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Multiple Solar Methods for Liquid Desiccant Regeneration

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1. Introduction

Major contribution in total electric power demand is from electric powered vapor compression refrigerant air conditioning (VCR). If somehow renewable energy can be harnessed for conditioning purpose lot of electric powered can be saved leading to sustainable development. LDAC system is one of the kind, works on solar and is being encouraged a lot.

LDAC (Liquid Desiccant Air Conditioning System) is the best alternative over electric powered AC's .Liquid Desiccant is the most important in system .Here LD (Liquid Desiccant) needs to be regenerated to achieve conditioning persistently and thus various regenerative methods along with their pros and cons are discussed in these survey.

LDAC system:

The process of conditioning in these systems is shown in fig below.

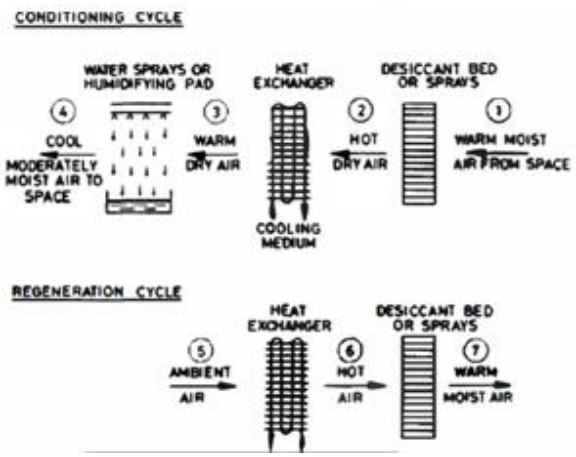


Figure A: Process of Conditioning

Conditioning Cycle: The LD is the hygroscopic solution which absorbs moisture from the air. Thus when warm moist air is passed through LD bed it absorbs moist and dehumidify air. When the water molecule is bonded to the desiccant molecule it liberate heat and thus we get Hot Dry Air from LD. This hot dry air converted to warm dry air through cooling medium. Further allowed to pass through water sprays which completely cools it further released to the space for conditioning. Regenerating cycle: There is limit of absorbing moisture by LD and once it is reached it, gets completely dilute and stops dehumidifying air. Thus to achieve the purpose of desiccant again, hot air is passed through the dilute desiccant bed which supply heat energy to break the bond of desiccant and water molecule and removes moisture from LD. Following psychrometric graph gives various phase transitions of air with reference to moisture content and temperature, while above conditioning and regeneration process.

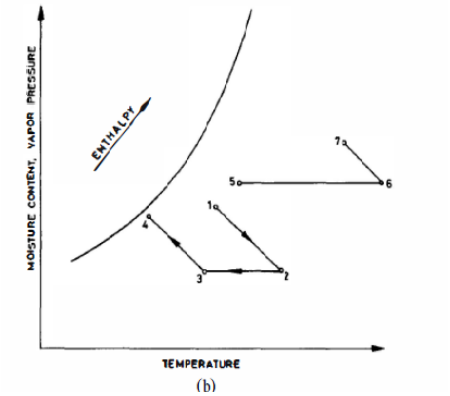
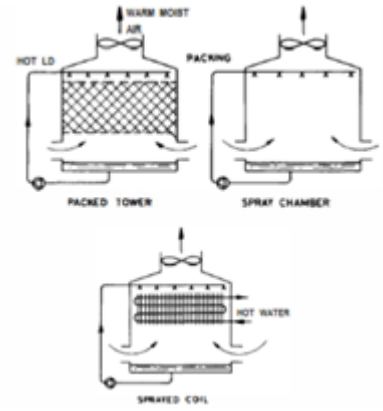


Figure B: Psychrometric Graph

Air Scavenging Regeneration System

After conditioning the liquid desiccant becomes Dilute, Further it can't dehumidify air until desiccant is regenerated. Thus as aim to regenerate LD, it is heated with air (ambient air). Further due to high water pressure from LD, moisture is removed from desiccant and transferred to air. Now air becomes warm and moisturized which is later removed from system by blower or conviction process and ultimately we get regenerated liquid desiccant in the system. Such process in which air is scavenged with aim to regenerate LD is Air Scavenging Regeneration.



Various types of air scavenging regenerator are show in fig below like packed bed tower, spray tower, sprayed coil device. In all the tower types the dilute LD is exposed to air along with heating system and blower and ultimately the regenerated LD is obtained by some mechanical arrangement. Fig (a) depicts a Falling film type contacting device in which desiccant can be regenerated by flowing hot

water(instead of cooling water), dilute desiccant solution and air simultaneously in respective compartment so that thermal energy from hot water removes the moist from dilute desiccant and further moist associate with air flow to remove out moist from the system. The regenerator made from polymer plate as in fig (b) have internal passage for hot water circulation which heat up the dilute desiccant and can be used as air scavenging regenerator.

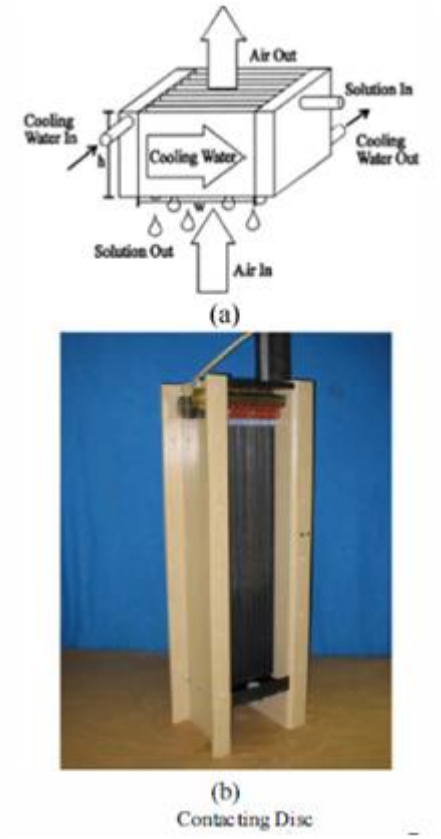


Figure C: Air Contacting Devices

Performance of LD Regenerator

The performance of regenerator is determined by C.O.P. (coefficient of performance). It basically gives the amount of water removed from dilute desiccant per unit heat supplied .Hence when heat of hot water is multiplied to numerator it gives dimensionless quantity I.e. C.O.P.

C.O.P= ((Water remove from L.D.)/ (Heat Supplied))*(latent heat of water)

In multistage regeneration, the latent heat evolve due to phase transition of water, is utilized in regeneration of L.D. These makes C.O.P greater than 2 (ideally 2) which means more moisture removal from same quantity of heat. Multistage regeneration is mostly seen in medium temperature solar collector.

Provision of heat

The thermal energy for regeneration of L.D. can be harnessed from solar radiation by various solar collectors. Classification of collectors are shown in figure (d), which is done on basis of amount of temperature attained by solar collectors.

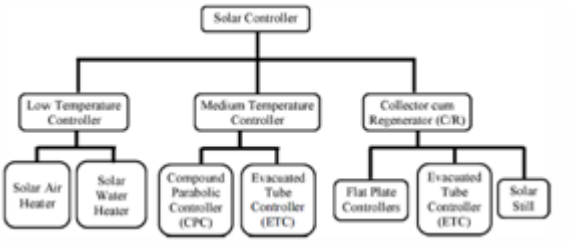


Figure D: Solar collector used for LD Regeneration

In low temperature collector:
a) Solar heater type: solar hot air can directly be used for heating L.D. to regenerate it.
b) Solar water heater type: it requires heat exchanger and circulating pump which may increase number of components.

In medium temperature collector: a) evacuated tube and compound parabolic collector: though there cost is high, multistage helps here to increase the C.O.P. They can heat up liquid desiccant to higher temperature.

In high temperature collector cum regenerator, the liquid desiccant is regenerated in collector itself. These eliminate the primary circuit for solar heat collection, number of component are also eliminated and parasitic power loss is also reduced. Some of its type are shown in figure as a) SOLAR STILL, b) Flat Plate liquid desiccant regenerator.

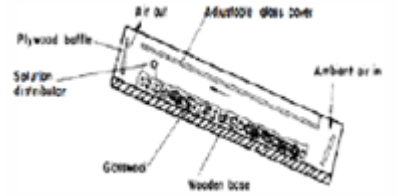


Figure E: Flat Plate LD Regenerator

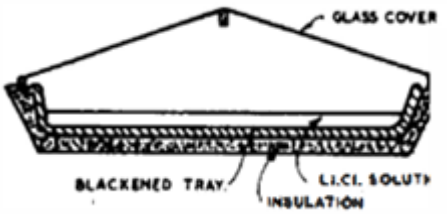


Figure F: Solar Still As LD Regenerator

In the absence of insolation i.e. during night time or rainy season, there will be no heat source for LD regeneration and the system will fail. To overcome these a latest system is also introduced as photovoltaic electro dialysis

Photovoltaic Electrodialysis Regeneration (PV-ED)

Apart from using solar heat for regeneration, a use of solar electric power is recent interest for regeneration. One of the recent technology that uses solar electric power for regeneration of desiccant is Electro Dialysis Technology(EDT).Here the ions are migrated through selective membrane in presence of electric field. Anion and cation are placed in between cathode and anode as matter of choice within an electrodialyzer. Under the influence of electric field the anion and cation locate themselves toward the anode and cathode in the electrodialyzer cells. Meanwhile the cations and anions passes through cation exchange membrane and anion exchange membrane

respectively. This migration of ions results in obtaining the concentrated solution in concentrate compartment and dilute solution in dilute compartment. Accordingly the pure water can be obtained along with concentrated desiccant solution. Below diagram shows schematic of Photovoltaic based ED system. The dilute desiccant from the dehumidifier is drained is drained to the regenerator in photovoltaic ED regeneration process. The regenerator driven by PV cells is made of ED pile formed from cells of mass situated between two electrodes in parallel configuration. In above diagram the compartment (a) is concentrate cell, compartment (b) is dilute cell and compartment (e) is electrode rinse cells. The dilute solution is introduced to cell (b) and after migration of ions, regenerated solutions are obtained in cell (a). Further the regenerated desiccant is scavenged from cell (a) and fed to desiccant bed of LDAC system. The photovoltaic cell was utilized to provide electric power for rejuvenative process. In addition, new regenerative double stage PV/T-ED system established. The performance analysis result shows that PV/T-ED system surpass the single stage one in point of systematic replenish of LD infusion.

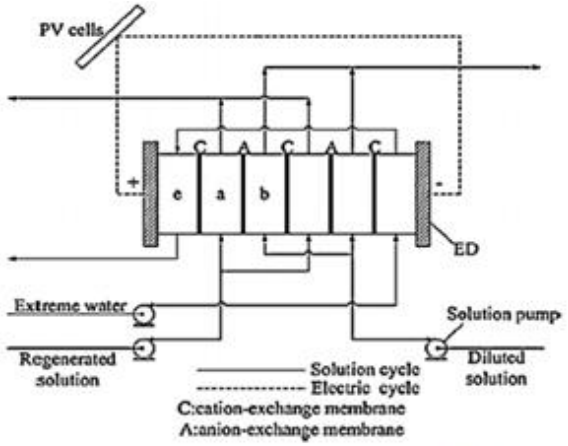


Fig. 16. A schematicof the PV-ED regeneration system [49].

Figure G: Schematic of PV ED Regeneration System

In the above systems a liquid desiccant needs to be removed from LDAC system for regeneration purpose. A new system is introduced where the purpose of LD and regeneration is achieved simultaneously without separating LD from system;

Desiccant Wheel:

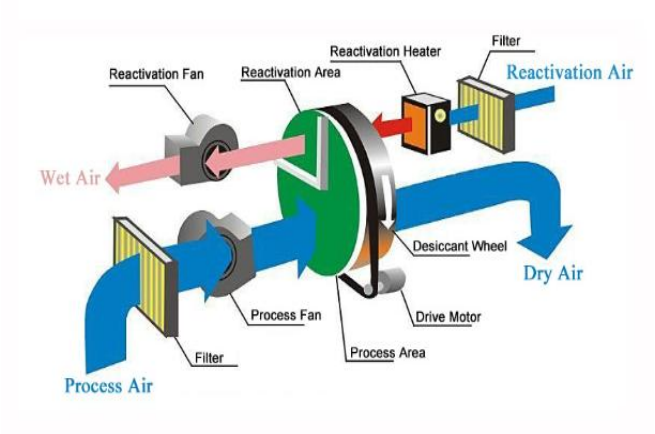


Figure H: Desiccant Wheel

These wheel contains a number of tapered pores protect with slot media carrying LD solution scattered continuously over the surface of rotor. These is structured into two section a) Process area, b) Regeneration area.

The air to be wizened is passed through the wheel (process compartment) and is dehumidified by the liquid desiccant and holds the water while rotating. Now the humidified LD passes through the regeneration medium and the moisture content is removed by the hot air stream to the outside .This method is highly efficient and uniform for dehumidification .Solar Power can be harnessed for functioning of reactivation heater, fan and drive motor.

2. Conclusion

These survey paper focuses on two regenerative methods of Liquid Desiccant a)Air scavenging type b) Photo-voltaic Electro dialysistype (PV-ED).The drawback of air scavenging type is overcome by PV-ED system. Whenever high insolation is present solar energy is harnessed and utilized directly by air scavenging type, however in PV-ED type the energy can be simultaneously utilized and stored for future need (when insolation is absent).Thus regeneration can be persistently achieved from PV-ED system irrespective of insolation high or low. However both the systems are effective in there domain since both are leading to sustainable development.

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