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Performance Analysis of VCR System using Diffuser at Condenser Inlet & alternative Refrigerants

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Abstract – *The aim of our project is to improve the Coefficients of Performance (COP). It is to require that compressor work decrease and refrigerant effect increase. The purpose of compressor in VCR system is to evaluate the pressure of refrigerant, but refrigerant leave the compressor with comparatively high velocity which may causes splashing of liquid refrigerant in the condenser tube, liquid lump & damage to condenser by erosion. It is needed to convert this kinetic energy in to pressure energy by using diffuser and other benefit is power consumption is less for same refrigerating effect, so performance is improve. The size of the condenser will also reduce due to more heat transfer, so cost of the condenser will be reduces. We also observe so many other difficulties in the VCR system when R 22 refrigerant is use. So our future plane is to reduce this difficulty by using alternative refrigerant (R 410) final shows which is best and suitable in VCR system.*

Keywords – *Compressor, Diffuser, Condenser, Evaporator, COP, Performance, R22*

I. INTRODUCTION

What is Refrigeration?
"The method of reducing the temperature of a system blow surrounding temperature & maintain it at the lower temperature by continuous absorbing the heat from system."

What is Refrigerant?
"It is heat carrying medium which absorb heat from space and reject heat to outside the refrigerator."

The COP of the system is increased by so many methods, but we are trying diffuser at the condenser inlet and alternative refrigerants. In this work, vapour compression refrigeration system, condenser is used to remove heat from high pressure vapour refrigerant and converts it into high pressure liquid refrigerant.

The refrigerant flows inside the coils of condenser and cooling fluid flows over the condenser coils. Condenser used in domestic vapour compression refrigeration system is air cooled condenser, which may be naturally or forced air cooled. Heat transfer occurs from the refrigerant to the cooling fluid. High pressure liquid refrigerant flows through an expansion device to obtain low pressure refrigerant. Low pressure refrigerant flows through the evaporator. Liquid refrigerant in the evaporator absorbs latent heat and get converted into vapour refrigerant which returns to compressor. Compressor raises the pressure and temperature of the vapour refrigerant and discharges it into the condenser to complete the cycle.

In the present cycle, the vapor refrigerant leaves the compressor with comparatively high velocity. This high velocity refrigerant directly impinges on the tubing of condenser which may cause damage to it by vibration, pitting and erosion. It results in undesirable splashing of refrigerant in the condenser coil. It also results a phenomenon called as "liquid lump". Liquid lump refers to a rise in the level of the condensed refrigerant liquid in the central portion of the condenser as compared to the level at the ends of the condenser. It reduces the effective heat transfer surface area which can reduce condenser efficiency.

Diffuser is the static device. It raises the pressure of flowing fluid by converting its kinetic energy. In vapor compression refrigeration system, to avoid the problems of high velocity refrigerant one of the way is to use diffuser at condenser inlet. It smoothly decelerates the incoming refrigerant flow achieving minimum stagnation pressure losses and maximizes static pressure recovery. Due to pressure recovery, at same refrigerating effect compressor has to do less work. Hence, power consumption of the compressor will be reduced which results improvement in system efficiency. As the refrigerant flow passes through the diffuser, pressure as well as temperature will be increased. In air cooled condenser for constant air temperature, temperature difference between hot and cold fluid will be increased. So, amount of heat rejected from condenser will be increased. To remove the same amount of heat less heat transfer area will be required.

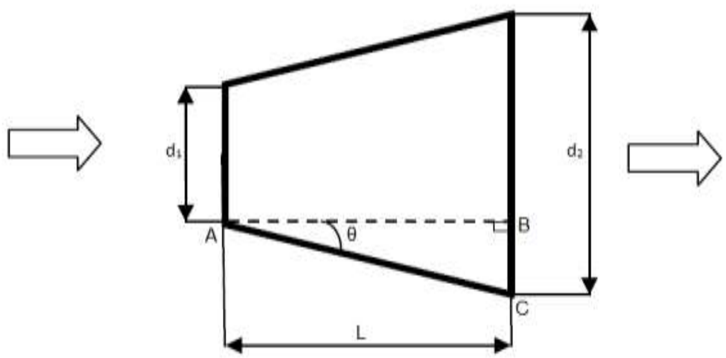


Figure: Geometry of Diffuser

The cross-sectional area of diffuser should reduce in the flow direction for supersonic flows and should increase for subsonic flows. The velocity of refrigerant leaving the compressor is sub-sonic. Hence, cross-sectional area of diffuser should be increasing.

II. EXPERIMENTAL SETUP

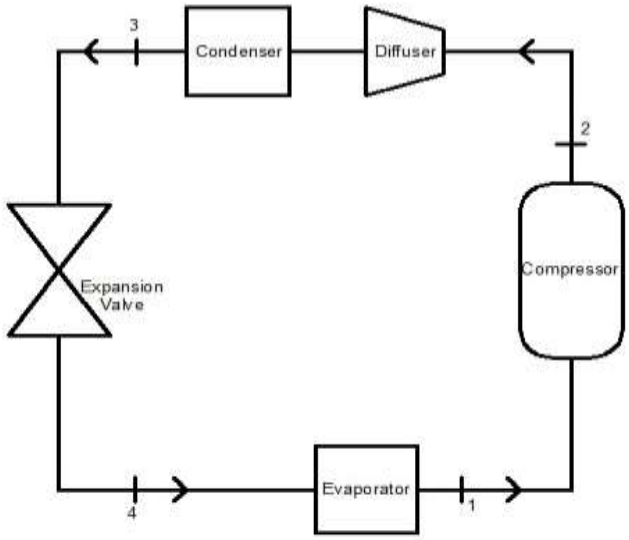


Figure 1: Schematic of VCR system with diffuser at condenser inlet

The schematic diagram of the vapour compression refrigeration system with diffuser at condenser inlet shown in Figure2.The main components of the systems are following:

(1) Compressor (2) Diffuser (3) Condenser (4) Expansion Valve (5) Evaporator

2.1 **Compressor:** Function of compressor is removing the vapour from evaporator and increase the pressure & temperature up to condensed into the diffuser

2.2 **Diffuser:** It raises the pressure of flowing fluid by converting its kinetic energy. In vapour compression refrigeration system, to avoid the problems of high velocity refrigerant, one of the ways is to use diffuser at condenser inlet.

2.3 **Condenser:** Function of the condenser is facilitating heat transfer surfaces through heat takes place from the hot refrigerant vapour.

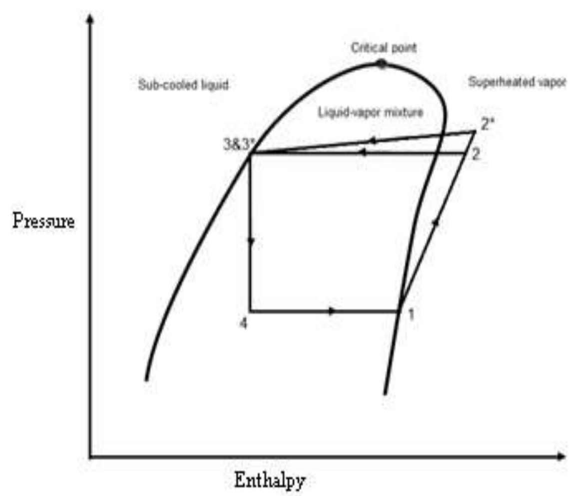
2.4 **Expansion Valve**: Its function is to meter the proper amount of liquid refrigerants and reduced the pressure of liquid refrigerant entering to the evaporator.

2.5 **Evaporator**: Function of evaporator is providing heat transfer surface through which low temperature liquid refrigerant can absorb heat from the space and it vaporized.

III. RESULT & ANALYSIS

Diffuser Angle = 27°

Sr. No.	Particular	Temperature (℃)	Pressure (Bar)
1	Compressor Inlet	12	-
2	Condenser Inlet	53	21
3	Expansion Valve Inlet	50	4.89



As shown in the above P-h Diagram the, Cycle 1-2-3-4-1 is for simple vapour compression refrigeration system and cycle 1-2‟-3-4-1 is for vapour compression refrigeration system with diffuser at condenser inlet.

3.1 **Compression Process:** Vapour Refrigerant at a low Temp. & Pressure P1 is Isentropically shown in P-h diagram line 1 to 2. Pressure is increased P1 to P2. Enthalpy also increases h1 to h2. While using Diffuser at condenser inlet Pressure P1 to P2’ & Enthalpy h1 to h2’.

3.2 **Condensing Process:** The high Pressure & Temp. Vapour refrigerant from the compressor is passes through condenser where it condensed so temp. is decreased, pressure remain constant (P2=P3) & Enthalpy decreased h2 to h3 as shown in p-h diagram 2 to 3. Phase change from vapour to Liquid

3.3 **Expansion Process:** Liquid refrigerant from the condenser is passes through expansion valve where Pressure reduced P3 to P4, Temp. Decreased & Enthalpy is remain constant (h3=h4) as shown in diagram 3 to 4.

3.4 **Vaporising Process:** Low pressure, Temp. & Enthalpy liquid refrigerant comes from expansion valve is passing through evaporator where it absorbs heat and evaporating from space to be cooled. Temp, Pressure remain constant (P4=P1) & enthalpy is increased from h4 to h1. Due to absorption of heat liquid refrigerant is converting into vapour refrigerant i.e. phasing change from liquid to vapour.

Here, h_1= 420 KJ/kg h_2’= 430KJ/kg h_3=412 KJ/kg h_4=270 KJ/kg
So,

$$COP = \frac{h1-h4}{h2'-h1}$$

Using this equation we get the value of COP. For above value the of enthalpy we get COP = 8.33

IV. CONCLUSION

Experimental analysis has been carried out to study the effect of diffuser at condenser inlet on vapour compression refrigeration system. Four diffusers were tested with divergence angles 27^0. Diffuser at condenser inlet resulted gain in pressure. By incorporating the diffuser at condenser inlet, size of condenser can be reduced.

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