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Experimental Determination of Dessicant Cooling System for Thermal Comfort

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Abstract - Desiccant cooling technology can be used to solve a variety of building comfort, quality and energy related issues. The main objective of my research work was to assess the feasibilities of utilization of solar energy for regeneration of desiccant wheel by hot air provided by solar air heater. It will help in saving electrical energy for regeneration of desiccant wheel.

In the research work the following assumptions are made:

a. The weight of this system is very less and the structure is also porous which allow easy passage for air
b. There is very less pressure drop across the wheel of the desiccant system.
c. Dew point is low in this system.
d. It has the high capacity for removing moisture from air.
e. Another advantage of this type of system is its simple ness
f. The energy (electricity) required dehumidifying and cool ventilation air is reduced to a great extent
g. Improves the efficiency of refrigeration equipment by operating at a higher evaporator temperatures and higher COPh. reduces the space

I. INTRODUCTION

Desiccant-based equipments have been widely used for industrial applications since 1930s and commercially since 1980s.

This technology has been widely used in USA and Northern Europe. In USA, the number of desiccant industrials has increased from 2 in 1980 to more than 10 in 2001 with more than 5700 systems installed in commercial buildings (Stabat, 2003). Several studies in Northern Europe (Dittmar, 1997, Lindholm, 2000), recently, these systems were used in Western Europe and especially in Germany where there are about 7 solar desiccant installations. In the chamber of commerce from Fribourg in Germany, an autonomous solar desiccant cooling system allows cooling two meeting rooms of 65 and 148 m2 containing 120 persons (Climasol). With 100m2 of solar collectors and 60 kW of cooling capacity, reductions in primary energy consumption are about 30000 kWh and in C02 emissions about 8800 kg/year. Currently in France, a solar desiccant system is installed in Chambery (in Eastern France) to refresh a 70m2-training-room.

This paper presents the results of the effectiveness of the desiccant wheel made with SOLID DESSICANT COOLING SYSTEM:

Rotor Dia in mm	Process Area (net)(ft2	Process Flow@500 FPM(CFM)	React Area (Net) (ft2)	React Flow@600 FPM(CFM)
230	0.21	125	0.21	139
345	0.50	311	0.454	301
410	0.69	429	0.71	444
510	1.12	729	1.12	731
710	2.11	112	2.01	1401
945	3.24	2257	3.48	2210
111	6.99	3601	6.211	3619
132	9.510	5701	8.99	5609
154	11.17	6990	11.02	7092
173	14.71	8271	14.27	8092

The design and operation of a desiccant system is based on the desiccant material used to accomplish the dehumidification. Desiccant materials attract moisture through the process of either adsorption or absorption. Adsorption is the process of trapping moisture within the desiccant material similar to the way a sponge holds water through capillaries. Most adsorbents are solid materials. Absorption is the process of trapping moisture

through a chemical process in which the desiccant undergoes a chemical change. Most absorbents are liquids.

Commercially available desiccant systems are based on five configurations or technologies.

- Liquid Spray Towers
- Solid Packed Tower
- Rotating Horizontal Bed
- Multiple Vertical Bed
- Rotating Desiccant Wheel

Now let us understand the working of Rotating Desiccant Wheel which uses solid desiccant material i.e. Silica Gel Desiccants remove water vapour by chemical attraction caused by differences in vapour pressure silica gel absorbent.

When air is humid, it has a high water vapor pressure. In contrast, there are very few water molecules on a dry desiccant surface, so the water vapor pressure at the desiccant surface is very low. Water molecules move from the humid air to the dry desiccant in order to equalize this pressure differential. With desiccants, moisture removal occurs in the vapor phase. There is no liquid condensate. Consequently, desiccant dehumidification can continue even when the dew point of the air is below freezing. This is different from cooling-based dehumidification, in which the moisture freezes and halts the process if part of the coil surface is below 32°F. Desiccants can be either liquids or solids, and there are many different materials of both types. The principles described here apply to both liquid and solid systems. However, the great majority of systems built for commercial buildings use solid desiccants.

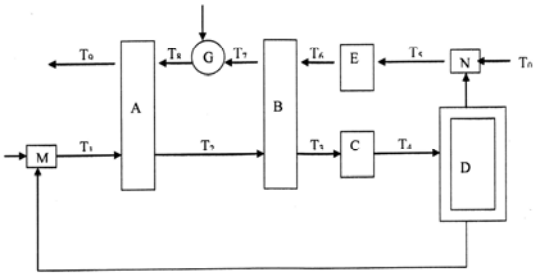

Fig. 3.1.1 The complete layout of the Desiccant Cooling System

Figure 3.1.1 shows the basic desiccant component—the wheel. The desiccant material, usually a silica gel or some type of zeolite, is impregnated into a support structure. This looks like a honeycomb which is open on both ends. Air passes Moist "process" air is passed through a rotating wheel, the wheel slowly rotates into a second, heated air stream. Desiccant so it can absorb more humidity when the wheel rotates back into the process air stream. Heater Desiccant Wheel Humid Process Air Moist which looks like a ceramic honeycomb. The desiccant in the wheel absorbs moisture. Then the hot "reactivation" air removes moisture from the Reactivation Honeycomb Matrix Dry Process Air to the HVAC System Reactivation Air Desiccant Wheel Operation Figure 3.1.1 Desiccant wheel operating principles through the honeycomb passages, giving up moisture to the desiccant contained in the walls of the honeycomb cells. The desiccant structure is formed into the shape of a wheel. The wheel constantly rotates through two separate air streams. The first air stream, called the process air, is dried by the desiccant. The second air stream, called reactivation or regeneration air, is heated. It dries the desiccant. A desiccant wheel rotates slowly, and contains more desiccant than an enthalpy wheel. By heating the reactivation air, it can remove much more water vapor than an enthalpy wheel. An enthalpy wheel has a small amount of desiccant, so it can move moisture from the supply air to the exhaust. But without heat for reactivation, its dehumidification capacity depends on the dryness of the exhaust air.

Now let us understand the layout of the desiccant system in detail. Firstly the fresh air from the atmosphere gets mixed with the some part of room air in the mixer M. From mixer M this mixed air goes to the Desiccant Wheel and have the temperature *T*\. Than this air passes through the Desiccant wheel A and losses its moisture the temperature of the air rises to T2. Now this air passes through the Enthalpy Wheel B so that the temperature of the air decreases and so the temperature of the air becomes T3 Now this air is cooled by an external source C which is a direct evaporative cooler to decrease the temperature of the air to T4. Than this cool air enters into the room D. from this room some air is directly sent to the mixer M to mix with the fresh air. And some air is extracted and sent to another mixer N from where reactivation air is prepared in the mixer N, The room air is mixed and attains the temperature T_5 than this air is again cooled with the help of direct evaporative cooler E. The temperature of the air becomes T6 which is much less than T5 than this cooled air is passed through the reactivation side is less than the temperature of the wheel on the process air side so the process air losses its temperature to the Enthalpy Wheel. After the reactivation air passes through the Enthalpy Wheel its temperature rises to T7 Now this air is again heated with the help of heater G to rise the temperature of the air to Tg. This hot air is passed through the Desiccant Wheel A to absorb moisture from it. Than the hot air move out of the wheel after attaining the temperature T9 this is the complete process which takes place in the Desiccant Wheel system.

II. APPLICATION

Desiccant wheel used in many air conditioning applications and are particularly best suited when:

- Latent load is large in comparison to sensible load.
- The production process requires low humidity levels.

The cost of energy to reactivate the desiccant is low compared to the cost of the energy to dehumidify by other means.

There are many areas where desiccant wheel are used such as Production, storage and packaging of moisture sensitive products in Pharmaceuticals, Foods, Beverages, and chemical industries, Supermarket, Ice Rinks, Refrigerated Warehouses, Movie Theatres, School, Hospital Operating Room, Hotels etc.

Psychometrics:

Psychometrics is the science that deals with thermodynamic properties of moist air. A psychometric chart graphically represents these properties. It is the most convenient and widely used tool to represent and solve numerous air conditioning process problems with moist air. The choice of enthalpy and humidity ratio as coordinates provides one such convenient graphical depiction. With this, all physical properties of moist air can be derived from any two properties of air with minimum thermodynamic approximations.

III. CONCLUSION:

From the present research work it is concluded that the energy and the initial cost of the desiccant cooling system can be reduced in comparison to the conventional cooling system. Now a day the refrigeration of desiccant wheel is doing with the help of electric heater. But it is found that regeneration of the desiccant wheel is possible with hot air provided by solar air heater it will reduce the energy cost. This work also enhances the further research possibilities.

A sufficient no. of experiments has been performed to evaluate the effectiveness of the desiccant wheel made with silica gel absorbent. Performance curve have been plotted with the help of experimentation which could be useful to study performance of the desiccant wheel. Since the present system is able to regenerate at the temperature range 60 to 70°c.

IV. RESULT AND DISCUSSION:

From the test result it is observed that the regeneration of silica gel desiccant wheel is possible by supplying the hot air from solar air heater. The moisture is removed by the desiccant wheel in the range of 4 to 10% the graph obtained by plotting different point is very similar to the standard graph which is found in the experimental work on the desiccant wheel in the laboratory

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