Anjali et al. 2016, Volume 4 Issue 2
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology
An Open Access Journal

Performance Analysis of a Solar Hybrid Air Conditioner with Waste Heat Recovery and Re-Use Using Evacuated Tube Collector

[1]Anjali, [2]D. Buddhi, [3]Nitish Kumar, [4]Hari Kumar Singh

Abstract

This paper introduced about general features of the Hybrid air conditioning system consisting of R140A vapor compression refrigeration cycle cascaded with solar driven and maximum COP (coefficient of Performance) compressor power consumption was obtained as 3.5 KW. The maximum total COP (coefficients of performance) and to optimize operation are obtained at different modes as heating and cooling. The system was calculated hourly variations and of different parameters such that condenser fins temperature, Evaporator cooling capacity, condenser capacity, compressor power consumption. In addition also co-efficient of performance were calculated at various parameter work done.

Keywords: Hybrid Air Conditioner system, Compressor, Evaporator, Condenser. Expansion Valve, Solar Evacuated Tubes Collector.

Introduction

In this system compressor is used to compress the refrigerant at higher pressure and is to increase its conditioning temp. That is generally higher than the ambient temperature. The performance of the system is affected by the increase in pressure which is mainly used to increase refrigerant conditioning temperature, resulting in reduction of the COP. Therefore, if the compressor work can be reduced by utilizing solar energy to increased the condenser temp. of the refrigerant cam improve the performance of the system by utilizing solar heat and reducing power consumption of compressor. Therefore, objective of this project is to evaluate the performance of an air-conditioning system with the integration of the solar heat in the air-conditioning cycle.

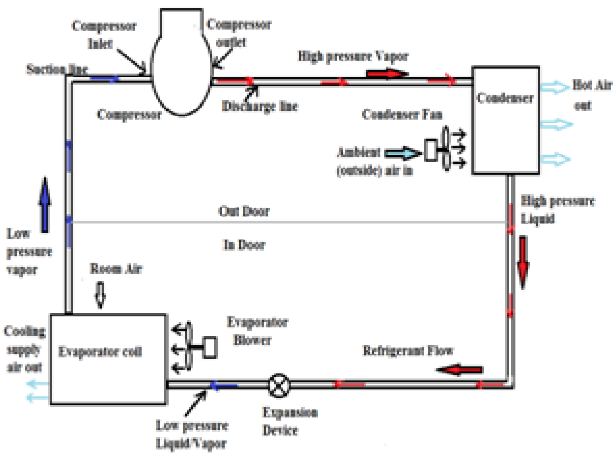

Figure 1: Flow diagram of General Air-Conditioner

Methodology

Compressor compress air at high temperature and high pressure, the refrigerant cycle being start with mixture of liquid and vapor gas R-410 and it enter to the Condenser (point E). During the refrigerant cycle process state that it changes liquid to gas form superheated at evaporator outer side. At high temperature of vapor comes to the compressor. Maximum pressure increasing the refrigerant temperature. Now the evacuated tubes are installed to compressor. And water storage tank is also

ISSN (Online): 2348-4098 , ISSN (Print): 2395-4752

installed on the compressor, and water storage tank connected to the solar tubes which balance the water tank temp. Therefore, solar tubes trap the solar heat the refrigerant to reach the sufficient super heat temperature in order to reduce the uses of electrical energy for compressor operation. Through the solar radiation water gets hot. The refrigerant gas (R-410) goes to the water storage tank at high temperature and pressure from the compressor through the copper coil (Point B to Point C) for heat exchange. The compressor turns off when the air conditioner room temperature is reached its desired set point temperature. The kinetic energy assists to take off longer time. So, decreasing its duty cycle and hence, the system increasing avg. COP. However in additional heat which is absorbed by the refrigerant in the water tank is required to rejection in condenser, and required slightly condenser area to rejection of heat, during the compressor operating time at full load condition. Further in condenser temperature reduction is takes place after the water storage tank and the reason is it de-superheated (Point E).The refrigerant liquid which is sub-cooled and moves to expansion valve and some heat were rejected outside from the condenser. Flash gas formation prevented by the sub-cooling before passing to expansion valve. And it increases the evaporator refrigeration effects. Through the capillary tubes high pressure of sub-cooled R-410 flows which decreases both pressure and temperature. Due to change in temperature cause Condensing temp. is not constant so, in partial load condition, the sufficient refrigerant temp. Which entering to condenser is less than that one of full load.

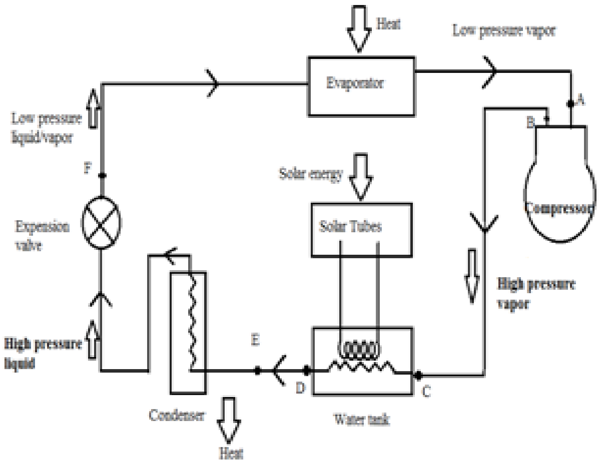

Figure 2: Flow diagram of A Solar Hybrid Air Conditioning system

Air conditioner is a device which consists of various equipments condenser, expansion valves, evaporator, solar tubes, A.C stabilizer and Refrigerant gas R410 A/1.0 kg already discussed above. The hybrid air conditioner runs on both electricity and solar energy. The solar tubes convert the heat energy into the electrical energy which runs the air conditioner and produced the cooling effect to the required room. With the electrical consumption capacity of 0.6 KWh per half an hour. The solar tubes are used of the heat absorbing capacity is to boil water 2.63 Lit to2.92 Lit per day. The 93% amount of absorbivity of electricity produced by the individual solar tube is 2 KW.

Disadvantages

- Disadvantage of this model is that the water storage tank temperature turns to increase the temperature of condenser in partial load condition.
- Initial cost of this system is high.

Advantages

- It does not produce any toxic and harmful gases.
- Hybrid solar Air-Conditioning system reduces energy consumption.
- It utilize the natural sources like solar heat and
- It is ecofriendly.

Observation and Result

The experiment was conducted with the help of Solar air conditioner using varios parameters and the result was calculated. The main aim of the experiment is to cool the room temperature using the solar heat. The coefficient of Performance (COP) was calculates using the formula

$\delta Q = \dot{m}\, \Delta h$

Q= amount of heat in KJ

$\dot{m}$= mass flow rate in Kg/s (m= 0.183 Kg/s)

Δh = Enthalpy in KJ/ Kg

Table 1: Observation of variation Coefficient of performance with Time on 10th July 2015

Time in hours	**Enthalpy Δh**		**COP**
	Suction (m^3/s)	Discharge (m^3/s)	
10:00	72	42	4.575
10:30	72.2	44	4.3005
11:00	72.2	42	4.6055
11:30	72	45	4.9508
12:00	76	43	5.0325
12:30	76	41	5.3375
13:00	76	42	5.185
13:30	72	43	4.4225

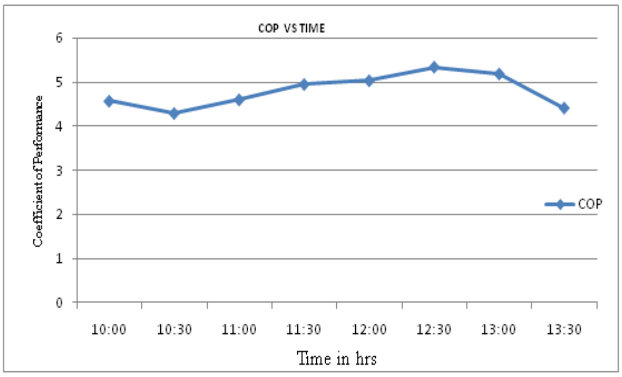

Figure 3: Variation of COP with Time on 10th July 2015

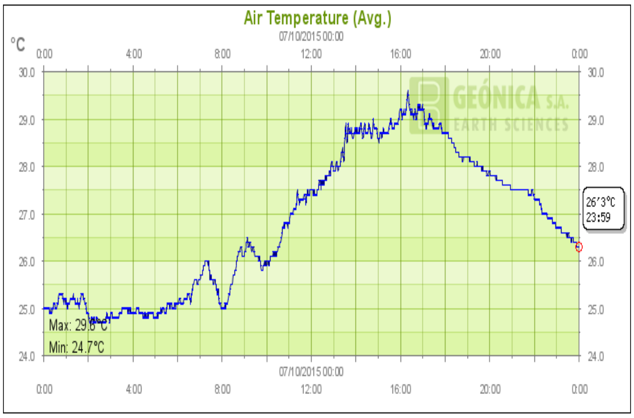

Figure 4: Variation of Ambient Temperature with Time in hrs on 10th July

Table 2: Variations of Different coefficient of performance (COP) with Time

Time	**COP 1**	**COP 2**	**COP 3**	**COP 4**	**COP 5**	**COP 6**
Date	09 July 2015	10 July 2015	24 July 2015	11 Aug 2015	12 Aug 2015	27 Aug 2015
10:00	4.58	4.58	4.47	4.58	4.58	5.41
10:30	4.58	4.30	4.42	4.58	4.58	4.35
11:00	5.19	4.61	4.47	4.58	4.58	4.80
11:30	5.11	4.95	5.76	4.80	4.58	3.58
12:00	5.11	5.03	5.34	4.80	4.73	3.58
12:30	5.11	5.34	4.04	5.26	4.73	3.66
13:00	4.73	5.19	4.19	3.16	4.12	3.36
13:30	4.73	4.42	4.04	3.16	4.12	4.65

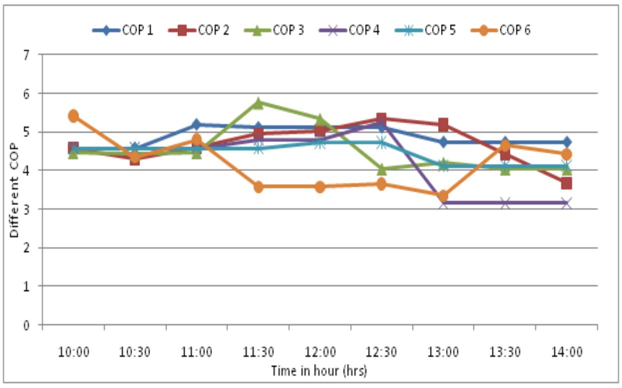

Figure 5: Variations of Different coefficient of performance (COP) with Time (T)

Table 3: Calculation of A Energy meter, Average Enthalpy of Discharge, Average Enthalpy of Suction and Average COP with Average Time on given Date below in the table

DATE	Avg. Time period in (hrs)	Avg. Energy meter (KWh)	Avg. Enthalpy Discharge (KJ/kg)	Avg. Enthalpy Suction (KJ/kg)	Avg. COP
9 July 2015	3.5	4.2	75	42.93	4.8
10 July 2015	3.5	4.2	64.55	42.62	4.8
24 July 2015	3.5	4.2	71.5	43.47	4.2
11Aug 2015	3.5	4.2	74.81	42.37	4.2
12Aug 2015	3.5	4.2	72.5	43.5	5.35
08 Sep 2015	3.5	4.2	66.47	34.16	4.9

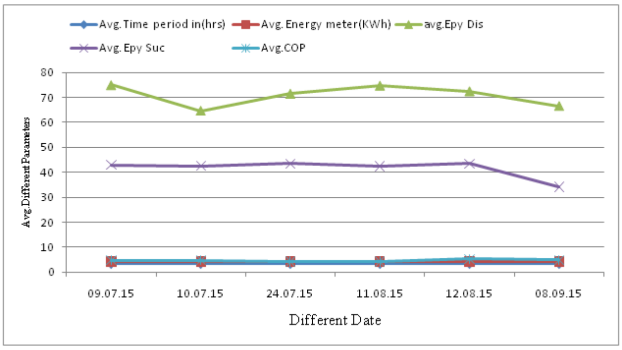

Figure 6: Variation of Different Avg. Parameters with Different Date

Conclusion

1. The purpose of this experimental work is to check the performance analysis of solar hybrid air conditioner with waste heat recovery reutilization with the help of evacuated tube collector. The working fluid used as refrigerant R410 in solar air conditioner system for air conditioning application.
2. This has been worldwide achieved where the alliance of developed nation for this regard has imposed and obligation for the rising nations as well as to wake up to the down of the new era and join the revolution of sustainable development.
3. Several researches have been conducted over the utilization of solar energy and innumerab1e researchers have been endowed and entrusted with severa1 modern modernism and this field, like solar hybrid air conditioner with the help of evacuated tube collector.
4. Through this research paper work has been used solar hybrid air conditioner with te use of evacuated tube collector and refrigerant R410 used in this experiment.
5. To reduce the electrical energy consumption by using solar hybrid air conditioner system.
6. Refrigerant R410 has been used as working fluid in this experiment which gave better results as compare to other refrigerant like R-11 and R-22. It is eco friendly in nature and doesn't produce toxic gases.
7. In this experiment, the system has been attaining the coefficient of performance (COP) approx. 5.

References

[1] Henning, H. Solar assisted air conditioning of buildings an overview. Applied Thermal Eng., vol.27, 2007, pp. 1734-1749.

[2] Wang Q, Liu YQ, Liang GF, Li JR, Sun SF, Chen GM. Development and experimental validation of a novel indirect-expansion solar-assisted multifunctional hear pump. Energy and Buildings; vol. 43, 2011, pp. 300-304.

[3] Al-Alili A, Hwang Y, Radermacher R, Kubo I. A high efficiency solar air conditioner using concentrating photovoltanic/thermal collectors. Applied Energy; vol. 93, 2012, pp. 138-147.

[4] Zambrano D, Bordons C, Garcia-Gabin W, Camacho EF. Model development and validation of a solar cooling plant. International Journal of Refrigeration; vol. 31, 2008, pp. 315-328.

[5] Kim DS. Feasibility of a compact heat recovery ventilation module with an integrated air-cooled solar absorption air-conditioner. International Journal of Thermal Sciences; vol. 50, 2011, pp. 1604-1614.

[6] Audah N, Ghaddar N, Ghali K. Optimized solar-powered liquid desiccant system to supply building fresh water and cooling needs. Applied Energy; vol. 88, 2011, pp. 3726-3736.

[7] Li Z, Deng S. An experimental study on the inherent operational charactristics of a direct expansion (DX) air conditioning (A/C) unit. Energy and Buildings; vol. 40, 2008, pp. 394-398.

[8] Vakiloroaya V, Zhu JG, Ha QP. Modelling and Optimisation of Direct Expansion Air Conditioning Systems for Commercial Building Energy Savings. Proc. Int. Symp. Automation and Robotics in Construction, Seoul, Korea, 2011, pp. 232-237.

[9] Bujedo LA, Rodriguez J, Martinez PJ. Experimental results of different control strategies in a solar air-conditioning system at part load. Solar Energy; vol. 86, 2011, pp. 1302-1315.

[10] Garcia-Gabin W, Zambrano D, Camacho EF. Sliding mode predictive control of a solar air conditioning plant. Control Engineering Practice; vol. 17, 2009, pp. 652-663.

[11] Huang BJ, Yen CW, Wu JH, Liu JH, Hsu HY, Petrenko VO, Chang JM, Lu CW. Optimal control and performance test of solar-assisted cooling system. Applied Thermal Engineering; vol. 30, 2010, pp. 2243-2252.

[12] Lygouras JN, Kodogiannis VS, Pachidis TH, Tarchanidis KN, Koukourlis C. Variable structure TITO fuzzy-logic controller implementation for a solar air-conditioning system. Applied Energy; vol. 85, 2008, pp. 190-203.

[13] Nunez-Reyes A, Normey-Rico JN, Bordons C, Camacho EF. A Smith predictive based MPC in a solar air conditioning plant. Journal of Process Control; vol. 15, 2005, pp. 1-10.

[14] Vakiloroaya V, Samali B, Madadnia J, Ha QP. Component-wise optimization for commercial central cooling plant. International Conference of the IEEE Industrial Electronics (IECON); Melbourne, Australia, 2011, pp. 2686-2691.

[15] Ha, Q. Data acquisition, monitoring and control for hybrid solar air-conditioners. Gerontechnology; vol. 11, 2012, p. 314.

[16] TRNSYS software. A transient system simulation program., version 16. <http://sell.me.wisc.edu/trnsys/>.

[17] Minitab Inc., 2010.

[18] Wigren, T. Recursive prediction error identification and scaling of nonlinear state space models using a restricted black box parameterization. Automatica, vol. 42, no. 1, pp. 159 168, 2006.

[19] Afonso CFA. Recent advance in building air conditioning systems. Applied Thermal Eng.; vol. 26, 2006, pp. 1961-1971.

Author's details

[1, 3]M.Tech Scholar, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

[2]Director of center of Excellence in renewable and sustainable Energy Studies

[4]Assistant Professor, Suresh Gyan Vihar University, Jaipur, Rajasthan, India

Copy for Cite this Article- Anjali, D. Buddhi, Nitish Kumar, Hari Kumar Singh, "Performance Analysis Of A Solar Hybrid Air Conditioner With Waste Heat Recovery And Re-Use Using Evacuated Tube Collector", *International Journal of Science, Engineering and Technology,* Volume 4 Issue 2: 2016, pp. 436- 440.