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PERFORMANCE OF CRIMPED CONDENSER WITH HIGH SIDE FLOAT VALVE ON THE VAPOR COMPRESSION REFRIGERATION SYSTEM (VCRS) BY USING R-134a REFRIGERANT

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Abstract

This Experimental set up reports about the Performance of a VCRS with crimped Condenser placed along with the High Side Float Valve by using R-134a as a Refrigerant. Now-a-days, Most of the Refrigerators work on the VCRS System. The VCR System consists of the important components like Compressor, Condenser, Expansion Device and Evaporator. The Performance of the System depends upon the components of the system.

The main aim of this project is to analyses the Performance of the domestic Refrigerator with Crimped Condenser along with the high Side float valve to that of the Existing System. High Side Float valve is placed on the high pressure side of the refrigerator to control the flow of the Refrigerant according to the mass flow rate, which will improve the energy efficiency of the system. The Performance of the System depends on all the components of the system. In the present Experimental work, the shape of the condenser is changed to Crimped shape i.e., by providing ridges to the condenser with an angle of 90^0 and the float Valve is placed at the end of the Crimped Condenser. Since the Crimped shape Condenser has ridges, it allows the refrigerant to flow in the coil and have the better thermal contact (surface area) between the surface of the coil and the refrigerant. Thus it rejects more amount of heat, which helps in improving the performance of the System.

The Performance Parameters include Refrigeration Effect, Mass flow rate, Work done by the Compressor, Coefficient of Performance. Finally it is observed that the Crimped Condenser with High Side Float Valve has given the maximum COP, when it is compared with the Existing System. Finally it is concluded that the Crimped Condenser along with high pressure float valve gives better performances than the Existing System.

Keywords: *Vapor Compression Refrigeration System, Crimped Condenser, High Side Float Valve, R-134a Refrigerant.*

I. INTRODUCTION

As most of the Refrigerators work on Vapor Compression Refrigeration System and consists of the components like Compressor, Condenser, Expansion Device and Evaporator. In the thermodynamic cycle of VCRS, the low pressure vapor refrigerant enters in to the Compressor and compressed in to high pressure vapor refrigerant, which then enters in to the condenser, where Condensation takes place i.e., High Pressure Vapor Refrigerant converts in to High Pressure Liquid Refrigerant. In Condenser the heat is rejected at constant Pressure. The High Pressure liquid Refrigerant enters in to the Expansion Device, where throttling takes place and converts in to Low Pressure Liquid Refrigerant at constant Enthalpy. Usually it is Capillary tube in Refrigerators. The Low Pressure Liquid Refrigerant has undergone Evaporation Process i.e., Low Pressure Liquid Refrigerant converts in to Low pressure Vapor Refrigerant in the Evaporator, where heat is absorbed by the Refrigerant at Constant Pressure.
The following fig 1.1 shows the Basic Vapor Compression Refrigeration System

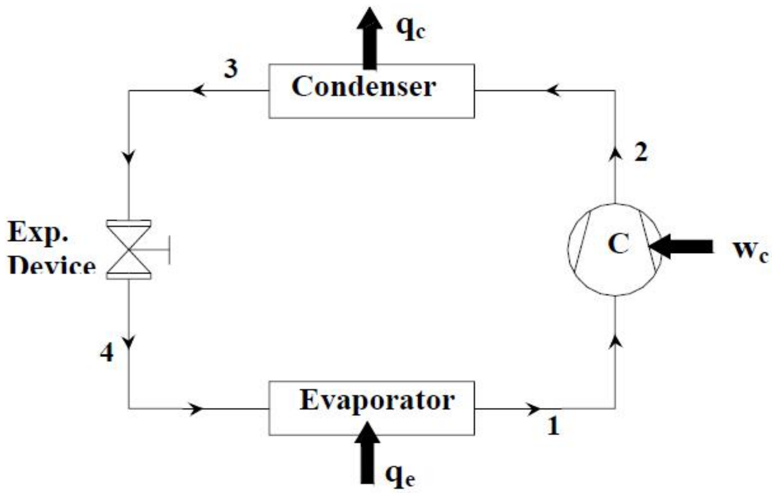

Fig 1.1: Outline of Basic VCR System

The Performance of the System depends on all the components of the system. In the present Experimental work, the shape of the condenser is changed to Crimped shape i.e., by providing ridges to the condenser with an angle of 90^0 and the float Valve is placed at the end of the Crimped Condenser. The flow of the Refrigerant will be controlled by providing Float Valve, which will improve the performance of the system. Since the Crimped shape Condenser has ridges, it allows the refrigerant to flow in the coil and have the better thermal contact between the surface of the coil and the refrigerant. Thus it rejects more amount of heat, which helps in improving the performance of the System.

II. OBJECTIVE

The main Objective of the Present Experimental work is

- To determine the Performance of the System with and without load Conditions.
- To Compare the Existing System with the Proposed System i.e., Crimped Condenser along with High Side Float Valve

III. COMPONENTS USED

- Domestic Refrigerator of 220 liters Capacity consists of Hermetically Sealed Compressor, Condenser, Capillary tube, Evaporator
- Copper tube
- High Pressure Float Valve
- Thermocouples
- Stop watch
- Pressure gauges
- R-134a Refrigerant
- Base Stand
- Power Supply(230V AC, 50 Hz)

IV. SYSTEM DESCRIPTION

The Domestic Refrigerator, which is used for the current Experimental work has the specifications of

1. Refrigerant used : R-134a (Tetrafluoro-ethane)

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2.	Refrigerator Capacity	:	220 liters
3.	Compressor Capacity	:	1/5 HP
4.	Condenser Sizes		
	I. Existing Iron Condenser		
	Length	:	7.3152m
	Diameter	:	4.76mm
	II. Proposed Crimped Condenser		
	Length	:	8.9916m
	Diameter	:	6.35mm
5.	Capillary tube		
	Length	:	2.7432m
	Diameter	:	0.036mm
6.	Evaporator		
	Length	:	7.62m
	Diameter	:	6.5mm
7.	High Pressure Float Valve	:	5MPa

5.1. Condenser:

The main purpose of Condenser is to reject the heat from the refrigerant to the Surroundings by removing excess heat through the process of Condensation of refrigerant**.** The amount of heat rejected is given by Q= UA (LMTD) U is the overall convective heat transfer Coefficient, A is the Surface area (m^2), LMTD: logarithmic mean temperature difference between the temperature of refrigerant and Surroundings (^OC)

In Domestic Refrigerators, the Condenser is made up of Iron and has a thermal Conductivity of 79.5W/mK and the Emissivity Coefficient is 0.14-0.38. In this Current Experimental work, the condenser is made up of Copper and has a thermal Conductivity of 385W/mK and the Emissivity coefficient is 0.023-0.052. The corrosion rate of Iron is relatively higher than that of copper.

When the Shape of the Condenser is changed to Crimped, the flow of refrigerant inside the coil will have higher surface area due to the ridges provided with an angle, which will be a blockage to the refrigerant to flow. Thus the surface area of the Crimped Condenser increases, which increases the heat transfer rate.

fig5.1.1: Normal Iron Condenser

fig 5.1.2: Crimped Copper Condenser

5.2. Expansion Device:

The main purpose of Expansion Device is

- To reduce the pressure from Condenser Pressure to Evaporator Pressure.

- To regulate/control the flow of refrigerant from high pressure liquid line to the Evaporator at a rate equal to the Evaporation rate in the Evaporator.

In domestic Refrigerators, Capillary tube is used generally to reduce the Pressure, which occurs due to the friction. To control the flow of refrigerant is an incomplete task in Domestic Refrigerators. So in our current Experimental Project, in order to control the refrigerant flow, a high Pressure Float valve is also used along with Capillary tube.

Capillary tube is a fixed opening type, where the flow area remains fixed. It is a long, narrow tube of constant diameter. The Pressure drop occurs due to the frictional resistance offered by the tube walls and also due to the increase of velocity or acceleration of Refrigerant when the liquid refrigerant evaporates in to mixture of liquid and vapor.

High Pressure Float Valve is of Variable opening type, where the flow area varies according to the load. It opens or closes depending upon the load sensed by the buoyant member called Float. It is fixed at the outlet of the Condenser. The high Pressure float valve used here is of metering electronic type, where it has to be given wiring to the compressor. Based on the load taken by the Compressor, the High pressure which has the magnet inside will open and close accordingly. Here the float is the magnet and float valve is a solenoid ball valve.

fig 5.2: High Pressure Float Valve

5.3. Refrigerant (Tetra-flouro Ethane):

The Refrigerant which is used in the Present Research work is R-134a, which is commonly known as Tetra-flouro Ethane. It belongs to Hydro Carbon Family and is widely used Refrigerant. It is non-toxic, non-flammable, non-explosive, highly affinity of moisture, immiscible in mineral oils, highly hygroscopic and has a good chemical stability

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Fig5.3: R-134a (Tetra-flouro Ethane) Refrigerant Cylinder

The following table shows the properties of R-134a Refrigerant, which is used in current Experimental Work

Table 5.3.1: Properties of R-134a Refrigerant

S.NO	PROPERTIES OF REFRIGERANT	VALUE
1	Name	Tetra fluoro ethane
2	Chemical Formula	CH_2CF_3
3	Group	HFC
4	Atmospheric Life	16
5	Cylinder Color	Light Blue
6	ASHRAE Safety Rating	A1
7	Ozone Depletion Potential(ODP)	0
8	Global Warming Potential(GWP)	1300
9	Type of Availability	Pure form or blended
10	Ratio of Specific heat of Refrigerant at constant pressure to Constant volume(C_p/ C_v)	1.31
11	Critical Temperature (T_{cr})	101.06^{O}C
12	Normal Boiling Point	-26.15^{O}C
13	h_{fg} at Normal Boiling Point	222.5 KJ/Kg
14	Pressure at Room Temperature	70 psi
15	Auto Ignition Temperature	770^{O}C
16	Solubility in water	0.11% by weight at 25^{O}C

Applications of R-134a:

- It is used as a replacement of R-12 Refrigerant in Domestic Refrigerators.
- It is widely used in water coolers, Air Conditioning Systems, Automobile A/C's and etc.

Disadvantages:

According to Montreal Protocol, the refrigerants belongs to HFCs should be phase out by 2030 and according to Kyoto Protocol, phase out the Substances that lead to Global warming by 2030. Since R-134a belongs to HFCs, it will fade out by 2030.

*Future Scope of R-134a***:**

R-1234yf commonly known as Tetrafluoropropene belongs to Hydro Fluoro Olefin (HFO) family has a GWP of 4, which is 99.7% lower than R-134a will replace R-134a, but it has to get approval from Environmental Agency.

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Since R-134a has a GWP of 1300, it will lead to the increase of Global Warming due to the emissions of CO_2. In order to Control the CO_2 emissions, Carb Fix is a collaborative research project led by Reykjavik Energy. It aims at developing safe, simple and economical methods and technology for permanent CO_2 mineral storage in basalts. Carbon Capture and Storage (CCS) is a technology that can capture up to 90% of the carbon dioxide (CO_2) emissions produced from the use of fossil fuels in electricity generation and industrial processes, preventing the carbon dioxide from entering the atmosphere. The use of CCS with renewable biomass is one of the few carbon abatement technologies that can be used in a 'carbon-negative' mode – actually taking carbon dioxide out of the atmosphere

V. EXPERIMENTAL WORK

1. The Copper coil of required dimensions is taken and has to be straightened the Coil.
2. Bend the coil in to desired shape i.e., Crimped shape of 90^{O} bend or pitch angle is to be done with the help of Bender.
3. Take the Domestic Refrigerator and fit the crimped condenser and high Pressure float valve with the help of tools like tube cutter, cutting plier, flaring bar, nose plier, Ratchet.
4. Check that the refrigerator is free from blockages for the refrigerant flow.
5. Install the Pressure gauges and temperature indicators i.e., thermocouples at each entry and exit of the Component.
6. Leakage tests are to be done by using soap solution.
7. Once the system has no leakages, Charge vacuums in to the refrigerator in order to make the system stable.
8. Now Charge the refrigerant R-134a along with anti-choke in order to remove the moisture present in the Compressor. Charge the refrigerator up to which it is about to gets the back pressure.
9. Take the readings of pressure and temperature of the Components for both the Conventional and Proposed System for load and unload Conditions separately.
10. Calculate for the Performance Parameters with the help of the readings.

VI. RESULTS AND DISCUSSIONS

Table 6.1: Comparison table for performance parameters of both Existing and Proposed System

S. No	Parameters	Existing System	Proposed System
1	Net Refrigeration Effect KJ/Kg	185	198
2	Coefficient of Performance (COP)	2.846	3.19
3	Mass flow rate to obtain 1TR Kg/min	1.135	1.06
4	Compressor Work KJ/Kg	65	62
5	Power Consumption in KW	1.229	1.095
6	Heat to be rejected in Condenser KJ/Kg	250	260
7	Heat Rejection per TR KJ/min	283.78	275.75
8	Heat Rejection Ratio	1.351	1.313
9	Compression Pressure Ratio	9.7	11.5

The Performance Parameters for VCR System have been calculated for both load and unload conditions. The following are the Results that have been compared for both the Existing and Proposed System. The following are the comparison of the different parameters like mass flow rate, Net Refrigeration Effect, Power Consumption, Coefficient of Performance (COP) and etc.

6.1. Comparison of mass flow rate

The following graph shows the Comparison of mass flow rate for both Conventional System (Existing System) and Proposed System under load and unloads.

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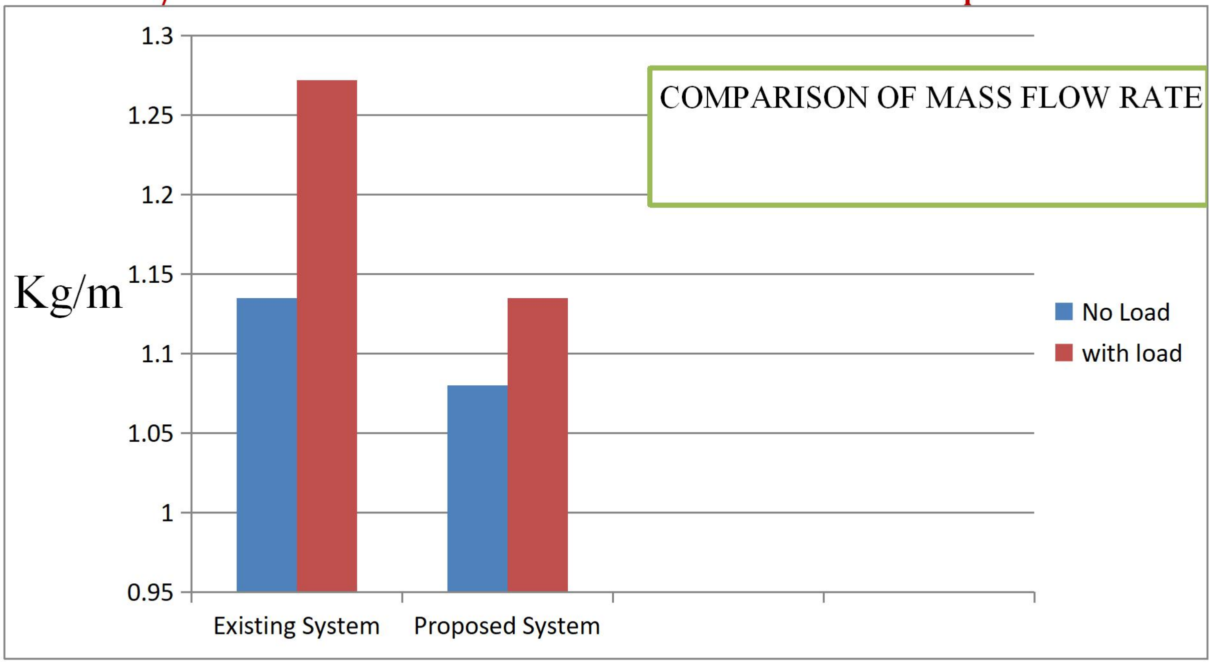

Fig 6.1: Comparison of Mass flow rates

From the above results, it is to be noted that the Mass flow rate of the Proposed System has been reduced to 4.85% from 1.135 Kg/min to 1.05 Kg/min.

6.2 Comparison of Net Refrigeration Effect:

The following graph shows the Comparison of Net Refrigeration Effect (NRE) for both Conventional System (Existing System) and Proposed System under load and unloads

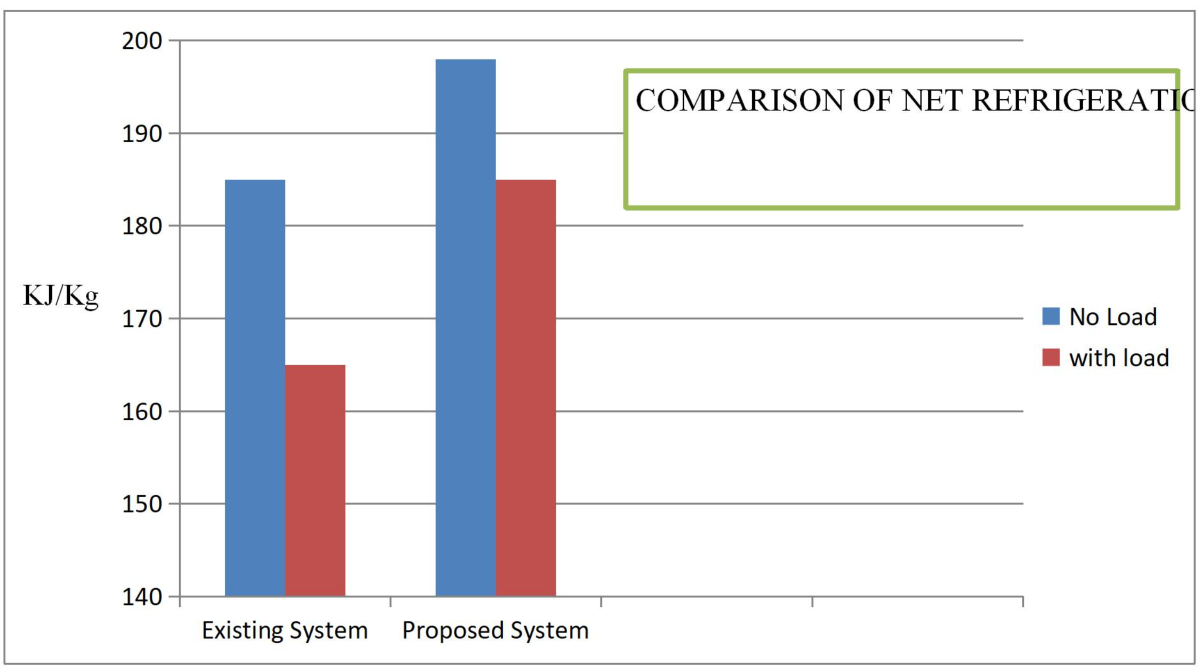

Fig 6.2: Comparison of Net Refrigeration Effect

It is obvious from the above result that the Net Refrigeration Effect of the Existing system has been increased to 7.02% from 185KJ/Kg to 198 KJ/Kg due to the change in shape of the Condenser.

6.3 Comparison of Power Consumption

The following graph shows the Comparison of Power Consumption for both Conventional System (Existing System) and Proposed System under load and unloads

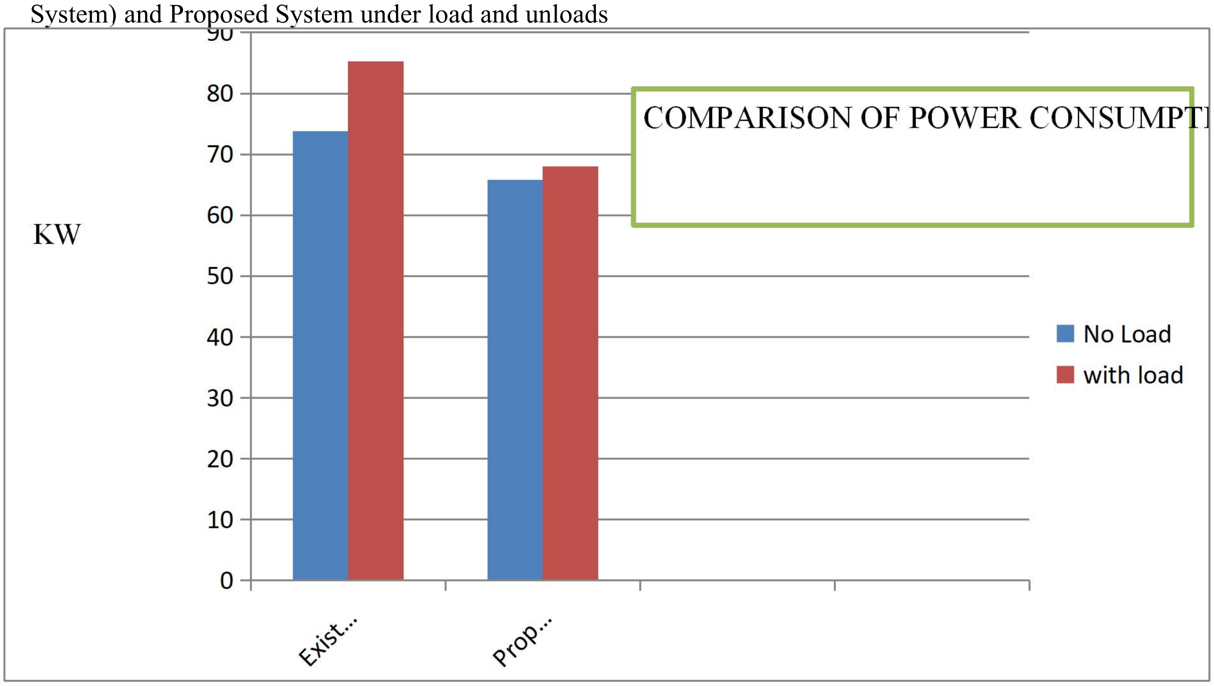

Fig 6.3: Comparison of Power Consumption

It is clear from the above result that the Power Consumption of the Compressor has been reduced to 10.88% from 73.78KW to 65.75KW.

6.4. Comparison of Coefficient of Performance (COP):

The following graph shows the Comparison of Coefficient of Performance (COP) for both Conventional System (Existing System) and Proposed System under load and unloads

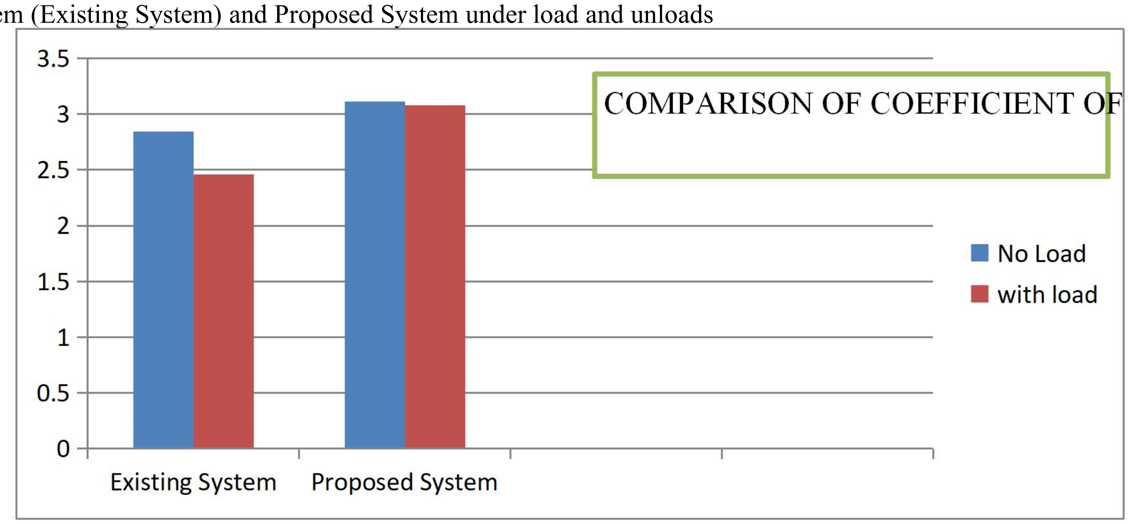

Fig 6.3: Comparison of Coefficient of Performance (COP)

From the above result, it is shown that the Coefficient of Performance (COP) of the Proposed System has been increased to 12.08% from 2.846 to 3.19.

VII. CONCLUSIONS

From the above results,

- It is concluded finally that, by changing the shape of Existing design to Crimped shape Copper Condenser the coefficient of performance will give better performances than the Normal Iron Condenser.
- In the Proposed System, the Net Refrigeration Effect is increased to 7.02%, Power Consumption reduces to 10.88%, Heat rejection is increased by 4%, mass flow rate reduces to 4.85%, COP increases to 12.08%.

VIII. FUTURE SCOPE OF WORK

There are different ways to increase the Performance of the VCR System. One such method is changing the Shape of the Condenser to Crimped shape with an angle of 90^0.

- By changing different pitch angles and Shape of the Condenser, the heat transfer in the condenser increases.
- By choosing different lengths and diameters, increases the more surface area and increases the rate of heat transfer in Condenser
- By choosing the material with highest thermal Conductivity or by providing Surface coating techniques to the chosen material, the thermal Conductivity can be increased. Thus increases the heat transfer rate.

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