International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 4
April 2018

Advanced Desiccants for HVAC System: A Review

Gyanesh Pallav
Indian Institute of Technology(Indian School of Mines) Dhanbad

Abstract:
The overall study of the advanced desiccant materials is to understand the behaviour of high performance , low cost, improved durability desiccants with an aim to improve the properties of current available desiccants like silica gel, activated carbon etc and to identify the reasons for the degradation in their sorption temperature which makes them suitable for HVAC system. The use of advance desiccants enhances the solar building technology by reducing the cost of commercial solid desiccant cooling systems to compete with conventional air conditioning. Lots of efforts were made by different researchers in making suitable advance desiccants that has better water sorption properties than silica gel and hence composite desiccants were developed .This paper presents overall study on advance desiccants that includes composite and polymer desiccants along with their merits ,demerits and applications. This review has a great significance for further research on advance desiccant materials for making them suitable for other applications.

Keywords: Composite desiccants ,Adsorption, Sorbents.

Contents:

Nomenclature:

ADM - Advance desiccant materials.
DCS -Desiccant cooling systems.
STES -Sorption thermal energy storage.
COP -Coefficient of performance.
R&D -Research and development.
PPM -Parts per million.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 4
April 2018

1. Introduction:

Desiccants are a subset of sorbents; they have a particular affinity for water. Virtually all materials are desiccants; that is, they attract and hold water vapour. Wood, natural fibres, clays, and many synthetic materials attract and release moisture as commercial desiccants do, but they lack holding capacity. Desiccants absorb moisture until they reach equilibrium with the surrounding air and then the moisture is then removed from the desiccants by heating the at the temperature between 50-260°C. [1].

Desiccants can be classified as solid, composite and polymer desiccants. Solid desiccants includes silica gel, zeolites, activated alumina , molecular sieve and activated carbon, whereas composite desiccants includes silica gel with lithium chloride, calcium carbonate, calcium chloride etc.

Both inorganic and organic materials are good candidates ADM for use in DCS. Silica gel and lithium chloride are now the most widely used desiccant materials used in wheel geometries in DCS.

2. Desiccants

A desiccant is hygroscopic substance that induces a state of dryness in its surroundings[2]. The process of attracting and holding moisture is described as either adsorption or absorption, depending on whether the desiccant undergoes a chemical change as it takes on moisture. Adsorption does not change the desiccant, except by addition of the mass of water vapour; it is similar in some ways to a sponge soaking up water. Absorption**,** on the other hand, changes the desiccant. An example of an absorbent is table salt, which changes from a solid to a liquid as it absorbs moisture[1]. Desiccants are used to dry the refrigerant circulating in air conditioning and refrigeration systems.

2.1 Need of desiccant materials: The expansion of the desiccant technology in the market place has sent engineers scrambling to learn about new applications for this technology. The requirement for more fresh air in the building has dramatically changed the way designers provide a healthy comfortable and productive environment for patients ,customers and employees. However when larger amount of fresh air are brought in to satisfy the new criteria for ventilation, a large amount of water in the air must be removed to maintain the reasonable humidity level in the conditioned space and ductwork. This problem is solved by using a desiccant based cooling unit as an integral part of the buildings HVAC system as it supplies the large volumes of fresh air required by the building codes.

2.2 Demand for comfort: Controlling comfort involves bringing the air temperature and the relative humidity into a reasonable range for human comfort and it is achieved by the use of desiccant materials as it is noted that the humidity is at least as important as the temperature as is often said ,**"It's not the heat it's the humidity".**

3.Solid desiccants

There are many solid desiccants available like silica gel, zeolites, Activated alumina , molecular sieve and activated carbon in which silica gel is widely used. Systems with solid desiccants are currently used in industrial air-drying applications and in DCS. These use a desiccant wheel in which air may flow in the axial direction only. The solid desiccant (typically silica gel and/or lithium chloride) is mounted onto a wheel and the air to be dried flows through one side of the wheel, while the desiccant on the other side of the wheel is being dried by an externally heated air stream. These two air streams are kept physically separated to maintain the distinctly separate functions of air dehumidification and desiccant regeneration. The commercial systems are primarily intended for specialized applications that require dehumidifying air and usually do not produce a significant net cooling.

4. Purpose of advance desiccants:

One purpose for performing this long-range research on different materials is to get an understanding of the behaviour of low-cost, high-performance technological materials, with a goal of extending the lifetime of these materials. Long-term materials research is required to improve the properties of advanced desiccant

materials (ADM) and to get the reasons for degradation of their sorption performance. The purpose of ADM research and development (R&D) is to provide new materials options for DCS. The ultimate purpose is to identify materials with optimal performance in the temperature range used in a DCS so that they replace the current desiccants by enhancing the performance of the current available desiccants. The performance of these materials can be ranked as compared to the performance of silica gel, which can be used as the standard for comparison. The life-cycle cost (i.e., initial cost, performance, and durability) has a direct relationship to the cost-effective deployment of any regenerative DCS.

5. Composite desiccants:

Composite desiccants comes under the ADM and lots of composite desiccants have now been discovered like silica gel with lithium chloride, silica gel with calcium chloride, silica gel with calcium nitrate, Attapulgite with lithium chloride etc. Composite desiccants are high performance , low cost, improved durability desiccants and are better than the current available desiccants like silica gel.

5.1 Silica gel with Lithium chloride:

Merits:

- Energy densities for composite sorbent is improved remarkably and have long-term heat preservation ability.
- Offers largest water uptake under typical working conditions.
- Complete water desorption can be reached at relatively low temperature.
- Complete water desorption can be reached from 60 to 100 °C.

Demerits:

- It is difficult to find the suitable silica gel-LiCl composite sorbents because of the effects of some imp. parameters like pore structure of matrix, mass concentration etc.

Applications:

Low temperature driven STES(Sorption thermal energy storage) systems[3].

5.2 Silica gel with calcium nitrate:

Merits:

- Water sorption is increased up to 0.2-0.3g/g due to the presence of salt inside the silica pores.
- Confinement of Ca(NO3)2 to the silica pores significantly hasten the sorption process which is limited by intra-particle diffusion.

Applications:

Air conditioning system applications[4].

5.3 Silica gel with zeolites:

Merits:

- Complete water desorption can be achieved at relatively low temperature, making it a candidate for efficient cooling or air conditioning applications.
- It is less costly as compared to the other desiccant materials

Demerits:

- Microporosity of the zeolite is blocked by the salts and so zeolite supported on silica is inferior water sorbent as compared to the CaCl2 supported on silica.
- COP is inferior to that of silica+CaCl2.

Applications:

Cooling & air conditioning applications[5].

5.4 Silica gel with calcium chloride:

Merits:

- Silica activated carbon/CaCl2 can outperform commonly used single adsorbents such as zeolites, activated carbon and silica gel.
- It can be used as an effective adsorbent in desiccant wheel dehumidification systems.
- Adsorption temperature up to 27°C can be achieved.

Demerits:

The mass and heat transfer performance is not much good so further so further study is needed in order to achieve higher COP values in practical adsorption cooling system.

Applications:

Desiccant wheel dehumidification system, Refrigeration plants etc[6].

5.5 Attapulgite with lithium chloride:

Merits:

- Increase of adsorptivity of water vapour in the broad range of water vapour pressure.
- Cheap adsorbent as cost of attapulgite is lower.
- Works efficiently at temperature lower than 170°C.

Demerits:

At high water vapour pressure the adsorption performances strongly depend on Chlorine content.

Applications:

Cooling & air conditioning applications[7].

6. CONCLUSION:

Accordingly, polymeric as well as composite materials could not only serve as both the desiccant but also the support structure in a desiccant wheel but also be replaced easily and inexpensively if their water sorption capacity degrades. The initial need of this research is to characterize the water sorption performance of polymeric and composite materials that could serve in an economically competitive DCS.

References:-

1. 2009 ASHRAE Handbook - Fundamentals (SI Edition)-American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (2009).
2. New commercial applications for desiccant based cooling by Kevin Macgahey.
3. Yu N, Wang RZ, Lu ZS, Wang LW. Development and characterization of silica gel–LiCl composite sorbents for thermal energy storage. Chemical Engineering Science. 2014 May 24;111:73-84.
4. Simonova IA, Freni A, Restuccia G, Aristov YI. Water sorption on composite “silica modified by calcium nitrate”. Microporous and Mesoporous Materials. 2009 Jun 1;122(1):223-8.
5. Cortés FB, Chejne F, Carrasco-Marín F, Pérez-Cadenas AF, Moreno-Castilla C. Water sorption on silica-and zeolite-supported hygroscopic salts for cooling system applications. Energy Conversion and Management. 2012 Jan 31;53(1):219-23.
6. Tso CY, Chao CY. Activated carbon, silica-gel and calcium chloride composite adsorbents for energy efficient solar adsorption cooling and dehumidification systems. International journal of refrigeration. 2012 Sep 30;35(6):1626-38.
7. Chen HJ, Cui Q, Tang Y, Chen XJ, Yao HQ. Attapulgite based LiCl composite adsorbents for cooling and air conditioning applications. Applied Thermal Engineering. 2008 Dec 31;28(17):2187-93.