive and damage the system components
Integration with conventional systems to remove latent heat load can reduce energy consumption	Cost effective only when there is a source of waste heat available to regenerate desiccant
Low operating cost	Limited application in high humidity climate areas.
Desiccants are commercially available and inexpensive	System effectiveness depends on a large extent on the desiccant properties.

LITERATUTE REVIEW

- The Solar Energy Research Institute (SERI) published a paper titled "An overview of open-cycle desiccant cooling system and materials" in September 1981. In this paper submitted by R. Collier, F. Arnold, R. Barlow a detailed analysis was made on the desiccant systems, historical and contemporary research on such systems. A detailed thermodynamic analysis was also carried and adsorption and absorption isotherms and isobars were plotted for different desiccant materials and their properties and feasibility for use in commercial systems as well as for domestic use discussed.

- The International Journal of Low Carbon Technologies published a paper in 2015 titled "Desiccant Cooling Systems: A review". The paper was published by MinaalSahlot and Saffa B. Riffat. They conducted in-depth analysis of different types of desiccant cooling systems, different desiccants, hybrid desiccant systems, their advantages over conventional VCR's. The commercial feasibility of such systems was also studied. Various case studies were done to collect data about COP, cost and energy consumption. The future improvements required and present system drawbacks were discussed. The use of desiccant cooling systems in industry as well as domestic appliances can result in a considerable reduction in total power consumption. These systems are sometimes most effective when coupled with a VCS which increases cooling effectiveness. While overall power consumption may increase the increase in cooling capacity offsets the increased cost.

- Desiccant system built and tested by Lof in 1955 at Solar Energy Research Institute, University of Wisconsin. It used liquid triethylene glycol air heated directly in a solar collector to generate the desiccant. The disadvantage of this system was the leakage of desiccant into the cooling space. When desiccants with corrosive nature were used it prove hazardous to the men and material near it. Also such difficulties render it totally unusable in domestic appliances.

- A glycol system was reported to have been built by Johannsen. It generates the weak solution in the solar collector. The solution flows as a liquid film in contact with the absorbing surface. The heated solution then releases the heat to the atmosphere. The comparative advantages of solar regenerative system over conventional desiccant systems were analysed.

EXPERIMENTAL ANALYSIS

Performance Index

The efficientworking of a desiccant cooling system depends on the performance of its constituting component, the calculation procedureforthedeterminationofeffectiveness of rotary heat exchanger, and direct evaporative cooler. The systemperformance depends on theperformanceofindividualcomponents. A discussion of determining important component relationsofindividualcomponentsisgivenhere.

Coefficient of performance(COP) :

The proposed COP is calculated from ,

COP = m(h1-h2)

Where,

m = mass flow rate of air,

h = Enthalpy of air,

W = Compressor's power consumption,

Q = Auxiliary regeneration heat rate which can be calculated by

Q =m1(h3-h4)

Where,

m1= Mass flow rate of desiccant solution and

h3 and h4 can be obtained by hs=CpT

Specific moisture removal:

It is defined as the amount of moisture removed from process air per each kg of desiccant solution. It can be calculated from

SMR = m(y1-y2)/m1

Where,

y1 and y2 are humidity ratios of process air at inlet and outlet of evaporator box respectively

The moisture removal capacity, MRC

It represents the mass flow rate of moisture removed by wheel

$$\text{MRC} = \rho_1 \dot{V}_{proc}(\omega_1 - \omega_2)$$

Dehumidification Coefficient of Performance. DCOP

The dehumidificationCoefficient of Performance. DCOP, represents the ratio between the thermal power related to the air dehumidification andthe thermal power supplied to the regeneration process.

OBSERVATIONS & GRAPHS

Experimental tests have been carried out at different parameters to evaluate the performance of the desiccant system. The performance parameters studied are evaporator temperature, COP, SMR, air supply temperature, air humidity ratio, desiccant concentration etc.. These are studied at specific design and perating conditions and the results are analysed and plotted in the form of graphs.

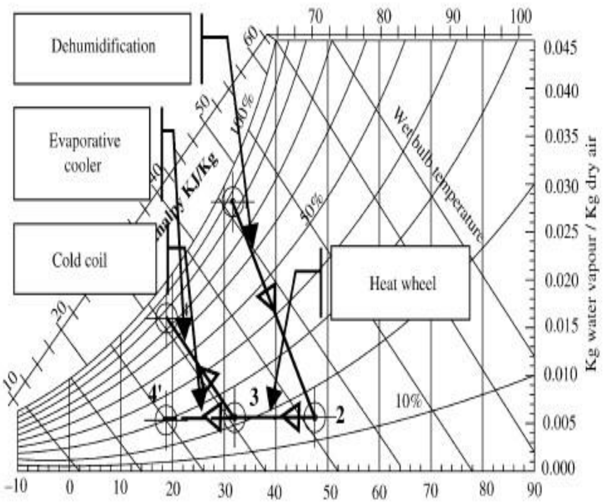

Fig. 2. Psychrometric chart illustrating the principle of desiccant cooling.

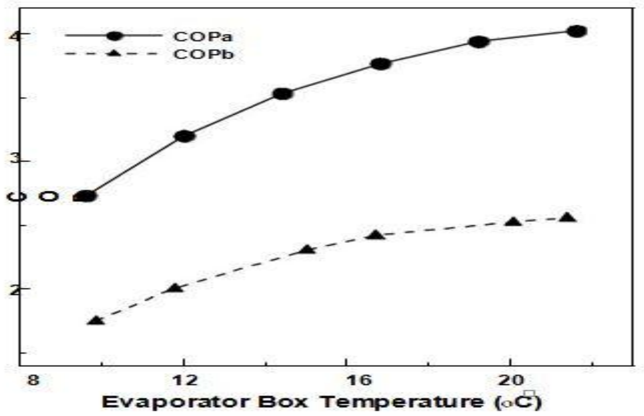

Fig.-Evaporator box temperature vs COP

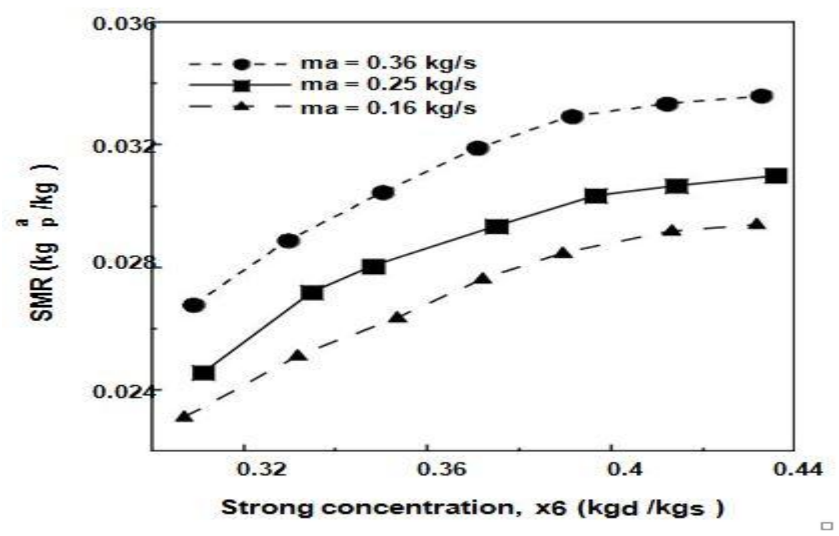

Fig.- Strong concentration vs specific moisture removal

CONCLUSION

This project carried out a detailed study of a desiccant evaporative cooling system with an experimental working model. Silica gel was used as the desiccant material for dehumidification as well as CO2 for sensible heat reduction. The system was evaluated on the basis of various performance parameters. The device design efficiency as well as future scope of such systems was analyzed. Conclusions derived from the reviewer as follows:

i. Desiccant cooling systems do not use any ozone-depleting refrigerants. Moreover, they can operate successfully on low-grade heat from solar energy, combined heat and power plant or waste heat from factories or chimneys.

ii. The most commonly used desiccant are silica gel, lithium chloride is popular because of low vapor pressure and stability while calcium chloride is cheap and easily available. However, both the salts are corrosive nature and require precaution before use. Among all the aqueoussalts, potassium formate is least corrosive and can be used as a viable replacement. Two liquid desiccants can also be mixed in suitable proportions too be maintaining more cost effective and efficient liquid desiccant.

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