Design of solid desiccant dehumidification wheel for food processing Industry

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Abstract - *The most commonly used cooling system is vapour compression system. In food processing industry, applications require RH and temperature within the specific limit but by using cold coil dehumidification we can't achieve required RH and temperature economically. The investigated method includes dehumidification with application of cooling, liquid desiccant dehumidification, dual cooling sources dehumidification and dehumidification wheel. By analysing following methods we understand that solid desiccant dehumidification which is suited for food processing industry. Required RH and temperature can be achieved by using solid dehumidification wheel. The applications of desiccant system are also expanding widely and showed higher potential as compared to VAC system. The desiccant air-conditioning (DAC) involves desiccant dehumidification for humidity control and evaporative cooling for temperature control. The DAC is an attractive technology because it is free from CFCs/ HCFCs/HFCs and can be regenerated by low grade thermal energy.*

***Key Words*: Desiccant wheel, Relative humidity, VAC, CFC, HCFC**

1. INTRODUCTION

Increase in population there is increase in demand of food current methods of food preservation are not fulfil all the needs also humidity and temperature control is essential for human thermal comfort. In current system refrigerants used which leads to global warming. In monsoon relative humidity is more than summer and winter. In food processing industry many applications required lower relative humidity for preservation of food.

Summer operation- characterised by low outdoor air RH and high temperature. Supplying this air into the room will increase temperature and lower RH. So supply air needs to be cooled to maintain room temperature. It also needs to be humidified to maintain room RH. So a pad type humidifier will operate for humidification with a sensible cooling coil at this time. During this time, heater will be off.

Monsoon operation- Characterised by moderate outside temperatures and high RH. If this air is supplied to the room, the room RH will rise. So in summer, the air must be dehumidified. To do this, the air will need to be cooled to cause condensation on the coil and this will remove moisture from air stream. But this could cool room air below the set point. So a heater in the air stream will increase its temperature so as to maintain room temperature as well. During this time, humidifier will be off.

Winter operation- Characterised by low outside temperature as well as low RH. Supplying this air to the room will cause room temperature to reduce as well as RH to reduce. To prevent this, the humidifier will humidify the supply air and then the heater will heat the supply air to maintain both temperature and RH in the room. There is also possibility of free cooling- supplying outside air directly into the room without heating if it is cold enough.

Desiccant dehumidification is new age technology which can be used for effective temperature and humidity control. The potential application of desiccant dehumidification are hospitals, museums, marine, ships, greenhouse, drying grains and product preservation. Desiccant wheel carries latent heat of air conditioner effectively and it reduces energy consumption and increase the COP of system.

This study mainly focus on solid desiccant which are compact and less corrosive in nature as compare to other desiccants.

2. LITERATURE REVIEW

1. Ahmad A. Pesaran performed experiment on A Review of Desiccant Dehumidification Technology

They studied applications of desiccant technology for dehumidifying commercial and institutional buildings. Because of various market, policy, and regulatory factors, this technology is especially attractive for dehumidification applications in the 1990s. After briefly reviewing the principle of operation, they present three case studies-for supermarkets, a hotel, and an office building. They also discuss recent advances and ongoing research and development activities.

2. Lewis G. Harriman III, Dean Plager, Douglas Kosar performed experiment on Dehumidification and Cooling Loads from Ventilation Air

They studied examination of typical behaviour of weather, shows that latent loads usually exceed sensible loads in ventilation air by at least 3:1 and often as much as 8:1. A designer can use the engineering shorthand indexes to quickly assess the importance of this fact for a given system design. To size those components after they are selected, the designer can refer to Chapter 24 of the 1997 Handbook of Fundamentals, which, for the first time, includes separate values for peak moisture and peak temperature.

3. S.J. Slayzak and J.P. Ryan performed experiment on Desiccant Dehumidification Wheel Test Guide

The study describes performance figures of merit that are useful in evaluating rotary dehumidification equipment and practical advice on how to successfully measure the physical parameters needed for calculating these figures. This Guide also calculates representative limits of uncertainty for these figures, giving experimentalists a reasonable sense of the maximum accuracy they can expect from good data in this field. This is necessary to prevent test results from being applied in ways that are not justified by the experimental method. Finally, we offer safeguards for testing to avoid damage to equipment and researchers.

4. Er. Amit Tiwari performed experiment on Design and Fabrication of Desiccant Wheel Dehumidifier

They studied experimental investigations on several commercially available and newly fabricated rotors are conducted in two different laboratories to evaluate performance trends. Experimental uncertainties are analysed and the parameters determining the rotor performance are investigated. It is found that the optimal rotation speed is lower for lithium chloride or compound rotors than for silica gel rotors. Higher regeneration air temperatures lead to higher dehumidification potentials at almost equal dehumidification efficiencies, but with increasing regeneration specific heat input and enthalpy changes of the process air. The influence of the regeneration air humidity was also notable and low relative humidity increase the dehumidification potential. Finally, the measurements show that rising water content in the ambient air causes the dehumidification capacity to rise, while the dehumidification efficiency is not much affected and both specific regeneration heat input and latent heat change of the process air decrease. For desiccant cooling applications in humid climates this is a positive trend.

3. PROBLEM STATEMENT

- Present system (AHU) cannot achieve required relative humidity for food processing industry.
- The required temperature and relative humidity is near about 27° C and below 45% respectively.
- By using solid desiccant dehumidification process the required RH and temperature of the system is achieved.

4. METHODOLOGY

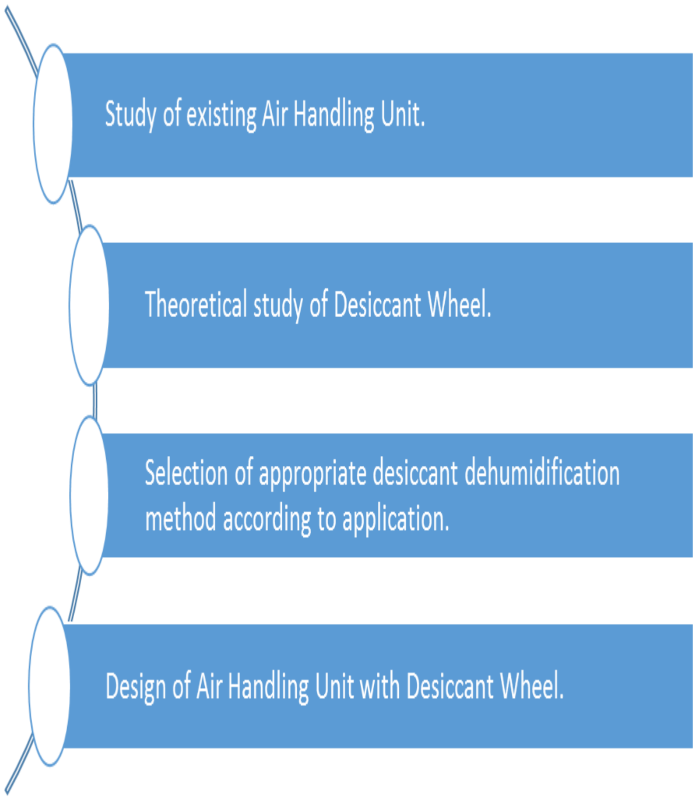

Chart-1: Methodology

5. LOAD CALCULATIONS

Load due to		**Sensible heat (BTU/hr)**	**Latent heat (BTU/hr)**
A. Walls	Wall 1	408.177	
	Wall 2	201.32	
	Wall 3	245.52	
	Wall 4	982.08	
B. Roof		728.64	
C. Glass	Glass 1	149.68	
	Glass 2	79.83	
	Glass 3	149.68	
D. Partition	Wall	627.2	
	ceiling	0	
	floor	2293.76	
E. Infiltration		64.152	91.8
F. Ventilation		419.1264	599.76
G. People		2450	2050
H. Lightning		2992	
I. Electrical		2992	
	Total	14783.1384	2741.56
Total heat load		**17524.6984**	

This data is recorded for 800 square. Ft room in 10 a.m. to 6 p.m.

As we know that,

1TR = 12000 BTU/Hr.

TR = 17524.6984/12000

TR = 1.4603

Also,

1mm = 1/304 ft.

COIL CFM = H×L×Velocity

= (572/304) × (650/304) ×500

=2010 CFM

And,

FILTER CFM = H×L×Velocity

= (610/304) × (610/304) ×500

= 2014 CFM

6. WORKING

This unit consists of desiccant wheel along with heater and cooler. In dehumidification and cooling process removal of moisture from air takes place. When air is passing through desiccant wheel granules of silica gel absorb moisture from air. This air then passes through heater. When this air is passing through heater moisture is removing from desiccant wheel, so that we can use the desiccant material again for the process. The temperature of heater is maintain about 50-70°C. After this, moisture is carried out from the room with the help of duct. This cycle is repeated.

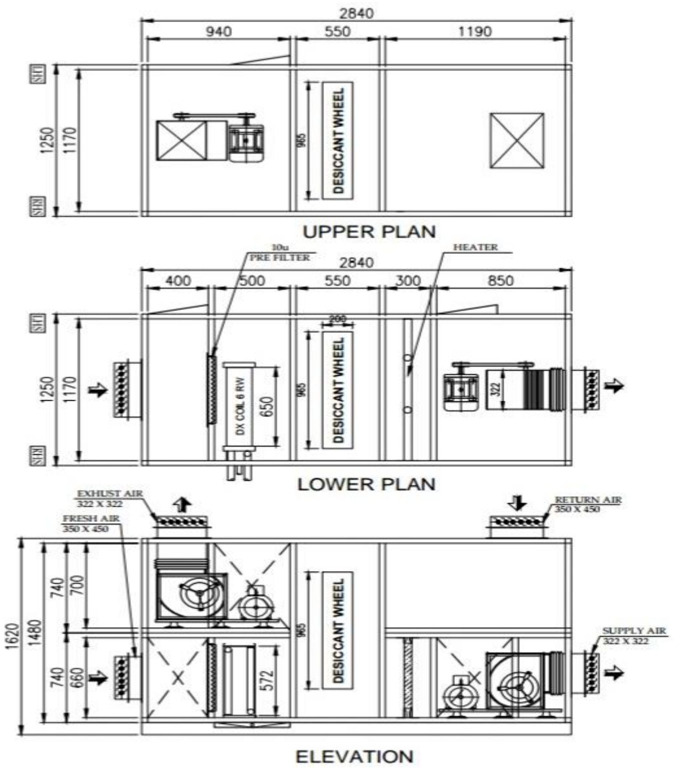

Fig -1: AHU with Desiccant Wheel

7. SPECIFICATIONS

PARTICULARS	DESCRIPTION
1.AHU CAPACITY	2000 CFM
1.1Static pressure	125mmW.G.
1.2AHU panel frame	Double skin extruded ALU. Thermal break profile
1.3Outer skin	24 G power coated
1.4Inner skin	24 G GI plane
1.5Pannel thickness	48 mm
1.6Colour outer	Pearl white
1.7Unit base	GSS
2.FAN DETAILS	
2.1Fan speed	3669 r.p.m.
2.2Type	Centrifugal
2.3Velocity	9.08m/s
2.4Blade type	Backward
2.5Fan absorbed power	1.84 kw.
3.MOTOR DETAIS	
3.1 Motor speed	2900r.p.m.
3.2 Rating	2.20kw(3HP)
3.3 Type	Nonflp
3.4 Pole	2P
4. COOLING COIL DETAILS	
4.1 Type	DX
4.2 Coil Sq. Ft.	4
4.3 Rows	6
4.4 Coil size(H×L)	572×650
4.5 Tube material	Aluminium
4.6 Tube Diameter	3/8 inch
4.7 Coil face velocity	500 m/s
4.8 Coil header material	Copper
4.9 Heater	1.5 kw.
5. CONDENSING DRAIN TRAY	
5.1 Thickness of drain pan	20 G thick
5.2 Material	SS
5.3 Insulation thickness	10 mm
6.FILTER DETAILS	
6.1 Pre- filter	Flange type
	610×610
6.2 HDPE Filter	Washable
7. DAMPER DETAILS	
7.1 Fresh air	Lower H=350 W=450
7.2 Return air	Upper H=350 W=450
7.3Supply air	Lower H=350 W=322
7.4 Exhaust air	Upper H=322 W=322
8. DESICCANT WHEEL	
8.1 Size	965×965×200
8.2 Desiccant material	Silica gel

9.ANTIVIBRATION TYPE	Rubber mount
10.VIEW GLASS	Provided
11.Lower dimensions(L×W×H)	2840×1250×(740+100)
Upper dimensions(L×W×H)	2840×1250×740

Table-1: Technical specification of AHU with desiccant wheel

8. RESULT

- CFM Measurement – Anemometer (Hand held digital type)
- Relative humidity measurement – Hygrometer (Thermal type)
- Temperature measurement – Thermostat
- Filter impurities – Particle counter

Temperature		
Number of readings (Random between 10am to 6pm)	**AHU**	**AHU with desiccant wheel**
1	27.4	29.2
2	24.8	26.5
3	28.3	30.1
4	26.5	28.4
5	27.1	29.1
6	28.3	29.8
7	25.7	27.5
8	26.4	28.6
9	27.3	29.7
10	25.8	27.8
Average	**26.71**	**28.67**

Table-1: Temperature readings

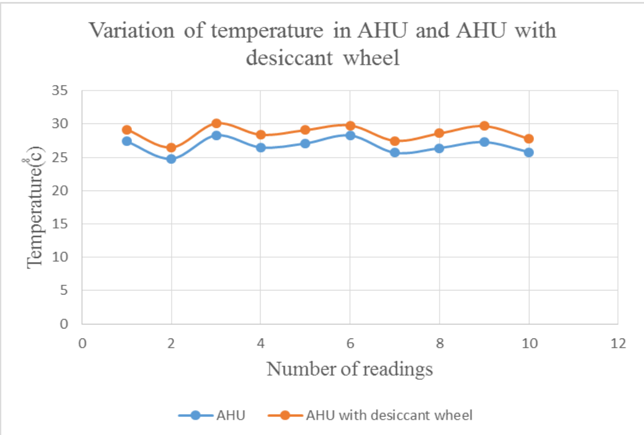

Fig -1: Variation of temperature in AHU and AHU with desiccant wheel

Table-2: RH readings

Relative humidity		
Number of readings (Random between 10am to 6pm)	**AHU**	**AHU with desiccant wheel**
1	54.2	43.1
2	56.4	44.8
3	58.2	45.3
4	52.6	41.4
5	53.7	42.1
6.	50.9	41.6
7	51.5	42.4
8	50.6	41.7
9	54.2	43.2
10	55.7	44.3
Average	**53.8**	**42.99**

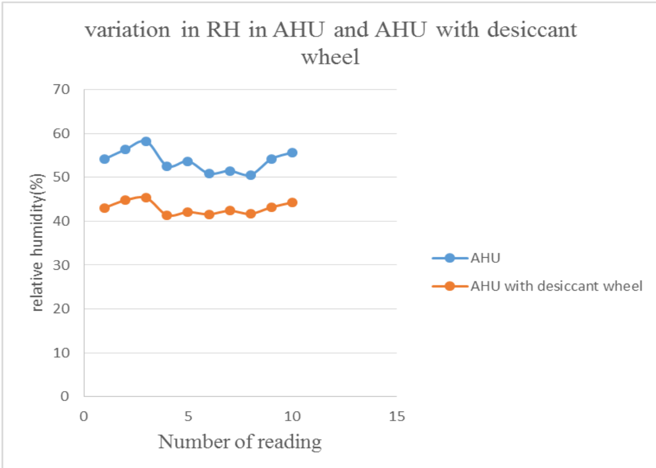

Fig -2: Variation of RH in AHU and AHU with desiccant wheel

9. CONCLUSION

By using solid desiccant dehumidification wheel we get average 42.99% relative humidity and average 28.67° C temperature. This system can be further use for pharmaceutical industry, hospitals, museums, marine, ships, green house, drying grains and product preservation. This system is more efficient and environmental friendly than conventional HVAC system. In this system, dehumidification and regeneration process can be achieved at same time successfully.

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