EXPERIMENTAL INVESTIGATION OF PERFORMANCE COMPARISON OF ELECTRIC POWERED VCRS WITH SOLAR ASSISTED VCRS

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ABSTRACT

Energy conservation and use of the renewable source of the energy in most efficient manner is the main challenge faced by the engineers in today's world. In this experiment our main objective is to develop a solar assisted and electric-powered conventional vapour compression refrigeration system (VCRS) connected in series. A minimum value for the total solar insulation needed to overcome internal irreversibility for start-up of the system is defined and the effect of the solar panel design parameters on this value is investigated. Initially, VCRS is electricity powered. Again, we power the VCRS with solar panels. The results indicate that the coefficient of performance (COP) of the proposed system is relatively equivalent as compared to the conventional VCRS but there is a saving of 5.63% in power consumption during peak load demands in case of solar assisted VCRS. It is noticed that the performance of the novel refrigeration system increases as sunlight becomes intense from 8:00 to 13:00 hrs.

Keywords: Solar Assisted Vapour Compression Refrigeration System, COP

I. INTRODUCTION

Refrigeration system uses solar energy which is eco friendly source of energy. The energy use associated with refrigeration system operation and the environmental impacts associated with its generation and distribution often outweighs the choice of energy source. To minimize environmental impacts associated with refrigeration system operation, it is reasonable to evaluate the prospects of a clean source of energy. Using solar as a primary energy source is attractive because of its universal availability, low environmental impact, and low or no ongoing fuel cost. Researchers have found that solar energy is an ideal source for low temperature heating applications such as space and domestic hot water heating. The use of solar energy to provide refrigeration is less intuitive. It provides refrigeration at temperatures below 0°C (32°F). We conclude that, photovoltaic-based vapour compression is presently a viable solar refrigeration technology. The basic principle of solar vapour compression refrigeration system is to form the foundation for nearly all conventional refrigeration. In the vapour compression cycle, cooling is provided in the evaporator as low temperature refrigerant entering the evaporator as a mixture of liquid and vapour is vaporized by thermal input from the load. The vapour exiting the evaporator in a saturated or slightly superheated condition enters a compressor that raises the pressure and, consequently, the temperature of the refrigerant. The high pressure hot refrigerant enters a condenser heat exchanger that uses ambient air or water to cool the refrigerant to its saturation temperature prior to fully condensing to a liquid. The high-pressure liquid is then throttled to a lower pressure, which causes some of the refrigerant to vaporize as its temperature is reduced. The low temperature liquid that remains is available to produce useful refrigeration. The major energy input to a vapour compression refrigeration system is the mechanical power needed to drive the compressor. The compressor power requirement is substantial because the specific volume of the refrigerant vapour, *v*, is large. Its coefficient of performance (COP) defined as the ratio of the cooling capacity to the total electrical power required. The COP for a system providing refrigeration at –10°C(14°F) while rejecting heat to a temperature at 30°C (86°F).Photovoltaic (PV) involve the direct conversion of solar radiation to direct current (dc) electricity using semiconducting materials. Solar photovoltaic panels produce dc electrical power that can be used to operate a dc motor, which is coupled to the compressor of a vapour compression refrigeration system. Incident solar radiation of 1,000 W/m^2 (10800 W/ft^2) and a module temperature of 25°C (77°F) is capable of being generated by a PV system.

Murthy et al. (1991) tested different ejector dimensions at the cooling capacity about 0.5 kW. R12 was used as the refrigerant. A COP in the range of 0.08-0.33 was obtained.A single stage solar driven ejector system with 3.5kW of refrigeration capacity at an evaporating temperature of 4ºC and a generating temperature of 90-105°C with R114 was designed by **Bejan et al. (1995). Göktun (2000)** proposed a solar assisted ejector-vapour compression cascade system. The inter-cooler was installed serving as a condenser for the vapour compression system and an evaporator for the ejector system. **Ersoy et al. (2007)** presented performance variations of a solar-powered ejector cooling system (SECS) using an evacuated-tube collector in different cities in Turkey.To assess system and refrigeration efficiencies of a solar assisted ejector cycle using water as a working fluid was theoretically studied by **Varga et al. (2009).**

II. EXPERIMENTAL SETUP

The experimental setup is categorized into two parts i.e.; one is solar powered source and another is electric powered vapour compression refrigeration system. In this experimental setup initially we run our compressor part with direct electrical power and further we move toward VCRS with solar assisted electrical power. First we calculate different parameters by using simple electric run VCRS system and then we calculate same parameters by using VCRS with solar assisted electrical power.

The solar powered VCRS set up is equipped with solar panels, voltage controller, battery of 12V, inverter (600W) and power cables and VCRS.

On the other hand, we have vapour compression refrigeration system. This setup consists only of compressor (100W), condenser, capillary tube and evaporator along with the working fluid termed as R134a.

INSTRUMENTS USED

1 Pressure Gauge

2Thermocouple

3Voltmeter and Ammeter

Two pressure gauges are used in this set up, one for the measurement of suction pressure before the compressor and other for the measurement of discharge pressure after the compressor. Thermocouple is used to measure the temperature of the working fluid. Thermocouple sensor of RTD PT100 type is used, which directly gives the value of temperature at various points in the air conditioning system. Voltmeter and ammeter are the devices used to measure the voltage and current of the input power to the air conditioning system. Both voltage and ammeter are of dial gauge manual type.

Figure 1: VCRS system run with simple electric power

Figure 2: VCRS system assisted with solar power

III. CALCULATION AND RESULT

Based on the experimental results, thermodynamic properties of the refrigerant at different points in the cycle are obtained using the P-H chart of refrigerant R-134a and the parameters such as mass flow rate, cooling capacity and COP of the system are calculated from the equations:

A. Compressor Work $W_c = V * I = m_{ref} * (h_2 - h_1)$

B. Mass flow rate of refrigerant $m_{ref} = \frac{Wc}{(h2 - h1)}$

C. Cooling effect produced $Qr = m_{ref} * (h_1 - h_4)$

D. COP $= \frac{Qr}{Wc}$

Where,

h1 = enthalpy of refrigerant at inlet of compressor in kj/kg (1)

h2 = enthalpy of refrigerant at exit of compressor in kj/kg (2)

h3 = enthalpy of refrigerant at exit of the condenser kj/kg (3)

h4 = enthalpy of refrigerant at entry of evaporator in kj/kg (4)

The voltage and ampere of the input power are obtained from the voltage meter and ampere meter attached in the experimental set-up. Using this voltage and ampere reading, work done of the compressor is obtained.

Table 1: Result obtained at ambient temperature 30 ^oC

Ambient air conditions : DBT - 30^{o}C, WBT - 23^{o}C, RH - 55%				
Parameter	**Symbols**	**Unit**	**Electrical**	**Solar**
Evaporator Absolute pressure	P_{eva}	bar	0.48	0.43
Condenser Absolute pressure	P_{con}	bar	11.96	11.07
Compressor inlet temperature	T_1	^{o}C	-12.17	-13.01
Compressor exit temperature	T_2	^{o}C	49	44
Condenser exit temperature	T_3	^{o}C	37	33.34
Total electric current	I	Ampere	0.75	0.71
Total electric voltage	V	Volts	215	215

Table 2: Result of the experiment at ambient air temperature 30°C

Performance Results of Air Conditioner (T_{amb} - 30^{o}C)				
Parameter	**Unit**	**Electrical**	**Solar**	**Variation**
Compressor Work , W_c	Watt	161.25	152.65	5.63%
COP	------	4.34	4.63	6.68%

IV. CONCLUSION

During the hot summer day when electrical energy at a peak demand at that time solar energy is alternate source of energy. We can save solar energy and utilize it for further household work. Similarly in this way we make a setup of VCRS which is assisted with solar panel which stored solar energy and we utilize this solar energy in order to run compressor of VCRS system. Initially we run our VCRS setup at ambient temperature 30 ^{o}C and after that VCRS with solar assisted setup is used at 30 ^{o}C. From the experimental performance we conclude that

COP of solar assisted setup is quite more as compare to simple VCRS system. Also power consumption of solar assisted VCRS system is less as compare to simple VCRS system which is about 5.63%. So we can use this solar assisted panel in normal air conditioning system. But initial setup cost is high as compared simple VCRS system; also performance of solar assisted setup is high and we get higher cooling capacity.

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BIOGRAPHICAL NOTES

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