EXPERIMENTAL INVESTIGATION ON SOLID DESICCANT – VAPOUR COMPRESSION HYBRID AIR-CONDITIONING SYSTEM USING SOLAR ENERGY

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Index

Table of Contents

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Abstract

Solid desiccant–vapour compression hybrid air-conditioning systems are considered as promising alternative to the conventional air conditioning systems because of the independent control of temperature and humidity and being environment friendly. Use of renewable solar energy can be a good source for regeneration heat provided in reactivating desiccant dehumidifier used in alternate cooling systems. Desiccant dehumidification assisted vapour compression-based hybrid air-conditioning systems can successfully couple to renewable solar thermal power to dampen electricity use and to conserve environment in place of traditional air-conditioning.

In the present research work, experimental investigation on solid desiccant vapour compression hybrid air-conditioning system using solar energy has been experimentally carried out for hot and humid weather of Vadodara. A test room having dimensions 3.5m × 3m × 2.6m has been selected for the study. The sensible and latent cooling loads are 2.3 kW and 0.6 kW respectively. The indoor comfort condition is taken as 50% RH and 26°C DBT. In this experimental studies desiccant wheel speed was kept constant at 20 revolution per hour. Process air flow rate were varying as 0.10 kg/sec, 0.12 kg/sec and 0.16 kg/sec and regeneration air flow rate was kept constant at 0.08 kg/sec. Regeneration air temperature were kept as 60 ℃, 80 ℃ and 100 ℃ during the experimental studies of the system regenerated by conventional air heater and between 48 ℃ to 69 ℃ during the experimental studies of the system regenerated by solar energy depending on solar intensity.

The overall system performance has been evaluated for a cooling season from September to October on the basis of various outdoor conditions. The results show that the performance of the system is significantly affected by variations in ambient temperature and humidity ratio. It is found that by increasing the process air flowrate adsorption rate, desiccant wheel effectiveness and COP of the system have been decreased. Hybrid solid desiccant-vapour compression air conditioning system assisted by solar energy is found more effective than the stand-alone conventional air conditioning system and hybrid system regenerated by conventional air heater for hot and humid climatic conditions. It is also found by TRNSYS simulation that Evacuated Tube Solar Collector can achieved regeneration temperature to regenerate Desiccant Wheel throughout year. The results also show that solar assisted solid desiccant – vapour compression hybrid air conditioning system is having better cooling performance as well as energy saving potential than conventional air conditioning system.

A brief description of the state of the art of the research topic

With the rapid development of economy and society, our modern life and industry consume large amounts of energy for cooling. The energy required for space cooling and air conditioning is estimated between 30-40% of total energy use. The maximum load on the electricity grid rises in hot and summer days, because of huge cooling requirements. The majority of building cooling can be accomplished by the electric-driven conventional vapor compression air-conditioners. Traditional VCR systems are found good at meeting sensible loads. But, when the sensible heat ratio (SHR) of air very low i.e., less than 75%, the conventional vapor-compression based air-conditioners are proven to be ineffective to meet latent load of cooling air [1].

In order to separates out moisture from the air to be conditioned, the air must be cooled below its dew point temperature; it is the temperature at which the water vapor in air condenses out on the evaporator cooling coil. Due to this in some cases, the air becomes excessively colder than the designed room supply temperature dictated by the room comfort. Depending on the system configuration, additional energy supply may be needed to reheat this overcooled air to rise its temperature up to the comfort supply room air temperature. Moreover, the coefficient of performance (COP) of vapor compression systems is found substantially lower to meet the above situation. So, the traditional air conditioners are found inefficient in the sufficient moisture removal due to overcooling the building or undue re-heating costs.

The solutions to this dehumidification problem have already been found out earlier in number of ways but all they generally pay a penalty for lower performance or efficiency, increased fan power, larger size, significant supplementary energy, or a combination of these. Now a days an innovative approach in the field of space cooling application has been introduced as a hybrid Solid desiccant and vapour compression refrigeration system to overcome environment and economics issue due to maximum use of standalone vapour compression air conditioning system. Solar thermal energy is feasible to reduce electrical power in hybrid air-conditioning system which can improves indoor room environment. In hybrid cooling, optimal air-conditioning would result as vapor-compression system performs only cooling operations while desiccant dehumidification system takes care of humidity control. Thus, in desiccant assisted hybrid cooling system both sensible and latent loads are handled separately and effectively. So, the desiccant-based hybrid cooling can control temperature and humidity of cooling air independently.

This type of hybrid cooling neglects the requirement of low dew point temperature of evaporator cooling coil and subsequently post-reheating in vapour compression refrigeration cooling unit. It also alleviates the condensation of air while cooling when outdoor humidity rises. Its operating costs saved substantially by the use of freely available solar energy for regenerating the desiccant wheel. The greatest cooling requirement in building during the summer season is also associated with availability of intense solar radiation provides an excellent opportunity to use of freely available renewable solar energy to integrate with desiccant based hybrid air-conditioning. Thus, desiccant assisted space cooling can meet the demands of thermal comfort, economy, energy conservation and environmental protection.

The desiccant dehumidification is divided basically into two types according to the type of desiccant material used i.e., solid desiccants or liquid desiccants. The most common use of the solid desiccants is in the rotary desiccant dehumidifier i.e., desiccant wheel. In solid desiccant cooling, incoming process air stream is dehumidified by forcing it through a desiccant material. To make system working continually, the water vapor adsorbed by desiccant material should be driven out by heating the desiccant material to its regeneration temperature which is dependent upon the nature of the desiccant used.

Solid desiccant cooling systems have been studied earlier by many researchers. One of the earliest comprehensive studies has been carried out by Sheridan and Mitchell [2]. They simulated the performance of the desiccant cooling system for hot and humid climate and found considerable energy savings as compared to conventional VCR cooling system. Worek and Moon [3] numerically modelled a hybrid air-conditioning system which integrates the solid desiccant dehumidifier with traditional VCR cooling system. The performance of hybrid cooling system was predicted by use of simulations and compared the same with the conventional VCR system and it is found to be better in a case when ambient humidity is high [4]. Further, the same authors have carried out experimental work on solid desiccant-based hybrid air-conditioning system [5]. It is shown that there is a significant improvement in COP in case of desiccant based hybrid air conditioning system as compared to traditional HVAC systems when the latent load is high. Sheng et al. [6] investigated the performance of hybrid desiccant cooling system coupled to heat pump system. It is found that the hybrid system requires lower temperature of heat source for regenerating the desiccant wheel. Moreover, the integrated heat pump and desiccant system can provide effective control of humidity and simultaneously improves energy efficiency. Suitability of the solid desiccant cooling to supplement the traditional VCR system was studied for hot and humid climate [07–11]. It is found that the substantial reduction in the size of the conventional vapor compression unit by effective reduction in the humidity ratio of incoming process air for the same capacity.

Definition of the Problem

Current research is an attempt to "Experimental Investigation on Solid Desiccant – Vapour Compression Hybrid Air Conditioning System using Solar Energy". In this research work hybrid air conditioning system is investigated to evaluate system performance in terms of adsorption rate, desiccant wheel effectiveness and COP. The main attempt for performance analysis of hybrid system is to find out optimize process air flow rate and regeneration air temperature that could enhance performance of the system. Hybrid system is regenerated by conventional air heater and solar energy for comparative study of energy saving performance.

Objective and Scope of work

After carrying out a detailed literature study and understanding the background of opportunities for research on solid desiccant - vapor compression hybrid air-conditioning system using solar energy, the following research objectives and scope of work have been considered as the main focus of the present study.

Research Objectives

Following are the objectives of the present research work:

- To prepare experimental setup for investigation on solid desiccant - vapour compression hybrid air-conditioning system using solar energy.
- To carry out experimental investigation on solid desiccant – vapour compression hybrid air-conditioning system regenerated by solar energy and conventional air heater.
- To conduct experiments in order to evaluate the system performance in terms of COP at various ambient conditions as well as for variations in different operating parameters such as process air flow rate and regeneration air temperature.
- To compare the system results with conventional air heater and solar energy as a regeneration heat source.
- TRNSYS simulation model for evacuated tube solar collector to find out the feasibility of solar energy as a regeneration heat source.

Scope of work

- The following extent of research can be drawn from the study:
- Determine viability and energy saving potential in solid desiccant – vapour compression hybrid air conditioning system using solar energy.
- Comparative study of solid desiccant – vapour compression hybrid air conditioning system regenerated by conventional air heater and evacuated tube solar collector for the energy saving.
- Investigation of the system by varying parameters like process air flow rate and regeneration air temperature.
- Prediction of evacuated tube solar collector as a regeneration heat source using TRNSYS simulation.

Original contribution by the thesis

The research works carried out as part of the thesis are presented in six chapters with reference section at the end. The present research work includes experimental investigation and energy performance of solid desiccant – vapour compression hybrid air conditioning system using solar energy. TRNSYS simulation of evacuated tube solar collector has been also included.

Chapter 1 briefs about the need for developing an alternate cooling technique, desiccant cooling, basic principle of desiccant cooling system, classification, application, hybrid solid desiccant and vapour compression air conditioning and solar energy.

Chapter 2 outlines the detailed literature review on solid desiccant – vapour compression hybrid air conditioning system regenerated by conventional air heater and solar energy which includes mathematical, simulation and experimental. At the end of the chapter, scope and objectives are described.

Chapter 3 presents the detailed experimental setup to investigate the performance of solid desiccant vapor compression hybrid air conditioning system using solar energy for hot and humid climatic conditions of Vadodara. At the end of the chapter, performance parameters and uncertainty analysis are described.

Chapter 4 presents the results and discussion by experimental investigation on solid desiccant vapor compression hybrid air conditioning system using solar energy in terms of adsorption rate, desiccant wheel effectiveness and COP at various ambient conditions as well as for variations in different operating parameters such as process air flow rate and regeneration air temperature. At the end of the chapter, validation of results and energy performance are described.

Chapter 5 discusses about the performance assessment of evacuated tube solar collector using TRNSYS simulation.

Chapter 6 elucidates the summary and important conclusions arrived from the study and scope for further research is also discussed.

Methodology of Research, Results / Comparisons

Research Methodology

The above-mentioned objectives are achieved by means of experimental investigation subparts are experimental setup preparation, performance parameters, uncertainty analysis and simulation of evacuated tube solar collector using TRNSYS simulation software. Detailed discussion on the methodology adopted and the results obtained from the research work are explained in the following sections.

Experimental Setup

An experimental set up for the solid desiccant - vapour compression hybrid air-conditioning system using solar energy was designed, fabricated and installed at Parul Institute of Technology, Parul University, Vadodara, Gujarat, India having a latitude of 22.2887° N, 73.3634° E. The setup consists of a rotary solid desiccant wheel, process air side duct, regeneration air side duct, conventional vapor compression air conditioning system, conventional plate type air heater, liquid to air heat exchanger, solar evacuated tube collector and measuring devices.

From process air duct return room air stream at state 1 passes through the rotary solid desiccant wheel as a process air side. Moisture from the process air is absorbed by rotating solid desiccant wheel because of the difference between partial pressure of moisture in the air and that in desiccant material. Thus, a warm and dry air stream exits the dehumidifier at state 2. An air conditioning system runs on a conventional vapor compression refrigeration system reduces the temperature of process air to state 3 without affecting its humidity ratio. At the regeneration side, ambient air at state 4 first passes through a liquid to air heating radiator and conventional heater. The ambient air is heated by a radiator using solar energy and also has an option for heating by a plate-type conventional heater to a required regeneration temperature at state 5. At last, hot regeneration air extracts humidity from the desiccant wheel and exits to ambient at state point 6. After regenerating the desiccant wheel, the air is finally exhausted to the atmosphere by an exhaust fan. A schematic diagram of a solid-desiccant vapour-compression hybrid air-conditioning system using solar energy has been illustrated in Fig. 1.

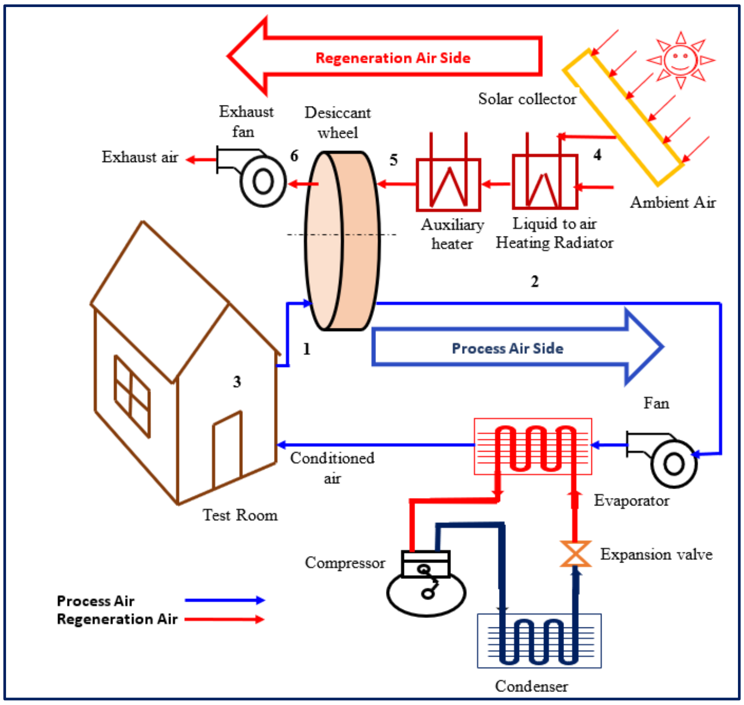

Figure 1 Schematic diagram of Experimental setup

A test room having dimensions 3.5m × 3m × 2.6m has been selected for the study. The sensible and latent cooling loads are 2.3 kW and 0.6 kW respectively [12]. The indoor comfort condition is taken as 50% RH and 26°C DBT. The temperature and relative humidity in the system are measured by hygrometers and thermocouples. Process air side and regeneration air side flow rate are measured by air velocity transmitter while solar radiation is measure by solarimeter.

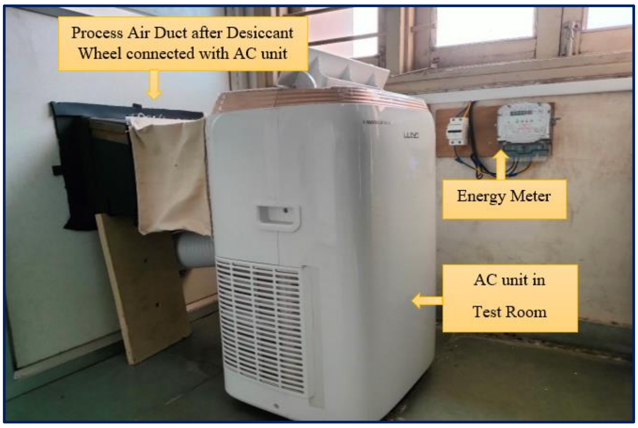

Figure 2 Photographic view of Test Room

The experimental runs are carried out for the cooling period of September to October, 2021 for the changing outdoor conditions i.e., at various ambient temperatures and humidity ratios. The experimentation covers the impact of operating parameters such as flow rate and regeneration air temperature on system performance. The photographic views of test room, experimental setup room and evacuated tube solar collector have been shown in Fig.2, Fig.3 and Fig.4 respectively.

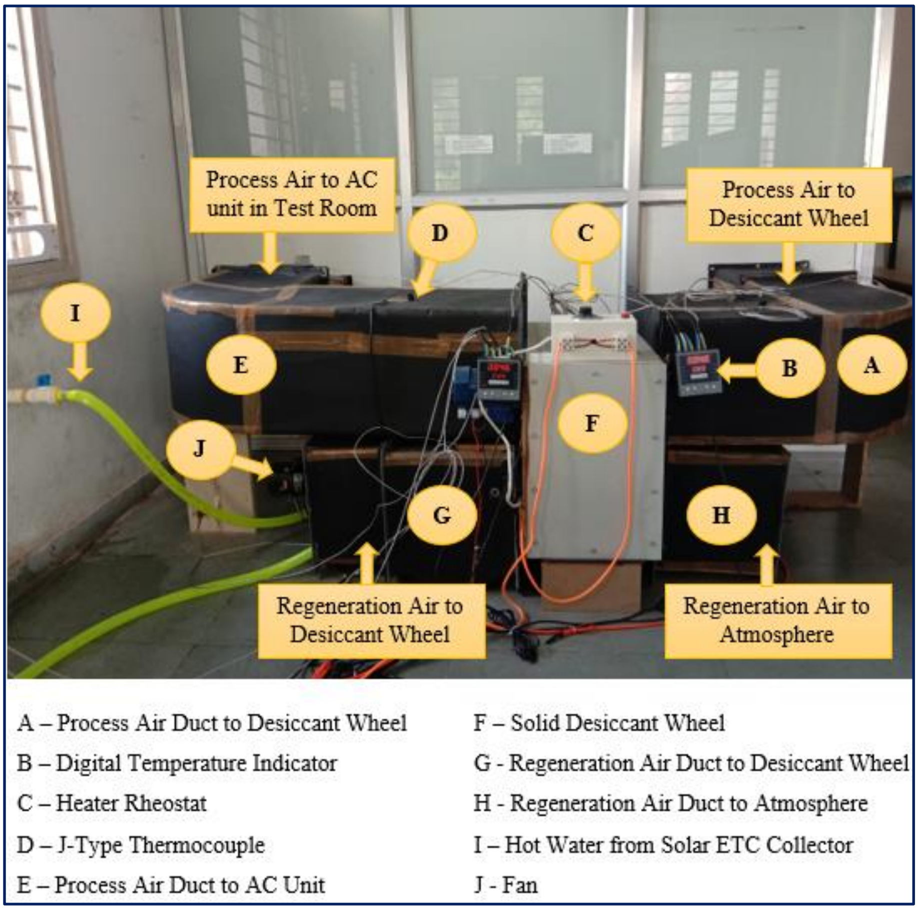

Figure 3 Photographic view of Experimental Setup Room

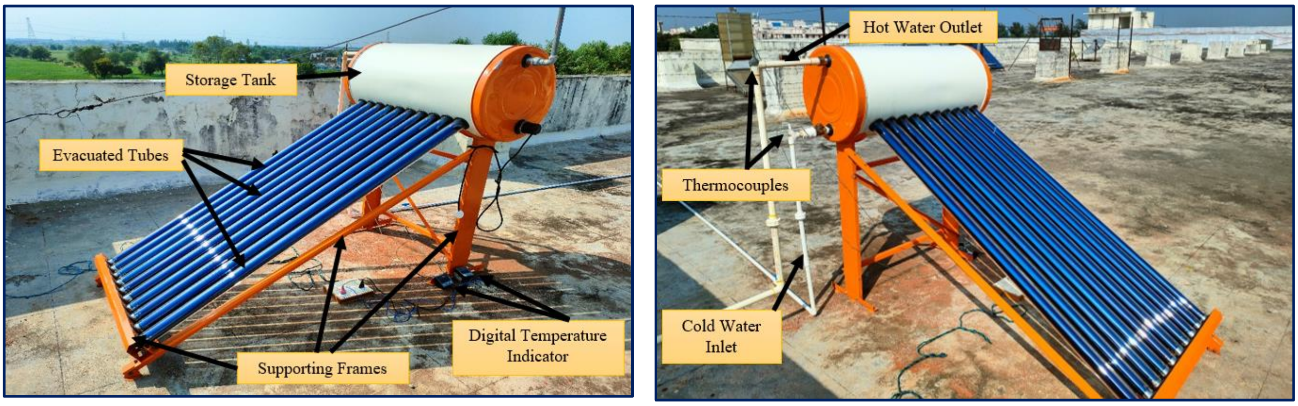

Figure 4 Photographic view of Solar Evacuated Tube Collector

Uncertainty Analysis

Accurate measurement of physical quantities is very difficult. Uncertainties due to instrumental, physical and human inadequacies are always present in measuring any physical quantity [13]. For the calculation of uncertainty analysis Klein's Method is used and can be expressed as [14].

$$w_r = \left[\left(\frac{\partial R}{\partial x_1} w_1\right)^2 + \left(\frac{\partial R}{\partial x_1} w_1\right)^2 + \cdots \ldots \ldots \ldots + \left(\frac{\partial R}{\partial x_1} w_1\right)^2\right]^{\frac{1}{2}} \quad (1)$$

Here R is a given function of the independent variables x1, x2 ....,xn and w1, w2,.....,wn are the uncertainties in the corresponding variables.

The inaccuracies in measurement of temperature, relative humidity and flow rate are ± 0.1 °C, ± 2% and ± 2% respectively. The maximum uncertainty associated with the adsorption rate and coefficient of performance are found to be ±5.49% and ±6.80% respectively.

Simulation of Solar Evacuated Tube Collector using TRNSYS

For the simulation of evacuated tube solar collector TRNSYS transient energy system simulation software was used [15]. Simulation studio project has been developed to perform simulations of the system as shown in Fig.5. Simulation results were obtained January to December. Input of the TRNSYS model included the yearly weather data files for the Vadodara, water flow rate in solar collector and temperature of water. The outputs of the simulation, were temperature of water before and after solar collector throughout the year.

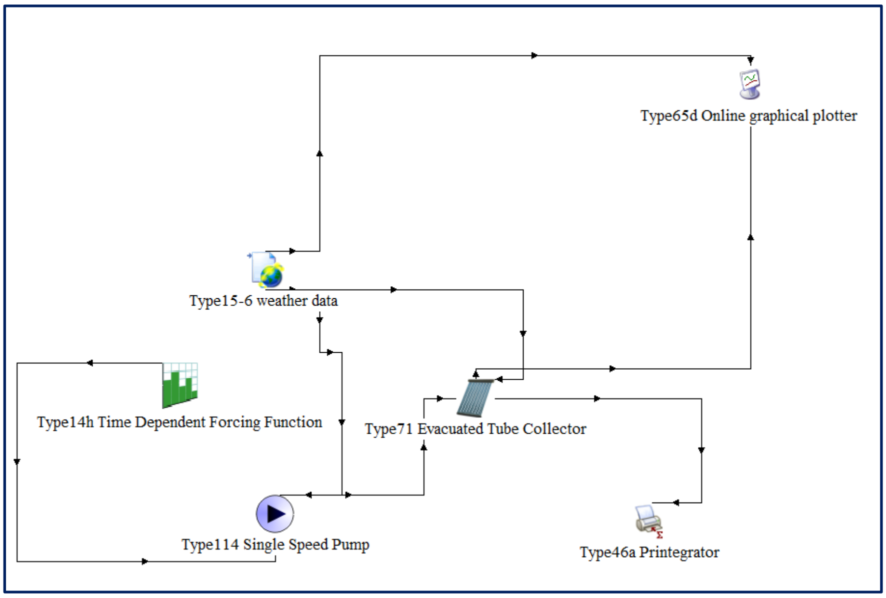

Figure 5 TRNSYS model of Evacuated Tube Solar Collector

Results and Discussion

The experimental studies have been conducted during September to October 2021 at Parul Institute of Technology, Parul University, Vadodara, Gujarat, India. The experimental data were recorded during day time from 11:00 a.m. to 17:00 p.m. at an interval of 1 hour.

During the experimental studies the ambient temperature was in the range of 28 – 35 °C. Humidity ratio of process air was in the range of 8 – 14 g water vapor / kg dry air. In this experimental studies desiccant wheel speed was kept constant at 20 revolution per hour. Process air flow rate were varying as 0.10

kg/sec, 0.12 kg/sec and 0.16 kg/sec. Regeneration air flow rate was kept constant at 0.08 kg/sec. Regeneration air temperature were kept as 60 °C, 80 °C and 100 °C during the experimental studies of the system regenerated by conventional air heater. Regeneration temperature were between 48 °C to 69 °C during the experimental studies of the system regenerated by solar energy depending on solar intensity.

Following Cases were taken for the experimental studies.

Case-I Process air flow rate 0.10 kg/sec, Regeneration air temperature as 60 °C, 80 °C and 100 °C, conventional air heater as a regeneration heat source.

Case-II Process air flow rate 0.12 kg/sec, Regeneration air temperature as 60 °C, 80 °C and 100 °C, conventional air heater as a regeneration heat source.

Case-III Process air flow rate 0.16 kg/sec, Regeneration air temperature as 60 °C, 80 °C and 100 °C, conventional air heater as a regeneration heat source.

Case-IV Process air flow rate 0.10 kg/sec, water mass flow rate in evacuated tube solar collector 0.5 litre per minute (LPM), solar energy as a regeneration heat source.

Case-V Process air flow rate 0.12 kg/sec, water mass flow rate in evacuated tube solar collector 0.5 litre per minute (LPM), solar energy as a regeneration heat source.

Case-VI Process air flow rate 0.16 kg/sec, water mass flow rate in evacuated tube solar collector 0.5 litre per minute (LPM), solar energy as a regeneration heat source.

- At 0.10 kg/sec process air flow rate and regeneration temperature of 60 °C, 80 °C and 100 °C regenerated by conventional air heater, reduction in humidity ratio has been achieved from 11.8 g/kg to 9.4 g/kg. Maximum adsorption rate and desiccant wheel effectiveness have been found as 0.91 kg/hr and 0.20 respectively at the regeneration temperature of 100 °C. Maximum COP has been found as 2.12 at the regeneration temperature of 60 °C.
- At 0.12 kg/sec process air flow rate and regeneration temperature of 60 °C, 80 °C and 100 °C regenerated by conventional air heater, reduction in humidity ratio has been achieved from 12.8 g/kg to 11.2 g/kg. Maximum adsorption rate and desiccant wheel effectiveness have been found as 0.71 kg/hr and 0.13 respectively at the regeneration temperature of 100 °C. Maximum COP has been found as 1.88 at the regeneration temperature of 60 °C.
- At 0.16 kg/sec process air flow rate and regeneration temperature of 60 °C, 80 °C and 100 °C regenerated by conventional air heater, reduction in humidity ratio has been achieved from 10.8 g/kg to 9.6 g/kg. Maximum adsorption rate and desiccant wheel effectiveness have been found as 0.67 kg/hr and 0.11 respectively at the regeneration temperature of 100 °C. Maximum COP has been found as 1.99 at the regeneration temperature of 60 °C.
- At 0.10 kg/sec process air flowrate, 0.5 litre per minute water mass flow rate in solar evacuated tube collector and solar energy as a regeneration heat source, reduction in humidity ratio has been achieved from 8.5 g/kg to 6.9 g/kg at the regeneration temperature of 55 °C. Maximum

adsorption rate and desiccant wheel effectiveness have been found as 0.55 kg/hr and 0.18 respectively at the regeneration temperature of 55 °C. Maximum COP has been found as 2.53 at the regeneration temperature of 55 °C.

- At 0.12 kg/sec process air flowrate, 0.5 litre per minute water mass flow rate in solar evacuated tube collector and solar energy as a regeneration heat source, reduction in humidity ratio has been achieved from 6.1 g/kg to 5.1 g/kg at the regeneration temperature of 64 °C. Maximum adsorption rate and desiccant wheel effectiveness have been found as 0.44 kg/hr and 0.16 respectively at the regeneration temperature of 64 °C. Maximum COP has been found as 2.45 at the regeneration temperature of 45 °C.

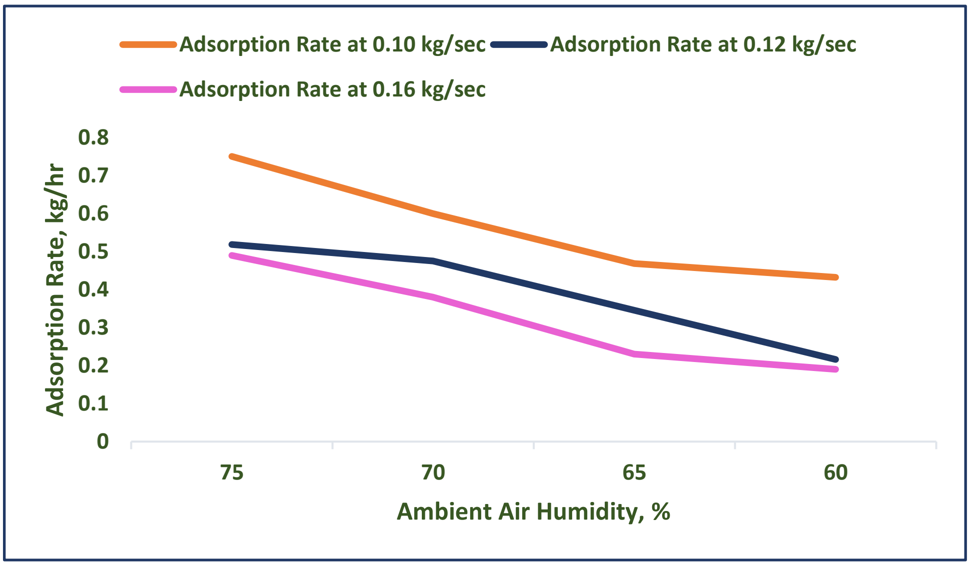

Figure 6 Effect of variation in adsorption rate at different flow rates

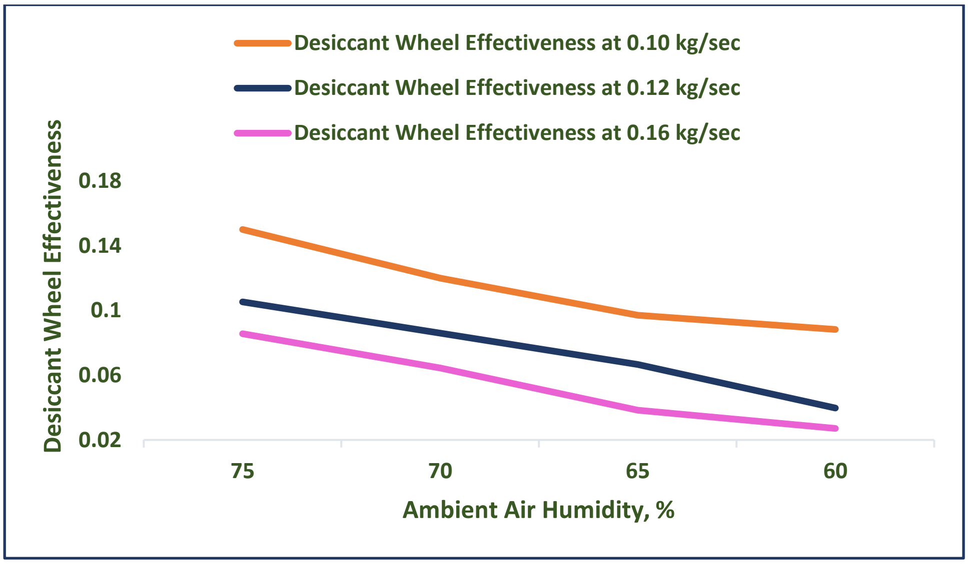

Figure 7 Effect of variation in desiccant wheel effectiveness rate at different flow rates

- At 0.16 kg/sec process air flowrate, 0.5 litre per minute water mass flow rate in solar evacuated tube collector and solar energy as a regeneration heat source, reduction in humidity ratio has been achieved from 8.4 g/kg to 7.3 g/kg at the regeneration temperature of 61 °C. Maximum adsorption rate and desiccant wheel effectiveness have been found as 0.65 kg/hr and 0.14 respectively at the regeneration temperature of 61 °C. Maximum COP has been found as 2.27 at the regeneration temperature of 57 °C.

- It is also found by the experimental investigation that by increasing the process air flowrate adsorption rate, desiccant wheel effectiveness and COP of the system have been decreased as shown in Fig.6, Fig.7 and Fig.8. The results also shows that COP of hybrid air conditioning system regenerated by solar energy is better than standalone conventional air conditioning system and hybrid air conditioning system regenerated by conventional air heater as shown in Fig. 9.

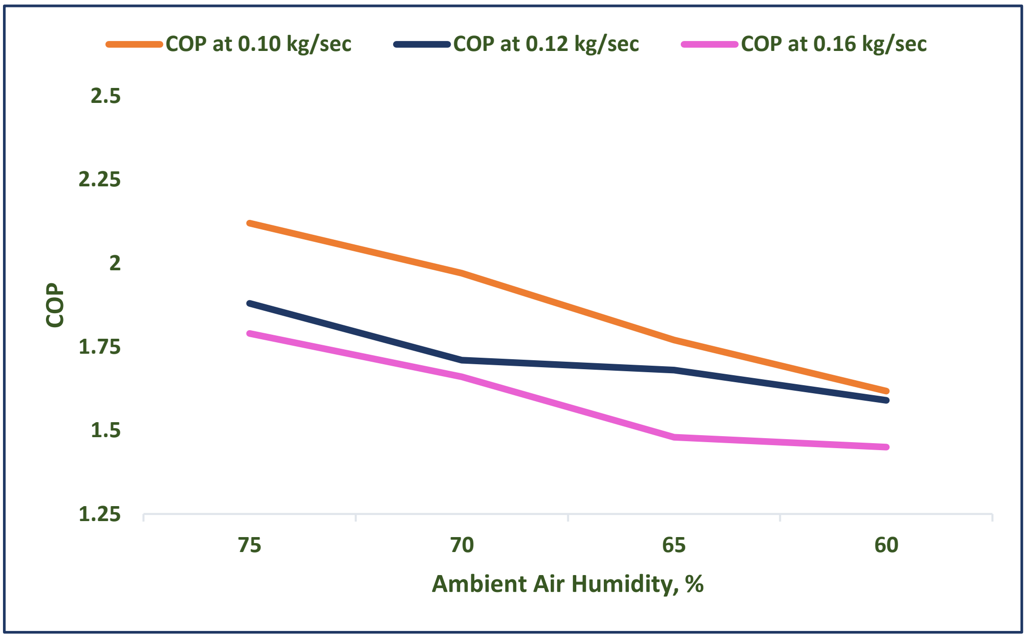

Figure 8 Effect of variation in COP at different flow rates

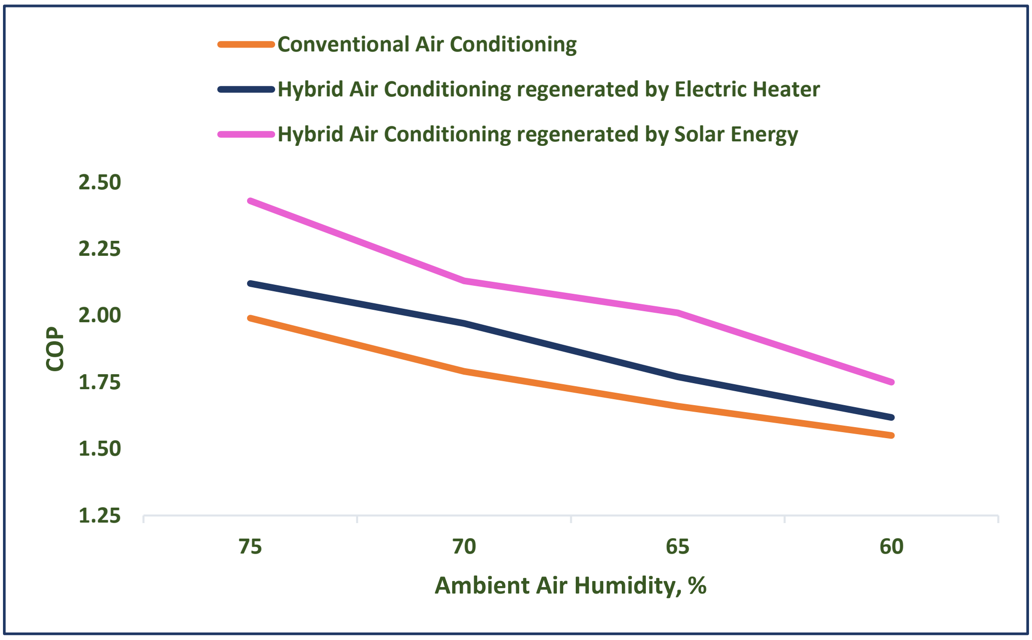

Figure 9 Effect of variation in COP for Conventional AC, Hybrid AC regenerated by Electric Heater and Hybrid AC regenerated by Solar Energy

Validation and comparison of current work with other kinds of literature

Yadav et al [16] have carried out experiments on a solar powered desiccant dehumidifier in India. Fig. 10 shows comparison of adsorption rate and desiccant wheel effectiveness between current study and experimental results by Yadav et al [16]. The current study results of adsorption rate and desiccant wheel effectiveness are in reasonable agreement with experimental results.

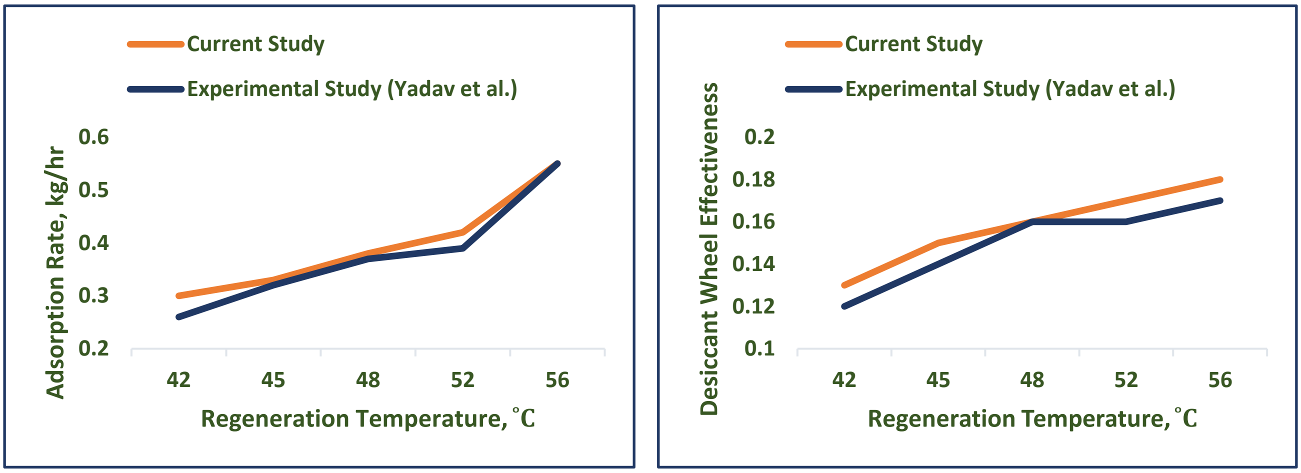

Figure 10 Validation of the current results with experimental results by Yadav et al.

Sheng et al [6] have carried out Experimental analysis on performance of high temperature heat pump and desiccant wheel system. Fig. 4.11 shows comparison between current study and experimental results by Sheng et al [6]. The current study results show a reasonably good match with experimental results.

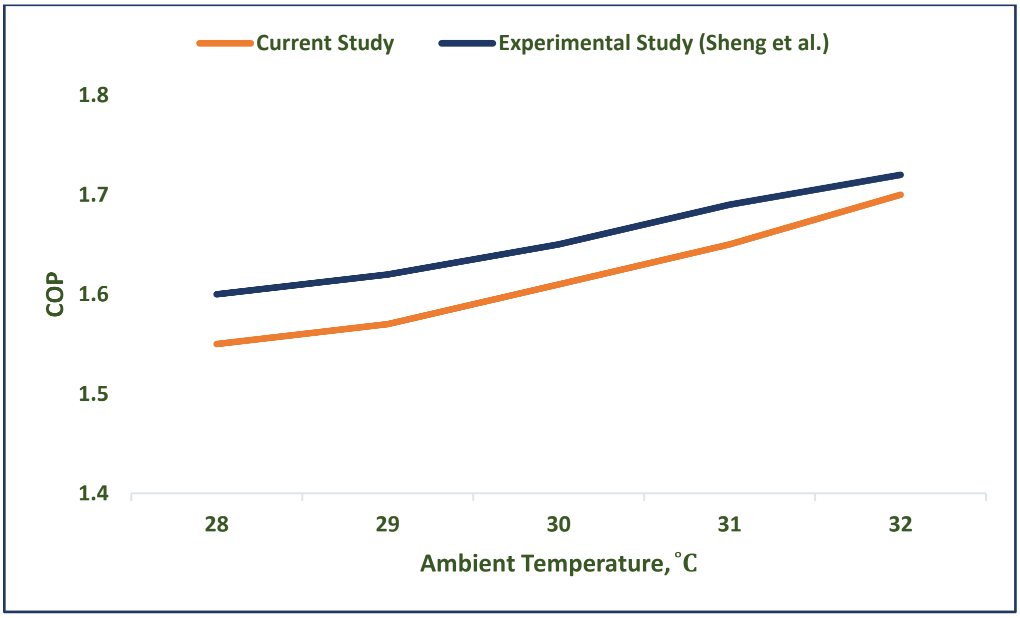

Figure 11 Validation of the current results with experimental results by Sheng et al.

Achievements with respect to objectives

Objectives	Achievements
To prepare experimental setup for investigation on solid desiccant - vapour compression hybrid air-conditioning system using solar energy.	An experimental setup has been prepared with all required components and measuring devices (Details of experimental set up is as presented in *the Experimental Setup* section.)
To carry out experimental investigation on solid desiccant – vapour compression hybrid air-conditioning system regenerated by solar energy and conventional air heater.	Experimental investigation of hybrid system regenerated by solar energy and conventional air heater have been investigated. (Details are as presented in *Results and Discussion* section*)*
To conduct experiments in order to evaluate the system performance in terms of COP at various ambient conditions as well as for variations in different operating parameters such as process air flow rate and regeneration air temperature.	System performance have been investigated by varying process air flow rate as 0.10 kg/sec, 0.12 kg/sec, 0.16 kg/sec and by varying regeneration air temperature as 60 °C, 80 °C, 100 °C. (Details are as presented in *Results and Discussion* section*)*
To compare the system results with conventional air heater and solar energy as a regeneration heat source.	Comparative results with conventional air heater and solar energy as a regeneration heat source are plotted and analysed. (Details are as presented in *Results and Discussion* section).
TRNSYS simulation model for evacuated tube solar collector to find out the feasibility of solar energy as a regeneration heat source.	TRNSYS simulation model have been created and simulated for evacuated tube solar collector. It is found by TRNSYS simulation that Evacuated Tube Solar Collector can achieved regeneration temperature to regenerate desiccant wheel throughout year. (Details are as presented in *TRNSYS simulation* section).

Conclusion

The conclusions drawn from current experimental investigation on solid-desiccant vapor-compression hybrid air-conditioning system using solar energy can be summarized as follows:

Various parameters, ambient conditions and cooling requirements are affecting the performance of solid-desiccant vapor-compression hybrid air-conditioning system using solar energy for air conditioning. Process air flow rate and regeneration air temperature are most important parameters which are affecting system performance for dehumidification. Based on experimental investigations following observations have been made:

- Regeneration temperature is the most important parameter that affects the system performance. By increasing the regeneration air temperature adsorption rate and desiccant wheel effectiveness have been increased but COP of the system decreased.
- The results show that the performance of the system is significantly affected by variations in ambient temperature and humidity ratio.
- The results show that by increasing the process air flowrate adsorption rate, desiccant wheel effectiveness and COP of the system have been decreased.
- The result shows that the annual energy consumption of conventional air heater powered solid desiccant – vapour compression hybrid air conditioning system is around 6 % lower than conventional vapour compression air conditioning system, while solar assisted solid desiccant – vapour compression hybrid air conditioning system is around 29 % lower than conventional vapour compression air conditioning system and annual energy saving by is 5694 INR and having payback period of 3 years.
- Hybrid solid desiccant-vapour compression air conditioning system is found more effective than the stand-alone conventional air conditioning system for hot and humid climatic conditions. Hybrid system required lesser tonnage capacity of conventional air conditioning as only sensible load has to accommodate.
- It is found that solar assisted solid desiccant – vapour compression hybrid air conditioning system is having better cooling performance as well as energy saving potential than conventional air conditioning system.
- It is found by TRNSYS simulation that Evacuated Tube Solar Collector can achieved regeneration temperature to regenerate Desiccant Wheel throughout year.
- It is also concluded from the research work that the environment protection makes the hybrid desiccant cooling system more attractive at time when depletion of energy resources and environmental degradation are of worldwide concerns.

Publications

International Journals

1. Mohsin J. Dadi and D.B. Jani. 2021. Experimental investigation of a solid desiccant wheel in hot and humid weather of India. International Journal of Ambient Energy: 1-9. DOI: https://doi.org/10.1080/01430750.2021.1999326. (SCOPUS)
2. D. B. Jani, Kiran Bhabhor, Mohsin J. Dadi, Sachindra Doshi, P. V. Jotaniya, Harish Ravat, and Kumar Bhatt. 2019. A review on the use of TRNSYS as a simulation tool in performance

prediction of a desiccant cooling cycle. Journal of Thermal Analysis and Calorimetry 1-21. DOI: https://doi.org/10.1007/s10973-019-08968-1. (SCIE)

3. Mohsin Dadi and D.B. Jani. 2019. Solar Energy as a Regeneration Heat Source in Hybrid Solid Desiccant – Vapor Compression Cooling System – A Review. Journal of Emerging Technologies and Innovative Research 6: 420-425. (UGC)

Intellectual Property Rights

1. Mohsin J. Dadi, D.B. Jani and Parul University. 2022. Solar Evacuated Tube Collector Assisted Solid Desiccant Vapour Compression Hybrid Air Conditioning Apparatus. Provisional Ordinary Patent, Application number 202221032037. Application dated 02-06-2022
2. Mohsin J. Dadi, D.B. Jani, and Parul University. 2022. Hybrid Solid Desiccant Air Conditioning System using Evacuated Tube Solar Collector. Industrial Design Registration having Application Number 365424-001. Application dated 02-06-2022. Current Status is waiting for technical examination.
3. Mohsin J. Dadi, D.B. Jani and Parul University. 2021. A Low-Cost Solid Desiccant Wheel. Ordinary Patent, Application number 202121036565. Application Published dated on 15-10-2021. First Examination Report issued on 27-04-2022.
4. Mohsin J. Dadi, D.B. Jani, Lukman J. Dadi, Manoj D. Motiyani and Parul University. 2021. Solid Desiccant Air Conditioning system. Industrial Design Registration having Application Number 350447-001. First Examination Report generated on 09-11-2021, Current Status is at Technical Examination of Amended Application.
5. Mohsin J. Dadi, Meet K. Soni, Palak V. Shah, Aditya S. Hire, Shivani I. Desai, Bhupesh V. Goyal, D.B. Jani and Parul University. 2021. Solid Desiccant Wheel for Moisture Removal. Industrial Design Registration having Application Number 350446-001. First Examination Report generated on 09-11-2021, Current Status is at Technical Examination of Amended Application.

International Conferences

1. Mohsin J. Dadi, D.B. Jani, Shivani I. Desai and Hasmukh Patel. 2022. Performance studies of Solid Desiccant Dehumidifier in Hot and Humid climate. Parul University International Conference on Engineering & Technology (PiCET-2022) organized by Faculty of Engineering & Technology, Parul University, India in association with Kennesaw State University, Georgia, US & ECE, Engineering School, Paris held at Parul University during May 21-22, 2022. (Paper will publish in Scopus Indexed AIP Publishing Proceeding)
2. Mohsin J. Dadi and D.B. Jani. 2020. Analytical analysis of Solid Desiccant Wheel through model and software provided by Novel Aire Company. International Web Conference on Smart Engineering Technologies – 2020 organized by Ramco Institute of Technology, Tamil Nadu.

3. Mohsin J. Dadi and D.B. Jani. 2019. TRNSYS Simulation of an Evacuated Tube Solar Collector and Parabolic Trough Solar Collector for Hot Climate of Ahmedabad. 3rd International Conference on Advances in Power Generation from Renewable Energy Sources (APGRES-2019), Government Engineering College, Banswara, Rajasthan, 11-12th February-2019. Available at SSRN: https://ssrn.com/abstract=3367102. or http://dx.doi.org/10.2139/ssrn.3367102.
4. Mohsin J. Dadi and D.B. Jani. 2019. Comparison of an Evacuated Tube Solar Collector and Parabolic Trough Solar Collector Using TRNSYS Simulation Software for Weather Condition of Ahmedabad and Cherrapunji. 1st Gujarat Technological University International Conference (GTU ICON-2019), GTU University Campus, Ahmedabad, 16th March 2019.

National Conferences

1. Mohsin J. Dadi and D.B. Jani. 2018. A critical review on Solid Desiccant Air Conditioning. 23rd ISTE State Annual Faculty Convention 2018 with National Conference on Role of Innovation and Human Values in Engineering & Technology, jointly organized by ISTE Gujarat Section & SSASIT, Surat on Saturday 15th December 2018.

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