

# Performance Evaluation of Vapour Compression Refrigeration System With Three Layer Zig -Zag Shaped Evaporator

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## ABSTRACT

This paper presents performance evaluation of the vapor compression refrigeration system with three layer zigzag evaporator. The main objective in the present work is to verify the performance of a domestic refrigerator of capacity 165 liters, R-600a as refrigerant with three layer zigzag shaped evaporator and comparing with that of the existing system. This evaporator assembly maximizes the refrigerating effect. An attempt made to verify the performance of the system by replacing the a single evaporator coil into three layers of zigzag shape coil to find the coefficient of performance (COP) and refrigeration effects. The proposed system with three layer zigzag evaporator designed and analysis carried out and studied the performance of the refrigerator.

## INTRODUCTION

Vapor compression Refrigeration system (VCR) is an improved type of air refrigeration system. The ability of certain liquids to absorb enormous quantities of heat as they vaporize is the basis of this system. The coefficient of performance of a refrigeration system is the ratio of refrigerating effect to the compression work; therefore the coefficient of performance can be increased by increasing the refrigerating effect or by decreasing the compression work. The Vapour compression refrigeration system is now-a-days used for all purpose refrigeration. It is generally used for all industrial purposes from a small domestic refrigerator to a big air-conditioning plant.

Basic components of VCR:

- 1).Compressor
- 2).Condenser
- 3).Expansion valve
- and
- 4).Evaporator

The refrigeration effect (output) is produced at evaporator in VCR. There are few methods of improving the COP for a Domestic Refrigerator which is operated by VCR. Increasing the refrigeration effect is one of the best way to improve the performance of VCR.

In this paper, it is observed that the refrigeration effect can also be increased by modifying the circulation of liquid refrigerant in the evaporator tube. The arrangement of tube is in three layers in zigzag manner, two layers are parallel and horizontal at top and one layer is vertical at bottom of evaporator. Further, this arrangement can also increase the cooling space/refrigeration zone in the refrigerator

## EXPERIMENTAL SETUP

In vapor compression refrigerating system basically there are two heat exchangers. One is to absorb the heat which is done by evaporator and another is to remove heat which is done by condenser and the heat of compression added in the compressor and condenses it back to liquid which is done by condenser. This project focuses on heat absorption in the evaporator and investigated the performance of three layer zigzag shaped evaporator using these evaporator in the present domestic refrigerator. In this project the evaporator surface and the length has been increased in zigzag form In order to know the performance characteristics of the vapor compression refrigerating system the temperature and pressure gauges are installed at each entry and exit of the component. Experiments are conducted on the evaporator. Different types of tools are also used like tube cutter to cut the tubes and tube bender to bend the copper tube to the required

angle. Finally the domestic refrigerator is fabricated as for the requirement of the project. Specifications of the domestic refrigerator for existing system and proposed systems tabulated below.

**TABLE1.Specifications of the domestic refrigerator for existing system and proposed systems:**

S. N O	SPECIFICAT IONS	EXISTIN G SYSTEM	PROPOS ED SYSTEM
1.	Refrigerant used	600a	600a
2.	Capacity of the compressor	0.16HP	0.16HP
3.	Length of the condenser	10m	10m
4.	Diameter of the condenser	0.54cm	0.54cm
5.	Length of the evaporator	36.09	12m
6.	Diameter of the evaporator	0.8cm	0.8cm
7.	Length of the capillary tube	3.75m	3.75m
8.	Diameter of the capillary tube	0.2cm	0.2cm
9.	Material used	aluminu m	copper
10.	Evaporator model	plate type	three layer

**Specifications of three layer evaporator**

- Number of layers = 3
- Radius of bend 1 = 2.54 cm
- Radius of bend 2 = 1.90 cm
- Pitch between bend 1 = 12.7 cm
- Pitch between bend 2 = 15.24cm
- Number of turns = 9

The following procedure is adopted for experimental setup of the vapor compression refrigeration system

The domestic refrigerator is selected, working on vapor compression refrigeration system. Pressure and temperature gauges are installed at each entry and exit of the components. Flushing of the system is done by pressurized nitrogen gas.

R 600a refrigerant is charged in to the vapor compression refrigeration system by the following process:

The systematic line diagram for charging is shown in the fig. it is necessary to remove the air from the refrigeration unit before charging. First the valve V<sub>2</sub> is closed and pressure gauge P<sub>2</sub>, vacuum gauge V are fitted as shown in the fig. the valve V<sub>5</sub> is also closed and valves V<sub>1</sub>, V<sub>4</sub>, V<sub>6</sub> and V<sub>3</sub> are opened and the motor is started thus the air from the condenser receiver and evaporator is sucked through the valve V<sub>1</sub> and it is discharged in to atmosphere through the valve V<sub>6</sub> after compressing it in the compressor the vacuum gauge V indicates sufficiently low vacuum when most of the air is removed in the system. The vacuum reading should be at least 74 to 75 cm of Hg. If the vacuum is retained per above an hour it may be concluded that the system is free from the air. After removing the air the compressor is stopped and valves V<sub>1</sub> and V<sub>6</sub> are closed, the valves V<sub>5</sub>, V<sub>2</sub> and V<sub>7</sub> of the refrigerant cylinder are opened and then the compressor is started whenever the sufficient quantity of refrigerant is taken in to the system which will be noted in the pressure gauges. The compressor is stopped. The valves V<sub>7</sub> and V<sub>5</sub> are closed and valve V<sub>1</sub> is opened the refrigerant cylinder is disconnected from the system the pressure gauge is used to note the pressure during the charging the system.

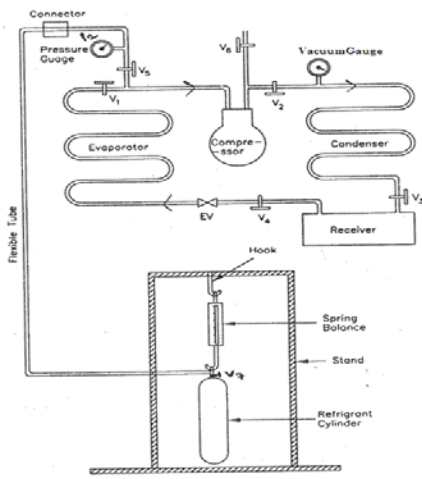


Fig. Charging of Refrigeration System.

Fig 1 . Charging of refrigeration system

PROPOSED SYSTEM OF THE REFRIGERATOR



FIG 2.EXPERIMENTAL DOMESTIC REFRIGERATOR

Leakage tests are done by using soap solution, In order to further test the condenser and evaporator pressure and check purging daily for 12 hours and found that there is no leakages which required the absolutely the present investigation to carry out further experiment. Switch on the refrigerator and observation is required for 1 hour and take the pressure and temperature readings at each section. The performance of the existing system is investigated, with the help of temperature and pressure gauge readings. The refrigerant is discharged out and condenser is located at the inlet of the capillary tube. Temperature and pressure gauge readings are taken and the performance is investigated. The readings are tabulated for three layer condenser. The tests were conducted and calculated values tabulated below .

**Schematic diagram of the domestic refrigerator**

1. At first layer = -2°C
2. At second layer = -2°C
3. At third layer = 0°C
4. Ambient temperature = 37°C

TABLE2. Experimental values of pressure and temperature

S. NO	PARAMETERS	EXISTING SYSTEM	PROPOSED SYSTEM
1.	suction temperature(°C), T <sub>1</sub>	28	24
2.	discharge temperature(°C), T <sub>2</sub>	71	68

3.	condenser temperature( $^{\circ}\text{C}$ ), $T_3$	38	34
4.	evaporator temperature( $^{\circ}\text{C}$ ), $T_4$	-4	-3
5.	suction pressure(bar), $P_1$	0.35	0.4
6.	discharge pressure(bar), $P_2$	14	10
7.	condenser pressure(bar), $P_3$	14	10
8.	evaporator pressure(bar), $P_4$	0.35	0.4

## RESULTS AND DISCUSSIONS

The performance of vapour compression system by using three layer with zig-zag shaped evaporator and compare with the existing system. The existing system coefficient of performance is 5.81 and three layer evaporator has been increased with an coefficient of performance is to 6.6

**Graph 1: Effect of evaporator on compressor work**

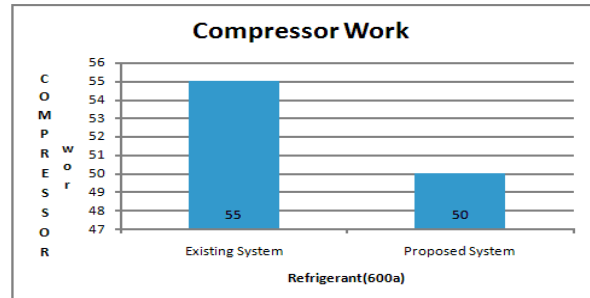


Fig shows the compressor work with the existing system. It is observed that compressor work is decreased with the existing system. Because, here the suction pressure is increased and discharge pressure is decreased, so the compressor work and compressor power decrease when compare proposed system with the existing system.

**Graph 2: Effect of evaporator on net refrigeration**

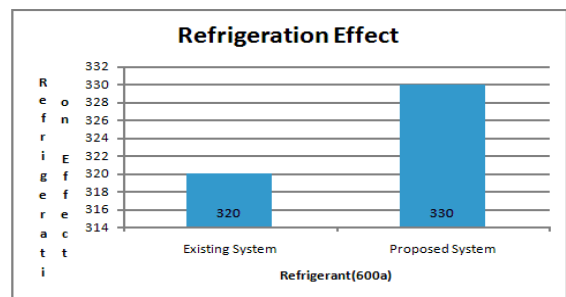
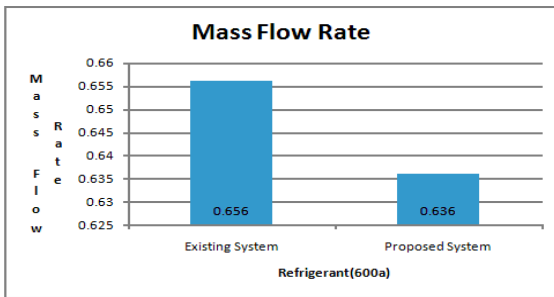


Fig show is observed that it net refrigeration increased with existing system. When suction pressure is increased and discharge pressure is decreased area of cooling space is increased from p-h chart and experimentally the evaporator surface and length also increased because of this reason net refrigeration effect is increased.

**Graph 3: Effect of evaporator on mass flow rate**

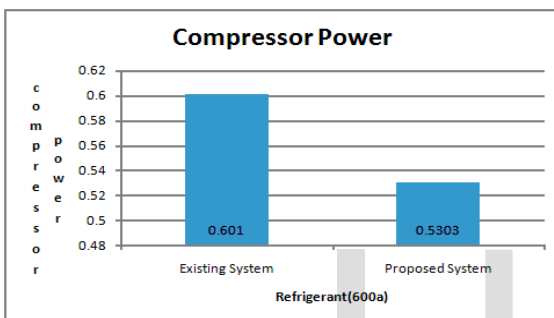
**Table 3. Calculated values of various parameters**

•S. NO	PARAMETERS	EXISTIN G SYSTEM	PROPOS ED SYSTEM
1.	Net refrigerating effect kJ/kg	320	330
2.	Coefficient of Performance (COP)	5.81	6.623
3.	Mass flow rate to obtain one TR kg/min	0.656	0.636
4.	Work of Compression kJ/kg	55	50
5.	Heat Equivalent of work of compression per TR kJ/min	36.09	31.81
6.	Compressor Power KW	0.601	0.5303
7.	Heat to be rejected in condenser kJ/kg	375	380
8.	Heat Rejection per TR kJ/min	246.093	249.375
9.	Heat Rejection Ratio	1.171	1.875
10.	Compression Pressure Ratio	40	25



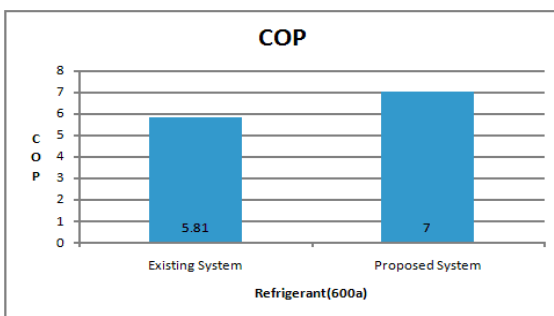
shows the mass flow rate with existing system. It is observed that it mass flow rate decreased with existing system.

**Graph4: Effect of evaporator on compressor power**



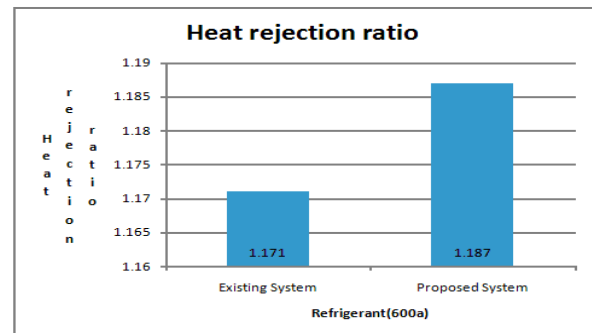
Shows the compressor power with exiting system. It is observed that it decreasing compressor with existing system, because of suction pressure increased and discharge pressure decreased.

**Graph 5: Effect of evaporator on coefficient of performance**



It is seen that the at the performance of the refrigeration system as the compressor work decreases with increase in coefficient of performance and decrease in heat rejection .when the evaporator performance is increased and compressor work is decreased the performance of the system is also increased because it is the ratio of the heat absorb from the system to compressor work.

**Graph 6: Effect of evaporator on heat rejection ratio**



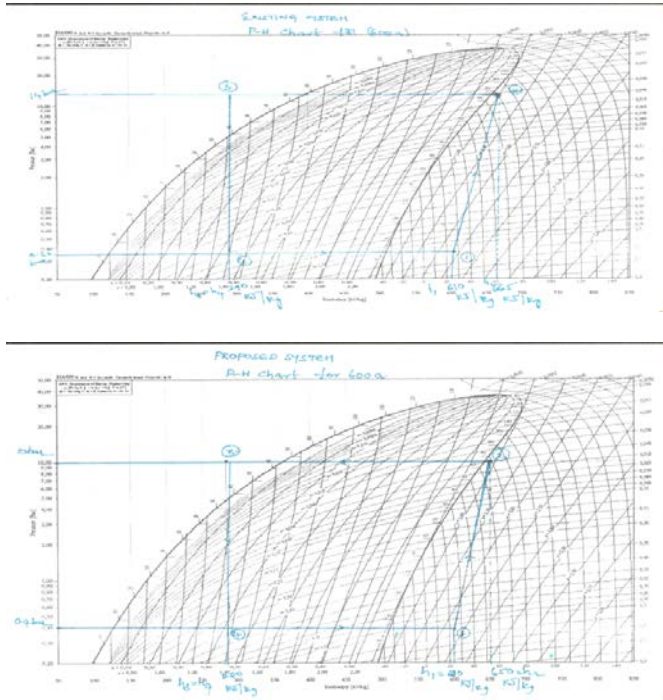
Shows the heat rejection ratio. It is observed the heat rejection ratio has been decreased because of the net refrigeration effect is increased and greater than the heat rejection compared with the existing system.

**CONCLUSIONS**

- In my present work an experiment set is prepared for both existing and proposed system. In the proposed system three layer zig-zag shaped evaporator is used. The capacity of the domestic refrigerator is 165Lts.
- Experiments are conducted for existing system and proposed systems. In both systems 600a refrigerant is used.
- In the proposed system the compressor work is less than compressor work of existing system. The percentage of reduction in compressor work is 9.
- In the proposed system the heat to be rejected in the condenser is greater than the heat to be rejected in existing system. The percentage of heat reduction in condenser is 1.3.
- In the proposed system the COP is greater than the COP of the existing system. The percentage of increase in COP is 13.
- From the above results, It is concluded that, the proposed system with 600a is giving the better performance than the existing system with 600a. Hence the proposed is best suitable for the 165lts of domestic refrigerator.

**APPENDIX**

**Refrigerant R600a Charts for existing and proposed systems**



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