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Enrichment Of Cop Of Vapour Compression Refrigeration System By Using Diffuser And Nozzle

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ABSTRACT: This investigational analysis exemplifies the design and test of diffuser at compressor inlet and nozzle at condenser outlet in VCR with the help of R134a refrigerant. The diffuser with divergence angle of 12°, 14° and the nozzle with convergent angle 12°, 14° is designed for same inlet and outlet diameters. Initially diffusers are tested at compressor inlet diffuser is used with inlet diameter equal to exit tube diameter of evaporator and outlet tube diameter is equal to suction tube diameter of the compressor. Diffuser helps to increases the pressures of the refrigerant before entering the compressor it will be helps to reduces the compression work and achieve higher performance of the vapour compression refrigeration system. Then nozzles are testing at condenser outlet, where as nozzle inlet diameter equal to discharging tube diameter of condenser and outlet diameter equal to inlet diameter of expansion valve. Extra pressure drop in the nozzle helped to accomplish higher performance of the vapour compression refrigeration system. The system is analyse using the I^{st} and II^{nd} laws of thermodynamics, to resolve the refrigerating effect, the compressor work input, coefficient of performance(COP).

KEYWORDS: Diffuser, Nozzle, Coefficient of performance, Refrigeration effect

I. INTRODUCTION

In VCR system, the refrigerant underneath goes phase changes from liquid to vapor and then vapor to liquid during a closed cycle by absorbing the warmth within the evaporator and reject the warmth at condenser. The coefficient of performance (cop), that may be a magnitude relation of heat transfer rate at the evaporator to the ability input to the compressor within the refrigeration system. The COP will be increased either by decreasing the compressor work or by increasing the refrigeration effect. completely different form of ways are tried out for improving the cop of the VCR system, as according in literature G.Naga Raju et al [1] in this paper have studied enhancement of cop of vapour compression refrigeration system by using the diffusers at compressor inlet and as well as condenser inlet. When using the diffuser at compressor inlet the coefficient of performance is increased by 6% and using the diffuser at condenser inlet the coefficient of performance is increased by 3%. Neeraj Upadhyay et al[2] to studied the analytical study of vapour compression refrigeration by using diffuser and sub-cooling.to improve the cop of the system either by decreasing the compressor work are increasing the refrigeration effect. In this paper to increasing the refrigeration effect by incorporating of diffuser and sub cooling process. By using the diffuser consumption power is by compressor and cop is enhanced from 2.65 to 3.38.Vivek Kumar et al [3] have developed a replacement configuration by inducting one. Diffuser in between the condenser inlet and compressor, 2.Heat exchanger at condenser outlet. By victimization these two to evaluate the various parameters like coefficient of performance, refrigerant impact and compressor work of this system with the help of R134a refrigerant. Compared these parameters with convectional system the cop of changed system increased by around 1.14. P.G.Lohote et al [4] have studied the performance of various condensers by changing the pressure and alter in cop of refrigeration system. Once changing the convectional condenser by small channel heat exchanger the pressure changes there are change in rate of heat transfer. This may helps to manage the heat losses occurring within the condenser section. So system of various condenser is provides the batter cop than the convectional system. Nurul Seraj1 et al [5] in this paper to studied to increased the coefficient of performance of VCR system the at the start the Diffuser of increasing Cross-Sectional area Profile Was Designed, invented and Introduced in Our VCR equipment. the dimensions of Diffuser chosen Was Of 15 Degree Divergence Angle. By using Diffuser Power Consumption is a smaller amount for Same refrigerant result therefore Performance Is Improved. the size of The Condenser can even Be Reduced because of additional Heat Transfer. S.Saboor et al

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[6] to check the experimental analysis of vapour compression refrigeration system by using the diffuser at condenser recess construct experimental approach to compensate the compressor work by providing a diffuser at the recess of the condenser. Diffuser converts the high rate accessible at the compressor discharge into the pressure energy. M. Yohan et al., [7] to study the use of diffuser in refrigeration system at condenser inlet. The performance can be enhanced by reducing the compressor work by using of diffuser. The system cop was increased by 6% and work of the compressor was reduced by 6.10%. P. Pranitha et al., [8] In this study to analysis the performance of VCR system by placing the nozzle and diffuser. Nozzle is incorporated at inlet of the evaporator and diffuser is incorporated at inlet of the condenser. BalaKartheek et al., [9] In this experiment judge the performance of the vapour compression refrigeration system by mistreatment the diffuser at condenser inlet and nozzle at inlet of the evaporator. The diffuser reduces the mechanical work needed to the refrigerant and nozzle enhances the refrigeration impact by providing a rise in velocity to the refrigerant. By exploitation these two systems performance is accumulated. B.Sandhya Rani et al., [10] in this paper study the experiment was successfully completed by incorporate the nozzle in the cycle at outlet of the condenser. The extra pressure dropped in the nozzle, these additional help to achieve the more performance of the refrigeration system. The convergent angle of nozzle is increases from 10° to 14°. The 14° convergent angle of nozzle is got the better cop of the system. K.JayaSudheer Kumar et al.,[11] to study this paper to evaluate the performance of the VCR system without and with nozzle at inlet of the expansion valve. By using the nozzle in the system again decreasing of refrigerant pressure before entering the evaporator. It improves the refrigeration effect and increase the cop of the system increases.

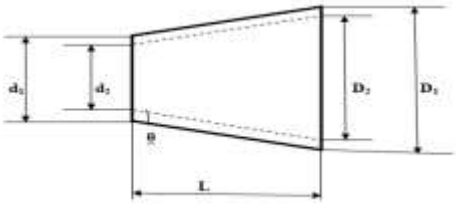
From the above literature survey i can understand the use of diffuser. None of the literature survey studied the effect of the diffuser and nozzle in VCR system, diffuser at compressor inlet will raise the same amount of pressure before entering the compressor of the refrigerant. It will reduce the work of compressor. Due to this reduction, the system performance will increase. Nozzle at condenser outlet reduces the pressure of refrigerant before entering to the expansion valve.

II. EXPERIMENTAL SET-UP AND METHODOLOGY

Manufacturing of diffuser and nozzle:-

Diffuser could be a passive device, it'll will increase the pressure energy by changing the out there mechanical energy at the inlets and also the nozzle could be a device that transforms the pressure energy into mechanical energy without the help of any external work. The flow of the refrigerant within the vapour compression refrigeration system is sub sonic flow. The diffuser and nozzle each may be manufactured with the subsequent dimensions. The diagrams of diffusers as shown below in figure 2.

Inlet diameter of entrance (d_2) =10 mm
Outlet diameter of entrance (d_1) = 12 mm
Outlet diameter of exit (D_1) = 16 mm
Inlet diameter of exit (D_2) = 14 mm
Angle (θ) = 12°**,** 14°



1. Line diagram of diffuser

1.Diffusers

Inlet diameter of entrance (d_2) =14 mm
Outlet diameter of entrance (d_1) = 16 mm
Outlet diameter of exit (D_1) = 12 mm
Inlet diameter of exit (D_2) = 10 mm
Angle (θ) = 12°**,** 14°

3. Nozzles

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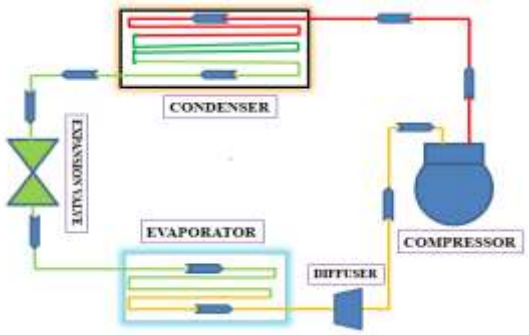
Experimental set up with diffuser at compressor inlet:-

It mainly consists of the main loop of system. The main loop is 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 1/8th 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 evaporator 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.

The readings were taken with ever-changing the diffuser at compressor inlet. By exploitation the five pressure gauges, these gauges area unit incorporated within the system to notice down the pressure at varied points (diffuser inlet, outlet, compressor outlet, condenser outlet and inlet of evaporator). By exploitation the temperature sensors, to measure the temperatures at varied points within the system like as pressure gauges. The voltage and also the current within the system are measured by using the voltmeter and ammeter. Power consumption of the system is constant that's 230wats.



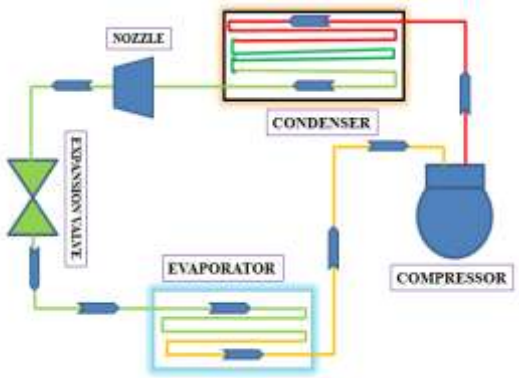
Line diagram of diffuser at compressor

Experimental set up

Experimental set up with nozzle at condenser outlet:-

Position	Pressure			Temperature		
	Without Diffuser	With Diffuser		Without Diffuse	With Diffuser	
		12^0	14^0		12^0	14^0
Compressor inlet	0.41	0.85	1.3	32	36	39
Condenser inlet	11.80	11.80	11.80	43	43	43
Condenser outlet	11.80	11.80	11.80	33	33	33
Evaporator Inlet	0.41	0.41	0.41	2.3	2.3	2.3

The schematic diagram of vapour compression refrigeration system with diffuser at expansion valve inlet shown in figure below. In on prime of set-up one in all the diffuser (14°) offers the most cop, it will mounted at compressor inlet. Presently all over again testing the nozzle at expansion valve expansion same as higher than. Expansion experiment carried while not nozzle and readings are noted. Then experiment will repeated with nozzle the readings (pressure & temperature) are noted. Nozzle at expansion valve, is to cut back the pressure coming from the condenser with none work input.



Line diagram with nozzle at expansion valve inlet

Experimental set up

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III. RESULTS AND DISCUSSION

Experimental Results with and without diffusers at compressor inlet:-

From **p-h** chart of **R134a**

h1 = 430kj/kg

h1' = 439kj/kg

h2 = 510 kj/kg

h3= h4= hf3 = 250kj/kg

Compressor work (W.D) = h2 - h1 = 510 – 430= 80kj/kg

Refrigeration effect = h1–h4 = 430 - 250=180 kj/kg

Diffuser work = h1' - h1 = 439 - 430= 9kj/kg

Reduction in compressor work =

(h2 - h1) – (h1' - h1) = 80 - 9= 79kj/kg

$$\text{COP without diffuser} = \frac{\text{Refrigeration effect}}{\text{Reduction in compressor work}}$$

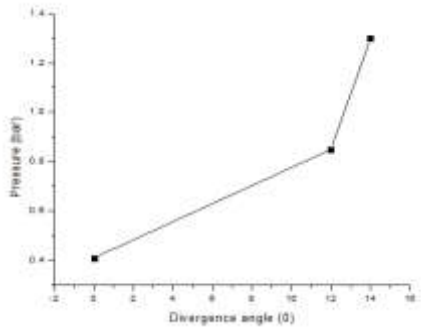
= 180 / 80= 2.25

$$\text{COP with diffuser} = \frac{\text{Refrigeration effect}}{\text{Reduction in compressor work}}$$

= 180 /71= 2.53

parameters →		Refrigeration work (kj/kg)	Reduction in compressor work(kj/kg)	COP
Without diffuser		180	80	2.25
With diffuser	12^0	180	75	2.40
	14^0	180	71	2.53

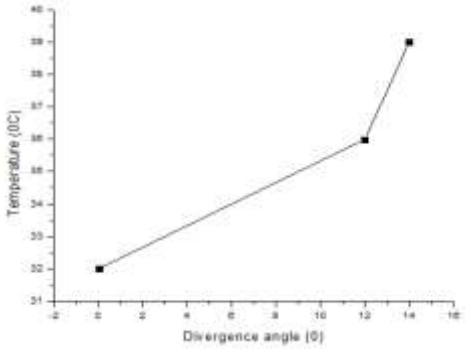
Pressure vs. diffuser divergence angles: -



Pressure vs Divergence angle

The above diagram shows the variation of pressure of a refrigerant with respect to the diffuser divergence angle. Initially the experiment was carried out without a diffuser. The pressure is 0.41 bars when 12^0 divergence angle of diffuser is placed at compressor inlet the pressure was increased to 0.85 bar. Then 14^0divergance angle diffuser is placed the pressure increased to 1.3 bars. This is the maximum pressure when we are using diffuser. The diffuser into pressure energy according to the first law of the thermodynamics.

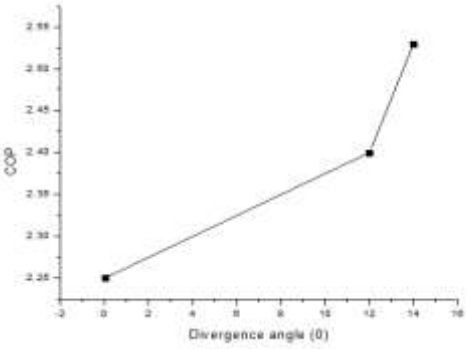
Temperature vs. diffuser divergence angles:-



Temperature vs Divergence angles

The above figure shows the variation of the temperature with respect to changing of diffuser divergence angles. Initially the temperature at 32^0 without a diffuser. Then the temperature of the refrigerant is increased from 36^0c to 39^0c when there are using the diffusers. The maximum temperature is 39^0c is obtained when we are using the diffuser of (divergence) 14^0 this is the maximum temperature.

COP vs. diffuser divergence angles:-



COP vs Divergence angles

The figure represents the effect of diffuser on co-efficient of performance in vapour compression refrigeration system. It was noted that the maximum percentage of reduction in compressor work and maximum percentage of coefficient of performance (COP) are obtained when we are using the 14^0 divergence angle of diffuser the COP also increases when using 12^0 but maximum COP was obtained at 14^0 diffuser. By applying I^{st} and II^{nd} 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 was without any power consumption.

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Experimental Results with and without nozzles at condenser outlet:-

The line diagram VCR system with nozzle at condenser outlet is shown above. In the above set up (Experiment with diffuser) one of the diffuser is given batter cop then the other one it will be fixed in the system and then experiment will repeat with nozzles at condenser outlet. In this one nozzle gives the batter performance.

Position	Pressure			Temperature		
	Without Nozzle	With Nozzle		Without Nozzle	Nozzle	
		12^0	14^0		12^0	14^0
Compressor inlet	0.39	0.39	0.39	30.5	30.5	30.5
Condenser inlet	11.65	11.80	11.80	40.2	40.5	40.5
Condenser outlet(Nozzle outlet)	11.00	10.60	10.20	30.2	25	23
Evaporator Inlet	0.39	0.36	0.30	2.3	2.3	2.3

Calculations for 14^0 Nozzle

From **p-h** chart of **R134a**

h1 = 418kj/kg

h2 = 492kj/kg

h3= h4= hf3 = 244kj/kg

Compressor work (W.D) = h2 - h1 = 492 – 418= 74kj/kg

Refrigeration effect = h1–h4 = 418 - 244=174kj/kg

COP with diffuser =

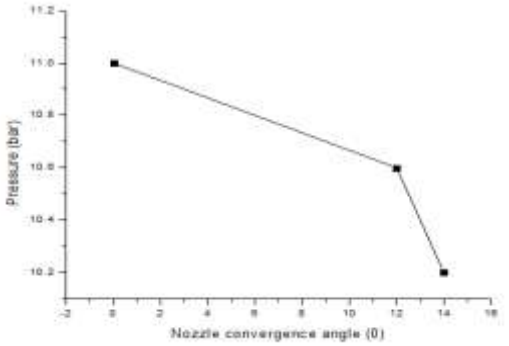
Refrigeration effect/ Compressor work

= 174 /74= 2.35

parameters →		Refrigeration work (kj/kg)	Reduction in compressor work(kj/kg)	COP
Without diffuser		180	80	2.25
With diffuser	12^0	180	75	2.33
	14^0	180	71	2.35

Pressure vs. nozzle converging angles: -

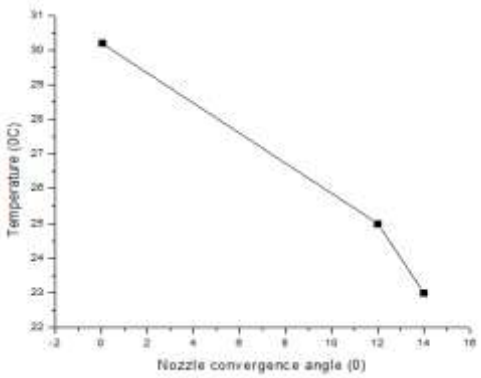
The above diagram shows the variation of pressure of a refrigerant with respect to the nozzle converging angle. Initially the experiment was carried out without a nozzle. The pressure is 11.00 bar when 12^0converging angle of nozzle is placed at compressor inlet the pressure was decreased to 10.60 bar. Then 14^0converging angle nozzle is placed the pressure decreased to 10.20bars. This is the maximum pressure reduction when we are using nozzle.



Pressure vs Nozzle converging angles

Temperature vs. nozzle converging angles:-

The above figure shows the variation of the temperature with respect to changing of nozzle converging angles. Initially the temperature at 30.2^0 without a nozzle. Then the temperature of the refrigerant is decreased from 25^0c to 23^0c when we are using the nozzles. The maximum temperature reduction is 34.2^0c is obtained when we are using the nozzle of (converging) 14^0 temperatures.



Temperature vs Nozzle converging angles

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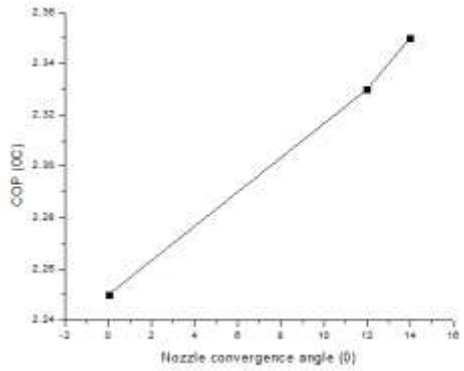
COP $_{vs.}$ nozzle converging angles:-



COP vs Nozzle converging angles

The figure represents the effect of diffuser on co-efficient of performance in vapour compression refrigeration system. It was noted that the maximum percentage of reduction in compressor work and maximum percentage of coefficient of performance (COP) are obtained when we are using the 14^0converging angle of nozzle the COP also increases when using 12^0 but maximum COP was obtained at 14^0nozzle. By applying I^{st} and II^{nd} law of thermodynamics. To the nozzle, it was observed that the increase in enthalpy is proportional to the kinetic energy of refrigerant. The rise in enthalpy was without any power consumption.

IV. CONCLUSION

Investigational analysis has been carried out to revise the consequence of diffusers at compressor inlet and nozzles at condenser outlet in VCR system. The two diffusers and two nozzles are tested with divergence angles of12°, 14°.

1.Diffuser at compressor inlet, Both the diffusers were given the better performance of the system (i.e2.40,2.53), but diffuser with divergence angle of 14° is given the maximum cop (2.53) as compared with other diffuser. Percentage of increase in COP is approximately 6.66% when we are using the12° diffuser and, 12.44%increases by using the14° diffuser. Reduction in compressor work 6.25% by using 12° diffuser and 11.25% by using 14° diffuser.

2. Nozzle at condenser outlet, Both the nozzles given batter performance (i.e2.33,2.35) but 14° nozzle given the maximum cop (2.35) as compared with other nozzle. Percentage of increase in COP is approximately 3.55% when we are using the 12° diffuser and, 4.45%increases by using the 14° diffuser. Reduction in compressor work 6.25% by using 12° diffuser and 11.25% by using 14° diffuser.

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