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Evaluation of Solar Hybrid Air Conditioning Structure

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ABSTRACT

Air-conditioning is the process of altering the properties of air to more favourable conditions, typically with the aim of distributing the conditioned air to an occupied space to improve comfort. An air-conditioner is a major or home appliance, system, or mechanism designed to change the air temperature and humidity within an area. In recent years, it is most widely used in the urban areas and consumes more amount of electrical energy as compared to other types of electrical appliances. The Solar PV panel based electrical appliances are used for domestic purpose due to frequent electrical power cut. Hence, in this work, we have developed a solar PV based hybrid air-conditioning system in which we have used solar power to heat the refrigerant before it enters the compressor, by installing a heat exchanger between evaporator and compressor and evaluated its performance. We have compared the performance of the solar hybrid air-condoning system with the conventional AC. From this work, we observe that the solar based air-conditioning is more power efficient than the conventional air conditioning system.

Key words: *Air-conditioning system, Photovoltaic panel, Band heater, Performance characteristics.*

I. INTRODUCTION

Air-conditioning is a process of moving heat from one location to another in controlled conditions. The cooling is typically done using a simple refrigeration cycle, but sometimes evaporation is used, commonly for comfort cooling in buildings and motor vehicles. In construction, a complete system of heating, ventilation and air conditioning is referred to as "HVAC"[1].

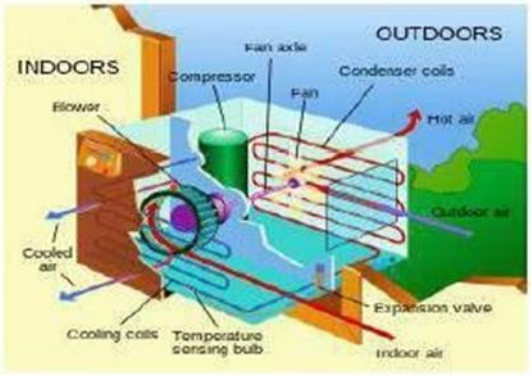

Fig1: Schematic air-conditions system.

Air conditioning can also be provided by a simple process called free cooling which uses pumps to circulate a coolant (typically water or a glycol mix) from a 2cold source, which in turn acts as a heat sink for the energy that is removed from the cooled space. Free cooling systems can have very high efficiencies, and are sometimes combined with seasonal thermal energy storage (STES) so the cold of winter can be used for summer air conditioning. Common storage media are deep aquifers or a natural underground rock mass accessed via a cluster of small-diameter, heat exchanger equipped boreholes. Some systems with small storage are hybrids, using free cooling early in the cooling season, and later employing a heat pump to chill the circulation coming from the storage. The heat pump is added-in because the temperature of the storage gradually increases during the cooling season, thereby declining in effectiveness. Free cooling and hybrid systems are mature technology.

II. HISTORY

In the late 19th century, the most common fluid for absorption cooling was a solution of ammonia and water. Today, the combination of lithium bromide

and water is also in common use. One end of the system of expansion/condensation pipes is heated, and the other end gets cold enough to make ice. Originally, natural gas was used as a heat source in the late 19th century. Today, propane is used in recreational vehicle absorption chillers refrigerators. Hot water solar thermal energy collectors can also be used as the modern "free energy" heat source. The basic concept behind air conditioning is said to have been applied in ancient Egypt, where reeds were hung in windows and were moistened with trickling water. The evaporation of water cooled the air blowing through the window, though this process also made the air more humid (also beneficial in a dry desert climate). In Ancient Rome, water from aqueducts was circulated through the walls of certain houses to cool them. Other techniques in medieval Persia involved the use of cisterns and wind towers to cool buildings during the hot season. Modern air conditioning emerged from advances in chemistry during the 19th century, and the first large-scale electrical air conditioning was invented and used in 1902 by Willis Carrier. [2] The introduction of residential air conditioning in the 1920s helped enable the great migration to the Sun Belt in the US. St George's Hall in Liverpool England, built between 1841 and 1854, was, in 2005, awarded a Blue Plaque by the Heritage Group of the CIBSE recognizing it as the World's First Air Conditioned Building.

III. EQUIPMENT USED FOR EXPERIMENT, WITH THERE SPECIFICATION

Table1: Equipment for solar air-conditioner

Equipment used for experiment	Specifications of the Equipment
Indoor unit	Company :NAPOLEON Product :split air conditioner Input Wattage : 1070 W Capacity : 3420 W Net weight : 10 kg Distinguishing feature : 2 star Net dimensions (mm) : 890×280×216 (W×D×H)
Outdoor unit	Company :NAPOLEON Product :split air conditioner Input Wattage : 1070 W Capacity : 3420 W Net weight : 30 kg Distinguishing feature : 2 star Net dimensions (mm) : 715×495×230 (W×D×H)

IV. EXPERIMENTAL SETUP

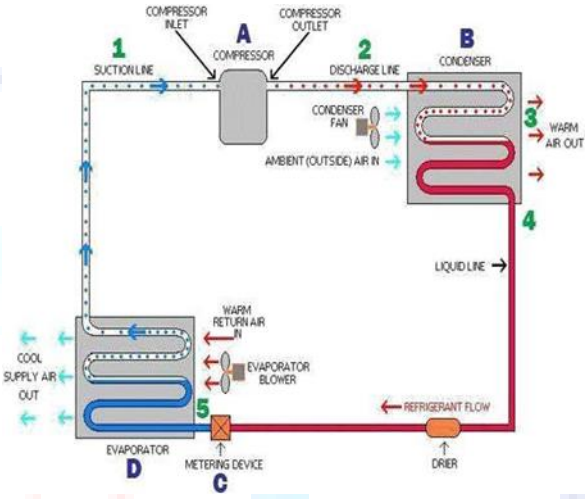

Fig2: Detailed basic refrigeration cycle

In case of conventional Air conditioner, the Refrigerant is compressed to a high temperature and high pressure in the compressor, before coming to condenser where the Refrigerant becomes a high pressure with normal temperature. Then there is a capillary where the Refrigerant turns to low temperature low pressure liquid through decompression, and then to indoor unit to achieve cooling function through heat exchanging in evaporator.[6]

In case of the solar air conditioner as shown in figure above, the Refrigerant will be passed through the coil of the solar collector for heat exchange before entering the Compressor. The hot water from the solar collector raises the temperature of the refrigerant entering the compressor. [7] In effect, the solar collector takes the load off the compressor. Hence a lower capacity Compressor will do the same job of the Compressor used in the conventional systems. It will lower the power and improve the Energy Efficiency Rate (EER) of solar air conditioner. [3]This results in a power saving to the tune of 40 to 50%. Because the hot water is stored in the ETC of the solar collectors, this phenomenon helps in reducing the power requirement in the nights also.

ALUCLATION FORMULAS

EER = (amount of heat removed in BTU/hr)/work input

Cooling effect = mass flow rate × enthalpy difference (kw)

Cooling effect = m × (h2 -h1) in kw

Mass flow rate= amount of air circulated / specific volume (kg/sec)

a) Coefficient Of Performance (COP)

COP= m× (h2 -h1) / work done

b) Capacity of refrigeration (COR) = m× (h2-h1) / 3.5 tonne

Let,

TR1, TR2, TR3, TR4, TR5 are the respective temperatures of the room

TR = (TR1+TR2+TR3+TR4+TR5)/5

V. RESULT AND DISCUSSION

FOR R-22 REFRIGERANT:

In the experiment above the refrigerant was heated before it enters the compressor and it was observed that there was an increase of 6 to 8 degree Celsius in the temperature of the refrigerant at the surface of the copper tube before it enters the compressor. It is also observed that due to heating the amount of power consumed by the compressor reduces by 14 percent approximately. [5]Therefore it can be concluded that the temperature of the refrigerant is an important parameter that affects the amount of power consumed by the compressor as it reduces the load on compressor by reducing the density and viscosity of the refrigerant. Effect of heating the refrigerant before it enters the compressor on the performance of AC was studied for 1 person load and the result is plotted graphically.

Fig3: Time Vs Power variation for 1 person load (Bar graph)

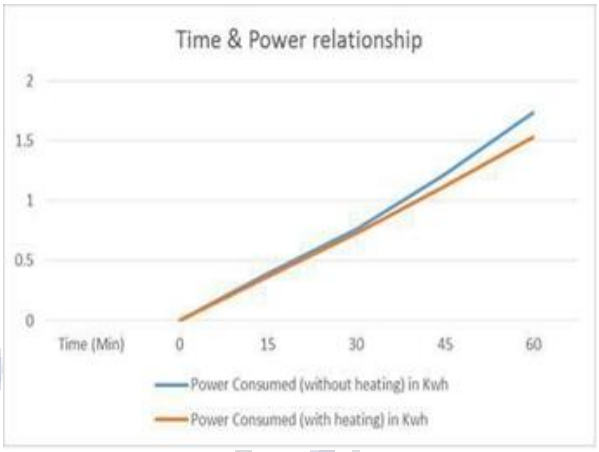

Fig4: Time Vs Power variation for 1 person load (Line diagram)

Effect of heating the refrigerant before it enters the compressor on the performance of AC was studied for 2 person load and the result is plotted graphically.

Fig5: Time Vs Power variation for 2 persons load (Bar graph)

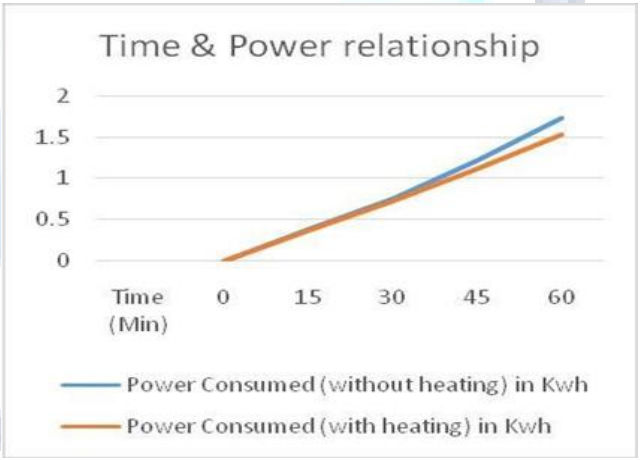

Fig6: Time Vs Power variation for 2 persons load (line diagram)

Thus it can be deduced from the graph that the power consumed by the compressor reduces significantly by heating the refrigerant before it enters the compressor. It is also confirmed from the

experiment that the load in a room is also an important factor that influences the amount of power consumed.

VI. CONCLUSION

`The following conclusions are drawn based on this work.

A solar hybrid air-conditioning system was developed and tested successfully. [8] It works as similar to the conventional system.

The solar PV based system generates power based on the intensity of the solar radiation.

From the field trails, we observe that the maximum solar energy can be obtained during the afternoon (between 12.00 Noon to 1.00 PM).

From the comparison of the performance of the solar hybrid air conditioner system with conventional system, we observe that both the systems work without any difficulties. Hence, solar energy can be used as an auxiliary power source for the conventional A/C.

The cooling load significantly affects the performance of the solar based systems. As the cooling load increases the performance of the system also increases up to optimum cooling load.

The heating of the refrigerant using solar energy, before entering to the compressor, significantly reduces the power required by the compressor. Hence, it increases the COP. From this we conclude that the solar hybrid air conditioner will be better replacement for the conventional systems.

SCOPE FOR FUTURE WORK

The scopes for future work are

- The effect of alternative refrigerant on the performance of the air conditioner shall be studied.
- Simulation work shall be carried out to study the performance of the solar based air conditioner
- A new evaporator system shall be developed and tested for solar based applications.
- The effect of process variables on the performance of the air conditioner shall be studied.

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