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Performance Investigation of Household Refrigerator Using Air-Cooled and Water-Cooled Condenser

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Abstract: ***In VCRC system, there are four components such as compressor, water-cooled condenser, expansion valve and evaporator. Compressor is the main part of this system. Compressor is also known as heart of this system.***
We people with normal health and habits, prefers to take tasteful diet in order to satisfy the tongue, in addition to fulfil the requirements of normal functioning of organs. But our habits for particular commodities call for the conservation of the commodities even for those periods during which they are not naturally available.
Refrigerator is the work consuming device. It is thermodynamic system which absorbs heat from low temperatures body and transfers it to the high temperature body that is atmosphere. Refrigerant is the substance which can absorb the heat in evaporator and loose heat in condenser in refrigeration system. In this system refrigerant R-134a is used because it's zero ozone depletion potential and low green house effect. It is chemically stable, non flammable, non explosive. Its heat rejection (heat transfer coefficient) capacity is more.
VCC is an improved type of refrigeration system. In this system, low pressure, low temperature vapour refrigerant from evaporator is drawn into the compressor through inlet valve where it gets compressed to high temperature, high pressure. This compressed refrigerant is discharged into the water-cooled condenser through discharge valve. Then in condenser heat is transferred from refrigerant to water cooled condenser and it gives latent heat to condensing medium then transfer to expansion valve (capillary tube). In this, to reduce the pressure of liquid refrigerant entering the evaporator. So the liquid refrigerant will vaporizes in the evaporator by absorbing latent heat from space which is to be cooled at low temperature.
Because of simplicity and low cost, capillary tubes are used as the expansion device in most small refrigeration and air conditioning system and also it allows high and low side pressure to equalize.
Keywords: Refrigeration, COP, water-cooled condenser, refrigerant.

I. INTRODUCTION

Vapour compression refrigeration system is an improved type of refrigeration system in which a suitable working substance is used to call refrigerant. Commonly used refrigerant are ammonia (NH3), carbon dioxide (CO2) and Freon. It is generally used for all domestic as well as industrial purpose.

A. Compressor
B. Water-cooled condenser
C. Expansion valve
D. Evaporator

Low pressure, low temperature vapour refrigerant from the evaporator is drawn into the compressor through the inlet valve where it is compressed to a high pressure and temperature, which is discharged into the water-cooled condenser through the discharge valve. Refrigerant, while passing through the condenser gives up its latent heat to the surrounding condensing medium which is normally air or water. Expansion valve is to reduce the pressure of liquid refrigerant entering the evaporator. So the liquid refrigerant wills vaporization the evaporator by absorbing latent heat from the space which is to be sold at low temperature. So the refrigerating effect is produced.

II. LITERATURE REVIEW

A. B.O. Bolaji et al investigated experimentally the performances of three ozone friendly Hydrofluorocarbon (HFC) refrigerants R12, R152a and R134a. R152a refrigerant found as a drop in replacement for R134a in vapor compression system.

B. B.O. Bolaji discussed the process of selecting environmental-friendly refrigerants that have zero ozone depletion potential and low global warming potential. R23 and R32 from methane derivatives and R152a, R143a, R134a and R125 from ethane derivatives are the emerging refrigerants that are nontoxic, have low flammability and environmental-friendly. These refrigerants need theoretical and experimental analysis to investigate their performance in the system.

C. Miguel Padilla et al found that R413A (mixture of 88% R134a, 9%R218, 3%R600a) can replace R12 and R134a in domestic refrigerator. Molina and Rowlands (1974) have been expanded into a comprehensive and very complex theory emphasis about 200 reactions that CFCs are significantly destroyed by UV radiation in the stratosphere. In the year 1987 Hoffman predicted 3 % global ozone depletion with contact of CFCs emissions of 700 thousand tone /year [4, 5,].

D. Mishra et al. Studied thermo physical properties by addition of different nanoparticle mixed with ecofriendly refrigerant are analyzed and their effects on the coefficient of performance (C.O.P.). The experimental results are indicating the thermal conductivity, dynamic viscosity and density of Nano-refrigerant (different nanoparticle i.e. Cu, Al_2O_3,CuO and TiO_2 with ecofriendly refrigerant R134a,R407c and R404A) increased about 15 to 94 %, 20% and 12 to 34 % respectively compared to base refrigerant on the other hand specific heat of Nano-refrigerant is slightly lower that the base refrigerant. Moreover Al_2O_3 /R-134a refrigerant shows highest C.O.P. of 35%. R404A and R407 with different nanoparticle show enhancement in C.O.P. about 3 to 14 % and 3 to 12 % respectively.

III.EXPERIMENTAL SETUP

In an air conditioning system, household refrigerator, freezers, etc. for this system four components are used, Evaporator, compressor, water cooled condenser and expansion valve.

1) *Compressor:* It is a mechanical thermodynamic device, in which pressure is increased as well as volume is reduced. Small reciprocating compressor from 5 to 30 HP is commonly seen in automotive application. Large reciprocating compressor from 1000 HP is used in large industrial application. In this hermetically sealed compressor is used. In this compressor and motor are operated on the same shaft and placed inside the casing which is hermetically sealed. Discharge line and service line come out of the casing and the service line is also changing of refrigerant and lubrication oil.

2) *Water-cooled Condenser:* In water-cooled condenser, water is used as a coolant which is replacement of air. Water passes through a heat exchanger where refrigerant passes inside the tube.

3) *Expansion Valve:* It reduces high pressure refrigerant to the low pressure refrigerant before the evaporator. It maintains required pressure difference in the high pressure line and low pressure line. It controls the flow of refrigerant according to the load of the evaporator. Capillary tube is used as an expansion device. Inside diameter is 0.5 to 2.25 mm and length varies from 0.5 to 5 m. The strainer is used at the inlet of the tube at high pressure line to protect from contaminants.

4) *Evaporator:* It is constructed either of steel pipe or copper tube pipe. It absorbs heat from the space which is cooled by means of refrigerants. It is connected low pressure line.

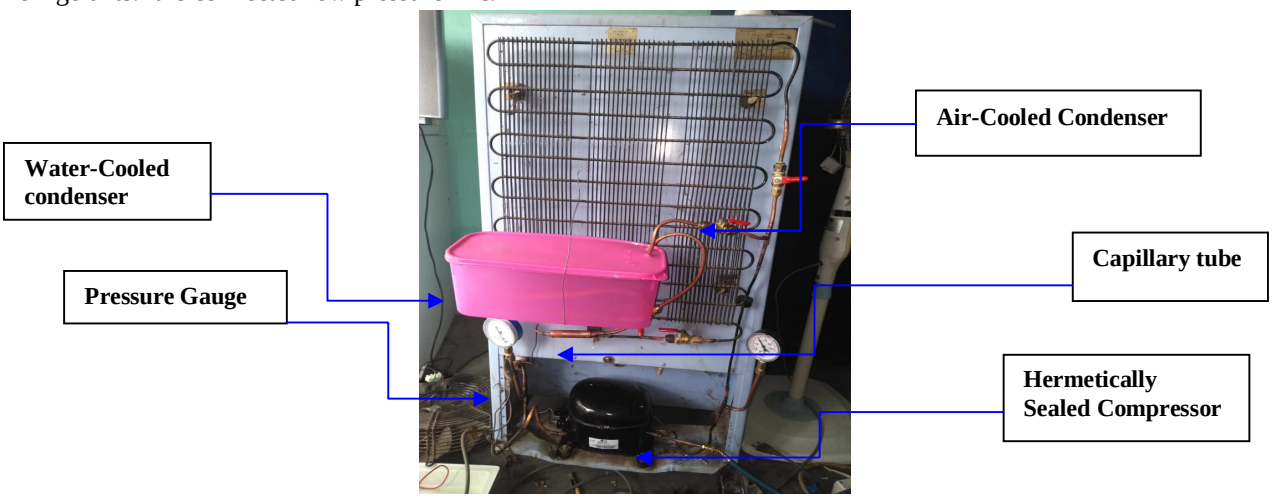

Fig 1 Experimental set up

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IV. EXPERIMENTAL PROCEDURE

Schematic diagram of the experimental setup is as shown in fig 1. After the assembly of all the components, the valve v_3 & v_4 was closed and v_1 & v_2 valve open then air cooled condenser is operated at five load condition that is no load, 4W, 6W, 8W, 10W. At v_1 & v_2 are closed and v_3 & v_4 open then water-cooled condenser was opened at various given load conditions. At each load conditions temperature and pressure are noted down at every 30min. The experiment was done untill steady state condition was attained in the evaporator. The energy consumption of both system is measured by using energy measure. The performance of air-cooled refrigerator and water-cooled refrigerator was measured and this takes result of air-cooled and water-cooled where completed.

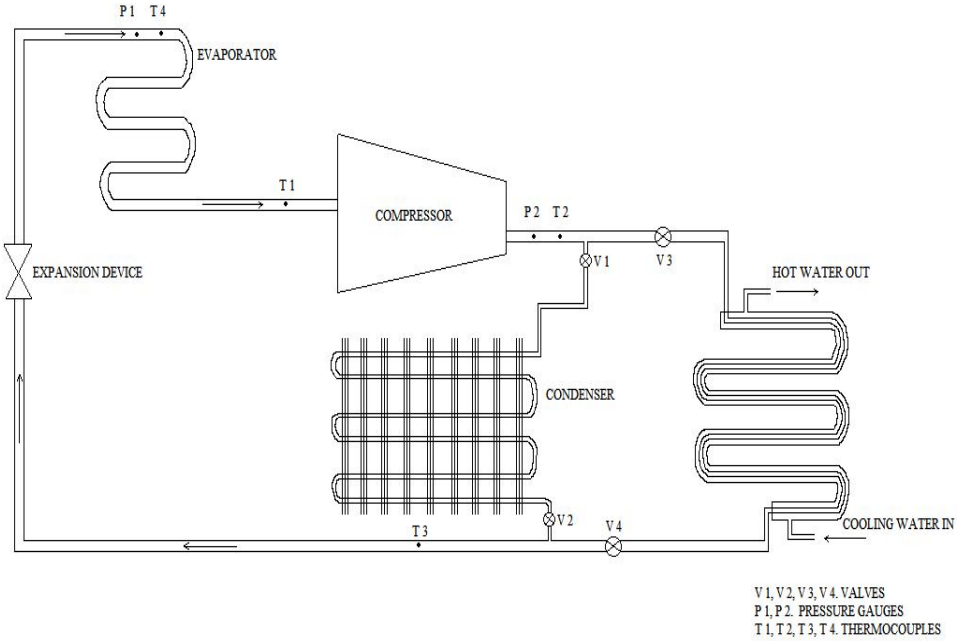


Fig.2 Schematic figure of vapour compression cycle with air-cooled condenser and water-cooled condenser [3]

V. RESULTS AND DISCUSSION

Fig3 shows COP variation of air-cooled and water-cooled condenser it have been seen that the COP was greater for the water-cooled condenser than the air-cooled condenser.This may be due to the inverse proportionality of COP to work done on all load conditions. These results confirmed that the performance of household refrigerator with water-cooled condenser was better than that of the air-cooled condenser.

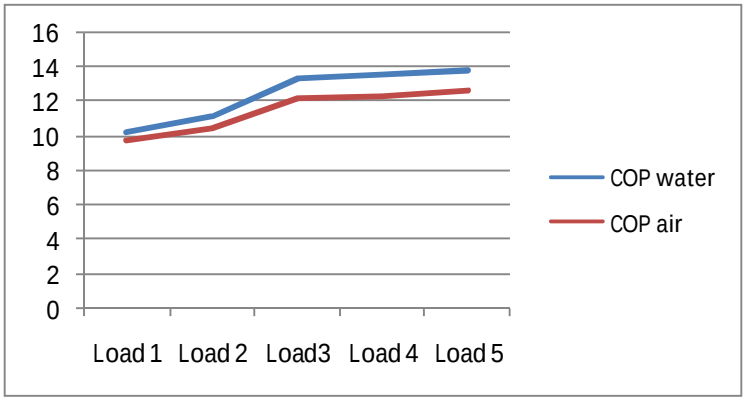
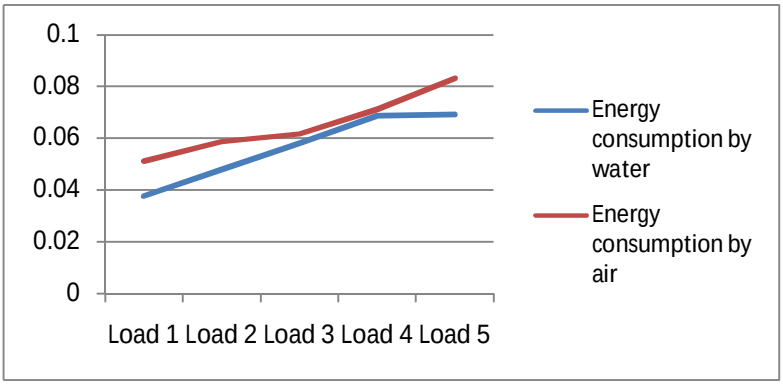


Fig 3: Load V/S Cop Graph

provides the energy consumption of the system at steady state for a time period of ten minutes. On using water-cooled condenser the energy consumption of the household refrigerator reduced by 14.20%(average).



VI. CONCLUSIONS

The main conclusion is listed as follows:

A. The household refrigerator worked normally and efficiently with water-cooled condenser.
B. On using water-cooled condenser the energy consumption of household refrigerator reduced by by 14.20%(average).
C. The hot water which was obtained from the water cooled-condenser can be utilized for household applications like cleaning, dish washing, laundry, bathing etc.

VII. ACKNOWLEDGMENT

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OBSERVATION TABLE

Table 3:- Shows the experimental readings of VCRC with air cooled condenser

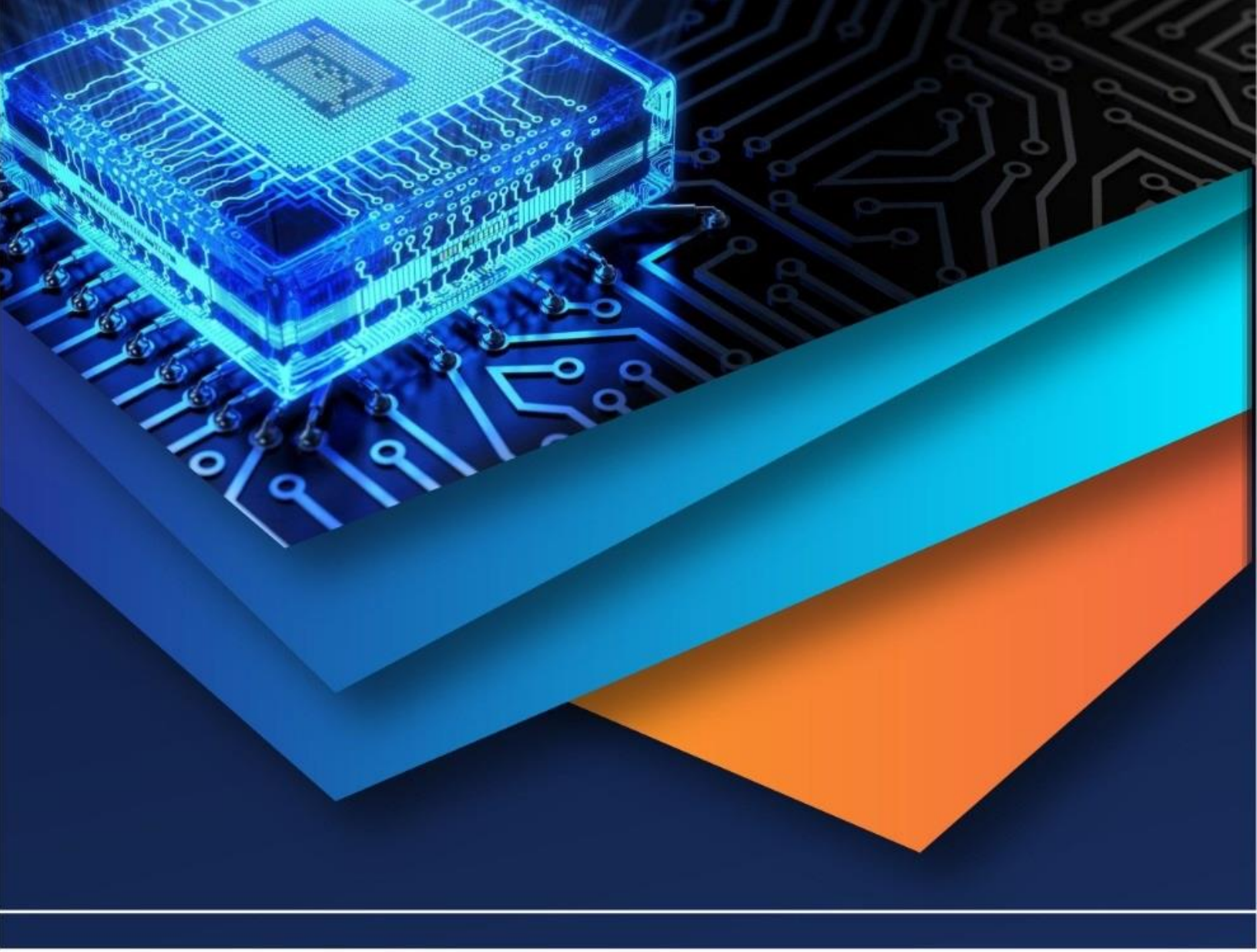
LOAD (litre)	P_1 (Bar)	P_2 (Bar)	T_1 (^OC)	T_2 (^OC)	T_3 (^OC)	T_4 (^OC)	COP
0	0.2729	17.2368	21.8	44.8	39.8	11.2	9.8
4	0.2729	17.2368	13.2	46.8	40.2	10.6	10.52
6	0.2729	17.2368	13.7	47.3	41.3	11.1	12.22
8	0.2729	17.2368	13.8	48.4	42.6	11.3	12.34
10	0.2729	17.2368	14.1	48.8	43.3	11.4	12.68

Table 4:- Shows the experimental readings of VCRC with water cooled condenser

LOAD (Litre)	P_1 (Bar)	P_2 (Bar)	T_1 (^OC)	T_2 (^OC)	T_3 (^OC)	T_4 (^OC)	COP
0	0.3447	16.8921	11.8	41.2	38.6	8.3	10.24
4	0.3447	16.8921	12.3	42.3	38.8	8.4	11.21
6	0.3447	16.8921	13.1	42.7	39.2	8.9	13.35
8	0.3447	16.8921	13.4	43.1	41.1	9.3	13.62
10	0.3447	16.8921	13.6	43.4	42.2	9.6	13.84

Table 5:- Shows the experimental readings of VCRC with Air-cooled condenser and water cooled condenser

AIR-COOLED CONDENSER		WATER-COOLED CONDENSER		POWER SAVINGS (KW)
LOAD(litre)	ENERGY CONSUMPTION	LOAD(litre)	ENERGY CONSUMPTION	
0	0.0512	0	0.0376	26.56%
4	0.0587	4	0.0479	18.39%
6	0.0617	6	0.0581	5.83%
8	0.0712	8	0.0687	3.51%
10	0.0832	10	0.0693	16.70%



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