Study the Effects of Solar Assisted Vapour Compression Air Conditioning System for Winter Applications

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Abstract— At present air conditioning system is working with the principle of vapor compression system. The efficiency of the air conditioning is measured with the term Coefficient of Performance. To improve the Coefficient of Performance of the vapor compression system during winter season, a solar assisted air conditioning unit is studied. In this system the refrigerant is heated after the compressor unit, using an evacuated tube collector with a hot water storage tank. Due to this effect more amount of heat will be released at the condenser for the same work input. This rejected heat is used to increase the heat added to the conditioned space without affecting the work input of the cycle during the winter conditions. Finally, experimental investigation will be made for finding the COP of the air conditioning system for winter applications.

Key words: Air Conditioning System, Vapour Compression System, Coefficient of Performance, Compressor, Condenser and Evacuated Tube Collector

I. INTRODUCTION

A. *Introduction about Air Conditioning System*

Air conditioning is the process of altering the properties of air to more comfortable conditions, typically with the aim of distributing the conditioned air to an occupied space to improve thermal comfort and indoor air quality. It improves the thermal comfort by altering the temperature and humidity. The benefits of Air Conditioning are to give a comfortable environment at work or at home throughout the seasons, Spring, Summer, Autumn and Winter. An Air Conditioning unit can have two functions - heating and cooling. With an auto changeover switch on most new units, you set the temperature and the unit will cool or heat as required automatically. Also air purification is another benefit as an anti-fungus filter is used in most modern air conditioning units. This catches allergy-causing mites, smoke particles and odors, making the air in your environment clean and fresh. Most of us take the ability to warm our homes for granted, but few appreciate the benefits of being able to remove unwanted heat during the summer months.

B. *Literature review*

When outside air temperatures reach uncomfortable levels, the coolest temperature we can hope to maintain within our homes is the same, despite any amount of ventilation through the use of conventional fans. In reality, our homes become even warmer than the outside air temperature, through solar gains and additional heat-loads from within. With air-conditioning equipment installed, we can quickly reduce the temperature within any of the rooms within the home to a comfortable level, whilst at the same time reducing the humidity to eliminate the 'stickiness' associated with summers. Doors and windows can be kept closed improving the security of your home, whilst at the same time keeping out nuisance insects and any external noise pollution. The air within the room is re-circulated through filters to trap dust and pollens, in turn benefiting people suffering from allergies and respiratory problems. Author J. R. MEHTA et al. in [7] explained the process of increasing the coefficient of performance in liquid desiccant based air conditioning along with evacuated tube collector and they showed the result with the efficiency of about 44.7% at an regenerative temperature of about 117^{0}C with the global radiation ranges from the 719 W/m^3.

VAIBHAV JAIN et al. in [9] worked to give the comparative results for using different refrigerant R22, R134-A,R410-A, R 407-C and M20 in the air conditioning system and showed the result such as R407-C will be eco-friendly with minimum emission of CFC when compared to R22. The older air conditioning system mostly uses R22 as an refrigerant and we can also change the refrigerant in older air conditioning system by small efforts.

The effect of sub-cooling and superheating of the vapour compression refrigeration system by using R22-alternative refrigerant explained by the authors ASHISH KUMAR et al. in [4] and they also measured important parameters of performance analysis such as refrigerant type, degree of sub-cooling and superheating on the refrigerating effect, coefficient of performance and volumetric refrigeration capacity also investigated and the conclude that R410-A and R407-C has the similar thermodynamic performance similar to R22.

R22 and R410-A has the similar performance in higher ambient temperature had proven by the author W. Vance Payne et al. in [10]. The only difference between R22 and R410-A when there is an increase of outdoor temperature, the capacity and efficiency of R410-A decreases than the R22 refrigerant using air conditioning system hence in this project R22 is chosen has the as the refrigerant in this project and the only limitation is that it has emission of CFC is higher when compared to others.

Authors S. S. JJADHAV et al. in [6] explained the evaluation of the air conditioning system by using refrigerant such as R22 and R410-A and they give us idea about the pressure levels in the system. R22 using air conditioning system needs low pressure levels to attain the saturated temperature when compared to the R410-A refrigerant using air conditioning system. Hence power consumption is highly reduced in the R22 refrigerant using air conditioning system.

Studies on solar assisted libr-H_2O absorption air conditioning system by the authors SELVARAJ M et al. in [8] gave an detailed report about coefficient of performance. They concluded that coefficient of performance increase about 0.5-0.8 by using evacuated tube collector. similarly evacuated tube collector is implemented in this vapour compression system to evaluate the coefficient of performance.

A hybrid solar air conditioner: Experimental investigation by the author ALI AL-ALILI et al. explained the solar based air conditioner in [2]. They had used the photovoltaic panel and thermal collector to run the air conditioning system. In this vapour compression system thermal collector. The design of the thermal collector in the vapour compression system is based on the reference [7].

A high efficiency solar air conditioner using concentrating photovoltaic/thermal collectors by the authors A. AL-ALILI et al. in [1] gave the details about the design of solar air conditioning which was highly efficient when compared with others. This design can also be considered for fabrication of vapour compression system so the thermal efficiency can be highly achieved by utilizing the solar thermal energy.

Review of solar thermal air conditioning technologies by the authors ALI AL-ALILI et al. in [3] gave concise details about solar adsorption cycles focused on the development and testing of various adsorbent refrigerant pairs, improving cycle components, and increasing the system efficiency. For the ejector cycles, many studies focused on using computer models and experimental works to investigate the performance of the ejector and find the key parameters affecting its operation. Although many researches have conducted for solar thermal cooling technologies, their overall efficiencies are lower than that of the vapor compression cycles. Therefore, improving efficiency of solar thermally operated cooling technologies is an essential future research topic.

The solar evacuated tube collector is used s the heating source to heat the refrigerant, so thereby improving the compression efficiency by varying the refrigerant flow. The benefits of the new design lie in the fact that the new designed system operates at a higher sub-cooling temperature after the air-cooled condenser which significantly result in increasing the overall system coefficient of performance. A novel solar-assisted air-conditioner system for energy savings with performance enhancement by the author Q.P. HA et al. in [5] explained the above evaluation of the performance of the system.

From the above literature survey this project is based on the vapour compression system involving evacuated tube collector for enhancing the coefficient of performance. R22 is used as an refrigerant in this vapour compression system because it need lower pressure levels to attain saturated temperature by the reducing the power consumption.

Heat pump is a term for a type of air conditioner in which the refrigeration cycle can be reversed, producing heating instead of cooling in the indoor environment. They are also commonly referred to, and marketed as, a "reverse cycle air conditioner". Using an air conditioner in this way to produce heat is significantly more energy efficient than electric resistance heating. Some homeowners elect to have a heat pump system installed, which is simply a central air conditioner with heat pump functionality (the refrigeration cycle can be reversed in cold weather). When the heat pump is in heating mode, the indoor evaporator coil switches roles and becomes the condenser coil, producing heat. The outdoor condenser unit also switches roles to serve as the evaporator, and discharges cold air. Heat pumps are more popular in milder winter climates where the temperature is low. F.Justin Dhiraviam et al. [11] deals with the calculations to be carried out in flow through pipes and heat exchangers. Naveenprabhu et al. [15] and [16] deals with the enhancement of heat transfer using nano fluids nothing but the nano sized particles are dispersed in the water in the presence of dispersion agent based up on the base fluids.

C. *Problem Identification*

At present the domestic winter air conditioners are employed with vapor compression system. The Coefficient of Performance (COP) of the conventional air conditioning system can be improved by solar assisted system. So by adding the heat to the refrigerant from the solar evacuated tube collector, the heat is added to the conditioned space without affecting the work input of the cycle.

II. RESEARCH METHODOLOGY

The various steps involved in the proposed methodology are:

1) Modification of Air conditioner with Solar evacuated tube collector and Hot water storage tank.
2) The evacuated glass tube actually consists of two walls of glass. In between the two walls, all the air is removed, resulting in a vacuum in the same manner as a clear
3) Thermos bottle would function. This vacuum is the best insulation one could ask for, and gives the evacuated tubes a much better heat retention than air space.
4) Hot water storage tank will be introduced at next to the compressor.
5) Evacuated tubes have been attached with hot water storage tank.
6) Evacuated tube collector is used to heat the water which is stored in the hot water storage tank.
7) Hot water mainly utilized for heat the vapour refrigerant
8) A Copper coil has been introduced between the compressor outlet and the condenser inlet.
9) The additional amount of heat will be given to the vapour refrigerant by using evacuated tube collector.
10) This rejected heat is used to increase the heat added to the conditioned space without affecting the work input of the cycle during the winter conditions.
11) Finally, experimental investigation will be made for finding the COP of the air conditioning system for winter applications.

A. *Specifications of window air conditioner*

- Make: LG Electronics Pvt. Ltd.
- Rated power supply: 230V AC, 50Hz, 1-Phase
- Cooling capacity: 19000 Btu/hr
- Refrigerant used: R-22
- Weight of refrigerant: 0.785 kg

- Power consumption: 1900 W
- Current: 9A1.

B. Technical Specifications of compressor

- Make: Matsushita Electric Industrial Co., Ltd
- Type: Rotary Compressor
- Model Number: 2K32S225A
  1) 2 - Approved Refrigerant (2 --> R-22)
  2) K - Series
  3) 32 - Displacement (32 cc/rev)
  4) S - Super Efficiency
  5) 225 - 220V & 50Hz
  6) A - Electrical Change
- Maximum Suction pressure: 114psig
- Maximum discharge temperature: 115 0C
- Maximum discharge pressure : 377psig
- Maximum Return gas temperature: 35 0C
- Motor used: Single phase permanent split capacitor AC motor

C. Properties of Vapour Refrigerant

Properties	Values
Name	R-22
Chemical name	Chlorodifluoromethane
Chemical formula	CHClF2
Molar mass	86.47 kg/kmol
Boiling temperature at one atm	-40.81 0C
Critical temperature	96.15 0C
Critical pressure	4990 kPa
Critical density	523.8 kg/m3
Critical volume	0.0019 m3/kg

Table 1: Properties of Vapour Refrigerant

D. Technical Dimensions of Hot Water Storage Tank

Length (l) = 0.45 m
Breadth (b) = 0.30 m
Height (h) = 0.33.5 m
Volume of the Water Storage tank
= l *b*h
= 0.45*0.30*0.335= 0.045225m^3
= 45.22 Ltr

E. Technical Dimensions Of Evacuated Tube Collector

Number of tubes = 2
Diameter of ETC tube = 40mm
Length of the tube = 1500mm

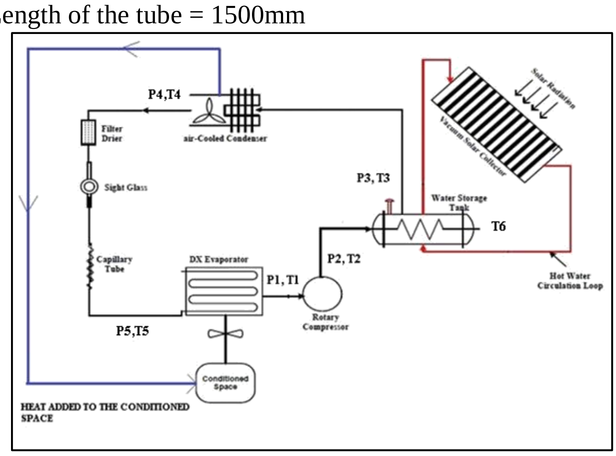

Fig. 1: Line diagram of Experimental Setup

F. Parameters used

- P1 – Pressure of the refrigerant before the compressor
- T1 – Temperature of the refrigerant before the compressor
- P2 – Pressure of the refrigerant after the compressor
- T2 – Temperature of the refrigerant after the compressor
- P3 – Pressure of the refrigerant after the hot water storage tank
- T3 - Temperature of the refrigerant after the hot water storage tank
- T3 ~ T2 – Difference in temperature represents the amount of heat added to the refrigerant by Evacuated tube collector
- P4 - Pressure of the refrigerant leaving the condenser
- T4 - Temperature of the hot air leaving the condenser
- P5 - Pressure of the refrigerant entering the evaporator
- T5–Temperature of the hot air entering inside the conditioned space
- To Calculate the COP of the solar assisted system

$$COP = \frac{(h_1 - h_5) + (h_4 - h_3)}{(h_2 - h_1)}$$

Where, h value is found from R22 Psychrometric chart

III. RESULTS AND DISCUSSION

The window air conditioner performance can be improved by adding heat to the desired effect for the same work input. This can be done through solar assisted heating system. The Coefficient of performance of the winter air conditioning system is found out by conducting the experimental investigation. The pressure and temperature gauge are used to measure the pressure and temperature at various salient points. The pressure and temperature at various salient points are used to found out the enthalpy at different points by using the R-22 pschrometric chart. Fig. 2 shows the variation of COP with respect to time for different hot water temperatures.

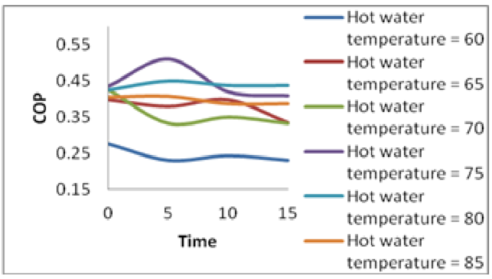

Fig. 2: Time vs COP

Fig. 3 presents the optimum hot water temperature at which the COP is maximum. Here, the Coefficient of performance is maximum, at operating temperature of 75ºC.

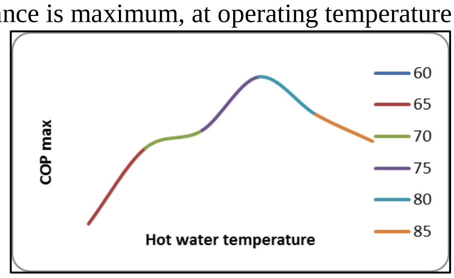

Fig. 3: Optimum Room temperature

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