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Performance and Analytical Study of Cooler Cum Air Conditioner based on Vapour Compression Refrigeration System

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Abstract

With the recent government organization and regulation for saving the water, trees, curtains to the use of these sources which contribute to global warming present day mankind uses various equipment in their daily need which includes conventional cooler, AC etc. This consumes large amount of water and electricity so for reducing the use of these main sources research involves the use of VCRS system which include eco-friendly refrigerant R134a in cooler system. This system is mounted in the research model in a proper manner so that it is compact in size. The refrigerant R134a absorbs the heat from air and makes the air cooled, itself getting vaporized in evaporator and then the cooled air is sent outward from the opening. In the research model with help of fan running on motor and gives the cooling effect. This use of VCRS system with eco -friendly refrigerant reduces the consumption of the water, electricity consumption and tree which is used for making wood wool in conventional cooler. This ultimately reduces the global warming. For making these purposes the project is developed.
Keywords: Compressor, Condenser, Evaporator, Refrigerant, Expansion Device

I. INTRODUCTION

For most people, certainly in the developed world, the word ‘refrigeration’ would probably evoke the image of a white or metallic-grey device in their homes which is used to keep food and beverages cool. These devices are generally reliable and low-maintenance and have a familiar, comforting quality, but do not solicit much thought or attention. However, refrigeration goes far beyond the domestic setting, or the supermarket or grocery store where ‘fridges’ are most commonly seen by the average person. The reality is that societies in the developed world depend on refrigeration to the point where it would be no exaggeration to say that many lives would be lost if all mechanical refrigerators were suddenly to fail.

Now a days, the equipment which produces refrigeration effects are on high demand, for example refrigerators, air coolers, air conditioners etc. Mostly the refrigerators are used to be seen in every house now days. The refrigerator is used for preserving the foods and also for cooling the water and other beverages.

In India, during summer season the temperature increases up to its peak mostly about range of 45°c to 50°c. During this season there is very increase in demand of cooling equipment’s such as air coolers, air conditioner etc. If we talk about traditional air coolers, these coolers have very high demand in India because they are cheap and affordable in every aspect and most of the Indian population is belongs to the middle class and thus they can afford these traditional coolers. But these coolers too have disadvantages such as they consumes large amount of water i. e about 45 to 50 litres of water every day. And also we know that middle class population of India is about 267 million. Although if we consider 250 million of population uses about 50 litres of water every day in their cooler, they consume 12500 million litres of water only in summer season which is very high amount. Also these coolers consume 250 rupees of electricity per month according to the Indian standards. Also these coolers consumes large amount of wood wool, which is obtained by cutting large amount of trees and trees are the essential parameter which is used for reducing global warming.

Now if we come on air conditioner, the cost this equipment is very high minimum it is about 20 to 25000 if we go for good ac in India. Also the electricity consumption of this air conditioning equipment is also very high i.e. about 2400rs per month for single air conditioner according to Indian standards. And these equipment's produce very adverse effect on the environment which ultimately leads to the global warming.

So for reducing such huge consumption of water, trees, electricity, which ultimately leads to wealth consumption, this research project includes to provide the cooling effect of air as such like the air conditioners without using water, wood wool and by consumption of low amount electricity. This ultimately leads to reducing the monthly tariff and also having very less effect to the environment

II. COMPONENTS

A. Compressor

We used Hermetic Sealed Compressors because these types of compressor eliminate the use of crankshaft seal which is necessary in ordinary compressors in order to prevent leakage of refrigerant. The hermetic sealed compressor is widely used for small capacity refrigerating systems such as in domestic refrigerators, home freezers and window air conditioners.
Specification: Inlet pipe = 0.6 cm, 220V / 50Hz, 1PH, thermally protected.

Fig. 2.1: Hermetic sealed compressor

B. Condenser

We used air cooled condenser in which the removal of heat is done by air. It consists of steel or copper tubing through which the refrigerant flows. The size of tube usually ranges from 6mm to 18mm outside diameter, depending upon the size of condenser. Generally copper tubes are used because of its excellent heat transfer ability. The condensers with steel tubes are used in ammonia refrigerating systems. The tubes are usually provided with plate type fins to increase the surface area of heat transfer. The fins are usually made from aluminium because of its light weight. The fins spacing is quite wide to reduce dust clogging.
Specification: Height =24cm, Length = 25.5cm, Width = 4cm Condenser pipe =1cm,
No coil present in condenser with IP/ OP is 8.

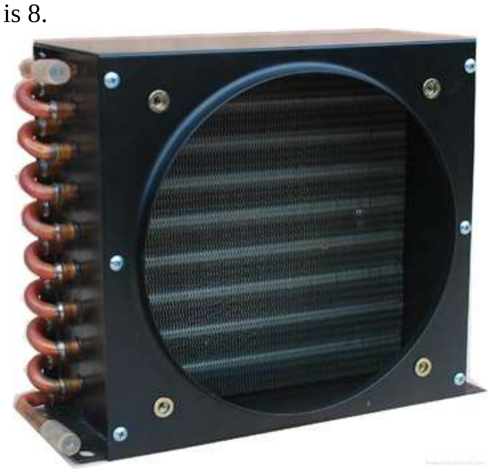

Fig. 2.2: Air Cooled Condenser

C. Evaporator

Evaporator is an important component together with other major components in a refrigeration system such as compressor, condenser and expansion device. The reason for refrigeration is to remove heat from air, water or other substance. It is here that the liquid refrigerant is expanded and evaporated. It acts as a heat exchanger that transfers heat from the substance being cooled to a boiling temperature.

Fig. 2.3: Evaporator

D. Expansion Valve

Are flow-restricting devices that cause a pressure drop of the working fluid. The valve needle remains open during steady state operation. The size of the opening or the position of the needle is related to the pressure and temperature of the evaporator. There are three main parts of the expansion valve that regulate the position of the needle. A sensor bulb, at the end of the evaporator, monitors the temperature change of the evaporator.

Capillary tube is one of the most commonly used throttling devices in the refrigeration and the air conditioning systems. The capillary tube is a copper tube of very small internal diameter. It is of very long length and it is coiled to several turns so that it would occupy less space. The internal diameter of the capillary tube used for the refrigeration and air conditioning applications varies from 0.5 to 2.28 mm (0.020 to 0.09 inches). Capillary tube used as the throttling device in the domestic refrigerators, deep freezers, water coolers and air conditioners.

Fig. 2.4: Capillary Tube

E. Fan

An apparatus with rotating blades that creates a current of air for cooling or ventilation.
Specification: Blade=230diameter, Angle=22degree.

F. Motor

The three-phase induction motor, also called an asynchronous motor, is the most commonly used type of motor in Industrial applications. In particular, the squirrel-cage design is the most widely used electric motor in industrial applications
Specification: 10W/60W, 220-230V, 50-50HZ, 0.35A/1300RPM.

G. Refrigerant

Refrigerant is a substance or mixture, usually a fluid, used in a heat pump and refrigeration cycle. In most cycles it undergoes phase transition from a liquid to gas and back again. Many working fluids have been used for such purposes. Fluorocarbon especially chlorofluorocarbons, became commonplace in the 20th century, but they are being phased out because of their ozone depletion effects. Other common refrigerants used in various applications are ammonia, sulphur dioxide, and non-halogenated hydrocarbons such as propane.

1) Refrigerant (134-a)

In CFCs and HCFCs present the chlorine content which contribute to the depletion of ozone layer.

– But the alternative refrigerant of CFCs and HCFCs is Hydro fluorocarbon HFCs (R134a, R152a, and R32) as there are no Content of chlorine.
– R134a is the leading replacement for domestic refrigerators.
– Although the Ozone Depletion Potential (ODP) of R134a is zero.

R134a is also known as Tetrafluoroethane (CF3CH2F) from the family of HFC refrigerant. With the discovery of the damaging effect of CFCs and HCFCs refrigerants to the ozone layer, the HFC family of refrigerant has been widely used as their replacement. It is now being used as a replacement for R-12 CFC refrigerant in the area of centrifugal, rotary screw, scroll and reciprocating compressors. It is safe for normal handling as it is non-toxic, non-flammable and non-corrosive.

Refrigerant	*Molecular wt.*	*Boiling pt.*	*Chemical Formula*	*(ODP)*
R134a	*102*	*-26.1^{0}C*	*C2H2F4*	*0*

Fig. 2.5: Refrigerant (R134a).

III. STEPS INVOLED IN VCRS SYSTEM

– 1-2 compression of vapour refrigerant is done in the compressor.
– 2-3 condensation of high pressure and temperature vapour refrigerant is condensed by the condenser. After condensation, the refrigerant changes in liquid form at same pressure and low temperature. There is a loss of temperature in the form of latent heat.
– 3-4 now, this low temperature liquid refrigerant enters the throttling valve which changes the phase of liquid into Mixture of liquid and vapour refrigerant.
– 4-1 now the mixture of liquid and vapour refrigerant enters the evaporator evaporates and achieve low temperature & low pressure due to gain of latent heat.

Simple Vapour Compression Refrigeration Cycle:

It is shown on T-S and P-H diagram below, at point 1, let T1, P1, and s1 be the properties of vapour refrigerant and the four processes of the cycle are as follows:

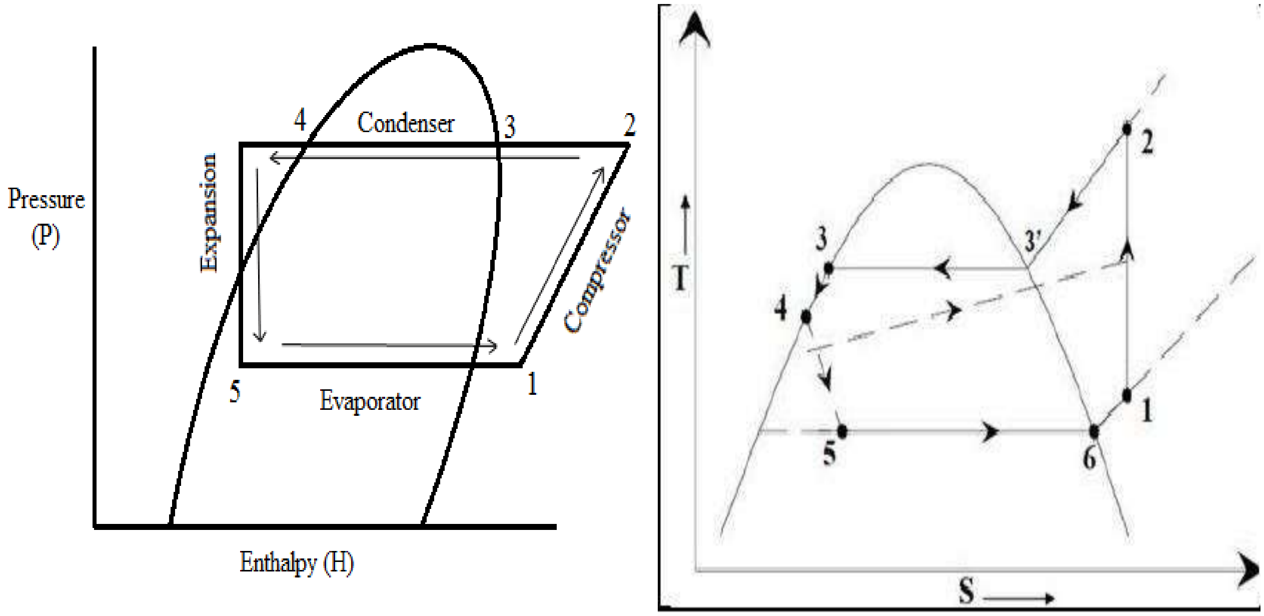

Fig. 3.1: P-H and T-S diagram simple vapour compression refrigeration cycle.

IV. WORKING

The machine has three main parts. They are a compressor, a condenser and an evaporator. The compressor and condenser are usually located on the outside air portion of the air conditioner. The evaporator is located on the inside the house. The working fluid arrives at the compressor as a cool, low-pressure gas. The compressor squeezes the fluid. This packs the molecule of the fluid closer together. The closer the molecules are together, the higher its energy and its temperature.

The working fluid leaves the compressor as a hot, high pressure gas and flows into the condenser you looked at the air conditioner part outside a house, look for the part that has metal fins all around. The fins act just like a radiator in a car and help the heat go away, or dissipate, more quickly.

When the working fluid leaves the condenser, its temperature is much cooler and it has changed from a gas to a liquid under high pressure. The liquid goes into the evaporator through a very tiny, narrow hole. On the other side, the liquid's pressure drops.

When it does it begins to evaporate into a gas. As the liquid changes to gas and evaporates, it extracts heat from the air around it. The heat in the air is needed to separate the molecules of the fluid from a liquid t a gas. By the time the working fluid leaves the evaporator, it is a cool, low pressure gas. It then returns to the compressor to begin its trip all over again. Connected to the evaporator is a fan that circulates the air inside the house to blow across the evaporator fins. Hot air is lighter than cold air, so the hot air in the room rises to the top of a room.

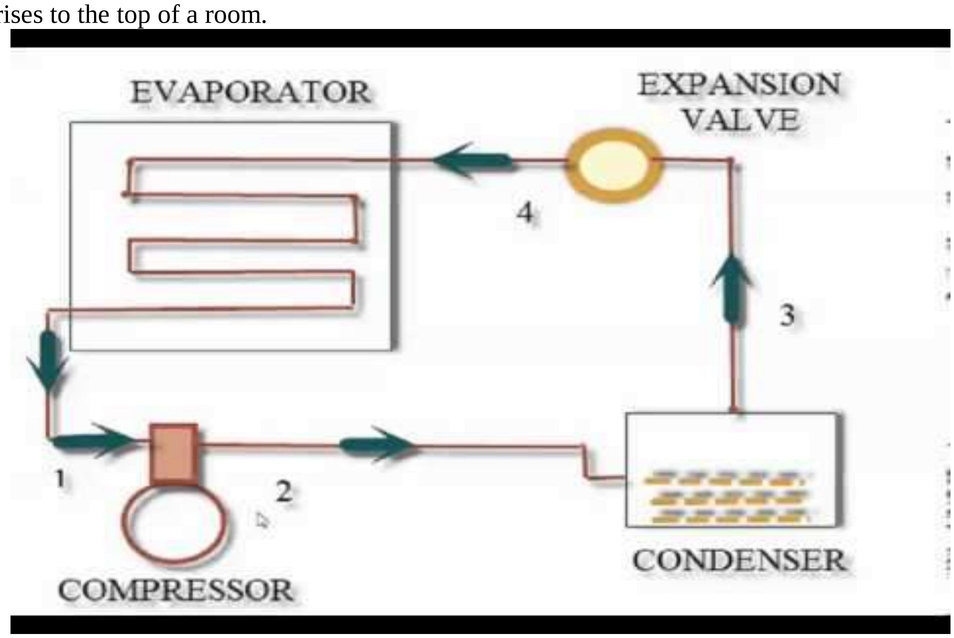

Fig. 4.1: Working VCR System

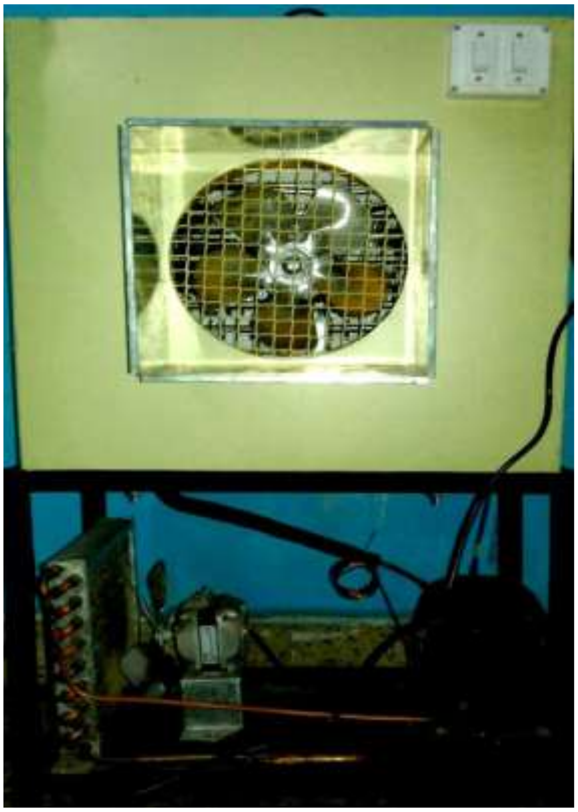

Fig. 4.2: VCRS Based Cooler.

V. OBSERVATION & CALCULATION

A. *Observations*

T1	*T2*	*T3*	*T4*	*P1*	*P2*	*h1*	*h2*	*h4*
13^0C	*56.1^0C*	*33.5^0C*	*0.3^0C*	*3bar*	*10.34bar*	*410*	*443*	*245*

Here,
T1= Temperature at the inlet of Compressor
T 2 = Temperature at the outlet of Compressor
T 3 = Temperature at the outlet of Condenser
T 4 = Temperature at the inlet of Evaporator
P 1 = Pressure at the inlet of Compressor
P 2 = Pressure at the outlet of Compressor
h1=Enthalpy at the inlet of compressor
h2=Enthalpy at the outlet of compressor
h4= Enthalpy at the inlet of Evaporator
The Table represents the observations for Relative Humidity

T_d	T_w
18^0C	*12.5^0C*

Here, T_d = Dry Bulb Temperature of air (D.B.T.)
T_w = Wet Bulb Temperature of air (W.B.T.)

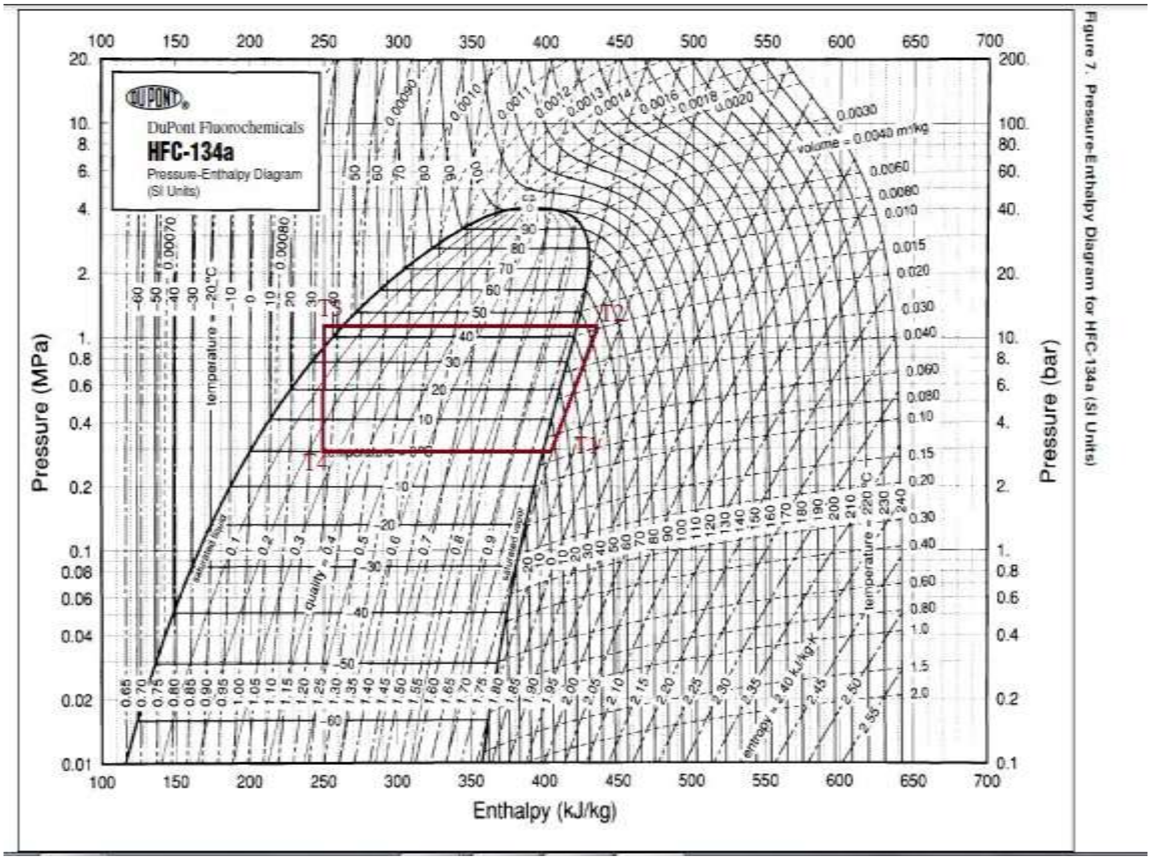

Fig. 5.1: R-134a representing the Sub-Cooling Process after Condensation.

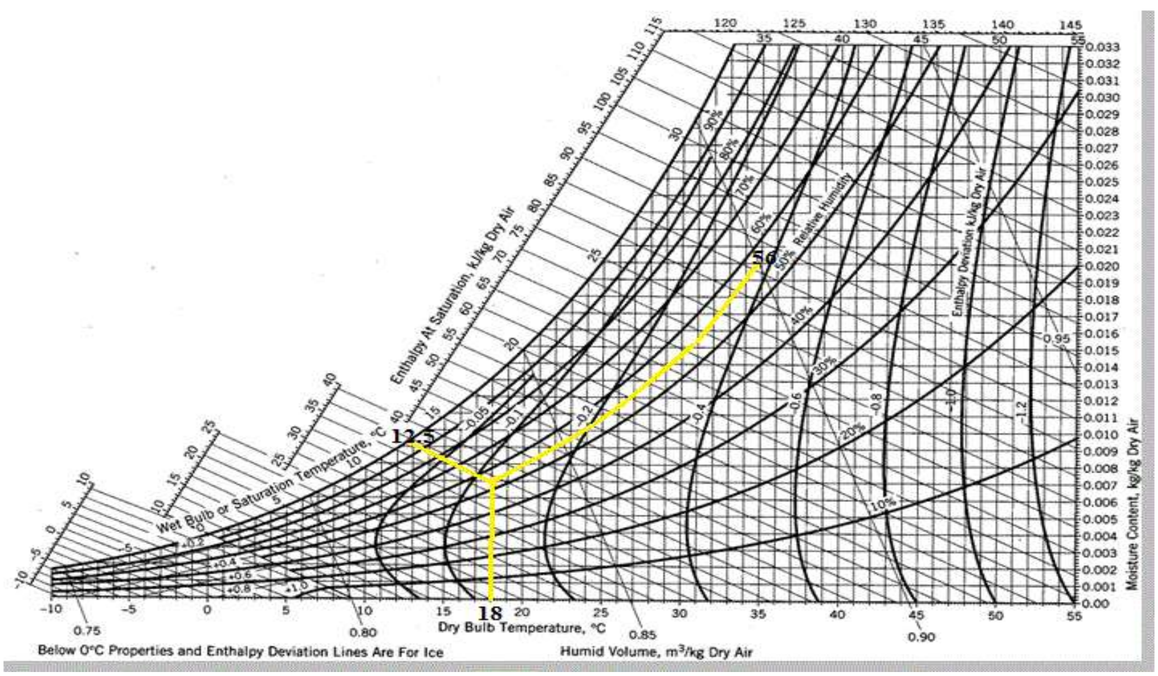

Fig. 5.2: Psychrometric chart indicating Relative Humidity.

B. Calculation

Hence the coefficient of performance is calculated as below:

COP=REFRIGERATING EFFECT/WORK DONE

$= (h_1 - h_4) \div (h_2 - h_1)$

$= (410-245) \div (443-410)$

COP =5

C. *Power Consumption*

Cooler electricity consumption
In this system three parts have consumed electricity, these are
Compressor
Inside motor (for evaporator fan)
Outside motor (for condenser fan)
Compressor =300 Watts
Inside motor =10 Watts
Outside motor =5 Watts
Overall consumption = compressor + inside motor + outside motor
= 300+10+5
= 315Watts
315 Watts = 1 hours = 315 W-hr.
1000 Watts consume 8 rupees
Therefore,
315 x 3.15 unit =992.25 watts
3 hr. 15 min. it consumes 8 units = 8 Rupees
6 hr. 30 min. it consumes 16 units= 16 Rupees
This cooler consumes power 1984.5 watts after each day when we used 6.30 hr. in a month.

D. *Monthly Bill*

Monthly electricity consumes in terms of rupees = 30(day) x16 (unit) = 480 Rupees.

E. *Air Conditioner Electricity Consumption*

As compare to air conditioner electricity consumption is 5 times more than a cooler.
Therefore,

F. *Monthly Bill*

Monthly electricity consumes in term of rupees = 480 x 5
= 2400 Rupees

VI. RESULT

Hence from the above calculations the coefficient of performance comes out to be 5.
Higher compatibility and portability is achieved which is more efficient than other cooling units.

VII. CONCLUSION

This project is very cheap and effective as compared with the conventional cooler and air conditioner system as it based on VCRs system. It has very low power consumption which ultimately increases the cop of the system which increases the cooling effect (refrigeration effect) of the system. It is portable. It has very low effect on environment as it saves electricity and water. One-time Installation procedure.
The concept is very cost effective as compared to AC.
Very Energy Effective system.

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