Evaluation of Available Heat at the Exhaust of Automotive Engine for Air Conditioning by Vapor Absorption System

Kautuk Sharma[1], Devendra singh Sikarwar[2]

[1] *Research scholar, Mechanical Engineering Department, PCST, Indore, MP, India*
[2] *Assistant Professor, Mechanical Engineering Department, PCST, Indore, MP, India*

ABSTRACT

This work presents an experimental study of an automobile air conditioning system using aqua-ammonia refrigerant based vapour absorption refrigeration system. This system is using the exhaust waste heat of an internal combustion 4-Stroke petrol engine as an energy source. The availability of energy that can be used in the generator and its effect on engine performance, exhaust emissions, auto air conditioning performance and fuel economy will evaluated

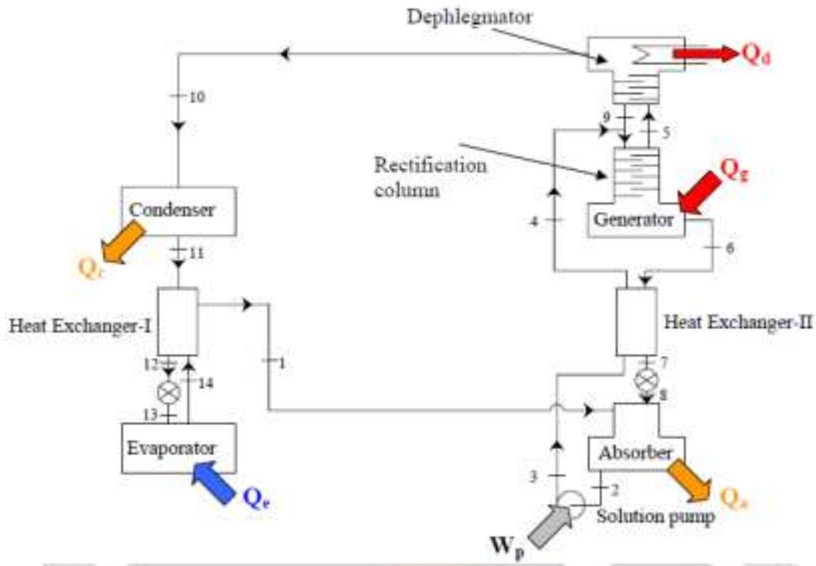
This system helps in reducing the consumption of fuel by utilizing the Exhaust waste heat of the system and hence optimizing the efficiency also no CFC refrigerant is used so have very little effect on environment. The exhaust gas heat available at the outlet of exhaust pipe is as high as it can run an air conditioning system of about 1 tonne capacity. Further the main purpose of this research is to utilize the exhaust waste heat to gain the maximum efficiency.

Keyword: - *Air Conditioning, Vapour Absorption System, Exhaust Gases, COP, Aqua-ammonia***,** *cooling load*

1. INTRODUCTION

Air conditioning is the cooling of indoor air for thermal comfort. In another sense, the term can refer to any form of cooling, heating, ventilation, or disinfection that modifies the condition of air. An air conditioner is an appliance, system, or machine which is designed to stabilize the air temperature and humidity within an area (used for cooling as well as heating depending on the air properties at a given time), typically by using a refrigeration cycle but sometimes using evaporation, commonly for comfort cooling in buildings and motor vehicles.

Vapor Absorption refrigeration system uses heat energy to change the refrigerant state unlike mechanical energy in vapor compression refrigeration system. The main advantage of using Vapor absorption cycle is that, the heat energy required to perform the operation can be extracted from the exhaust of the automobile. There are also many other advantages of vapor absorption system as it contains fewer moving parts thus lowers the noise level, also it required less electrical input to run the displacement pump as compared to compressor in vapor compression system.



1.1 Aqua-ammonia Solution

Ammonia (R-717) is one of the oldest and most widely used of all the refrigerants. Its greatest application is found in large and commercial reciprocating compression systems where high toxicity is secondary. It is also widely used in absorption systems. It is a chemical compound of nitrogen and hydrogen and under ordinary conditions, it is a colorless gas. Its boiling point at atmospheric pressure is -33.3˚C and its melting point from the solid is -78˚C. The low boiling point makes it possible to have refrigeration at temperatures considerably below 0˚C without using pressures below atmospheric in the evaporator .Its latent heat of vaporization at -15˚C is 1315 KJ/Kg. Thus, large refrigerating effects are possible with relatively small sized machinery. The condenser pressure at 30˚C is 10.78 bar. The condensers for R-717 are usually of water cooled type.

In the vapour absorption system ammonia is the refrigerant and water is the absorbent. This is known as the *Aqua-ammonia* absorption system. Ammonia vapour is vigorously absorbed in water. So when low pressure ammonia vapour from the evaporator comes in contact in the absorber with the weak solution (the concentration of ammonia in water is low) coming from the generator, it is readily absorbed, releasing the latent heat of condensation

1.2 Working Principle

The heat from the Exhaust flue gases is utilized in the generator to heat the strong Aqua-ammonia solution. The refrigerant gets vaporize, separated from water and went through the condenser where it is liquefied. The liquid refrigerant then flows to the evaporator where it is vaporize by extracting the heat from the air. This vapor refrigerant from the evaporator then flows to the absorber where it is absorbed by the weak solution thereby forming a strong solution. This strong solution is then pumped to the generator and thus the cycle is**.**

2. METHODOLGY

There is a working model of three cylinder four stroke engine of MARUTI 800. The entire Test performs on this working model.

In this Project Exhaust gas heat is proposed for air conditioning of *three cylinder four stroke* passenger cars (Maruti 800) by vapour absorption refrigeration system. The exhaust of car is used to heat the ammonia solution in the generator. The temperature of exhaust heat is measured at different Engine Load and different-different RPM.

Figure -1: 4-Stroke petrol Engine Test Rig.

2.1 Description Of Engine

Engine Model	**MARUTI 800**
Number of cylinder	Three
Number of Stroke	Four
Length of Stroke	72 mm
Bore Diameter	66.5 mm
Radius of dynamometer	.5m
Torque	59 N-M at 2500 rpm

Table-1 Description of 4-stroke Maruti 800 Car

2.2 Assumptions—

1) *Vehicle in is running condition*
2) *Fuel consumption is same at fixed for RPM and Torque.*
3) *Cooling water flow rate is fixed for RPM and Torque.*
4) *Air flow rate is fixed for RPM and Torque*

2.3 Testing Procedure—

1) Properly arranged whole Set up of experiment.
2) Connect the Rope brake dynamometer from engine properly
3) Fill the burette with Fuel (Petrol) at accurate level and note down the datum reading.
4) Now rope is stretched until spring balance indicator will shows 5 kg.
5) Now engine is started then Note down the reading of burette which shows the fuel Consumption rate.
6) Take reading of U tube manometer which shows the pressure in mm of water column.
7) Now set the RPM by accelerator.
8) Measure the RPM by tachometer as per requirement and let the engine stabilize.
9) Note down the exhaust gas temperature shows by digital temperature meter.
10) Note down the temperature of air passed from the engine.

11) Take the reading of cooling water temperature from digital temperature.
12) Then set rpm at 2000 & take the reading of Exhaust gas, cooling water and air Temperature.
13) Repeat this procedure for 2500 & 3000 rpm also.
14) Then set the spring balance load at 8 Kg for 1500, 2000, 2500 &3000 rpm and take the Readings.
15) Then set the spring balance load at 10 Kg for 1500, 2000, 2500 &3000 rpm and take the Readings.

2.4Observation Table—

Load (Kg)	RPM	Temperature of Cooling water (˚C)	Temperature of Air (˚C)	Temperature of Exhaust gas (˚C)
5	**1500**	39.7	23.1	501
	2000	40.1	23.7	507
	2500	40.7	23.7	513
	3000	41.1	24.6	520
8	**1500**	41.1	24.2	515
	2000	41.9	25.2	521
	2500	42.2	25.3	527
	3000	42.1	25.3	534
10	**1500**	41.3	24.5	528
	2000	41.9	24.8	533
	2500	42.1	25.3	541
	3000	42.7	26	544

Table-2 Tempeature of Air, Cooling Water and Exhaust gases at Variable speed

3. CALCULATION

- Pulley Radius (r) = .5 m
- Fuel flow rate (m) = 8.33 X 10^{-04} Kg/Sec
- Cooling water flow rate (m_w) = 0.12 Kg/Sec
- Air flow rate (m_a) = .23 Kg/ Sec
- Calorific Value of petrol = 42500 KJ / Kg
- Total energy in Fuel = 8.33 X 10^{-04} Kg/Sec X 42,500 KJ /Kg
- Total energy in Fuel = 35.4 kW

Let,

- Radius of Dynamometer = r
- Load on Dynamometer = W
- Torque Produced/ Required = T
- Revolution per minute = N

3.1 Formulae used

a) Torque = r × W × 9.81……………………………………………………………………....**Eq(3.1)**

Where r = Pulley radius

W= Load on dynamometer

b) Brake Power = $\frac{2\pi}{60000} NT$ ……………………………………………………......**Eq.(3.2)**

Where

N=Revolution of dynamometer wheel per minute

T = Torque produced

c) Heat Supplied = m × C_p × dT…………………………………………………………………**Eq(3.3)**

Where m = cooling water flow rate in Kg/Sec

C_p = Specific heat of water/ Ventilation air at constant pressure

dT = Change in temperature of cooling water/ Ventilation air

Net Energy will be = Total energy in fuel – (Break Power + Heat Supplied to cooling water + Heat Supplied to Ventilation air)…………………………………………………………....**Eq. (3.4)**

3.2 Calculation for 5 Kg Load—

Table 3.1

Torque (Nm)	RPM	Break Power (kW)	Heat Supplied (kW)		Net Heat Supplied (kW)
			Cooling Water	Ventilation air	
24.525	1500	3.85	7.51	1.87	22.1
	2000	5.20	7.57	2.01	20.63
	2500	6.42	7.84	2.01	19.15
	3000	7.71	8.12	2.1	17.5

Table-3 Calculation of Neat heat supplied and varying RPM for 5 Kg Load

3.3 Calculation for 8Kg Load—

Table 3.2

Torque (Nm)	RPM	Break Power (kW)	Heat Supplied (kW)		Net Heat Supplied (kW)
			Cooling Water	Ventilation Air	
39.24	1500	6.16	8.07	2.12	19.06
	2000	8.22	8.46	2.26	16.47
	2500	10.27	8.86	2.23	13.903

	3000	12.33	8.57	2.3	12.22

3.4 Calculation for 10Kg Load—

Table 3.3

Torque (Nm)	RPM	Break Power (kW)	Heat Supplied (kW)		Net Heat Supplied (kW)
			Cooling Water	Ventilation Air	
49.05	1500	7.70	8.2	2.18	17.61
	2000	10.27	8.51	2.26	14.35
	2500	12.84	8.57	2.3	11.62
	3000	15.42	8.87	2.52	8.62

3.5 Cooling Load estimation

Let assume Average Solar radiation in middle India is 700 W/m^2

Consider Area of Roof is = 1.5 X 1

= 1.5 m^2

= 700 / 1.5

= 1050 Watt = **1.05 KW**

Table 3.5

Cooling Load	Amount of Heat (KW)
Solar heat lose through Roof area	1.05 KW
Solar heat loss through Glass area	.53 KW
Heat Lose due to Occupants	1.5 KW
Heat lose due to other (infiltration, Air leakage)	1 KW
Total	**4 KW**

4. RESULT

By Subtracting Losses from the Net energy, we will get the following results.

Table 4.1

Load (Kg)	RPM	Before consider Losses(KW)	After consider Losses(KW)
5	1500	22.21	**18.21**
	2000	20.63	**16.63**
	2500	19.15	**15.15**
	3000	17.5	**13.5**
8	1500	19.06	**15.06**
	2000	16.47	**12.47**
	2500	13.903	**9.903**
	3000	12.22	**8.22**
10	1500	17.61	**13.61**
	2000	14.35	**10.35**
	2500	11.62	**7.62**
	3000	8.62	**4.62**

5. CONCLUSIONS

We can see very easily 4.62 KW heat is minimally available at maximum load. It shows that 1 tonne refrigeration system can be installed.

It will require only installation cost after that there will be no any type of expenditure for the running of Vapour absorption refrigeration system. It is eco-friendly also

6. REFERENCES

[1]. Khaled S. AlQdah[1] “Performance and Evaluation of Aqua Ammonia Auto Air Conditioner System Using Exhaust Waste Energy” Tafila Technical University, Zip code: 66110, Tafila, Jordan.

[2]. Isaac Mathew Pavoodath[2] “Absorption AC in Vehicles Using Exhaust Gas” International Conference on Automation, Control and Robotics (ICACR'2012) December 21-22, 2012 Bangkok (Thailand).

[3]. Dürnholz, M., Eifler, G., and Endres, H[3]., "Exhaust-Gas Recirculation - A Measure to Reduce Exhaust Emissions of DI Diesel Engines," SAE Technical Paper 920725, 1992, doi:10.4271/920725

[4]. Arias, D., Shedd, T., and Jester, R.,[4] "Theoretical Analysis of Waste Heat Recovery from an Internal Combustion Engine in a Hybrid Vehicle," SAE Technical Paper 2006-01-1605, 2006, doi:10.4271/2006-01-1605

[5]. R.Farrington & J.Rugh[5] " Impact of vehical Air-condition on fuel economy, Tailpipe emission and electric vehicle range" National Renewable Energy Laboratory (NREL) 1617 Cole Blvd. Golden, CO 80401 U.S.A

[6]. S.S Mathapati, Mudit Gupta, Sagar Dalimkar[6] " A study on automobile air- conditioning based on absorption Refrigeration system using exhaust heat of a vehicle". Singhad Institute of Technology, Lonavala, Maharashtra.

[7]. Sachin Kaushik, Dr.S.Singh[7] "Thermodynamic Analysis of Vapor Absorption Refrigeration System and Calculation of COP" Bipin Tripathi Institute of Technology,Dwarahat, Almora, Uttarakhand (India) 263653

[8]. Text book Refrigeration and Air Conditioning by C.P Arora, R.S Khurmi And J K Gupta[8].