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HYBRID SOLAR DESICCANT COOLING SYSTEM

Swapnil Ghatol[*1], Tejaswini Rajput*[2]

[*] Department of Mechanical Engineering, Siddhivinayak Technical Campus School of Polytechnic & Research Technology (SPRT) Shegaon Road, Khamgaon-444303, Maharashtra, India.

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ABSTRACT

Now days, air conditioning systems are a must for almost every commercial and residential building to achieve comfortable indoor conditions. The increasing energy demand, and increasing oil prices and pollution levels raise the need for alternative air conditioning systems which can efficiently utilize renewable energy resources. The desiccant systems are reasonably-priced, produce no CFCs, and capable of both drying and filtering the air. They provide an opportunity to control humidity and temperature independently, and have the capability of using low quality thermal energy. Using excess summer heat from solar collectors to drive desiccant cooling systems is often proposed. A two-wheel desiccant system using solar heat for desiccant regeneration is typically discussed. The two-wheel system uses a desiccant wheel that is "matched" with a heat exchanger wheel. The heat exchanger recycles heat for the desiccant regeneration and improves system efficiency.

KEYWORDS: Desiccant System, renewable energy, humidity

I. INTRODUCTION

Nowadays, people pay a lot of attention to environmental problems. The temperature on the Earth and the amount of greenhouse gases are increasing and especially the amount of carbon dioxide. Mainly it happens because of production of energy. However, producing and consumption of energy is increasing every year.

A great part of energy, which people produce, goes to the heating and cooling of buildings. Therefore, production of energy for heating, cooling, air conditioning systems also leads to increasing of the amount of carbon dioxide in the atmosphere.

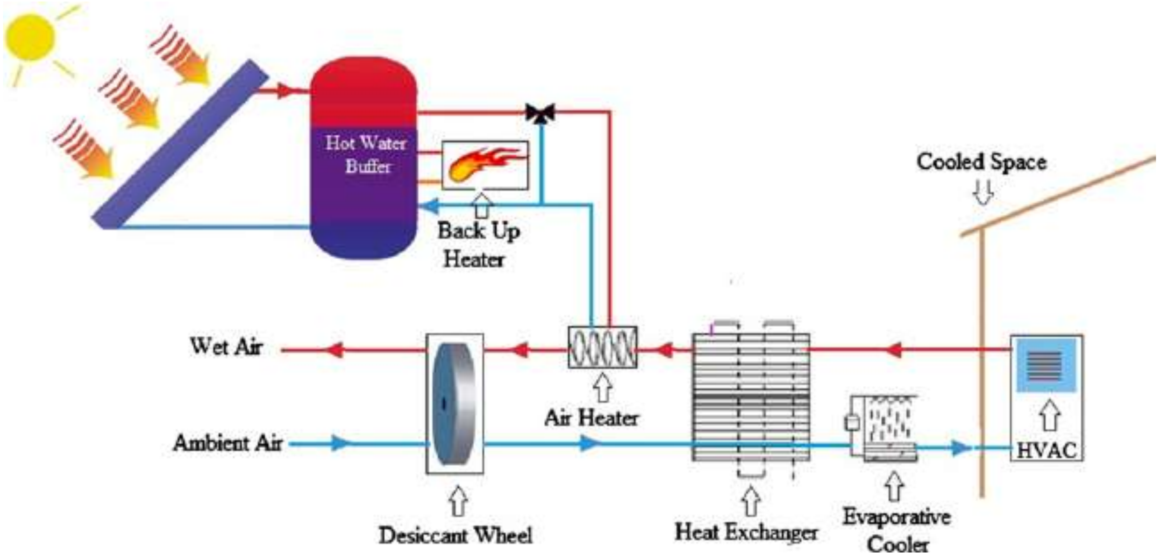
SA desiccant material naturally attracts moisture from gases and liquid. The material becomes as moisture is absorbed or collected on the surface; but when heated, the desiccant dries out-or-regenerate and can be use again. Conventional solid desiccant includes silica gel, activated alumina, lithium chlorate salt and molecular sieves. Titanium Silicate a class of material called 1m, and synthetic polymer are new solid desiccant material design to be more effective for cooling application. Liquid desiccant includes lithium chlorate, lithium bromide, calcium chloride and triethylene glycol solution.

In a dehumidifier, the desiccant removes moisture from the air, which release heat and rises the air temperature. The air is then cooled by heat re-covers units and cooling devices such as evaporative cooler or the cooling coil of a conventional air conditional. In a stand alone desiccant system, air is first dried, and then cooled by a heat exchanger and a set of evaporative coolers. This system is free of ozone-depleting CFC and HCFC refrigerant. In most systems, a wheel containing desiccant continuously dehumidify outside air entering the cooling unit. The desiccant is then regenerated by thermal energy.

DESICANT EVAPORATIVE COOLING SYSTEM

Desiccant cooling systems are very good at providing latent cooling by reducing the humidity ratio of building air. However, when the desiccant cooling system must handle the entire load, it overdrives the process air so evaporative cooling can be used for the sensible cooling. A typical recirculation cycle for the desiccant cooling system.

Combining the ability of the desiccant dehumidifier to handle the latent load and the ability of the vapor compression subsystem to meet the sensible cooling load leads to a very efficient system. The dehumidifier subsystem needs to remove only enough moisture to satisfy the building's needs, thereby reducing the size of the dehumidifier and lowering the required regeneration temperature from the 70' to 80'~ needed by the desiccant cooling system to 50' to 60' for the hybrid system. The vapor compression subsystem needs only to cool the process air to the required supply temperature and not to the dew point temperature. As a result, the coil temperature can be raised from 7 ' to 13Owhich increases the efficiency of the system. The combination can be further enhanced by using the heat rejected by the condenser of the vapor compression sub- system to help regenerate the desiccant in the dehumidifier. This synergistic action makes the hybrid system an energy efficient alternative to conventional building air- conditioning systems.



1. Desiccant Evaporative Cooling System Schematic

A typical two-wheel desiccant cycle is shown in Figure 2. The psychometrics for the cycle along the lines from A to B to C and the “2-wheel limit line”. The regeneration cycle is shown along E, G, I and J. The “2 wheel limit line” in Figure 3 represents the continuum of temperature and humidity possible by evaporative cooling the dry air from point C to D. As shown, the line does not deliver both cooler and drier air than the original state point E. To achieve the necessary cooling that removes both internal and external heat gain and humidity loads, the condition along the line C to D must be substantially cooler and drier than the exist ing state point E within the building.

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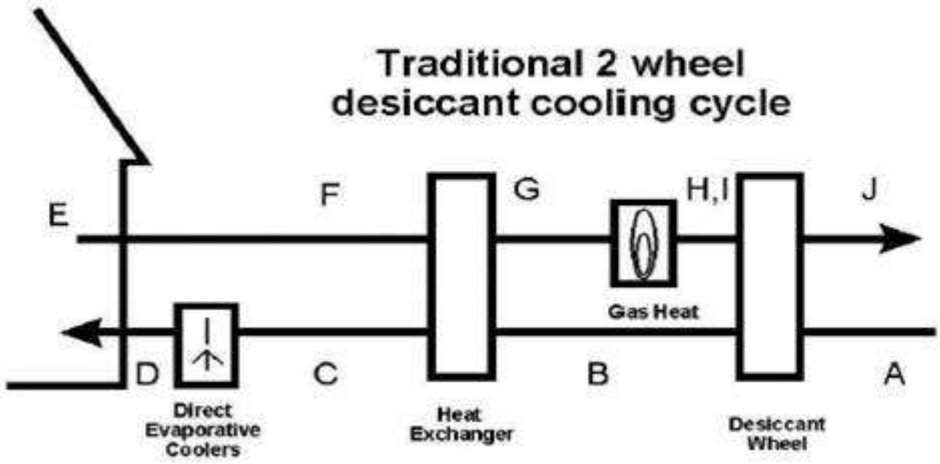

2. ***Traditional 2 Wheel Desiccant Cooling System***

The line C' D represents one such cooler drier condition. To achieve this condition usually requires an additional cooling system that completes the final cooling from point C to point C'. Compression refrigeration is most often used for this final cooling in conjunction with a desiccant system for dehumidification. However, in most cases, consumers will buy only one cooling system, a compression system, to meet their entire cooling needs.

Solar Thermal Tile System

The solar thermal tile system is a mid-temperature air heating collector. It is design such way that the collector was at a slope of 20 degrees from the horizontal, an angle that would roughly equal a roof pitch of 4 in 12. The sun was at an angle of 37 degrees below perpendicular to the collector. This system support desiccant regeneration with the large quantities of excess summer heat. Because the system is an air heating system, it is well suited for direct delivery of solar heated air for desiccant regeneration.

3. ***Solar Thermal Tile System***

Experimental Setup

The solar hybrid desiccant cooling system was established near the test room located in Solar Technology Park, UKM Malaysia. Figure 1 shows the experimental setup of system that conducted to the test room by ducts. The test room has a length 3 m, width of 2 m, and height of 3 m. The desiccant cooling system consist of three main

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units: a) solid desiccant wheel which is used silica gel as absorber, b) heat sources which is used evacuated tube collector and auxiliary heater c) and cooling unit which is used a heat recovery wheel, and vapor compression air conditioning system as cooling coil.

4. Experimental setup of solar desiccant cooling system

Table 1 shows specification components of solar hybrid desiccant cooling system. The desiccant wheel is designed to operate with both a 50% area for reactivation and 50% for process (50/50). The diameter of the wheel is 250 mm and its width is 533 mm. The heat recovery wheel is an aluminum honeycomb structure with 77.8% efficiency. It rotates at 12 rev min-1.

Component	Specification
Desiccant wheel	WSG 250x200 model, 1/80 Hp, 200 scfm flow rate
Heat recovery wheel	HRW –500 model, 800 CFM (supply side), 800 CFM (exhaust side) flow rate, 415 V / 3Ph./50Hz
Blower	ASF604 model,240V,Single Phase 50Hz
Heat exchanger	radiator from Perodua Kancil
Heater	WFH-24065 model,240V, 1.5m/s Air velocity
Hot water tank	Termomax model , capacity: 120 liter
Solar Collector	vacuums tube
Pump	JP Basic 3 GF-model, 50m Max head, 45 L/min Capacity
Hot water pump	815-BR-C Magne-Boost model, 4.1 Max head,2850 RPM

Table 1. Specification of solar cooling components

The diameter of the regenerator is 700 mm and its width is 700 mm. The electrical consumptions of the motor blower motor and electrical heater are about 150 W, and 1500W respectively. Hot water with 80-120 ºC temperature is produced by using 12m2 solar evacuated tube while electrical heater is installed as auxiliary heater in cloudy time. The installed cooling coil of vapor compression system is 10,000 btu/hr.

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Analysis Tools

To analyze the performance of the desiccant/vapor compression hybrid systems, we needed to define the analysis tools that could evaluate the steady-state performance of the components and systems. The key component, the dehumidifier, was modeled with laboratory validation by the DESSIM computer model Also, we used the MOSHMX

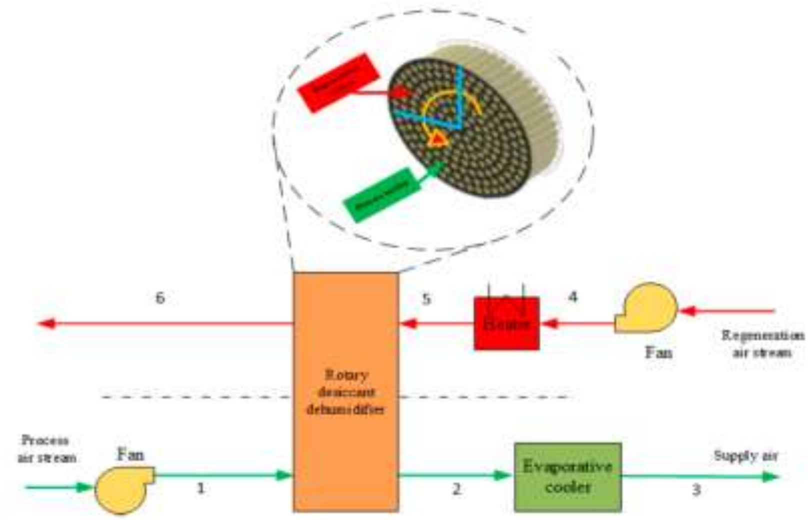
Finite-difference model for heat and mass transfer independently verify test runs. We used both models to predict the behavior of tile parallel passage dehumidifier operating in a hybrid-desiccant/vapor-compression system,

The heat recovery wheel used in two of the systems was modeled using information from tests with parallel-passage heat exchangers conducted at Monash University (Australia) [These heat exchangers have effectiveness's of up to 93%. The data from these tests were used to determine the efficiency of the heat recovery at process conditions.]

Performance data on the indirect evaporative cooler were obtained from the work of Prescod 181 on a plate-type cross-flow heat exchanger in which one of the air streams is evaporatively cooled by spraying water in the channel This arrangement provides a low sink temperature for the other air stream. An effectiveness of 90% was assumed in this analysis. More detailed analysis is required in subsequent studies

Desiccant Dehumidifier

The proposed liquid desiccant dehumidifier is a rotary wheel of radius R and width L. The rotor consists of a number of identical narrow slots uniformly distributed over its cross-section as shown in Figure



5. A Schematic Of The Desiccant Dehumidifier Cooling System

The slots are covered with porous media impregnated with a solution of liquid desiccant. The wheel has separate sections for the flow of process air and regeneration air. One fourth of the air is used for regeneration and three fourths for the process air. These two streams of air flow in a counter arrangement. There is no carryover of liquid desiccant because it does not involve any spraying of liquid desiccant solution. The porous media used should have following characteristics: , the vapor diffusion resistance should be low to increase the moisture transfer process from air to desiccant. The modulus of elasticity should be high to avoid blockages and flow disturbances in the flow channels. The liquid penetration pressure should be high to avoid any leakage of desiccant into the air.

II. RESULTS AND DISCUSSION

To check these zones, complete calculations were made for some building types. As an example, a typical layout has been prepared for a restaurant building consistent with the typical architectural standards. It has been modeled and its total loads calculated with conventional HVAC engineering software. The results show consistency of the selected zones with the calculated latent load fractions.

Now a day there are not many manufactures of this system because this system is not common yet. Munter are one of these manufacturers. Munters has a good information about their systems that is why there is a review their desiccant cooling system, which is called DesiCool as an example of the desiccant cooling system. DesiCool is a solid desiccant system.

Profitability chart of munters desiCool system.

			Munters DesiCool	Air conditioning unit with compressor cooling and heat recovery 60%
Operating hours per year		h	8400	8400
Fan	Supply air	kWh	12,8	13,6
	Discharge air	kWh	13	11,9
Cooling	Rotor + 1 evaporative cooler	kWh/a	206	-
	Heat recovery	kWh/a	167	-
	Rotor + 2 evaporative coolers	kWh/a	251	-
	Compression cooling	kWh/a	-	84566
	Secondary pumps	kWh/a	-	2216
	Regeneration heat for cooling	kWh/a	3343	-
	Water	m3/a	109	-
Electricity	Heat recovery rotor	kWh	2188	-
	Dehumidifi cation rotor	kWh	2188	
Heating	Re-heater	kWh	85217	315754
Prices	Electricity	€/kWh	0,11	0,11
	Heat	€/kWh	0,06	0,006
	Water	€/m3	2	2
Costs	Ventilation per year		23612	23591
	Cooling* per year		486	9546
	Heating per year		5594	18945
Yearly running costs		€	29855	52084
	Difference per year	€ 22 390		
	Saving per year	43%		

Note*- this chart includes all uses listed under "cooling"

III. CONCLUSION

This study shows that a packaged system with hybrid-desiccant/vapor-compression air- conditioning can be a technically feasible alternative to conventional air-conditioning systems. Resource energy savings of 30%-80% can be realized over a wide range of operating conditions, when comparing steady-state performance of the hybrid with conventional systems. These results show promise for developing energy-efficient, air- conditioning by extending existing state-of-the-art technology and warrant further research and analysis.

Seasonal simulations of the hybrid systems should be undertaken to establish realistic energy savings when operating under variable loads and transient-operating conditions. These system studies should include the simple System 1 studied in this report, where the dehumidifier and vapor-compression subsystems are operated in series, and System 3, which incorporates the indirect evaporative cooler. This analysis must also include development and evaluation of control strategies for operating the various subsystems together.

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