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Experimental Analysis of Vapour Compression Refrigeration System

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Abstract: In this experiment to design and testing of diffuser at the condenser inlet. Experiment was carried by using of R134a refrigerant. The angle of diffuser is 15°. The inlet diameter of the diffuser is equal to the compressor outlet tube diameter and exit diameter is equal to the inlet tube diameter of condenser. The system performance is analyzing by using of thermodynamic first and second law, to calculate the coefficient of performance.

Index Terms: Diffuser, Refrigerating effect, cop.

I.INTRODUCTION

In vcr system the refrigerant under goes phase changes from vapor to liquid state and then liquid to vapor state. In the refrigeration system reject the heat in condenser and heat will be absorbed in evaporator. The cop is the ratio of refrigeration effect to work input to the compressor. The system performance is mainly increases by increasing the refrigeration effect or by decreasing the work of the compressor. Different type of techniques are find on the way to improve the cop of the system, as reported in literature.

G.Naga Raju et al [2] have studied the effect of diffusers at compressor inlet and condenser inlet. When diffuser placed at compressor inlet the cop will increased by approximatly 6% due to reduction of the compressor work. When diffuser placed at condenser inlet the cop will increased by approximatly 3% due to increased in refrigerating effect.

A.Selvaraju et al.,[2] have studied to analyzed an ejector with environmental friendly refrigerants. The vapour ejector refrigeration system is a heat operated system using the low grade energies like solar energy, waste heat from industries, and it also operated at generator temperature as low as 650c. Investigation is carried out for analyzing the performance of the system with few selected refrigerants (R134a, R152a, R290, R600 and R700) only.R134a refrigerant given the batter performance and higher critical entrainment ratio than other refrigerants.

B. Santosh Kumar et al [3] has investigated that system consists of components like compressor, condenser, expansion valve and evaporator. The system performance depends on the performance of all the components of the system. Further an attempt is made in modifying the conventional shaped condenser to spiral shaped condenser and with varying pitch the performance of system is evaluated. Finally, it is noticed that spiral shaped condenser has given the maximum COP among all observations. They concluded that the conventional shape of condenser is again compared with spiral shape condenser by varying pitch from 1.5 inch to 2.25 inch. The optimum COP is obtained at 2-inch pitch of the coil of the value 4.25 for the spiral shape condenser which shows an increase of 18.8% when compared to the conventional copper condenser COP of value 3.577.

M. Yohan et al.,[4] in this paper carried the experimental investigation on refrigeration system by using the nozzle at evaporator inlet. Nozzle is a device, it converts the pressure energy into kinetic energy without any input. This concept to reduce the flooding effect on the compressor during the no load conditions and increases the coefficient of performance the system. With the help of nozzle only vapor refrigerant will enter into the compressor and protect it from damages

Vivek Kumar et al.,[5] have developed a new configuration by inducting 1.Diffuser in between the condenser inlet and compressor,2.Heat exchanger at condenser outlet. By using these two to evaluate the different parameters like coefficient of performance, refrigerating effect and compressor work of this system with the help of R134a refrigerant.Compared these parameters with convectional system the cop of modified system increased by approximately 1.14.

P.G.Lohote et al.,[6] have studied the performance of different condenser by changing the pressure and change in cop of refrigeration system. When changing the convectional condenser by micro channel heat exchanger the pressure changes there are change in rate of heat transfer. This will helps to control the heat losses occurring in the condenser section. So that system of different condenser is gives the batter cop than the convectional system.

Dhanasi et al.,[7] to improve the coefficient of performance of domestic refrigerator with two refrigerants and wrinkle condenser. Initially he carried the experiment with two refrigerants (R-134a &R-600a) and convectional condenser, evaluated the performance. Further carried the experiment with wrinkle shaped condenser and evaluated the performance. The wrinkle shaped condenser gives the maximum cop than the other refrigeration systems.

From the above literature survey i can understand the use of diffuser. None of the literature survey studied the effect of the diffuser in vcr system, it will rise the some amount of pressure before entering the condenser of the refrigerant without giving the power input and increases the rate of heat rejection in the condenser. For the same refrigeration effect the compressor work is reduced. The system performance will increase.

II. EXPERIMENTAL SETUP AND METHODOLOGY

A. Manufacturing of diffuser

The flow of the refrigerant in the vcr system is subsonic. The diffuser is increases the pressure of the refrigerant without any work input. The diffusers are shown in figure2.

Diffuser length (L) = 10 mm
Outlet diameter of diffuser inlet (d_1) = 10 mm
Inner diameter of diffuser inlet (d_2) = 6 mm
Outlet diameter of diffuser outlet (D_1) = 14 mm
Inner diameter of diffuser outlet (D_2) = 10 mm
Divergence angles (θ) =15°.

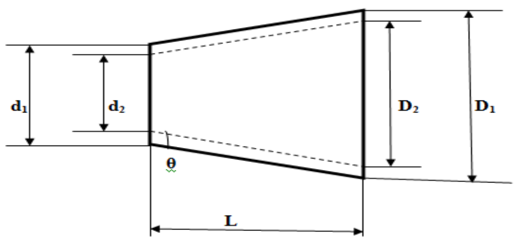

Fig.1.Line diagram

Fig.2. Diffuser

B. Experimental setup

The refrigeration system consists of the main loop of system. The loop consists of a compressor, condenser, capillary tube valve (expansion valve) and evaporator. The compressor used in this one is hermetically sealed reciprocating type compressor and capacity is 1/8 th TOR. The condenser and evaporator both are the coppered single tube. In this single flow tube condenser, inner side refrigerant flows and air is flows out side of the tube. The refrigerant then flows in to the evaporateor through expansion valve. The capillary tube is used to control the flow rate of the refrigerant in to the evaporator coil and also to set the difference pressure. In the one flow tube evaporator, the refrigerant flow through the inner side of the tube and water is in storage tank outside of the tubes. To minimize the heat losses, the tube is insulated. The four diffusers were tested at compressor inlet by changing one by one diffuser.

Initially readings are taken without diffuser. Then readings were taken by using the diffuser at condenser inlet. By using the five pressure gauges, these gauges are incorporated in the system to note down the pressure at various points (diffuser inlet, outlet, compressor outlet, condenser outlet and inlet of evaporator). By using the temperature sensors, to measure the temperatures at various points in the system like as pressure guages. The voltage and the current in the system are measured by using the voltmeter and ammeter. Power consumption of the syatem is constant that is 230wats.

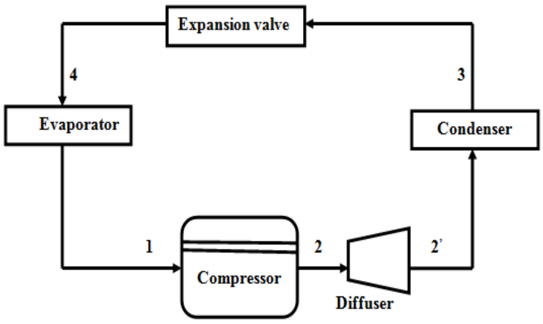

Fig.3. experimental set up line diagram

Fig.4. Diffuser in set up

III. RESULTS AND DISCUSSIONS

A. experimental readings

Table 1, 2 shows the experimental readings of pressure and temperature.

Table 1. without diffuser

P_1(Psi)	P_2(Psi)	P_3(Psi)	P_4(Psi)
0	170	170	0
T_1(°c)	T_2(°c)	T_3(°c)	T_4(°c)
30	40.5	36	-10

Table2. With diffuser

P_1(Psi)	P_2^*(Psi)	P_3(Psi)	P_4(Psi)
0	178	178	0
T_1(°c)	T_2^*(°c)	T_3(°c)	T_4(°c)
30	42.1	36	-10

P_1 = Suction pressure
P_2 = Discharge pressure
P_2^* = Pressure at exit of diffuser
P_3 = Pressure at exit of condenser
P_4 = Pressure at the exit of expansion valve
T_1 = Suction temperature
T_2 = Discharge temperature
T_2^* = Temperature at exit of diffuser
T_3 = Temperature at exit of condenser
T_4 = Temperature at the exit of expansion valve

B. Calculations.

From the **p-h** chart

h_1 = 430 kj/kg
h_2 = 504 kj/kg
h_2^* = 509 kj/kg
$h_3 = h_4 = h_{f3}$ = 259 kj/kg

work input to compressor (W.D) $= h_2 - h_1 = 504 – 430$
$= 74$ kj/kg

Refrigeration effect $= h_1 – h_4 = 430 - 259$
$=171$ kj/kg

Diffuser work $= h_2^* - h_2 = 509 - 504$
$= 5$ kj/kg

Reduction in compressor work $= (h_2 - h_1) – (h_2^* - h_2)$

= 74 - 5
= 69 kj/kg

$COP_{\text{without diffuser}}$ = 171 / 74
= 2.31

$COP_{\text{with diffuser}}$ = 171 / 69
= 2.47

Table 3: shows the experimental output readings.

Parameters	Without diffuser	With diffuser
Refrigerating effect	171	171
Reduction in compressor work	74	69
COP	2.31	2.47

C. Variation of pressure with and without diffuser

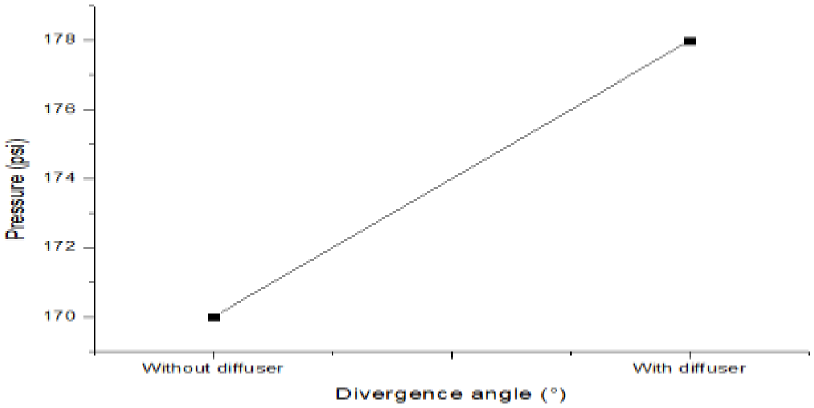

Fig.5 variation of pressure without and with diffuser

Figure 5 represents the effect of diffuser on the pressure. It should be found that, initially the pressure at 170 psi without any diffuser. Then pressure is increases to 178 psi when using the diffuser. The increasing pressure doesn't taken the any input from the compressor. Gain in pressure was also depends on discharge pressure. Because, as the discharge pressure increases mass flow rate increases which results increase in kinetic energy of the refrigerant. Due to this, maximum kinetic energy is available at diffuser inlet for the conversion to pressure energy. Hence, maximum gain in pressure was obtained at 178psi for diffuser.

D. Variation of temperature with and without diffuser

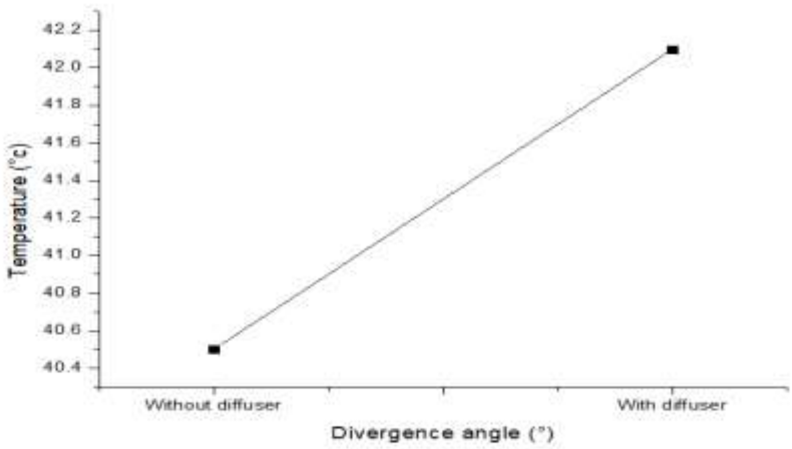

Fig.6 variation of temperature without and with diffuser

Figure 6 represents the effect of diffuser on the temperature. Initially temperature at 40.5°c without using the diffuser. When using diffuser, the temperature increasing up to 42.1°c when using the diffuser. The maximum temperature is obtained when using the diffuser.

E. Variation of cop with and without diffuser

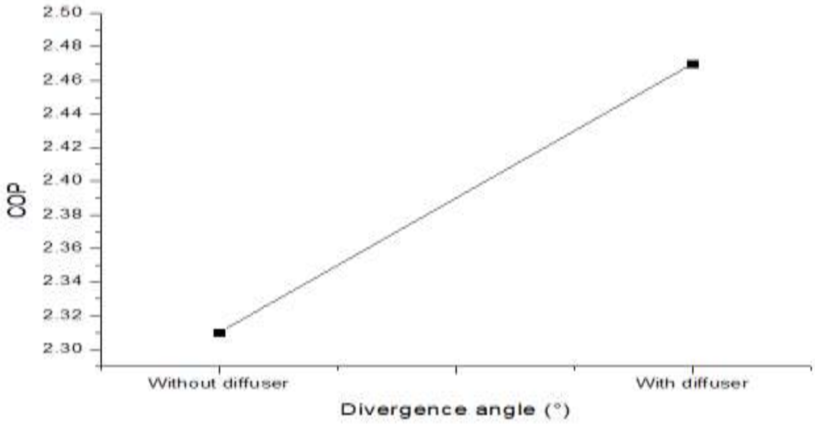

Fig.7 variation of cop without and with diffuser

Figure 7 represent the effect of diffuser on coefficient of performance when using the diffuser in the refrigeration system. It was noted that the maximum percentage of reduction in compressor work and maximum obtained COP are obtained when using the diffuser 15⁰. By applying the first law of thermodynamics to the diffuser, it was observed that the increase in enthalpy is proportional to the kinetic energy of refrigerant. The rise in enthalpy is without any power consumption.

IV. CONCLUSION

The experimental investigation was carried out to study the effect of diffusers at condenser inlet of vapour compression refrigeration system. The diffuser are tested in the system.

1. By using of diffuser in the system cop is increased as compared with the experiment without diffuser from 2.31 to 2.47. The pressure increases from 170 to 178 psi and the compressor work reduced by 6.9%. Percentage of increase in COP is approximately 6.9%.

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