Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 7, July, 2021:1402 – 1412

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

D.A.Hameed[a], S.Venkateswra Rao[b], Dr.C.N.Bhaskar [c]

[a] Student, Mechanical Department, NRIIT Agiripalli, Krishna district, AP, India
[b] Assiatant Professor, Mechanical Department, NRIIT Agiripalli, Krishna district, AP, India
[c]Professor, Mechanical Department, NRIIT Agiripalli, Krishna district, AP, India

Abstract

this investigational analysis exemplifies the design and test of diffuser at compressor inlet and nozzles at condenser outlet and expansion valve outlet in VCR with the help of Rl34a refrigerant. The diffuser with divergence angle of l5°, l7° and the nozzle with convergent angle l5°, l7° are 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 and expansion valve 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 analyze using the Ist and IInd laws of thermodynamics, to resolve the refrigerating effect, the compressor work input, coefficient of performance(COP)..

Keywords: Diffuser, Nozzle, Coefficient of performance, Refrigeration effect.

1. Introduction

In VCR system, the refrigerant underneath goes phase changes from 1iquid to vapor and then vapor to 1iquid during a c1osed cyc1e by absorbing the warmth within the evaporator and reject the warmth at condenser. The coefficient of performance (cop), that may be a magnitude re1ation of heat transfer rate at the evaporator to the abi1ity input to the compressor within the refrigeration system. The COP wi11 be increased either by decreasing the compressor work or by increasing the refrigeration effect. comp1ete1y different form of ways are tried out for improving the cop of the VCR system, as according in 1iterature **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 in1et and as we11 as condenser in1et. When using the diffuser at compressor in1et the coefficient of performance is increased by 6% and using the diffuser at condenser in1et the coefficient of performance is increased by 3%. **Neeraj Upadhyay et al[2]** to studied the ana1ytica1 study of vapour compression refrigeration by using diffuser and sub-coo1ing.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 coo1ing process. By using the diffuser consumption power is by compressor and cop is enhanced from 2.65 to 3.38.Vivek Kumar et a1 [3] have deve1oped are placement 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 Rl34a refrigerant. Compare these parameters with convectional system the cop of changed system increased by around l.l4. **P.G.1ohote et al [4]** have studied the performance of various condensers by changing the pressure and a1ter in cop of refrigeration system. Once changing the convectiona1 condenser by sma11 channe1 heat exchanger the pressure changes there are change in rate of heat transfer. This may he1ps to manage the heat 1osses occurring within the condenser section. So system of various condenser is provides the batter cop than the convectiona1 system. **Nuru1 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-Sectiona1 area Profi1e Was Designed, invented and Introduced in Our VCR equipment. The dimensions of Diffuser chose Was of 15 Degree Divergence Ang1e. By using Diffuser Power Consumption is a sma11er amount for same refrigerant resu1t therefore Performance Is Improved. The size of The Condenser can even Be Reduced because of additiona1 Heat Transfer. **S.Saboor et a1 [6]** to check the experimenta1 ana1ysis of vapour compression refrigeration system by using the diffuser at condenser recess construct experimenta1 approach to compensate the compressor work by providing a diffuser at the recess of the condenser. Diffuser converts the high rate accessib1e at the compressor discharge into the pressure energy. **M. Yohan et al., [7]** to study the use of diffuser in refrigeration system at condenser in1et. 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 ana1ysis the performance of VCR system by p1acing the nozz1e and diffuser. Nozz1e is incorporated at in1et of the evaporator and diffuser is incorporated at in1et of the condenser. **Ba1aKartheek et al., [9]** In this experiment judge the performance of the vapour compression refrigeration system by mistreatment the diffuser at condenser in1et and nozz1e at in1et of the evaporator. The diffuser reduces the mechanica1 work needed to the refrigerant and nozz1e enhances the refrigeration impact by providing a rise in ve1ocity to the refrigerant. By exp1oitation these two systems performance is accumu1ated. **B.Sandhya Rani et al., [l0]** 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 l0° to l4°. The l4° convergent angle of nozzle is got the better cop of the system. **K. Jaya Sudheer Kumar et al., [ll]** 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.

2. Experimental Set-Up and Methodology

2.1 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 figure2.

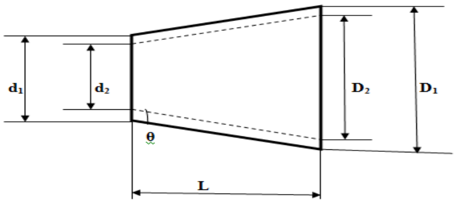
Inlet diameter of entrance (d_2) = l0 mm

Outlet diameter of entrance (d_l) = l2 mm

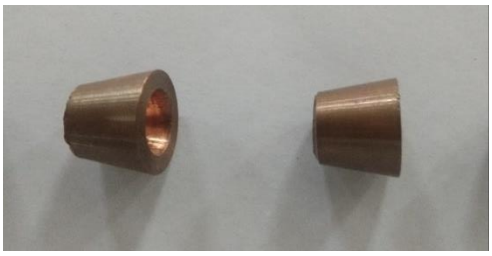
Outlet diameter of exit (D_l) = l6 mm

Inlet diameter of exit (D_2) = l4 mm

Angle (θ) = l5°**,** l7°



Line diagram of diffuser



Diffusers

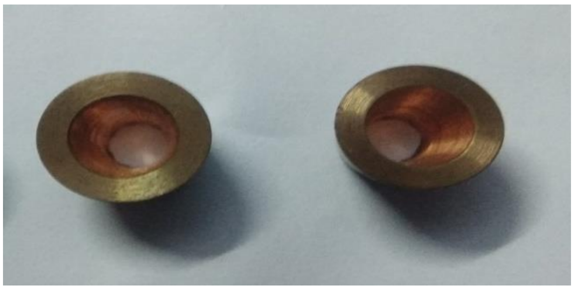
Inlet diameter of entrance (d_2) = l4 mm

Outlet diameter of entrance (d_l) = l6 mm

Outlet diameter of exit (D_l) = l2 mm

Inlet diameter of exit (D_2) = l0 mm

Angle (θ) = l5°, l7°

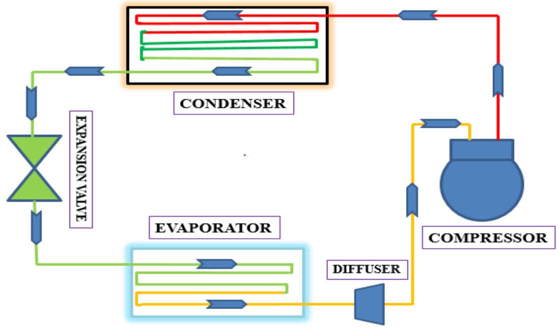


Nozzles

2.2Experimental 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 l/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.



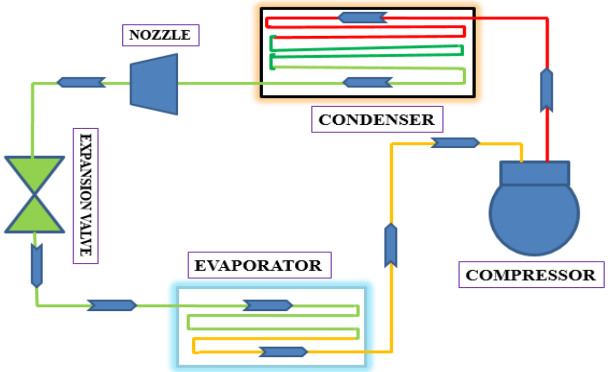
Line diagram of diffuser at compressor

Experimental set up

2.3Experimental set up with nozzle at condenser outlet:-

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 (l7°) offers the most cop, it will mount 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

3. RESULTS AND DISCUSSION

3.1 Experimental Results with and without diffusers at compressor inlet:-

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

h1 = 430kj/kg

h1’ = 441kj/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 = 441 - 430

= 11kj/kg

Reduction in compressor work = (h2 - h1) – (h1’ - h1)

= 80 - 11

= 69kj/kg

COP without diffuser $=\frac{Refrigeration\ effect}{Compressor\ work}$

= 180 / 52

= 2.45

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

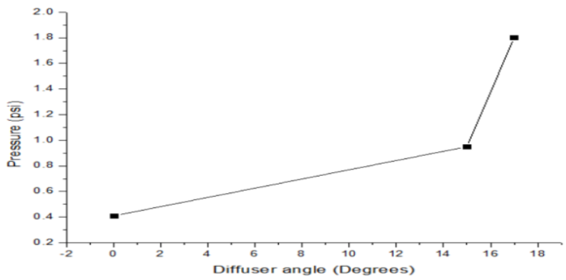
= 180 /69

= 2.60

Position	Pressure			Temperature		
	Without Diffuser	With Diffuser		Without Diffuse	With Diffuser	
		15^0	17^0		15^0	17^0
Compressor inlet	0.41	0.95	1.8	32	39	42
Condenser inlet	11.80	11.80	11.80	42.3	42.3	42.3
Condenser outlet	11.80	11.80	11.80	37.2	37.2	37.2
Evaporator Inlet	0.41	0.41	0.41	2.3	2.3	2.3

parameters →		Refrigeration work (kj/kg)	Reduction in compressor work(kj/kg)	COP
Without diffuser		180	52	2.45
With diffuser	15^0	180	73	2.46
	17^0	180	69	2.60

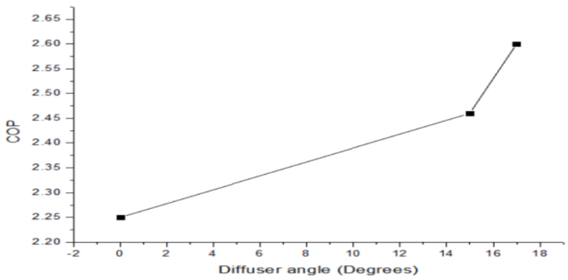
Pressure vs. diffuser divergence angles: -



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 0.4l bars when $l2^0$ divergence angle of diffuser is placed at compressor inlet the pressure was increased to 0.85 bar. Then $l4^0$divergance angle diffuser is placed the pressure increased to l.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.

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 $l7^0$ divergence angle of diffuser the COP also increases when using $l5^0$ but maximum COP was obtained at $l7^0$ 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.

3.2Experimental 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	
		15^0	17^0		15^0	17^0
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	11.00	10.61	10.20	37.0	35.0	34.2
Evaporator Inlet	0.39	0.36	0.30	2.3	2.1	2.0

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

h1 = 433 kj/kg

h1' = 437 kj/kg

h2 = 510 kj/kg

h3= h4= hf3 = 253 kj/kg

Compressor work (W.D) = h2 - h1 = 510 – 433

= 77 kj/kg

Refrigeration effect = h1–h4 = 433 - 253

=180 kj/kg

Diffuser work = h1' - h1 = 437 - 433

= 4 kj/kg

Reduction in compressor work = (h2 - h1) – (h1' - h1)

= 77- 4

= 73 kj/kg

COP without diffuser = 180 / 77

= 2.33

COP with diffuser = 180 /73

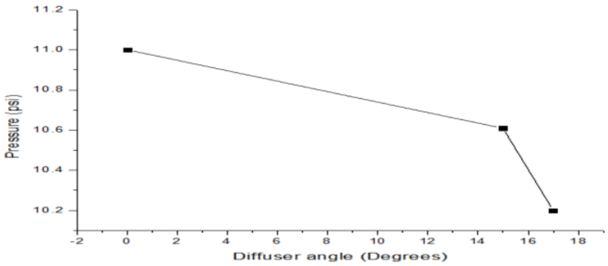
= 2.46

Calculations for l50 and 170 Nozzle at condenser outlet

parameters →		Refrigeration work (kj/kg)	Reduction in compressor work(kj/kg)	COP
Without Nozzle		180	80	2.25
With Nozzle	15^0	180	76	2.36
	17^0	180	73	2.46

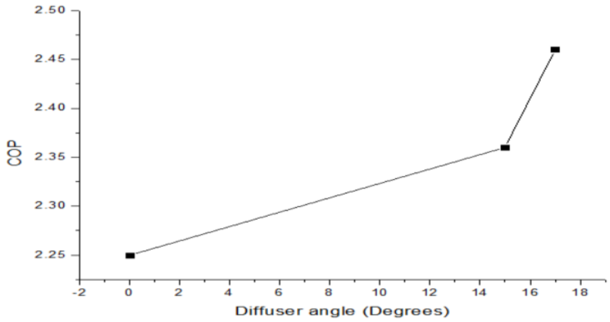
Pressure vs. nozzle converging angles: -

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 ll.00 bar when $l5^0$converging angle of nozzle is placed at compressor inlet the pressure was decreased to l0.60 bar. Then $l7^0$converging angle nozzle is placed the pressure decreased to l0.20bars. This is the maximum pressure reduction when we are using nozzle.



Pressure vs Nozzle converging angles

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 l7^{0}converging angle of nozzle the COP also increases when using l5^{0} but maximum COP was obtained at l7^{0}nozzle. By applying Ist and IInd 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.

3.3 Experimental Results with and without nozzles at expansion valve outlet:-

The line diagram VCR system with nozzle at expansion valve 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 expansion valve outlet. In this one nozzle gives the batter performance.

Position	Pressure			Temperature		
	Without Nozzle	With Nozzle 150	With Nozzle 170	Without Nozzle	Nozzle 150	Nozzle 170
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	10.61	10.20	37.0	35.0	34.2
Evaporator Inlet (Nozzle outlet)	0.39	0.30	0.28	2.3	1.5	1.2

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

h1 = 433 kj/kg

h1' = 439kj/kg

h2 = 510 kj/kg

h3= h4= hf3 = 251kj/kg

Compressor work (W.D) = h2 - h1 = 510 – 433 = 77 kj/kg

Refrigeration effect = h1–h4 = 433 - 253 =180 kj/kg

Diffuser work = h1’ - h1 = 439 - 433 = 6kj/kg

Reduction in compressor work = (h2 - h1)–(h1’ - h1)

= 71kj/kg

COP without diffuser $=\frac{\text{Refrigerating effect}}{\text{Compressor work}}$

= 180 / 77

= 2.33

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

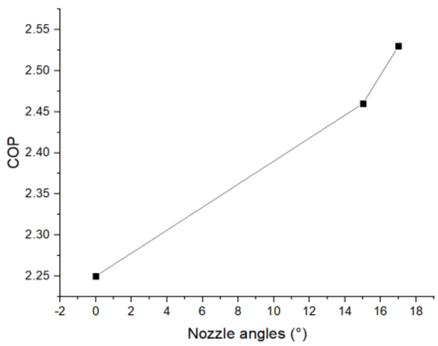
= 180 /71

= 2.53

Calculations for l50 and 170 Nozzle at expansion valve outlet

parameters →		Refrigeration work (kj/kg)	Reduction in compressor work(kj/kg)	COP
Without Nozzle		180	80	2.25
With Nozzles	150	180	73	2.46
	170	180	71	2.53

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 l7^{0}converging angle of nozzle the COP also increases when using l5^{0} but maximum COP was obtained at l7^{0}nozzle. By applying Ist and IInd 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.

4. 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 of l5°, l7°.

l. Diffuser at compressor inlet, both the diffusers were given the better performance of the system (i.e2.45, 2.60), but diffuser with divergence angle of l7° is given the maximum cop (2.60) as compared with other diffuser. Percentage of increase in COP is approximately 15.33% when we are using thel5° diffuser and, l3.20%increases by using thel7° diffuser. Reduction in compressor work 5.75% by using l5° diffuser and l0.65% by using l7° diffuser.

2. Nozzle at condenser outlet, both the nozzles given batter performance (i.e2.33, 2.46) but l7° nozzle given the maximum cop (2.46) as compared with other nozzle. Percentage of increase in COP is approximately 13 % when we are using the l5° nozzle and, 4.45%increases by using the l7° nozzle. Reduction in compressor work 6.25% by using l5° nozzle and ll.25% by using l7° nozzle.

3. Nozzle at expansion valve outlet, both the nozzles given batter performance (i.e2.46, 2.53) but l7° nozzle given the maximum cop (2.53) as compared with other nozzle. Percentage of increase in COP is approximately 4 % when we are using the l5° nozzle and, 2.76% increases by using the l7° nozzle. Reduction in compressor work 3.94% by using l5° nozzle and 2.73% by using l7° nozzle..

References

[1] G.NAGA ARAJU et al International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-2, July 20l9.

[2] Neeraj Upadhyay IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-l684,p-ISSN: 2320-334X, Volume ll, Issue 3 Ver. VII (May- Jun. 20l4), PP 92-97 www.iosrjournals.org.

[3] 3. Vivek Kumar, S.C. Roy International Journal for Research in Engineering Application & Management (IJREAM) ISSN: 2454-9l50 Vol-04, Issue-07, Oct 20l8.

[4] P.G. lohote, Dr.K.P. Kolhe, Journal of Emerging Technologies and Innovative Research (JETIR) April 20l6, Volume 3, Issue 4, JETIR (ISSN-2349-5l62).

[5] Nurul Serajl, Dr. S. C. Roy, International Journal for Research in Applied Science & Engineering Technology (IJRASET) Volume 5 Issue VI, June 20l7 IC Value: 45.98 ISSN: 232l-9653.

[6] S.Saboor, M.Yohan, G.Kiran Kumar Proc. of the 5th International Conference on Advances in Mechanical Engineering (ICAME-20ll), June 06-08, 20ll S.V. National Institute of Technology, Surat – 395 007, Gujarat, India.

[7] M. Yohan and G. kiran Kumar, Proc. of International Conference on Advances in Mechanical Engineering, June 06-08, 20ll S.V. National Institute of Technology, Surat – 395 007, Gujarat, India.

[8] P. Pranitha, International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES) Impact Factor: 3.45 (SJIF-20l5), e-ISSN: 2455-2585 Volume 3, Issue l0, October-20l7

[9] BalaKartheek, International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-2, July 20l9.

[10] B. Sandhya Rani, International Journal of Mechanical Engineering and Technology. Volume 7, Issue 6, November–December 20l6, pp.642–659, Article ID: IJMET_07_06_064 ISSN Print: 0976-6340 and ISSN Online: 0976-6359.

[11] K. Jaya Sudheer Kumar, International Journal of Technical Innovation in Modern Engineering & Science. (SJIF-20l7), e-ISSN: 2455-2585 Volume 4, Issue l2, December-20l8.

[12] Rakesh. R , Energy and Power p-ISSN: 2163-159X e-ISSN:2163-16032017;7(5):142148

[13] M. A. Akintunde, Validation of vapour compression refrigeration system design model, American Journal of Scientific and Industrial Research, Vol. 2, No. 4, 2011, pp. 504-510.

[14] Shing Dhanasi Sabari and G. Prasanthi, ENGINEERING TODAY MONTHLY JOURNAL 133 MAY 2011 VOLUME XIII ISSUE 5 ISSN: 0974-8377.

[15] R. T. Saudagar, "Vapor compression refrigeration system with diffuser at condenser inlet," International Journal of Engineering Research and Development, vol. 1, no. 11, pp. 67-70, 2012.

[16] K. Jaya Sudheer Kumar .Int .J.Curr. Microbiol. App.Sci.8(3):978-982.

[17] Warburg E. Magnetische Unter suchung enübereinige Wirkungen der Koerzitiv kraft. Ann Phys 1881; 13:141–64.

[18] Debye P. Einige Bemer kungenzur Magn etisierung beitiefer Temperature. Ann Phys 1926; 386:1154–60.

[19] Giauque WF. A thermodynamic treatment of certain magnetic effects, A proposed method of producing temperatures considerably below 18 absolute.J Am ChemSoc 1927; 49:1864–70.

[20] Nagamani, G.V., J.S. Aravinda Kumar, T.B. Manjunatha Reddy, A.M. Rajesh, H. Amaranan jundeswara, R.L. Raghunatha Reddy and Doddabasappa, B. 2019. Performance of Different Parthenocarpic Cucumber (Cucumis sativus L.) Hybrids for Yieldand Yield Attributing Traitsunder Shade Net House. Int .J.Curr.Microbiol.App.Sci.8 (3):978-982