नोजजDESIGN AND FABRICATION OF SOLAR ASSISTED VAPOR ADSORPTION REFRIGERATION SYSTEM

Submitted in partial fulfillment of the requirements
Of the degree of

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

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2020

CERTIFICATE

This is to certify that the Research work titled **DESIGN AND FABRICATION OF SOLAR ASSITED VAPOR ADSORPTION REFRIGERATION SYSTEM** that is being submitted by **Gaurav Agrawal, Prashant Tripathi, Tariq Anwer Khan and Ashish Kumar Yadav** is in partial fulfillment of the requirements for the award of **Bachelor of Technology**, is a record of bonafide work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

Supervisor

Internal Examiner **External Examiner**

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This thesis/dissertation/project report entitled **Design and Fabrication of Solar Assisted vapor Adsorption Refrigeration System** by **Gaurav Agrawal, Prashant Tripathi, tariq Anwer Khan and Ashish Kumar Yadav** is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

The proposed analysis deals with double bed vapor adsorption refrigeration system (VARS) combined with low grade heat discharge from condenser of Rankine-Reheating power plant and ETC type solar collector respectively for effective space cooling purpose for large area. The source temperatures available for both bed of VARS are 60^{o}C from condenser exhaust and 70-80^{o}C from ETC solar system. The adsorbent and adsorbate pair for double bed VARS has been recommended by activated charcoal and silica gel as adsorbents and methanol and water as adsorbate respectively.

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List of abbreviations

1. **ETC-Evacuated Tube Collector**
2. **VADRS-Vapor Adsorption Refrigeration System**
3. **WEC- World Energy Council**
4. **BTU-British Thermal Unit**
5. **COP-Co-efficient of Performance**
6. **SCP-Specific Cooling Power**
7. **AC-Activated Charcoal**
8. **GHG-Green House Gas**
9. **ORC-Organic Rankine Cycle**
10. **HVAC-Heating Ventilation & Air-Conditioning**
11. **CFCs-ChlorfluoroCarbons**
12. **HCFCs–Hydrochlorofluorocarbons**
13. **HFCs-Hydrofluorocarbons**
14. **ODP-Ozone Depletion Potential**
15. **GWP-Global Warming Potential**
16. **HRSG-Heat Recovery Steam Generator**
17. **HPT-High Pressure Turbine**
18. **LPT-Low Pressure Turbine**
19. **CV-Control Volume**
20. **VCRS-Vapor Compression Refrigeration System**
21. **SVAdRS – Solar Assisted Vapor Adsorption Refrigeration System**
22. **SW – Solidworks**

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1. Introduction

1.1 Project background

In 1824 Faraday was conducting the experiment regarding liquification of gases, so one of his experiment he took silver chloride(AgCl) powder in flask 1 and created a vacuum in flask 2 and connected the flask and flask 2 was placed inside the continuous water supply. He injected ammonia vapor and stared heating the falsk1 which was containing AgCl. The ammonia starts liberate and collected in flask 2 and he stopped heating flask 1 . After some time he observed that the ammonia starts to vaporize and was absorbed by the silver chloride powder again. This gives birth to the vapor adsorption refrigeration system.

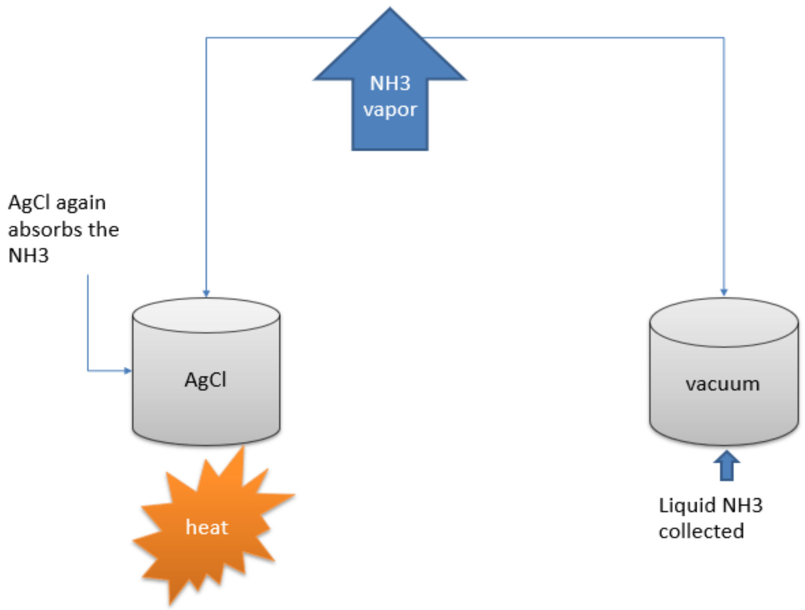
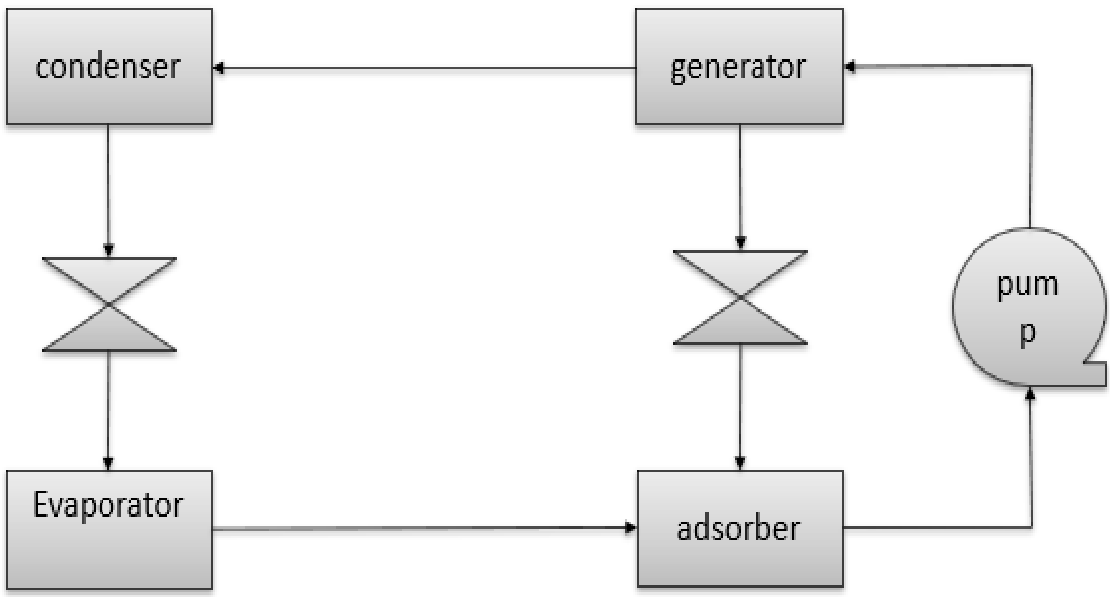


Fig.1 experimental set up of faraday's experiment

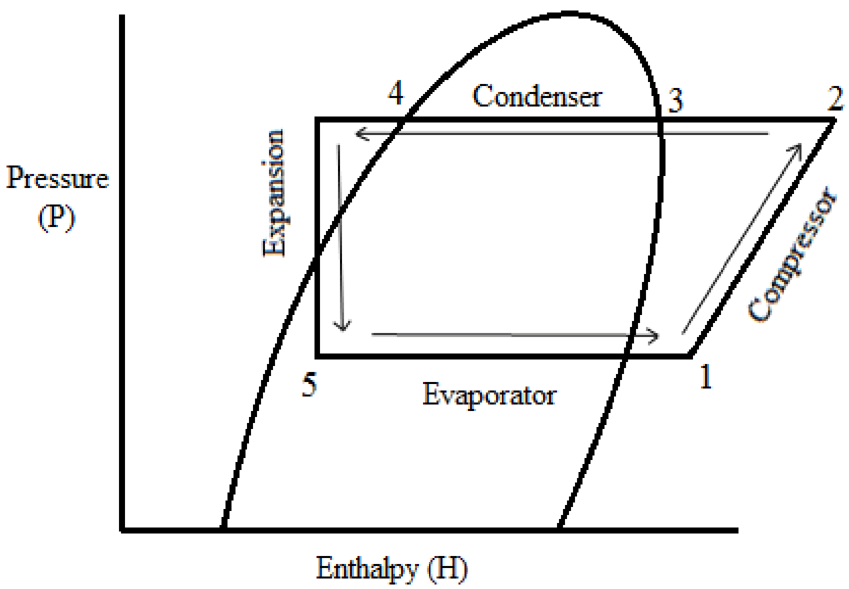
Observations of Faraday's Experiment

- Faraday observed that the liquid NH3 started boiling and reabsorbed by the silver chloride. this means the solubility of ammonia differs at different temperature.
- At lower temperature solubility of ammonia in silver chloride was high, but when it was heated solubility becomes low and vapors were generated and subsequently vapors were condensed in the flask 2 in liquid form. However, when heating was removed its tendency of absorbing the ammonia started increasing and absorbed the ammonia again.
- Pressure inside the circuit reduced and that temperature became correspondance to the saturation temperature of the liquid NH3 and it started boiling and vapors were absorbed by the silver chloride powder (AgCl)



1.2 Research purpose and meaning

- The size of the compressor is decided by the volume of the vapor at position 1. If the capacity of the system is large then automatically the volume of the saturated vapor at point 1 will be large . suppose a plant of 1000 or 3000 TR capacity then the size of the compressor will be very large.
- In case of refrigerant if volume of vapor is converted into the liquid then volume of the fluid can be reduced by (1/200)th of the volume of vapor .
- Suppose if we condense 200 lit of vapor into liquid then it would be around 1 lit.
- So 1 lit is easily handled as compared to 200lit of vapor because much less enery is used .



1.3 Objective of Study

❖ Analysis of solar double bed VADRS system.

❖ Condenser heat recovery (low grade heat energy) by using single bed VADRS of Rankine-Reheating power plant.

❖ Solar integrated multiple bed (double bed) low grade heat recovery by using VADRS .

❖ Increasing the COP of the system by using heat exchangers

❖ Use of regenerative cycles, in which two adsorption cycles are operated out of phase such that when one is being heated, the other is being cooled.

2. LITERATURE REVIEW

2.1 Introduction

In the current economical and energetic context, implementing technologies using renewable energy as heating source is offering a double advantage: the reduction of pollution and of the fuel cost. One of the main concerns of the modern human is to provide comfort in buildings. The main utilities that make a building „alive" are: electricity, domestic hot water, heating/cooling according to external ambiance. In this study the attention is focused on providing cooling during summer for a public establishment. In 1824 Faraday was conducting the experiment regarding liquification of gases, so one of his experiment he took silver chloride (AgCl) powder in flask 1 and created a vacuum in flask 2 and connected the flask and flask 2 was placed inside the continuous water supply. He injected ammonia vapor and stared heating the falsk1 which was containing AgCl. The ammonia starts liberate and collected in flask 2 and he stopped heating flask 1. After sometime he observed that the ammonia starts to vaporize and was absorbed by the silver chloride powder again. This gives birth to the vapor adsorption refrigeration system. Faraday observed that the liquid NH3 started boiling and reabsorbed by the silver chloride. this means the solubility of ammonia differs at different temperature. At lower temperature solubility of ammonia in silver chloride was high, but when it was heated solubility becomes low and vapors were generated and subsequently vapor were condensed in the flask 2 in liquid form. However, when heating was removed its tendency of absorbing the ammonia started increasing and absorbed the ammonia again. Pressure inside the circuit reduced and that temperature became correspond to the saturation temperature of the liquid NH3 and it started boiling and vapors were absorbed by the silver chloride powder (AgCl). The size of the compressor is decided by the volume of the vapor. If the capacity of the system is large then automatically the volume of the saturated vapor will be large. suppose a plant of 1000 or 3000 TR capacity then the size of the compressor will be very large. In case of refrigerant if volume of vapor is converted into the liquid then volume of the fluid can be reduced by (1/200) of the volume of vapor. Suppose if we condense **200 lit of vapor** into liquid then it would be around **1 lit.** so 1 lit of liquid is easily handled as compared to 200lit of vapor because much less energy is used. Therefore, to reduce the energy consumption and cost of the plant we are requiring the vapor adsorption refrigeration system.

2.2 Reviews

2.2.1 K. Sumathy et al (2003) studied about the adsorption of methanol onto carbon-based adsorbents and founded that the D-R equation is the most appropriate adsorption isotherm model to correlate the adsorption equilibriums for the both assorted adsorbent/refrigerants pairs.

2.2.2 N.M khattab (2004) designed adsorbent bed and evaporative system, the net COP achieved by him was 0.159 in June and 0.136 in November in Egyptian climatic conditions.

2.2.3 EE Anyanwu (2005) studied about the thermodynamic design procedure for solid adsorption solar refrigeration system and concluded the application of thermodynamic approach to system using different pairs of adsorbent-adsorbate pairs.

2.2.4 Khairul Habib et al (2006) studied theoretical analysis of the solar powered combined adsorption refrigeration cycles using evacuated tube solar collector and founded that The net COP and chiller efficiency was 0.12 and 0.25 respectively for cycle time between 450 to 500 seconds.

2.2.5 El-Sharkawy(2009) Studied on adsorption of methanol onto carbon based adsorbents and founded that the (D-R) equation is the most appropriate adsorption isotherm model to correlate the adsorption equilibriums for the both assorted adsorbent/refrigerant pairs. The Dubinin Raduskevich (D-R) equation is used to fit the adsorption isotherms of adsorbate and refrigerants pairs ; $\mathbf{w=w_0 exp[-D(T\ ln(\frac{P_s}{P}))^2]}$ where W stands for the equilibrium uptake and W0 is the maximum uptakes P is the equilibrium pressure and Ps is the saturation pressure corresponding to the adsorption temperature T.

The term D is an adsorption parameter that depends on the adsorbent/adsorbate pair.

2.2.6 Mahmoud Salem Ahmed et al (2010) worked on different types of adsorbent adsorbate pair which used in solar adsorption systems and concluded that, Silica gel and chlorides with water gives maximum COP whereas zeolite with water shows poor performance working under similar conditions.

2.2.7 Mohand Berdia (2014) worked on cold production by solar adsorption refrigeration in Algeria's climate and Founded that COP and specific cooling power increased with increase in heat source temperature and decreased with decreasing evaporative temperature.

3. PROBLEM DESCRIPTION

3.1 Field experiences

The results of field monitoring of such systems in several locations of possible application are important to establish system reliability as well as provide operating data. This is also expected to provide experience of user reactions to the system as in the case with photovoltaic (PV) powered refrigerators. More than 800 PV powered medical refrigerators were installed and evaluated throughout the developing world by the World Health Organisation (WHO), Centre for Disease Control, US Agency for International Development, European Community and other agencies. This enabled the WHO to specify a requirement for solar refrigeration in its Expanded Programme on Immunization because of its important role in maintaining the vaccine cold chain in Third World rural clinics. Sponsored widespread field testing of all solar refrigeration technologies are considered complete solutions to the problems of maintaining the vaccine cold chain in rural clinics of developing countries.

3.2 Technical problems

The major technical problem associated with solar powered adsorption technology is its poor heat and mass transfer characteristics. The adsorbents, such as activated carbon, zeolite and silica–gel, in use have low thermal conductivity and poor porosity characteristics. The effect is the bulky collector/generator/adsorber component and, thus, its excessive heating capacity, leading to rather low system COP. Spinner reported a slight improvement of the system performance from adsorbent stabilization with graphite binders. Possible solutions suggested by researchers include:

(i) Use of two cycles with different adsorbent/adsorbate combinations.

(ii) Use of regenerative cycles, in which two adsorption cycles are operated out of phase such that when one is being heated, the other is being cooled. None of these possible solutions, however, is yet to be adopted in commercially tried solar adsorption refrigeration to permit evaluation of the effectiveness.

3.3 Economic problem

The principal challenge for adsorption refrigerators powered by solar energy is to overcome several failed attempts to commercialize them. Commercialization of the silica–gel/sulphur dioxide refrigerator in the 1930s and the activated carbon–methanol refrigerator in 1960s, both of which used a fossil fuel based heat source, were unsuccessful because of the emergence of more efficient vapor compression refrigerators using cheap conventional energy, including electrical energy. More recently, the commercially tried adsorbent/adsorbate combination of activated carbon–methanol and zeolite–water refrigerators proved to be technically successful but too expensive to penetrate the market. The BLM company of France and Comesse Soudure of South Africa produced the activated carbon–methanol refrigerators. The Zeopower company of the USA manufactured the zeolite–water refrigerators. However, the unit price of about US$ 1500 for the BLM system for a daily ice production of 5.5 kg was considered too high by about 30% to get a real market.

component	Technical specifications
condenser	Capacity: 200 W
Evaporator	Capacity: 150 W Material: copper
Expansion Devices	Capillary tube
Adsorbent bed	Material: stainless steel
solar concentrator	Area: $3m^2$ made of stainless steel
Adsorbent	1.Activated charcoal of 0.25mm granular size 2. Silica gel of 3nm granular size
Adsorbate	1. Methanol 2. water
Heat exchanger	counter flow heat exchanger

Table1: The specifications of main components of solar adsorption Refrigeration system.

4. EXPERIMENTAL SET UP

The solar-assisted adsorption refrigeration system consists of a parabolic solar concentrator, water tank, adsorbent bed, condenser, expansion device (capillary tube), evaporator and heat exchanger as shown in fig1. The specifications of the components used in the system are given in Table 1. As per the study by Mahmoud Salem Ahmed et. al [3] founded that Silica gel and chlorides with water pair was had the highest COP value. Zeolite with water pair has the minimum value for COP. so we are using activated charcoal/ methanol and silica gel/water as the adsorption working pairs for this project of two bed vapor adsorption refrigeration system. Comparison of different adsorption working pairs given in table 2.

PAIRS	WORKING	COP	T_e(*C)	Td(*C)	SCP (w/kg)
PHYSICAL ADSORBENT	Activated carbon /ammonia	0.61	-5	100	2000
	Activated carbon /methanol	0.78	15	90	16
	Activated carbon/ethanol	0.8	3	80	NA
	Silica gel/water	0.61	12	82	208
	Zeolite/water	0.25	6.5	350	200
CHEMICAL ADSORBENT	Metal chloride/ammonia	0.6	-10	52	NA
	Metal hydrides/hydrogen	0.83	-50	85	300
	Metal oxides/water	NA	100	200	78

Table2: Comparison of different adsorption working pair

5. WORKING PRINCIPLE

Water gets heated while flowing through the solar concentrator by natural circulation. When the hot water is circulated around the adsorbent bed, the temperature in the adsorbent bed increases. This causes the vapor pressure of the adsorbed refrigerant to reach up to the condensing pressure. The desorbed vapor is liquefied in the condenser. The high pressure liquid refrigerant is expanded through the expansion device to the evaporator pressure. The low pressure liquid refrigerant then enters the evaporator where it evaporates by absorbing the latent heat of evaporation. The hot water from the tank drained off and is refilled with cold water. The temperature of the adsorbent bed reduces rapidly and the pressure in the adsorber drops below the evaporator pressure. The experiments are carried out keeping the evaporator temperature constant. The same procedure is repeated for the different evaporator loads.

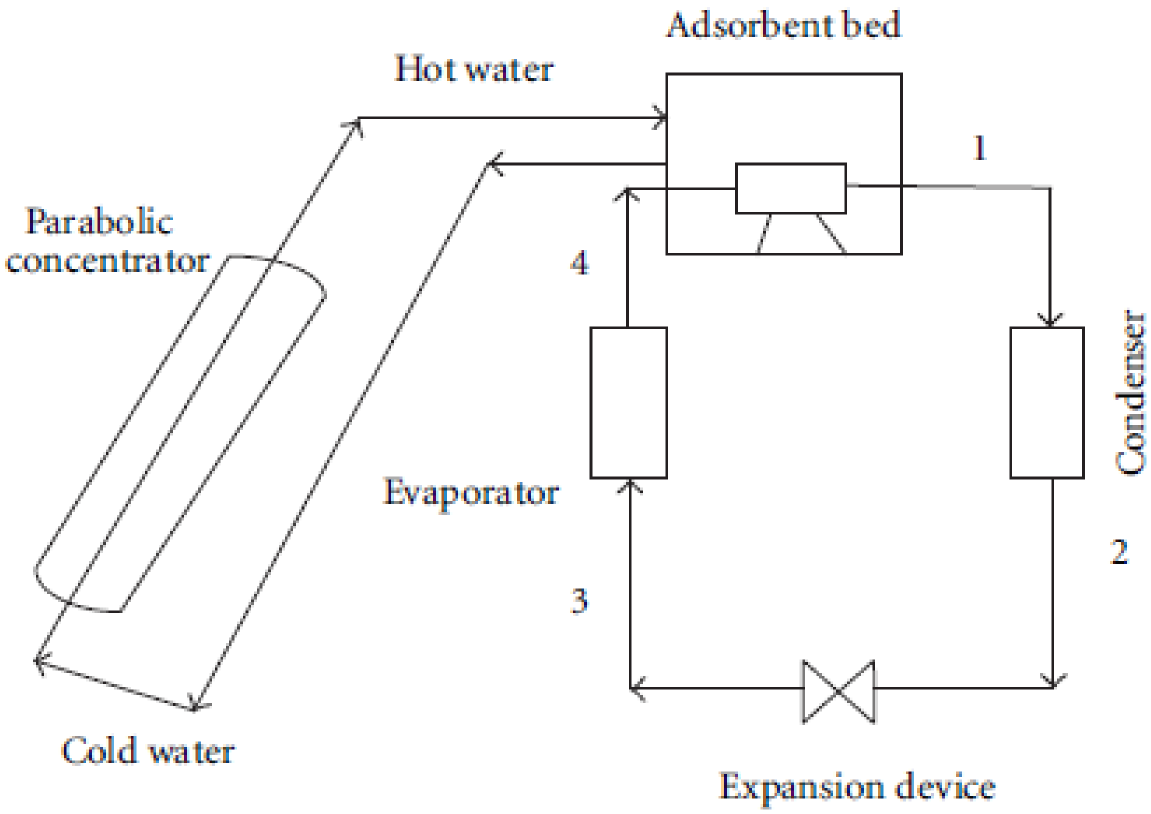
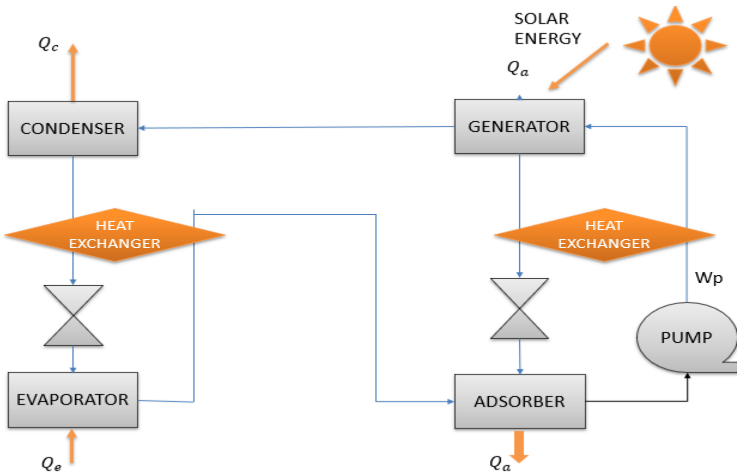


Fig.1 schematic of Basic Vapor Adsorption refrigeration cycle.

6. RESEARCH GAP

It is clear that the vapor adsorption system has a strong potential to be used as an alternative cooling system.In this PROJECT we are working on the high efficiency (COP) and highly effective refrigerants and adsorbents. High Efficiency can be achieved by installing heat exchangers.Using the solar thermal energy as waste energy to provide heat to the generator. Use of regenerative cycles, in which two adsorption cycles are operated out of phase such that when one is being heated, the other is being cooled.

COP increases by installing heat exchangers, heat exchangers are installed at 2 positions.Between fluid coming out from the condenser and the fluid coming out from the evaporator evaporator & Between fluid coming out from the generator and fluid coming out from the pump as shown in fig2. At first position, hot fluid comes out from condenser gets heat exchanged with fluid coming out from the evaporator after cooling. Firstly, before going to the evaporator fluid will be subcooled and we know that the subcooled system will generate more refrigeration effect thus cop will be increased. Secondly, less heating will be required in adsorber to heat the adsorbent. At second position, Fluid coming out from generator is low solution. It will be richer after getting heat exchanged with the fluid coming out from the pump which is at high temperature, hence less heating will be required in adsorber.



7. PERFORMANCE PARAMETER

The main performance parameters used for the present study are cycle coefficient of performance, specific cooling power, and solar cooling coefficient of performance

1. **Cycle COP** is defined as the ratio of cooling effect to the total energy required for desired cooling effect:

$$\text{COP}=\frac{\textit{cooling effect}}{\textit{total energy input}}=\frac{Q_e}{Q_T} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(1)}$$

the total energy input to the system is given by.

$$Q_T=Q_{isotropic\ heating}+Q_{desorption} \quad \ldots\ldots\ldots\ldots \quad \textbf{(2)}$$

The total heat supplied to the system is equal to the Enthalpy change of solar heated water

$$Q_T=m*C_p(T_{fi}-T_{fo}) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(3)}$$

Cooling effect is as follows:

$$Q_e=m_w C_{pw}(\Delta T_w) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \textbf{(4)}$$

2. **Specific Cooling Power (SCP)**. Specific cooling power indicates the size of the system as it measures the cooling output per unit mass of adsorbent per unit time. Higher SCP values indicate the compactness of the system:

$$\text{SCP}=\frac{\text{cooling effect}}{\text{cycle time per unit of adsorbent mass}}$$

$$=\frac{Q_e}{m_a\times\tau_{cycle}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

3. **Solar COP** since the system is solar-powered, the solar coefficient of performance is also to be defined. This is defined as the ratio of cooling effect to the net solar energy input:

$$\text{Solar COP}=\frac{Q_e}{Q_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Heat Balance

$$Q_c + Q_a = Q_e + Q_g + W_p \quad \text{(Heat Entering = Heat Leaving)}$$

$$\frac{Q_c + Q_a}{T_a} = \frac{Q_e}{T_e} + \frac{(Q_g + W_p)}{T_g} \quad \text{— (1) (change in Entropy)}$$

$$\frac{Q_c + Q_g}{T_a} = \frac{Q_e}{T_a} + \frac{Q_g + W_p}{T_a} \quad \text{— (2)}$$

from Eqn (1) & (2)

$$\frac{Q_e}{T_e} + \frac{Q_g + W_p}{T_g} = \frac{Q_e}{T_a} + \frac{Q_g + W_p}{T_a}$$

$$Q_e\left(\frac{1}{T_e} - \frac{1}{T_a}\right) = (Q_g + W_p)\left(\frac{1}{T_a} - \frac{1}{T_g}\right)$$

w.k.T $\quad \text{COP} = \dfrac{\text{Ref Effect}}{\text{Heat Transfer taking Place in Evaporator + Pump work}}$

$$\text{COP} = \frac{Q_e}{Q_g + W_p}$$

$$\text{COP} = \frac{\frac{1}{T_a} - \frac{1}{T_g}}{\frac{1}{T_e} - \frac{1}{T_a}}$$

$$\text{COP} = \frac{(T_g - T_a)/T_a T_g}{(T_a - T_e)/(T_e \cdot T_a)}$$

$$\boxed{\text{COP} = \frac{T_e}{T_a - T_e} \cdot \frac{T_g - T_a}{T_g}}$$

8. EES MODELLING

EES is a general equation-solving program that can numerically solve thousands of coupled non-linear algebraic and differential equations. The program can also be used to solve differential and integral equations, do optimization, provide uncertainty analyses, perform linear and non-linear regression, convert units, check unit consistency, and generate publication-quality plots. A major feature of EES is the high accuracy thermodynamic and transport property database that is provided for hundreds of substances in a manner that allows it to be used with the equation solving capability.

The performance parameters such as cycle COP, SCP, discharge temperature, and solar COP are predicted by using EES. In this study, the pressure, temperature and solar intensity are used as input parameters whereas the cycle coefficient of performance, specific cooling power, discharge temperature, and solar cooling coefficient of performance are predicted in the output layer.

Determination of Q _ Heat _ AQ _ Cool _ A COP_Th_A_COP_Th_B,Q_Heat_B,Q_Ref_B,Q_Heat_NetQ_Ref_NetQ_Cool_Net SCP_ Net COP _ Solar, COP _ Th _ combined of combined solar and heat recovery vapor adsorption refrigeration system”

“Known information”

m _ad _ A=[kg]; x _ max _ A = 60; x _ A=60; x _ min _ A = 20; Cp _ ad _ A =0.71 [kJ/kg-k]; Cp _ r _ A =1.66[kJ/kg-k] “Activated charcoal-Methanol pair used activated charcoal is adsorbent and methanol is refrigerant”

m_ad_B+2.93[kg]; x _ max _ B = 60;
X _ min _ B =20; Cp _ ad _ B = 0.71[kJ/kg-k]; Cp _ r _ B=1.3[kJ/kg-k] “Silica gel -Water pair used silica gel is adsorbent and water is refrigerant”

T _ gen _ A=328[k]; T _ ad _ A=293[k]; T _des _ A=363[k] “T _ ad _ A TAKEN FOR 450 s”
T _ gen _ B=333[k]; T _ ad _ B=293[k]; T _ des _ B=343[k] “T _ ad _ B TAKEN FOR 90 s”
H_D_A=2000[kJ/kg]; L_E_A=1104[kJ/kg] “L_E latent heat of evaporation can be estimated by empirical formula L_E= 5.33;55+6.2974” T_evp0.0133T^2”
H_D_B=250[kJ/kg]; L_E_B=198.6[kJ/kg] “L_E latent heat of evaporation can be estimated by empirical formula L_E= 5.33;55+6.2974 T_evp-0.0133 T^2”
T _ evp _ A=275[k]; T _ cond. _ A=303[k],t _ A=450[second] T_ evp _ B=270[k]; T _ cond _ B = 290 [k], t _B=90[second]
“Uncertainly Analysis of Waste Heat recovery Vapor Adsorption System”
Q_Heat_A=m_ad_A”(Cp_ad_A+Cp_r_A*x_max_max_A)+(T_gen_AT_ad_A)+m_ad_A*[Cp_ad_A+Cp_t_A*(x_max_A X_min_AV2)* (T _ des _ A T _ gen _ A) + m _ ad _ A*(x _ max _ A-x _ min _ A)^H_D_A “total heat transfer through adsorption bed A”
Q _ Ref _ A = (x _ max _ A-x _ min _ A) * m _ ad _ A*L_E_A “refrigerating effect” Q _ Cool _ A = m _ ad _ A*(x _ max _ A – x _ min _ A)*Cp _ r _ A*(T _ cond _ A – T _ evp _ A) .

Performance Parameters	Resultant Value
Plant Efficiency	0.488
Net Work Output	2133 kJ/kg
Turbine work output	294.7 & 1072 kJ/kg
Pump Work	16.23 kJ/kg
COP of combined VARS	0.46 to 0.51
Specific Cooling Power	70-90 W/kg
COP gain by Solar energy	0.48-0.74 (most effective COP)

Table:3 Result outcome from EES modelling.

PARAMETRIC RESULTS BED-1

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File Edit Search Options Calculate Tables Plots Windows Help Examples

Table 1 | Table 2 | Table 3

1..10	$COP_{Th,A}$	$Q_{Cool,A}$	$Q_{Heat,A}$	$Q_{Ref,A}$	SCP_A	$T_{ad,A}$ [k]	$T_{cond,A}$ [k]	$T_{des,A}$ [k]	$T_{evp,A}$ [k]	$T_{gen,A}$ [k]	$x_{max,A}$	$x_{min,A}$
Run 1	0.488	854.6	33543	17222	23.32	293	303	363	270	328	20	10
Run 2	0.4852	1688	58643	30139	40.53	293	310.5	370.5	273.3	333	30	12.5
Run 3	0.4803	2687	84050	43056	57.51	293	318	378	276.5	338	40	15
Run 4	0.4749	3850	109765	55973	74.25	293	325.5	385.5	279.8	343	50	17.5
Run 5	0.4692	5179	135787	68890	90.76	293	333	393	283	348	60	20

PARAMETRIC RESULT BED-2

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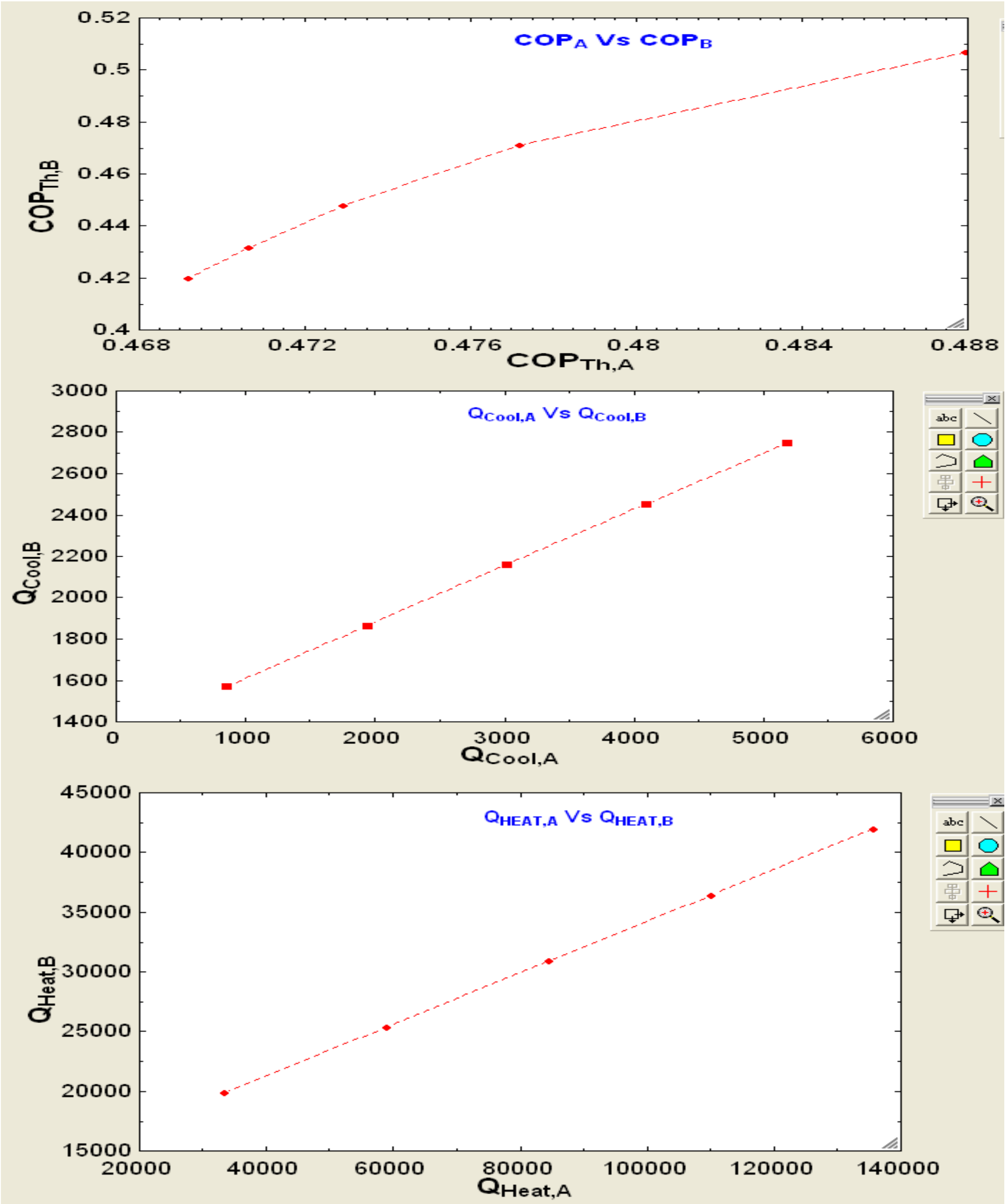
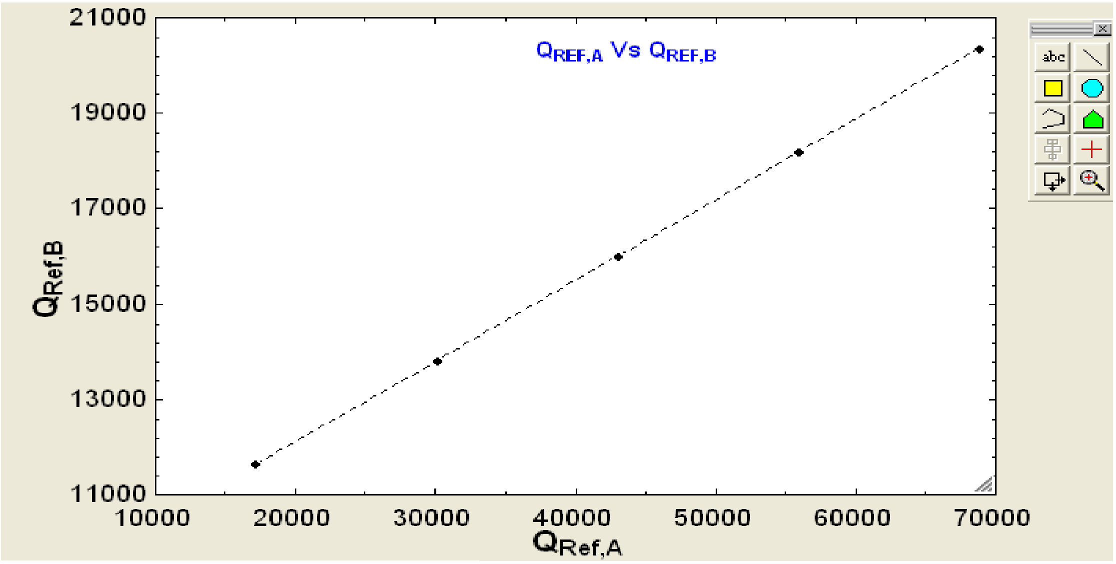
Table 1 | Table 2 | Table 3

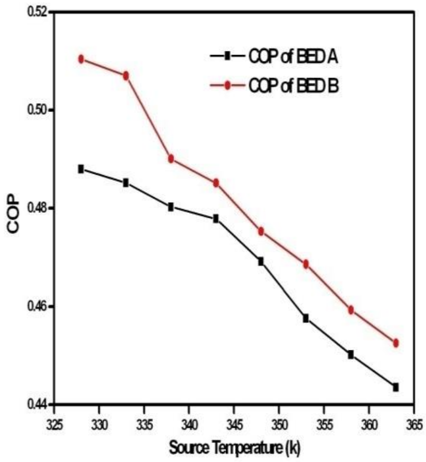
1..5	COP_{Solar}	$COP_{Th,B}$	I_g [W/m2]	$Q_{Cool,B}$	$Q_{Heat,B}$	$Q_{Ref,B}$	SCP_B	$T_{ad,B}$ [k]	$T_{cond,B}$ [k]	$T_{des,B}$ [k]	$T_{evp,B}$ [k]	$T_{gen,B}$ [k]	$x_{max,B}$
Run 1	0.004811	0.507	750	1570	19858	11638	38.18	293	288	343	268	333	30
Run 2	0.005529	0.482	775	1865	24804	13820	45.34	293	291.8	351.8	271.8	340.5	36.25
Run 3	0.006202	0.4593	800	2159	30136	16002	52.49	293	295.5	360.5	275.5	348	42.5
Run 4	0.006834	0.4387	825	2454	35855	18184	59.65	293	299.3	369.3	279.3	355.5	48.75
Run 5	0.007429	0.4199	850	2748	41961	20366	66.81	293	303	378	283	363	55

GRAPHICAL RESULTS

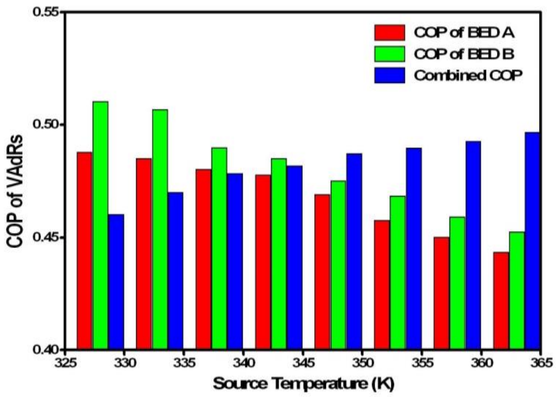




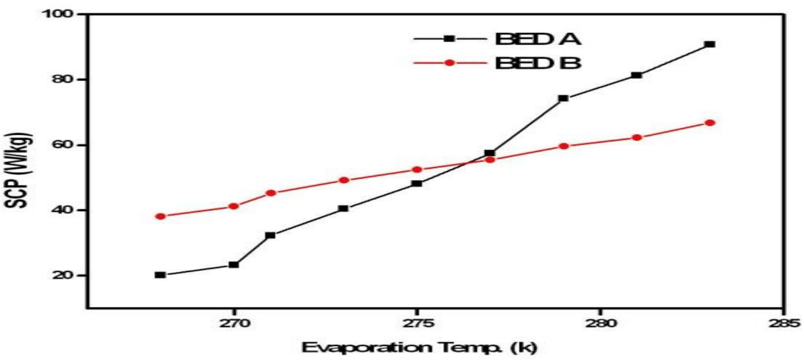
Q_REF,A Vs Q_REF,B
Q_Ref,B
Q_Ref,A
21000
19000
17000
15000
13000
11000
10000
20000
30000
40000
50000
60000
70000
abc



COP of BED A
COP of BED B
COP
Source Temperature (k)
0.52
0.50
0.48
0.46
0.44
325
330
335
340
345
350
355
360
365



COP of BED A
COP of BED B
Combined COP
COP of VAdRs
Source Temperature (K)
0.55
0.50
0.45
0.40
325
330
335
340
345
350
355
360
365



BED A
BED B
SCP (W/kg)
Evaporation Temp. (k)
100
80
60
40
20
270
275
280
285

9. MERITS

1. Significant energy savings.
2. Have low maintenance cost.
3. No noise as well as no vibrations.
4. Eco friendly.
5. Wide range of adsorbent.
6. No dangerous chemicals.
7. Zero ozone depletion potential refrigerant.
8. Ability to work in mobile condition.

10. DEMERITS

1. Less COP as compared to vapor compression refrigeration system.
2. At nights and cloudy days, we can’t attain high enough temperature
3. Large Size and weight of the system is another demerit.

11. APPLICATIONS

1. Food processing industries
2. Jute industries
3. Commercial purposes
4. Air conditioning
5. Cold storages

13. FUTURE SCOPE

1. Need to improve the COP of the system
2. Size of the condenser, evaporator and generator should be reduced so as to reduce the size and weight of the system.
3. Any method that improves the efficiency even marginally would improve the economic viability of operating such devices.
4. Applications of nanotechnology in adsorbents material development would be very promising.
5. Combination of adsorption refrigeration cycle and other refrigeration cycle scan be used to improve the overall efficiency of the system.

14. REFERENCES

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Article Submission	Article Review	Status Ack.	Copyright transfer and Processing Charges	Payment Approved	Paper Published

ARTICLE DETAILS

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Stream	Mechanical Engineering
Publication Date	Yet to be Published
Status	Accepted Pelease Wait until the further process is done.