EXPERIMENTAL INVESTIGATION OF VAPOUR ABSORPTION SYSTEM

AUTHOR

1.ME Student Mech Engg Dept,Godavari COE, Jalgaon ,Maharashtra, India

2.Asso. Prof. & Head, Mech Engg Dept,Godavari COE, Jalgaon ,Maharashtra, India

3.Asst.. Prof. & ME Co-Ordinator, Mech Engg Dept,Godavari COE, Jalgaon ,Maharashtra, India

4.Asst.Prof., Mech Engg Dept,Godavari COE, Jalgaon ,Maharashtra, India

ABSTRACT

With the depleting energy resources recycling of waste energy or recovery of energy from the exhaust of processes or engine is vital method and important of energy conservation. Refrigeration another absolute requirement that needs to be catered, conventionally the vapour compression cycle is the preferred method but it comes with an handicap that the non-conventional energy resources cannot be employed to operate the same. The vapour absorption system using ammonia as refrigerant on the other hand is a method which can be used to harness this recovered process heat or heat carried by the exhaust gases of the engine.

The project aims at the design development analysis and performance evaluation of one such scaled system for volume size of 5 liters by utilization of vapour absorption system using ammonia as refrigerant. The paper includes experimental investigation of vapour absorption refrigeration system i.e. to find coefficient of performance of the system. Work includes the heat load calculation and design selection of components of system to suffice the requirements, The critical components of the system have been designed and developed using Unigraphix software and thermal analysis of the components has been done using Ansys Work bench 16.0.

Keywords: *Waste heat recovery, COP, Vapour absorption system, Ammonia, Thermal Analysis.*

---

1. INTRODUCTION

The vapor absorption refrigeration system comprises of all the processes in the vapor compression refrigeration system like compression, condensation, expansion and evaporation. In the vapor absorption system, the refrigerant used is ammonia, water or lithium bromide. The refrigerant gets condensed in the condenser and it gets evaporated in the evaporator. The refrigerant produces cooling effect in the evaporator and releases the heat to the atmosphere via the condenser.

The major difference between the two systems is the method of the suction and compression of the refrigerant in the refrigeration cycle. In the vapor compression system, the compressor sucks the refrigerant from evaporator and compresses it to the high pressure. The compressor also enables the flow of the refrigerant through the whole refrigeration cycle. In the vapor absorption cycle, the process of suction and compression are carried out by two different devices called as the absorber and the generator. Thus, the absorber and the generator replace the compressor in the vapor absorption cycle. The absorbent enables the flow of the refrigerant from the absorber to the generator by absorbing it.

Another major difference between the vapor compression and vapor absorption cycle is the method in which the energy input is given to the system. In the vapor compression system, the energy input is given in the form of the mechanical work from the electric motor run by the electricity. In the vapor absorption system, the energy input is given in the form of the heat. This heat can be from the excess steam from the process or the hot water. The heat can also be created by other sources like natural gas, kerosene, heater etc. though these sources are used only in the small systems.

2.OBJECTIVE

A) To find coefficient of performance of the system.

B) To compare the COP before changing the absorber volume and after changing absorber volume

3.ASSUMPTIONS BEFORE CONDUCTING THE EXPERIMENT

In this experiment following assumptions is made.
a .The vapour leaving the condenser is saturated at condenser temperature.
b .The strong solution leaving the absorber is saturated at absorber temperature.
c. The weak solution leaving the generator is saturated at generator temperature.
d. The strong solution is heated only up to saturation temperature, and no vapour generation takes place in the heat exchanger.
e. No pressure changes except through the pump.
f. The work input for the pump is negligible relative to the heat input in the generator. Therefore, the pump work is neglected for the purpose of analysis.
g. Steady state and steady flow.
.

4.EXPLAINATION OF MODEL AND OTHER PARTS

Fig.No.1-Three D Model of Vapour Absorption Refrigeration System

In this model absorber, generator, solution pump, condenser coil, evaporator coil, cabinet , thermostat ,small bulb as load, exhaust fan , cooling purpose condenser fan etc are the parts in this vapour absorption system.
First of all with the proper setting of thermostat heater is started then solution 12 V DC pump is started then as soon as pumps starts solution delivers to generator in which solution is heated . Heating of solution takes place due to indirect heating of air by air heater , air is sucked over generator and delivered to atmosphere. Here heated air is used to heat the generator. When heat is applied to strong solution the solution becomes weak and this weak solution send back to absorber vessel .Strong solution vapours generated send to condenser for conversion of vapour to liquid (due to condenser cooling fan temperature decreases hence conversion of vapour to liquid take place) This high pressure liquid funelling through capillary tube as expansion valve. Here due to Joule Thompson effect pressure decreases , such low pressure low temperature refrigerant passes in the cabinet where evaporator coil is placed it absorbs latent heat of air and thus the air is cooled. From evaporator this refrigerant is passed to absorber , here absorbent is kept water this water absorbs ammonia and thus the solution becomes strong and ready for further cycle.

4.1HEATER-

Heater is a single phase AC heater with 300 Watt power, provided with helical mild steel fins that improve heating ability of heater through enhanced heat transfer

Fig No. 2 Heater

The heater arrangement is used as an alternative to the exhaust system that is proposed in the above data. The air heater heats the air which then passes over the heater module using heat pipe mounted on the generator

4.2GENERATOR

The generator pipe receive rich water ammonia solution at the bottom via the pump, as the generator body is heated the vapours generated are sent to the condenser section via the top hole where as the lean water ammonia solution is sent back to the absorber via the central hole

Fig No. 3 Generator

4.2 EXHAUST FAN

Exhaust fan is 230 volt AC 4 inch span axial fan that pulls the hot air over the heat pipe module thereby heating the generator where in the ammonia vapours are produced to be sent to the condenser section.

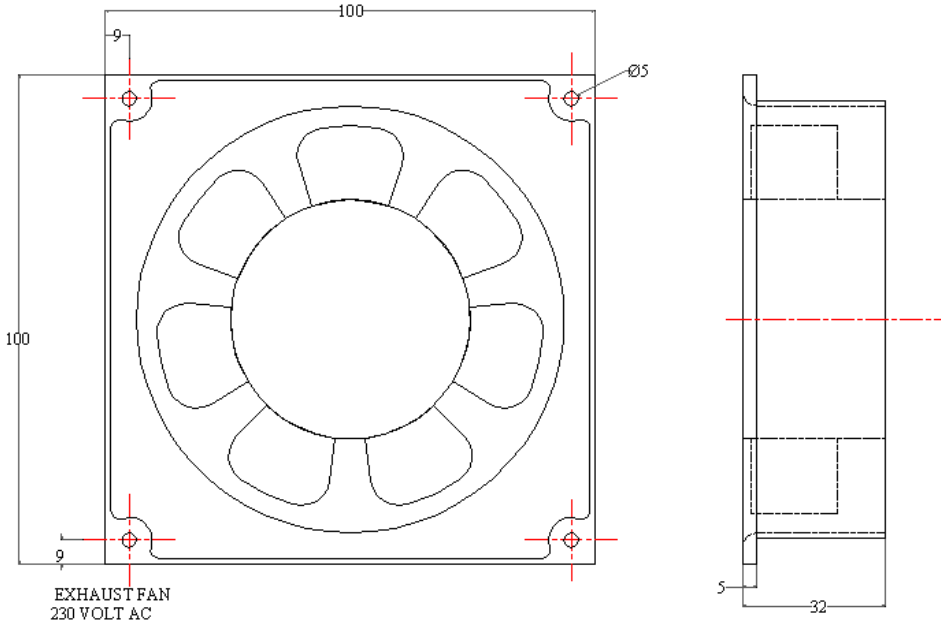


Fig No.4 Exhaust Fan

4.3DIGITAL TEMPERATURE INDICATOR

In our set up we have purchased total six digital temperature indicators for taking readings at six point such as temperature before generator , temperature after generator, evaporator temperature , condenser temperature, temperature before absorber, cabinet temperature. The sensor of temperature indicator is attached with teflon tape to evaporator tube , condenser tube and other tubes as shown in the figure below so that error remaining for temperature at six points is constant.

Fig No. 5 Digital Temperature Indicator

4.4 VOLTAGE REGULATOR- For experimentation we require voltage regulator for varying the absorber volume flow rate .In the following figure voltage regulator is shown.

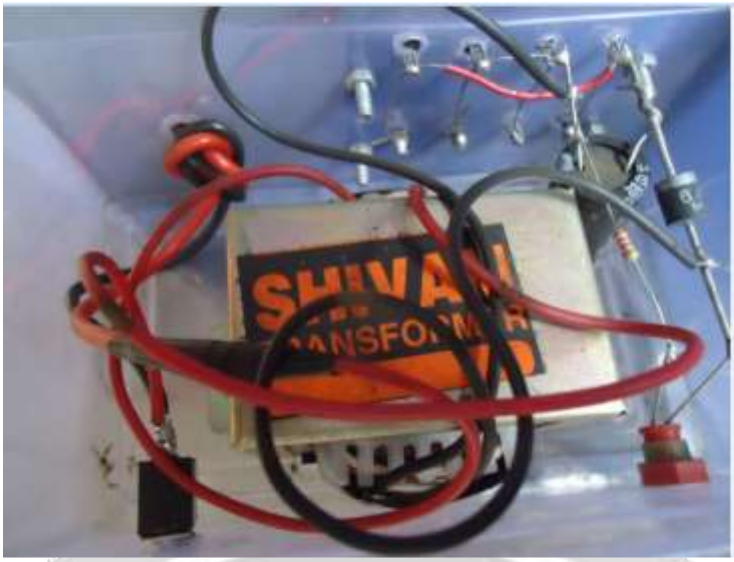


Fig No.6 VOLTAGE REGULATOR

The design of experimentation has given a road map of how the experimentation is planned but implementation of experimental plan and conduction of actual test run requires a systematic detailing of execution. Presentation of those details is the main substance of this paper. Keeping these points in mind this paper is divided into two main parts namely.

- Experimental procedure
- Observations.

5.EXPERIMENTAL PROCEDURE FOR BOTH CONSTANT VOLUME AND VARIABLE VOLUME

1.Switch ON the supply to the system and switch ON the main switch to start the heater
2. Check all the temperatures (i.e. 1, 2, 3, 4, 5, and 6)
3. Let the system run for some period (till the temperature in the evaporator tank starts decreasing)
4. Now note down the readings as per the observation table.
5. When cabinet temperature (T6) reaches around 15˚C, switch on variator. Adjust the load between 6 to 12 Volts. Ensure that the cabinet temperature does not increase when bulb is switched on.
6. If T6 increases, reduce the power supplied to bulb.
7. Note down 5 – 6 readings at interval of 5 minutes.
8. Calculate the results as per the calculation procedure.

5.1 Observation Table: For constant volume flow

Sr. No	T1 (^{o} C)	T2 (^{o} C)	T3 (^{o} C)	T4 (^{o} C)	T5 (^{o} C)	T6 (^{o} C)	V volt	I amp	POWER	TIME
01	31	34.6	18	31	29	21	12	1.2	14.4	10

TABLE NO.1

only one sample reading is given here for calculation purpose.

where T1: temperature before generator. , T4: condenser temperature

T2: temperature after generator T5: temperature before absorber

T6: cabinet temperature T3: evaporator temperature

5.2CALCULATION & RESULT TABLE

COP (Theoretical) = T3 (T2 – T5) / T2 (T5 – T3)
COP = $T_e (T_g - T_a) / T_g (T_a - T_e)$
For Reading No.1,
COP (Theoretical) = 18 x (34.6-29) / 34.6 (29-18) = 0.2648
COP (actual) = load applied / Heat supplied to generator
Load applied = V x I = 14. 4 w**att**
Heat supplied to generator = m* Cp * Δt
= 0.014 x 1.009 x 12 *0.3 = 50.85 watt
COP act = 14.4 / 50.85 =0.283

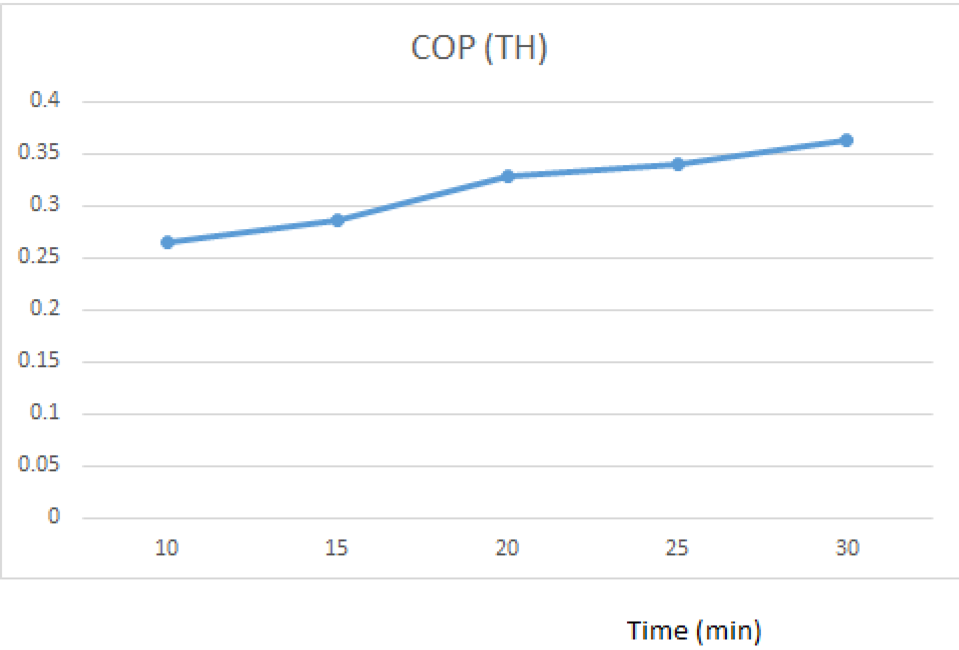
6.RESULTS AND DISCUSSION

A-For constant volume flow

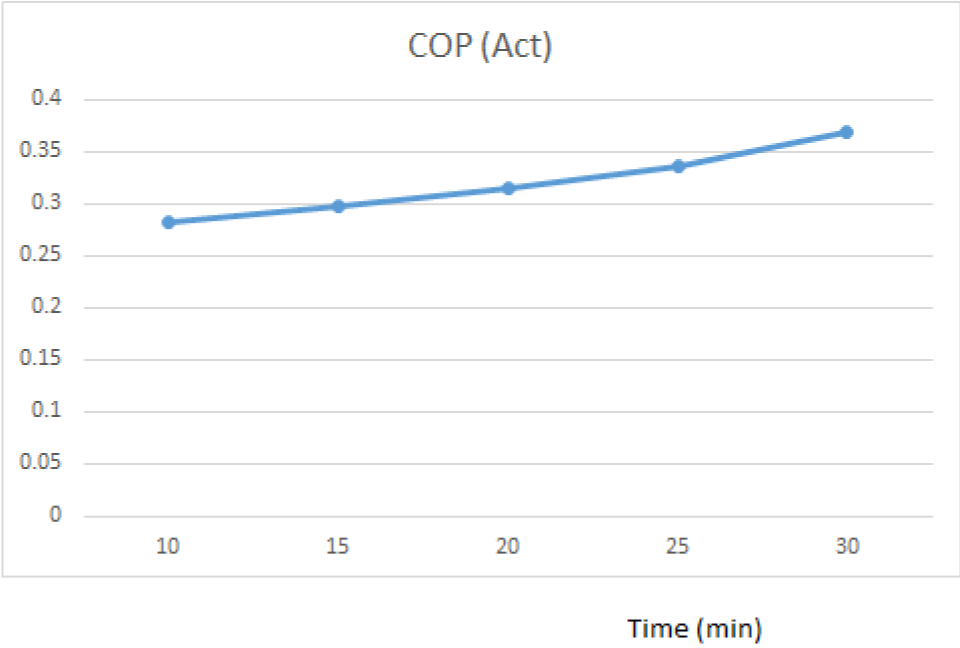
Sr.No	Time (min)	COP (Th)	COP (Act)
01	10	0.264844982	0.283166
02	15	0.285714286	0.298069
03	20	0.328638498	0.314629
04	25	0.340480145	0.336435
05	30	0.362907977	0.369347

TABLE NO .2

Graph of COP (theoretical) Vs. time

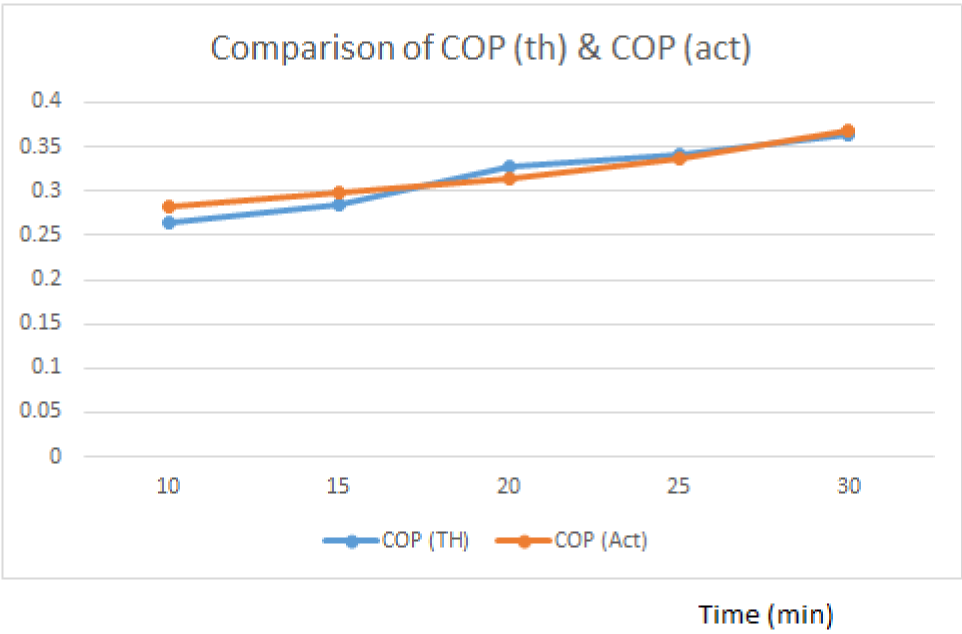


The theoretical COP of the system is seen to increase with time with maximum COP observed is 0.3629
Graph of COP (actual)Vs time



The Actual COP of the system is seen to increase with time with maximum COP observed is 0.3694 observed is 0.3694

Comparison Of COP(theoretical) and COP(actual)



7.0EFFECT OF CHANGE IN COP BY CHANGE IN ABSORBER VOLUME

In Vapour compression system we can check flow of refrigerant by using rotameter because compressor maintains flow of refrigerant flow through each part such as condenser , expansion valve and evaporator. In condenser state of refrigerant is liquid so refrigerant is always fitted after condenser outlet in vapour compression system. But our system is vapour absorption system so refrigerant flow is checked with the help of instruments as below.

Here flow rate is calculated by using stop watch . For one minute proper voltage is set then Liter per minute is find out. For full voltage full flow is observed similarly for haif of the voltage we get haif flow . In such a way we can find out mass flow of refrigerant.

Experimental Procedure:

1.Switch ON the supply to the system and switch ON the main switch to start the heater
2. Check all the temperatures (i.e. 1, 2, 3, 4, 5, and 6)
3. Let the system run for some period (till the temperature in the evaporator tank starts decreasing)
4. Now note down the readings as per the observation table.
5. When cabinet temperature (T6) reaches around 15˚C, switch on variator. Adjust the load between 6 to 12 Volts. Ensure that the cabinet temperature does not increase when bulb is switched on.
6. If T6 increases, reduce the power supplied to bulb.
7. Note down 5 – 6 readings at interval of 5 minutes.
8. Calculate the results as per the calculation procedure.

Observation Table: For variable volume flow

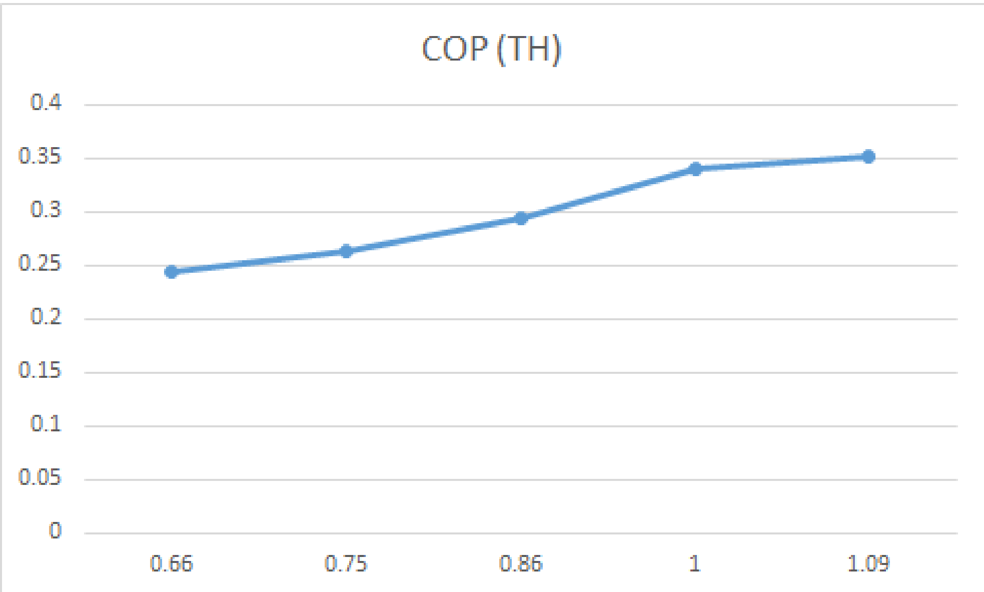
Sr. No	Flow rate of pump (kg/min)	T1 (^{o} C)	T2 (o C)	T3 (o C)	T4 (o C)	T5 (o C)	T6 (o C)	V volt	I amp	POWER
01	0.66	32	34.6	19.4	31	30	26	12	1.2	14.4

RESULT TABLE

Flow rate (kg/min)	COP (Th)	COP (Act)
0.66	0.243319882	0.255488
0.75	0.262400331	0.269682
0.86	0.293254262	0.287965
1.0	0.340480145	0.329902
1.09	0.352071897	0.357683

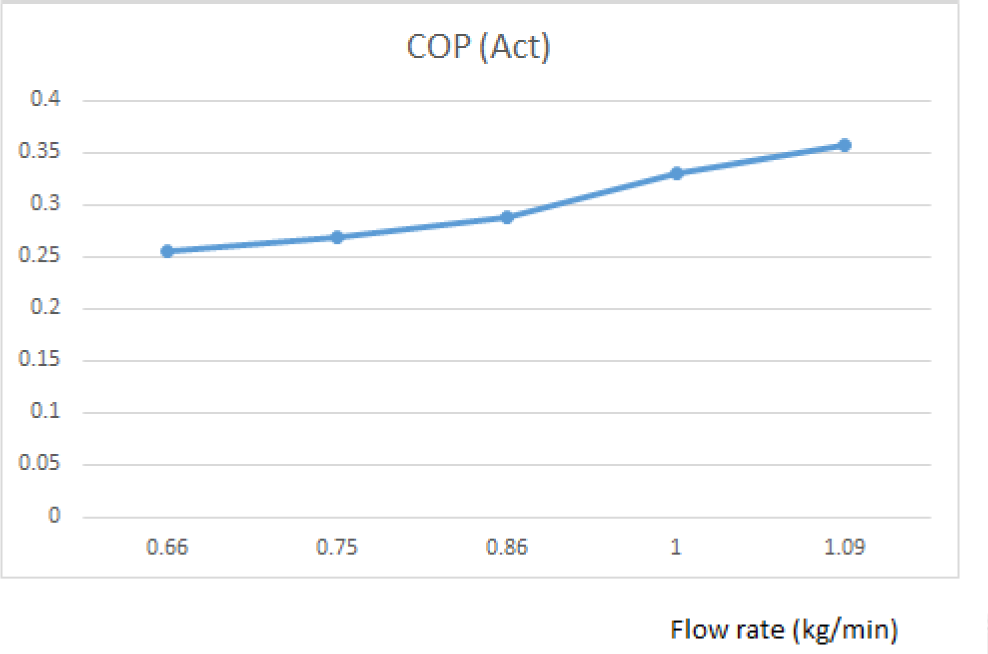
Here calculation for variable volume flow COP is calculated as in previous process.

Graph of COP (Theoretical) Vs Flow rate (kg/min)



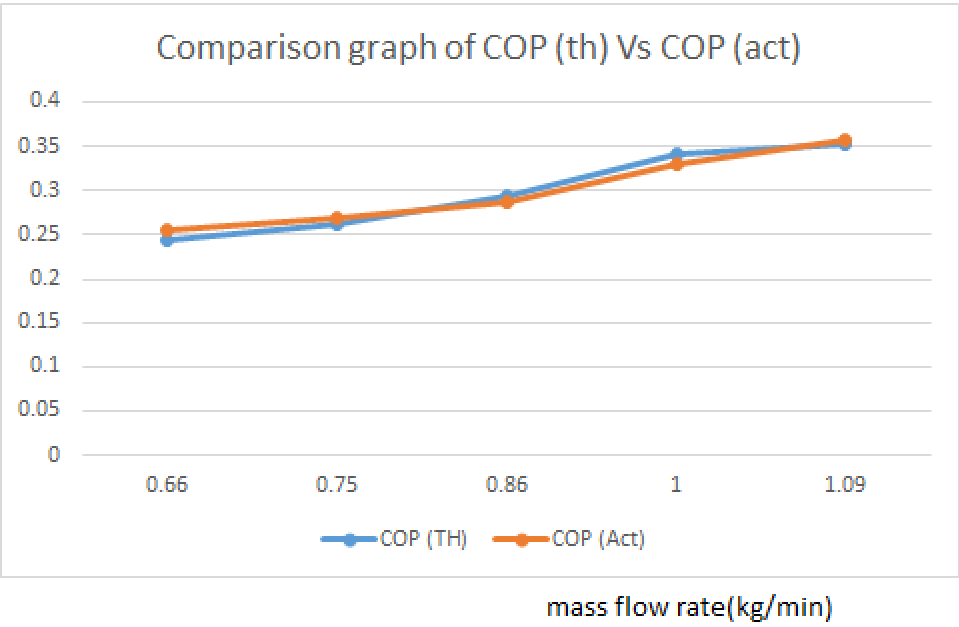
Flow rate (kg/min)

The theoretical COP increases with the increase in the flow rate
Graph of COP (actual) Vs Flow rate (kg/min)



The actual COP increases with the increase in the flow rate

Comparison Of COP(theoretical) and COP(actual)



The comparison of COP (theoretical) and COP (actual) shows that they are in close agreement indicating that the experiment is validated

It is seen that the ideal COP of an absorption system is the sole function of temperatures at which reversible energy transfer takes place. In addition , the expression for COP indicates that there is a fictitious heat engine which works between the generator and absorber temperatures, and a fictitious heat pump works between the evaporator and absorber temperatures.The fictious work output of the heat engine is used to execute the heat pump.

8.SCOPE FOR FUTURE WORK

This system is designed to reduce the impact of emmission mandating using HCFCs or CFCs as refrigerants to the atmosphere and to preserve perishable goods. However , the system is limited to only electrical power source. Hence, it is recommended that other sorces of powering the machine (solar, waste heat, etc) should be encouraged for further studies to improve its operation and performance. It is also proposed that high aluminium pipe materials should used as the condenser. This will increase the capacity of the generator thus speeding up the heating process of the system.

1.Closed loop circuit can be developed to link pump flow and refrigerating effect.

2.Multiple generator sets can be used to improve the performance of system

3.System can be made hybrid by use of Peltier modules in circuit that will increase the refrigerating effect.

4.Scope for future work is to include analyzer,rectifier and working fluids hydrogen to convert the strong solution into weak solution and to facilitate the faster rate of evaporation in the evaporator in vapour absorption system.

9.CONCLUSION

Keeping in mind the environmental safety point of view , this system is eco-friendly as it involves the use of ammonia (a natural gas) as a refrigerant and is not responsible for green house effect and Ozone layer depletion.

NH3-H2O is the most suitable working fluid due to its high latent heat and excellent heat and mass transfer properties.Ammonia absorption technology has great potential to offer economical and innovative solutions to various refrigeration requirements. Absorption machine theory has existed for many years, however just recentely this technology has reached a stage where it is also a commercially viable option. The small capacity application potential of ammonia absorption refrigeration technology makes it a strong candidate for the refrigeration technology of the millennium

1.For good performance the value of L/D should be less than one i.e. the ratio of lift to depression is less than one then the system is said to be performing good.And in my experiment for each reading the value of L/D is less than one.(Refer following table for L/D)

2.The Theoretical COP of system increases with the increase in time.

3.The actual COP of system increases with increase in time.

4.The Theoretical COP of system increases with the increase in flow rate.

5.The actual COP of system increases with increase in flow rate.

Sr. No	T1 (^{o} C)	T2 (^{o} C)	T3 (^{o} C)	T4 (^{o} C)	T5 (^{o} C)	T6 (^{o} C)	Lift =L (T2 – T5)	D=Depression (Ta-Te)	L/D
01	31	34.6	18	31	29	21	5.6	11	0.51

10.REFERENCES

JOURNAL PAPERS

[1] Harish Shingane,Arpitsingh Kanpuriya, Darshan Ranekar, Sachin Hakdale, Ashish Jumnake and Prof. Saurabh Rathod. Experimental set up of vapour absorption refrigeration system by using NH3-H2O refrigerant with various proportion, *IJARIIE-ISSN(O)-2395-4396,vol-3Issue-2,2017*

[2] Shekhar D Thakre, Prateek D Malwe,Rupesh L Raut, Amol A Gawali,Cooling of a truck cabin by vapour absorption refrigeration system using engine exhaust, *IJRET,eISSN:2319-1163IpISSN:2321-7308*

BOOK

1.A course in Refrigeration and Air-Conditioning by Domkundwar, Arora.

BIOGRAPHIES

A.G.Patil has received the B.E. Mechanical Engineering degree from Institution of Mechanical Engineers (India) Mumbai. Now, pursuing M.E.in Mechanical with specialization in Thermal Engineering from Godavari College of Engineering, Jalgaon which is affiliated with North Maharashtra University, Jalgaon in Maharashtra State (India)

Dr.V.H.Patil has received his Ph.D.degree from Amaravati University in 2018. His title of Ph.D thesis was **"Failure analysis and performance evaluation of boiler Tube in Thermal power Station."** His specialization is in Tribology and Maintenance Engineering. Today he is working as Associate Professor and Head of Mechanical Engineering Department in Godavari College of Engineering, Jalgaon which is affiliated with North Maharashtra University, Jalgaon in Maharashtra State (India)

Prof.T.A.koli has received the B.E. Mechanical Engineering degree from BAMU Aurangabad and ME Design from NMU Jalgaon. He is ME co-ordinator. He has total 16 years experience

Prof.K.M.Mahajan has received the B.E. Mechanical Engineering degree and ME Mechanical Engg degree with specialization in Thermnal Engg from North Maharashtra University, Jalgaon, Maharashtra State (India). Currentely he is working as Assistant Professor in Godavari College of Engineering Jalgaon, Maharashtra State (India)