Performance Analysis of Vapour Compression Mini Ice Cream Plant By Using Different Size Capillary Tube

Rajkumar Singh Chauhan[1], Neelesh Soni[2], Siddharth Kosti[3]
[1]Research Scholar, [2, 3]Assistant Professor SRCEM Banmore Near Gwalior M. P.

Abstract - In this paper experiment is performed on mini ice cream plant by using different size capillaries tube (0.79 & 1.12mm) with R134a gas as a refrigerant, The parameters were compared for finding out the efficient capillaries tube size between the two. All the readings were recorded and compared for finding the efficient setup. The results show that the COP of experiment no.1 (when the size of capillary tube is 0.79mm) is varied from 4.2 to 5.7 and the COP of experiment no.2 (when the size of capillary tube is 1.12mm) is varied from 5.3 to 6.1. By comparing the two cases it is found that COP of experiment no.2 is optimum than the experiment no.1 for the mini ice cream plant, work done in compressor in experiment no.1 has found optimum as compare with experiment no.2, refrigerating effect in experiment no.2 has found optimum as compare with experiment no.1.

Keywords - Evaporator, Compressor, Condenser, Capillary tube, Fan, Pump & Brine solution.

INTRODUCTION

An experiment is carried out to improve the working parameters of mini ice cream plant based on vapour compression refrigeration cycle. We have attempted to develop an mini ice cream plant which can give the best performance in given inputs and also which is least harmful to the environment. There are many ice plant based on VCRS in the market, but the reach is done to obtain the best combination of components selection with R134a gas refrigerant in mini ice cream plant to get the better performance.

Ch Mary et.al. [1] has analyzed the different process of the system and founds that convection coefficient increased due higher fan speed, heat convey in the evaporator and condenser with the surroundings increases, thus reduce the work done by the compressor on the refrigerant. Vapor compression cycle was more efficient with fans.kumar Chethan et.al. [2] analysis on VCR system with ammonia refrigerant and results were recorded. The suction & delivery pressure of compressor, temperature of evaporator and condenser are recorded and coefficient of performance is calculated. The results achieved will be validated through CFD simulation. Further between compressor and condenser diffuser has been installed , so that power input to the compressor has been deducted there by enhancing the COP. The enhancement will be made through CFD simulation;.Abed et. al. [3] used domestic refrigerator of 0.142 m3 capacity to study the effect of coiled diameter and pitch distance of a capillary tube. He has taken five capillary tubes of same dimension as original capillary tube of the refrigerator. The capillary tubes are shaped in five different shapes, each one has different coil diameter (D) with three different coil pitch (P) is tested. Capillary tube coiled diameter affect the cycle COP strongly on analysis the work done, as the capillary coiled diameter (D) increases cycle COP also. The pitch of capillary tube coiled shows small effect on the cycle COP. Mass flow rate of refrigerant increases with increase in capillary coiled diameter. Bolaji et. al. [4] investigated experimentally and compared the performances of three ozone-friendly Hydro fluorocarbon (HFC) refrigerants (R32, R134a and R152a) in a VCRS. The result showed that R152a obtained highest COP than R134a and R32, Also, R152a offers the best advantageous environmental requirements; zero ODP and very low Global Warming Potential (GWP). Khan saheb & Kapadia, [5] reviewed the various literature regarding the performance and GWP of hydrocarbons refrigerants & their mixture. In present world, about 80% of the domestic refrigerators use R134a as refrigerant because of its high thermodynamic & thermo physical property. Although R134a has high GWP & its emissions leads to global warming so alternate hydrocarbon refrigerant are required. After reviewing the various literatures he has found that the hydrocarbons (R290 and R600a) refrigerants and their mixture gives superior performance in small capacity domestic refrigerator compare to R134a.Prasanna & Kishore, [6] Performed & analysis on vapour compression refrigeration (VCR) system with R-12 refrigerant and measure the results. The effect on main parameter is recorded. Further the investigations are done by bringing shell and coil heat exchanger at the end of compressor.

METHODOLOGY

MATHEMATICAL CALCULATION

Compression process: The work done in compression, which is given by the enthalpy increase across the compressor.

$$W_{comp} = h_2 - \acute{h}_1$$

Refrigerant effect: To evaluate the refrigerant effect which is the enthalpy change across the evaporator. This is expressed by.

$$RE=h_1-h_4$$

Coefficient Of Performance: Define as the refrigeration effect (heat absorbed) divided by the net work done on the cycle (work input) as following.

$$COP = \frac{RE}{Wcomp}$$

Where,

Wcomp : work done in compression (KJ/S)

h_2: Enthalpy of outlet refrigerant from compr-

essor (KJ/KG)

$\acute{h}_1$: Enthalpy of inlet refrigerant to compressor

(KJ/KG)

RE: refrigerating effect in evaporator (KJ/S)

h_4: Enthalpy of inlet refrigerant to evaporator

(KJ/KG)

COP: Coefficient of performance of vapour

compression unit.

EXPERIMENTAL SET UP

Different components (Evaporator, Condenser, Compressor, Capillary tube & inlet outlet valve) are assembled for the construction of mini ice cream plant. After collecting all parts, these were assembled to prepare final model. After assembling the plant set up appear like.

OBSERVATION

After preparing the complete experiment setup a number of experiments were carry out and The observations taken during experiments are enclosed in annexure1.

COMPONENTS OF SETUP

SR.NO	COMPONENT
1	Evaporator
2	Compressor
3	Condenser
4	Capillary tube
5	Cooling Fan
6	Thermocouple
7	Pump
8	Voltmeter
9	Ammeter
10	Pressure Gauge

EXPERIMENT NO.1

The experiment has conducted by using R134a refrigerant with 0.79 mm size capillary tube. Different parameters like temperature of refrigerant at different points Suction & discharge pressure of the refrigerant in the compressor, voltage & current consumption by the compressor during experiment were observed and listed in the table.No.1

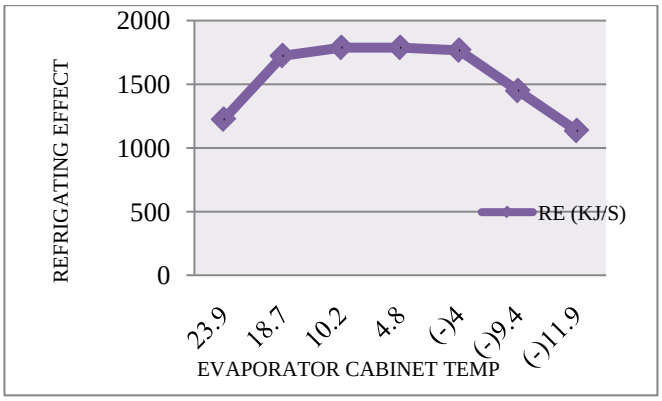
EXPERIMENT NO 2

The experiment has conducted by using R134a refrigerant with 1.12 mm size capillary tube. Different parameters like temperature of refrigerant at different points Suction & discharge pressure of the refrigerant in the compressor, voltage & current consumption by the compressor during experiment were observed and listed in the table No.2

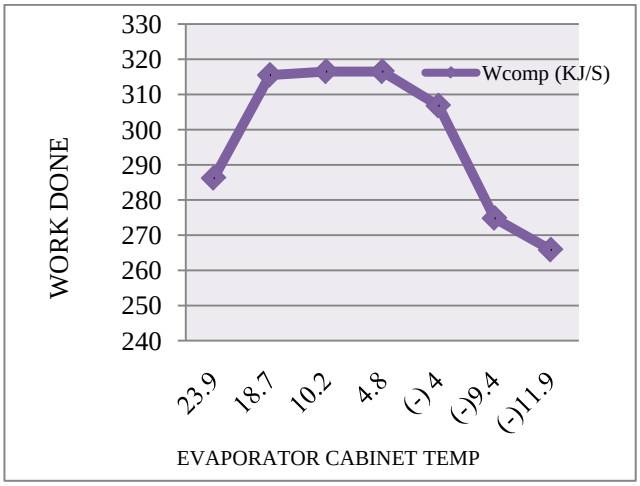
RESULTS AND DISCUSSION

After conducting experiments, certain data was obtained. On the basis of this data/ parameters. Mathematical calculations were carried out and results were obtained and compare

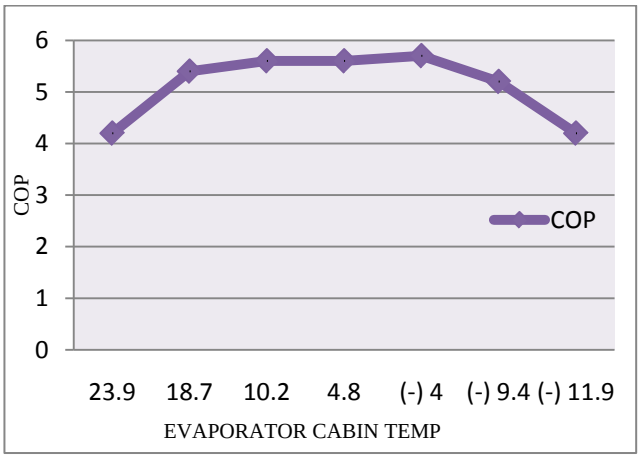
Variation of refrigerating effect with respect to evaporator cabin temperature for experiment No.1.



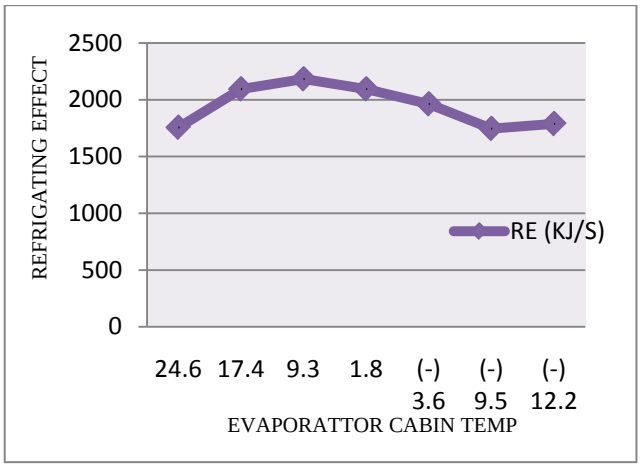
Variation of work done in compressor with respect to evaporator cabin temperature for experiment No.1.



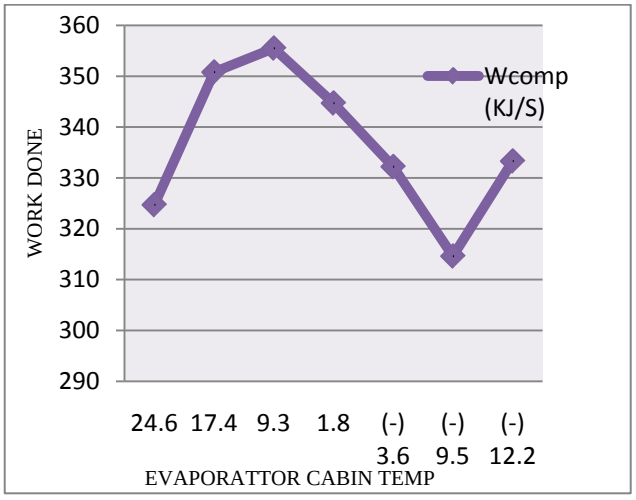
Variation of Coefficient of performance with respect to evaporator cabin temperature for experiment No.1.



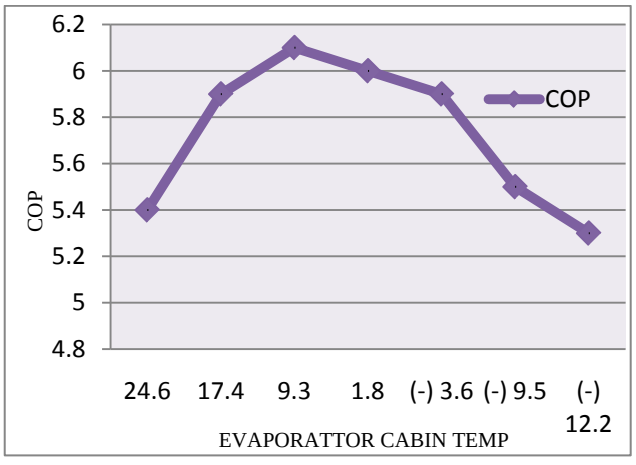
Variation of refrigerating effect with respect to evaporator cabin temperature for experiment No.2.



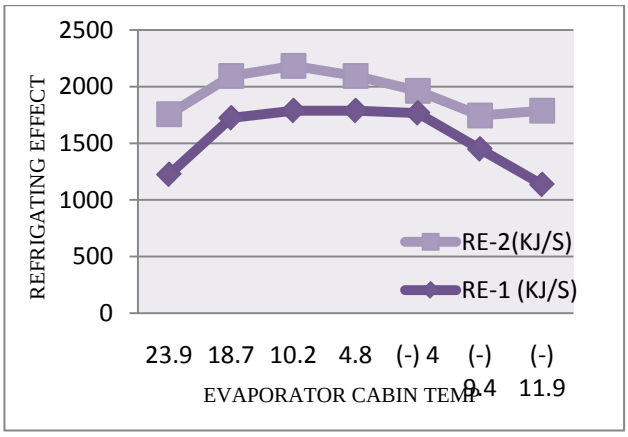
Variation of work done in compressor with respect to evaporator cabin temperature for experiment No.2.



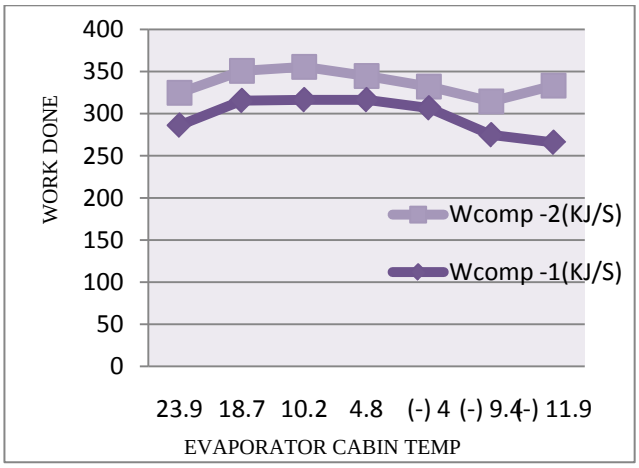
Variation of Coefficient of performance with respect to evaporator cabinet temperature for experiment No.2.



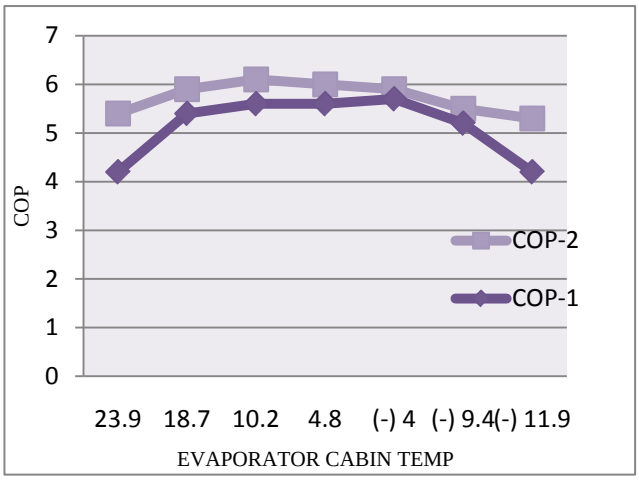
Comparison of Refrigerant effect for experiment No.1 and experiment No.2 with the evaporator cabin temperature



Comparison of work done for experiment No.1 and experiment No.2 with the evaporator cabin temperature.



Comparison of Coefficient of performance for experiment No.1 and experiment No.2 with the evaporator cabin temperature.



CONCLUSION

1. COP has found optimum in experiment no.2 as compare with experiment no.1. Maximum COP for experiment no.2 is 7% more than the Maximum COP for experiment.no.1.
2. Work done in compressor in experiment no.1 has found optimum.
3. Refrigerating effect in experiment no.2 has found optimum as compare with experiment no.1.

FUTURE SCOPE

More experiment can be done by varying the use of different ecofriendly refrigerant gas, also a forced convection cooling can be applied in the condenser for cooling refrigerant gas to enhance the coefficient of performance of the system.

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ANNEXURE-1

Experiment no. 1 : Using capillary tube size -0.79mm and refrigerant R-134A											
Sr.no	**Time**	**V**	**I**	**P_S**	**P_D**	**T_1**	**T_6**	**T_4**	**T_2**	**T_3**	**T_5**
1	12:10	233	1.3	0.34	11.71	31.3	23.9	28.1	40	35	1
2	12:30	233	1.4	1.17	13.1	31.5	18.7	26	48	30	-1
3	12:50	229	1.4	1.31	13.44	32	10.2	19.5	63	34	-1.2
4	13.1	227	1.4	1.31	13.44	32	4.8	16.8	68	36	-1.6
5	13.3	225	1.4	1.37	13.1	32	-4	-0.8	65	31.5	-1.3
6	13:50	222	1.2	0.82	12.06	33	-9.4	17.5	55	27	-9.9
7	14:10	226	1.2	0.27	11.44	33	-11.9	13.4	50	26	-7.8

Experiment no. 2 : Using capillary tube size – 1.12mm and refrigerant R-134A											
Sr.no	**Time**	**V**	**I**	**P_S**	**P_D**	**T_1**	**T_6**	**T_4**	**T_2**	**T_3**	**T_5**
1	12:10	230	1.4	1.24	14.82	31	24.6	27.5	55	24	1.7
2	12:30	231	1.5	1.86	15.85	32	17.4	23.1	61	30	9
3	12:50	233	1.5	1.93	15.78	32	9.3	18.9	70	34	7
4	13.1	232	1.5	1.86	15.65	32	1.8	13.5	73	32	4
5	13.3	228	1.5	1.72	15.3	32	-3.6	8	71	31	2.6
6	13:50	229	1.4	1.31	14.75	32	-9.5	-6.8	66	31.6	-0.5
7	14:10	239	1.4	1.17	14.47	32	-12.2	-9.9	62	31.5	-2.1

Here,

V = Voltage
A = Current Ampere
P_S = Suction Pressure
P_D = Discharge Pressure
T_1 =Atmosphere Temp
T_2=Refrigerant temperature at compressor outlet.
T_3=Refrigerant temperature at condenser outlet.
T_4 =Refrigerant temperature at compressor inlet.
T_5=Refrigerant temperature at capillary outlet.
T_6= Brine Temp