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Investigation of Condenser Cooling Medium Temperature on AHU Performance

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Abstract: *The component housed in large, open box-shaped units called a module that houses the necessary ventilation requirements for purifying, cooling, or re-establishing the indoor air in a building or premises is known as an air handling unit, or AHU. Energy efficiency is a key component of an air handling unit, and the European Eco-plan Guideline 1235/2014 will make it mandatory starting in 2016. Energy input for idle and moderate load is reduced by the desiccant haggle ooling loop mix in AHU. Desiccant cooling frameworks have been suggested as a successful method for reducing the amount of moisture in stored air. In comparison to fume pressure systems, they don't use ozone-depleting coolants and use less energy. The current task is to investigate the display*

Keywords: Air cooled condensers, Ambient temperatures, Fin cleaning, Heat transfer. Performance analysis.

I. INTRODUCTION

A condenser is a heat transfer device or unit used to condense a substance from its gaseous to its liquid state, typically by cooling it. In doing so, the latent heat is given up by the substance and will transfer to the condenser coolant. Condensers are typically heat exchangers which have various designs and come in many sizes ranging from rather small (hand-held) to very large industrial-scale units used in plant processes. For example, a refrigerator uses a Condenser to gel rid of heat extracted from the interior of the unit to the outside air. Condensers are used in air conditioning and industrial chemical processes. Such as distillation, steam power plants, and other heat-exchange systems. The use of cooling water or surrounding air as the coolant is common in many condensers. In the condenser the latent heat of condensation is conducted to the cooling medium flowing through the cooling tubes. Desiccant wheel system, the latent load deals by the system is 27.56% of total load. Desiccants can be solids or liquids and can hold moisture through adsorption or absorption. The desiccant dehumidifier wheel removes the moisture from the process air and the heat of adsorption gets decreased in the process air, thereby increasing the temperature of the process air leaving the desiccant wheel.

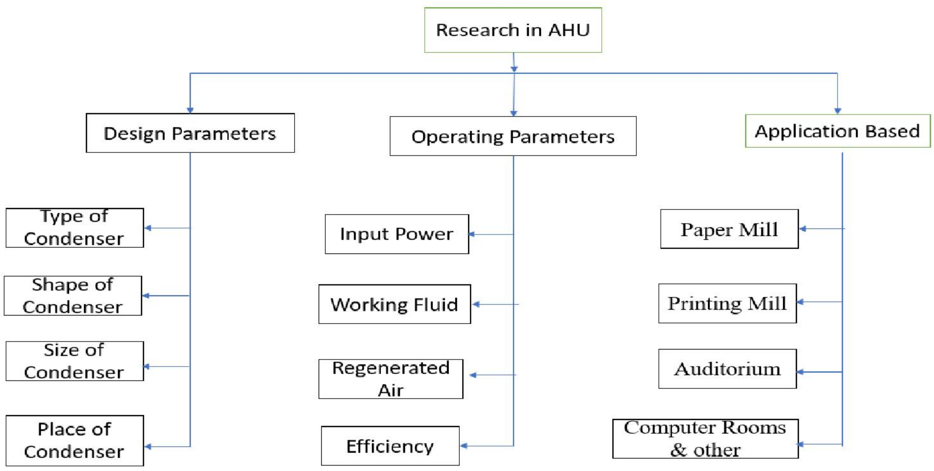

Fig.no 1 Research on AHU

II. METHOD AND MATERIALS

The very first step is gathering data on the desiccant wheel, hybrid air conditioning system, and vapour compression refrigeration system. In this, we examine the various components' theoretical and operational concepts.

The work is broken down into many steps in this project, including the design and modification of the test ring, performance testing of the redesigned system under various indoor and outdoor situations, and comparison of the results with and without the desiccant wheel.

The technology we employ while working includes the ones listed below:

I. Air-Conditioning Technology: To perform the thermodynamic analysis, the scientific disciplines of psychometric and cooling load estimation are used.

II. Manufacturing Technology: Various manufacturing techniques and equipment utilised in the construction of refrigeration and air conditioning systems will be employed to create the system.

III. DESCRIPTION OF THE TEST APPARATUS

This AHU consists of different apparatus to perform different functions. They are described below

Desiccant wheel:

The desiccant wheel may absorb and adsorb moisture from the air since it is constructed of hygroscopic material.

It is positioned before the evaporator in the suction duct and after the condenser in the return duct, and it is placed between the two ducts.

The process of suction duct moisture absorption ensures that the evaporator only handles reasonable loads, and the process of return duct adsorption ensures that the moisture present in the desiccant wheel is eliminated.

To absorb and adsorb the moisture content of the air, the desiccant wheel spins at a rate of 20 RPH.

Process Blower:

As the name implies, it works. This blower is fitted after the evaporator for transferring the cooled air to the artificial room where load is given. While going through this process there is suction in the evaporator outlet duct and due to which the atmospheric air get sucked forcefully because of Low pressure head i.e. vacuum. The process blower which we used for our system is of 500cfm

Regeneration Blower:

Regeneration blower is used to regenerate air for desiccant wheel, as the name suggests. After the condenser, where hot air is removed and provided to the desiccant regeneration section for moisture adsorption, the regeneration blower is installed. As a result, we deduct the power load needed to heat the air before to the desiccant wheel in the return duct for the regeneration process. The regeneration blower has a 300 CFM capacity, which is more than enough for regeneration.

Damper:

To adjust the mass flow rate of air at various locations within this test rig in accordance with requirements, a total of 7 dampers have been placed. The first damper, which controls the mass flow rate of the process air, is located at the suction duct just before the desiccant wheel. For the purpose of cooling the condenser, a second damper is installed at the Recirculation port, through which the recirculated air from the artificial chamber passes. A third damper is furthermore installed in the recirculation port for condenser cooling, where the condenser is cooled by ambient air. The return duct where the regenerated air is discharged into the atmosphere has a fourth damper installed at the desiccant will output. Fifth damper installed at recirculation duct where mass flow rate is measured

Ducts:

There are 4 ducts are present this test ring for various purpose at various location.

- Suction Duct: It is an entrance of the fresh air and it sucked or inhaled by the Process Blower.
- Return Duct: In this Duct used for air, air is throwing out of the system to the atmosphere.
- Recirculating Duct: In this duct, air is reused to save or reduce work on cooling coil.
- Flexible Duct: These flexible ducts are installed on the blower. Because of its flexibility it can installed anywhere of the system for taking to air.

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Cooling Coil:

This is a conventional cooling coil it also known as evaporator. The conventional cooling coil is situated at suction duct. And its location is next to the desiccant wheel which is ahead of the process blower suction side. It is use for cooling of the air which is going to artificial room through process blower to achieve required cooled environment inside the room which has Cooling capacity 2TR.

Condenser:

This is also conventional condenser coil which is use for condensate the refrigerant or shifting the boiling point of refrigerant. Condenser is situated in the return duct which is before the suction side of the regeneration blower. After onwards the hot air from the condenser is used for the heat recovery for desiccant wheel through flexible duct.

Heating Coils:

Heating coil are installed at various location for generating artificial climatic conditions. It Is placed in exact entrance of air in suction duct and second is placed at return duct between the desiccant and outlet of regeneration blower for heating the air if needed. Last heating coil is placed inside the artificial room for maintaining the required temperature as per the condition required.

Artificial Room:

In this room we are tested various climate condition and combination with temperature and humidity. The artificial room located at exact Right side of system. This room is used for producing the different climatic conditions as per the requirement such as high humid climate, high temperature and others.

Control Panel:

There are total two control panel in the system which is used to control the different equipment's of the system such as blower's, refrigeration unit, heaters, humidifiers, sensors. The control panel consist of energy meters to monitor the actual accurate energy consumptions of different equipment's so that we get exact power consumption of the system.

IV. INSTRUMENTATION

The various measurements are taken in this system such as, Temperature, Velocity, Relative humidity and Power consumption.

Relative humidity measurement (sample) The relative humidity measure at various location to be as follows.

- Before and after of the desiccant wheel.
- Inlet and outlet of the evaporator.
- Inlet and outlet of the condenser.
- In the artificial room.
- To measure the relative humidity RHT sensor is used this is precise about +-0.1 accuracy.

Temperature measurement(sample):

The temperature measure at various location to be as follows.

- Before and after of the desiccant wheel.
- Inlet and outlet of the evaporator.
- Inlet and outlet of the condenser.
- In the artificial room.
- To measure this temperature RHT sensor is used this is precise about +-0.1 accuracy.

Velocity Measurement (sample):

For measuring velocity at various location to be as follows.

- Before and after of the desiccant wheel.
- Inlet and outlet of the evaporator.
- Inlet and outlet of the condenser.
- In the artificial room.
- For measuring velocity Anemometer is used.
- This sensor is precise for checking velocity

Power Consumption Measurement (sample):

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- Regeneration blower
- Process blower
- Compressor
- Desiccant wheel
- Heating coils
- To indicate energy consumption above components we use energy meters these are about 0.1 accuracy.

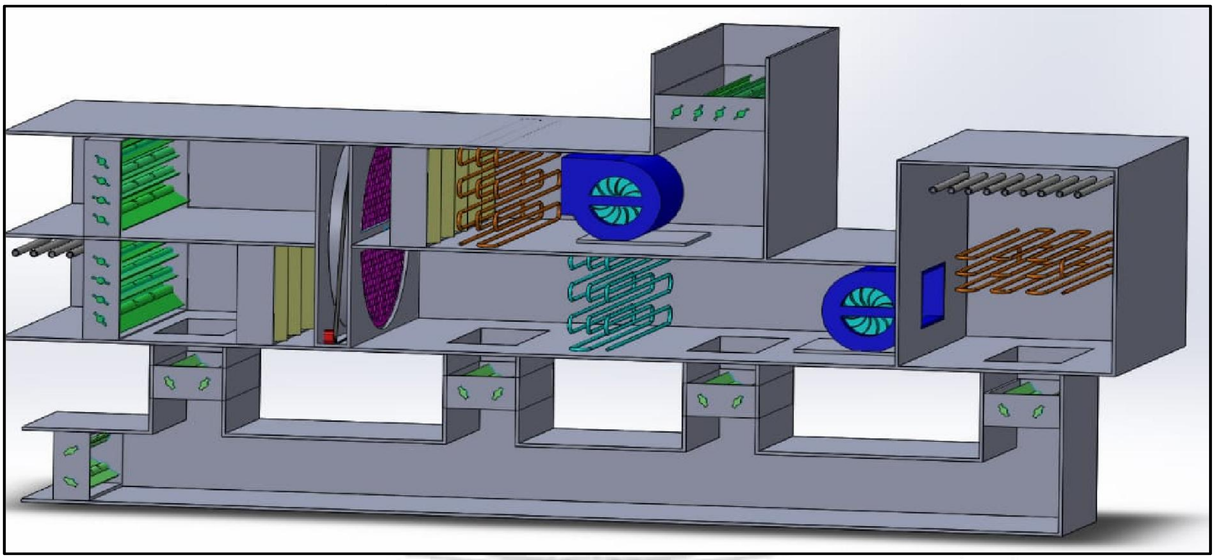
Pressure measurement (sample):

- DP sensor is used to Measure the pressure in artificial room with respective atmosphere.
- DP sensor module are very precise to measure the Differential pressure.
- For monitoring pressure, we use combination of digital display with DP sensor.

V. EXPERIMENTAL SET UP

Desiccant Hybrid Air Handling Unit performance is being investigated using an experimental setup for a variety of operating conditions (both indoor and outdoor), including high humidity, high humidity, and high temperature locations, locations requiring 100% fresh and pure air, and locations requiring recirculated air. Air is dehumidified when it passes through the bottom half of the desiccant wheel after entering the suction duct from damper 1. The air is then heated and dehumidified before entering the evaporator coil, where it is sensibly cooled to lower its temperature. Air from the evaporator coil is drawn in by the process blower and sent into the room via the flexible duct. According to the load (sensible and latent load) qualities inside the space

Development of project setup/model (MODEL OF PROTOTYPE): -



Working of Hybrid Air Conditioning system: Experimental setup was design for investigating the performance of Desiccant Hybrid Air Conditioning System for various operating conditions (indoor and outdoor condition) like high humid places, high humid and high temperature places, the places where 100% fresh and pure air is required and where the recirculated air is required. When the air enters the suction duct from damper no.1 then it moves through the lower part of the desiccant wheel where the dehumidification of air occurs. After onwards the heated and dehumidified air enters the evaporator coil where its temperature is reduced by sensible cooling. The process blower sucks the air from the evaporator coil and passes into the room through the flexible duct. Inside the room as per load (sensible and latent load) properties of air changes which include temperature and humidity this can be maintained by heaters and humidifiers. Then the air from the room is divided into two streams which can be controlled by the dampers as per the requirement. The first requirement is to pass the air from the room to the condenser for the regeneration process which effectively cools the condenser, further the air is sucked by the regeneration blower. The hot air (suck form condenser) by regeneration blower is forced over the upper size of the desiccant wheel (which is rotating) after that hot and humid air (carried by the desiccant wheel) from process air leaves to the atmosphere. The second requirement is to pass the air from the room to the recirculation duct. The recirculation of air is controlled by damper no 6. The recirculation of air can be done in two ways to the system. The first one is by damper no.7 which opens the passage for recirculated air before the desiccant wheel and the second one is through damper no 6 which supply their recirculated air directly to the evaporator inlet (as a conventional air conditioning system). These two processes are carried out for achieving the various indoor and outdoor conditions required according to different climatic conditions and applications. Generally, the different conditionings like high latent heat places, high humid and high-temperature places and for the application where 100% fresh air is required and for where recirculated of air is required. These conditions are perfectly and efficiently with less consumption of power is achieved by this system

VI. DATA REDUCTION

The data analysis procedure determines the specific percentages reduction in specific power consumption with condenser heat recovery. Also, the data analysis determines the correlation between performance parameter, power input and percentage reduction in specific power consumption. The following is brief description of the data-reduction equation.

% reduction in (KW/TR) = [(KW/TR) WD - (KW/TR) D] / (KW/TR) WD) *100_ _ _ _ _ _ _ _ (1)

CALULATIING THE (KW/TR) For both conditions i.e. for with desiccant wheel and without desiccant wheel.

(KW/TR) = WI / TR_ (2)

Where, WI=WR + WP + WC_ _ _ _ _ _ (without desiccant) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ (3)

WI = WR +WP +WC+ WD) _ _ _ _ (with desiccant) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _(4)

TR =QL/3.517_ (5)

Coefficient of performance, COP can be calculated as follows

COP = QL/WI_ (6)

Cooling capacity can be calculated as follows

QL= mà (hi -ho) _ (7)

QL = mà (hi-h1) _ (8)

Where , mà = ρ*A*V _ (9)

ρ – Density of flowing fluid.

A – Area of Duct.

V – Average velocity of flowing fluid.

QH = mr *cp*(Tco - Tci) KW _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ (10)

Calculating Heat Rejection Factor QH/QL _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ (11)

Experimental Validation: -

Comparative study of with desiccant assisted AHU and without desiccant assisted AHU for various air flow combinations.

Desiccant Wheel		**ON**					**OFF**			
Damper	D1	100	70	50	30		100	70	50	30
	D7	0	30	50	70		0	30	50	70
Before Desiccant Wheel	T1	29.8	31.5	34.6	35.2		31.4	33.1	34.4	34.4
	RH1	53.9	48.8	40.9	40.8		53.8	49.9	46	45.8
Evaporator inlet	TE1	45.3	47.6	32.5	31.7		33.8	30.9	29.5	27.6
	RH_TE1	14.9	13.8	35	37.9		46.1	47.1	48.8	49.8
Evaporator Outlet	TE2	27.9	26	21.3	19.1		23.1	20.5	20.5	20.5
	RH_TE2	60	61.8	68.9	71.9		90.4	85.4	85.2	85.5
Condenser Inlet	TC1	38.4	35.7	31.8	31.2		30	28.3	28.6	28.8
	RH_TC1	60	62.2	49.8	43.9		52.3	55.5	55.2	56.7
Condenser	TC2	50.3	64.6	67.3	67.8		62.2	65.8	66.9	69.8

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Outlet	RH_TC2	13.5	9.2	8.7	7.7		10.8	8.5	8.4	8.2
Room	T3	35.3	32.6	28.2	26.4		29.4	26.6	27.1	28.6
	RH3	55	58.4	54.2	52		55.2	52.3	55.1	56.3
WORK INPUT	Compressor	1	1	1	1		1.08	1.08	1.08	1.08
	Regenerati -on Blower	0.18	0.18	0.18	0.18		0.2	0.2	0.2	0.2
	Process Blower	0.6	0.6	0.6	0.6		0.63	0.63	0.63	0.63
	Desiccant Wheel	0.05	0.05	0.05	0.05		0	0	0	0
Cooling Capacity (QL)		5.08	8.49	7.23	10.48		5.655	6.804	7.192	6.722
COP		3.08	4.63	3.95	6.02		2.96	3.56	3.76	4.02
TR		1.44	2.14	2.05	3.25		1.60	1.93	2.04	1.91
Power Consumpti -on		0.696	0.595	0.779	0.880		1.187	0.987	0.933	0.999

VII. RESULTS AND DISCUSSION

Effect on performance of AHU with and without desiccant wheel for air combination of 100% atmospheric air to the condenser.

BLOCK DIAGRAM

TEST RESULTS

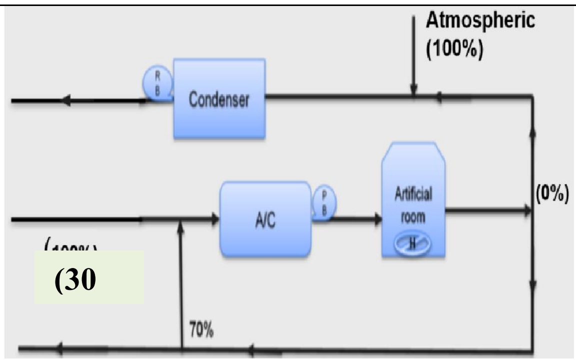

Fig. A) 100 % atmospheric air for condenser without desiccant

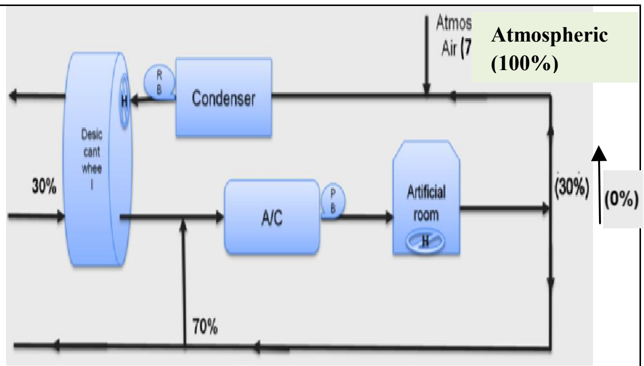

Fig. B) 100% atmospheric air for condenser with desiccant

Desiccant Wheel	Climatic conditions T (*C)	Indoor RH (%)	Supplied air to condenser atmospheric: recirculated	QL (kW)	WI (kW)	COP	kW/TR	QH (KW)	QH/QL
ON	**25**	**40**	**100%: 0%**	**28**	**3.89**	**4.29**	**0.65**	**9.86**	**0.35**
	30	**50.5**	**100%: 0%**	**29.5**	**4.00**	**3.76**	**0.75**	**10.02**	**0.33**
OFF	**26.5**	**38.5**	**100%:0%**	**19.95**	**4.51**	**3.42**	**0.99**	**13.76**	**0.68**
	32	**55.7**	**100%: 0%**	**18.2**	**4.78**	**3.1**	**1.2**	**14.00**	**0.76**

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Effect on performance of AHU with and without desiccant for air combination of 70% atmospheric and 30% recirculated air to the condenser

BLOCK DIAGRAM

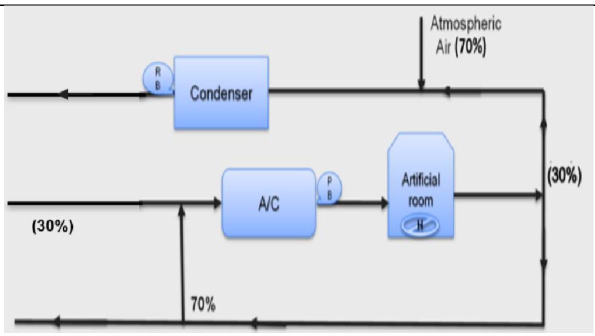


Fig .a) 70-30% of air for condenser without desiccant

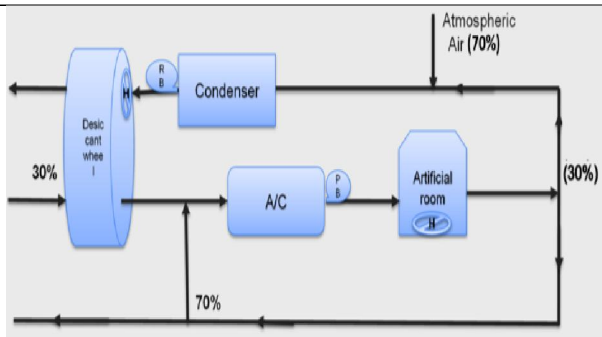
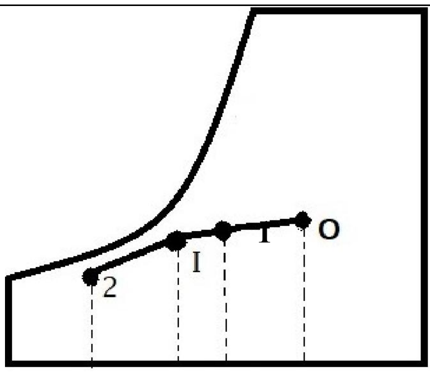


Fig. b) 70-30 % of air for condenser with desiccant

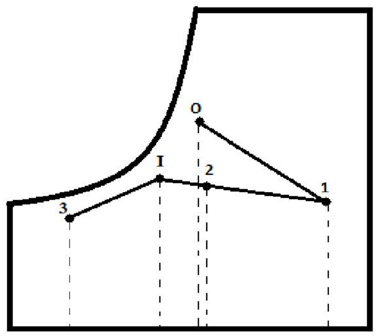
TEST RESULTS

Desiccant Wheel	Climatic Indoor conditions T (*C)	RH (%)	Supplied air to condenser atmospheric : recirculated	QL (kW)	WI (kW)	COP	kW/TR	QH (KW)	QH/QL
ON	**25.5**	**34.3**	**70%: 30%**	**30.05**	**3.65**	**7.89**	**0.39**	**9.15**	**0.32**
	31	**52.2**	**70%: 30%**	**32.60**	**3.82**	**8.27**	**0.37**	**9.5**	**0.29**
OFF	**27.7**	**33.5**	**70%: 30%**	**20.05**	**4**	**4.29**	**0.91**	**13**	**0.65**
	34.3	**54.5**	**70%: 30%**	**18.22**	**4.2**	**3.89**	**0.77**	**13.2**	**0.72**

Psychometric process: -



Psychometric Process recirculated air with desiccant wheel



Psychometric Process recirculated air with desiccant wheel

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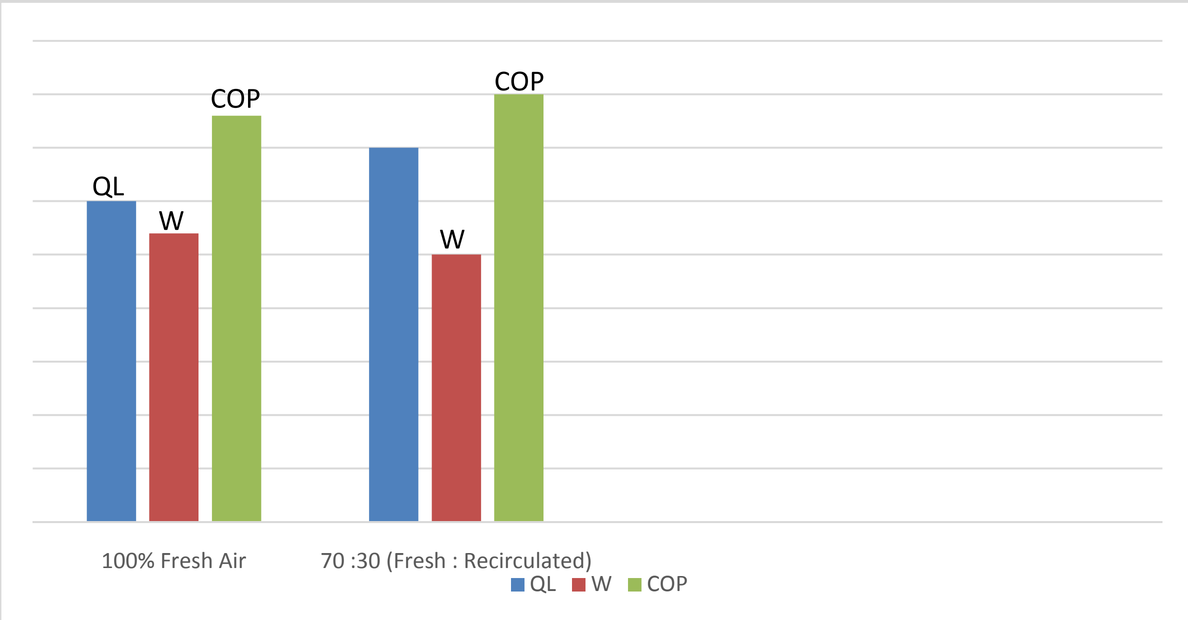
From psychometric chart process (0~1) shows that outside air enters the system having humidity and some temperature. Process (1~2) shows dehumidification and heating. As during dehumidification process there is some rise in temperature of air. When the desiccant wheel is OFF, the evaporator must handle both sensible as well as latent load. When DPT at cooling coil< DPT at 2 then process (2~3) takes place i.e cooling and dehumidification. When the desiccant wheel is ON, the evaporator must handle only sensible load and due this compressor work is reduced and requires less energy. When DPT at cooling coil > DPT at 2 but less than DBT of air at 2 then the process (2~3') takes place. i.e sensible cooling. The process (2~3) and (2~3') show heating and humidification inside the condenser when desiccant wheel is OFF and ON respectively.

Graphical Representation: -

The comparative graphical representation of both combinations (100% fresh air and 70%:30%(Fresh: recirculated air)) with comparing its COP, work input(WI) and Colling Capacity (QL) as shown below



Nomenclature (Sample): -

ρ Density of the fluid
A Area of duct
V Velocity of air
ma Mass flow rate
Hi Indoor enthalpy
ho Outdoor enthalpy
ha Evaporator outlet enthalpy
QL Cooling capacity
WI Total Work Input
WP Work input by Process blower
WR Work input by Regeneration blower
WC Work input by Compressor blower
TR Tons of Refrigeration AHU Air Handling Unit
COP Coefficient of performance
KW/TR Specific power consumption of the system (KW/TR)
D Specific power consumption of the system with desiccant wheel (KW/TR)
WD Specific power consumption of the system without desiccant wheel

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Tci Condenser Inlet Temperature
Tco Condenser Outlet Temperature

VIII. CONCLUSION

In order to increase occupant comfort, air conditioning involves eliminating heat and moisture from inside an occupied room. Desiccant wheels, which remove moisture from latent loads with little energy input, can be used to minimise this usage. When a hybrid air conditioning system uses a desiccant wheel and a traditional cooling coil, the energy input is reduced. Investigating the condenser's performance in a hybrid air conditioning system using various cooling methods.

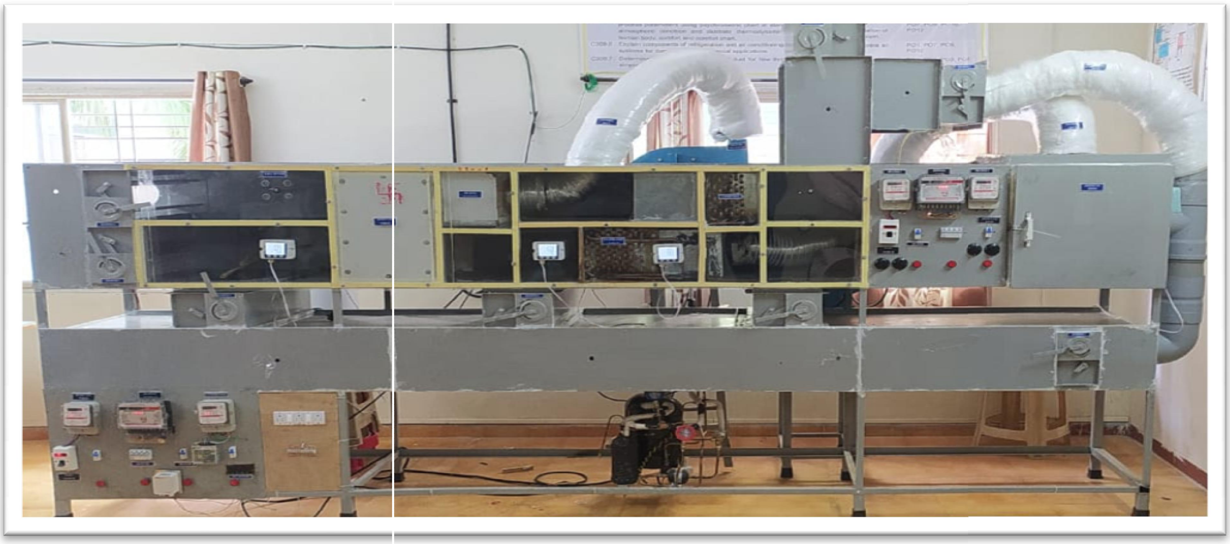
We test numerous combinations to see in which condenser performs best in order to determine the effectiveness of adjusting condenser cooling temperature medium. Following are some combinations:

1) 70% atmospheric and 30% recycled air to condenser. 2) 100% atmospheric air to the condenser, or 100%-0%.

We found that the system operates more effectively when the ratio is 70% to 30%. In this procedure, 30% of the cooled air is returned to the condenser to prevent overheating. Here, we can reduce our HVAC energy use by 25%.

Hybrid Ahu systems use dehumidification and heat regeneration techniques, which reduce power usage by 50% when compared to traditional air-conditioning systems.

Actual Setup: -



REFERENCES

[1] Hybrid desiccant cooling systems in supermarket applications, ASHRAE Trans 91 (Part-1B) (1985) 457–468. P.R. Burns, J.W. Mitchell, and W.A. Beckman.

[2] J. Singh, Desiccant cooling: growing potential and desiccant cooling systems. Arctic India Engineering.

Hybrid desiccant cooling systems in supermarket applications, ASHRAE Trans 91 (Part-1B) (1985) 457–468. P.R. Burns, J.W. Mitchell, and W.A. Beckman.

[4] P.L. Dhar, S. Jain, Assessment of solid desiccant-based evaporative cooling cycles for typical hot and humid regions, International Journal of Refrigeration, 18 (5) (1995), 287-96. Jain and co.

[5] The possibility for solar powered single stage desiccant cooling in southern Europe is discussed in [5] P. Mavroudaki, C.B. Beggs, P.A. Sleigh, and S.P. Haliday. 22 Applied Thermal Engineering 1129–1140 (2002).

[6] Jia, C.X., Wang, R.Z., Dai, Y.J., and Wu, J.Y. A hybrid desiccant air conditioning system analysis. Application Therm Engineering 2006, 26, 2393-2400. (Cross Ref)

[8] Walke PV, Tidke DJ, Rambhad KS. Review of solid desiccant dehumidification and regeneration techniques. (2016) Renew Sustain Energy Rev, 59:73–83.

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[9] Experimental examination of dehumidification performance of an evaporative cooling-assisted internally cooled liquid desiccant dehumidifier, Beom-Jun Kim, Soo-Yeol Yoon, Yoo-Suk Byon, and Jae-Weon Jeong, Applied Energy, 235, 177-185, (2019).

[10] Integration of solar aided solid desiccant cooling system with effective evaporative cooling approach for separate load handling, Ghulam Qadar Chaudhary, Muzaffar Ali, Nadeem Ahmed Sheikh, Syed Ihtshamul Haq Gilani, and Shahab Khushboo, Applied Thermal Engineering, 140 696-706, (2018).

[11] GRI, "Dehumidification-A Major Opportunity for Natural Gas," December 1992. The Gas Research Institute in Chicago has a technology focus.