A Proposed Model for Utilizing Exhaust Heat to run Automobile Air-conditioner

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Abstract: *In these paper three fluid vapor absorption systems is used for air conditioning of four strokes, four cylinders passenger car. The capacity of air conditioner is one ton. The exhaust of car is used to heat the ammonia solution in the generator. The temperature of exhaust heat is measured at different engine speed under 1/4th and half opening of throttle valve. The analysis shows that the maximum amount of useful heat available in the exhaust gas is about 6 KJ/sec. In this study it is found that the amount of heat required for generator is 3.02 KJ/sec. However the heat present in the exhaust is more than this amount. Therefore, the required heat to run the one-ton air conditioner that is needed to convert ammonia solution into ammonia vapor is sufficient.*

Keywords: Automobile Exhaust, Air Conditioning, Load Factor, Vapor Absorption Cycle, Three Fluid System

1. INTRODUCTION

Like other air conditioner systems, the automobile air conditioner must provide adequate comfort cooling to the passenger in the conditioned space under a wide variety of ambient conditions. In automobile air conditioning load factors are constantly and rapidly changing as the automobile moves over highways at different speeds and through all kinds of surroundings. As the car moves faster there is greater amount of infiltration into the car and the heat transfer between the outdoor air and the car surface is increased. The sun baking down on a black top road will raise its temperature to 50^0C – 60^0C approximately and thus increases the amount of heat transmitted into car. When driving through a grassy terrain, much less radiant heat is experienced than when passing through sandy flats or rocky hills. Therefore, the car is subjected to varying amounts of heat load when its orientation changes during the journey.

An automobile engine utilizes only about 35% of available energy and rests are lost to cooling and exhaust system. If one is adding conventional air conditioning system to automobile, it further utilizes about 5% of the total energy. Therefore automobile becomes costlier, uneconomical and less efficient. Additional of conventional air conditioner in car also decreases the life of engine and increases the fuel consumption. For very small cars compressor needs 3 to 4 bhp, a significant ratio of the power output. Keeping these problems in mind, a car air conditioning system is proposed using exhaust gases. The advantages of this system over conventional air-conditioning system are that it does not affect designed efficiency life and fuel consumption of engine.

Horuz [1] has compared the performance of a vapor absorption refrigeration system based on natural gas and engine exhaust gases. Hosoz and Ertunc [2] have analyzed automobile air conditioning system using artificial neural network technique. Jabardo et al. [3] have developed the model of an automobile air conditioning system with variable capacity compressor. Jiangzhou et al. [4] have done experimental study on locomotive cabin. Mezrhab and Bouzidi [5] have computed the thermal comfort inside the car. Tamura et al. [6] have analyzed automotive cooling and heating air conditioning system.

2. DESCRIPTION OF PROPOSED MODEL

The proposed model is based on three fluid vapor absorption systems. It consists of basic components needed for vapor absorption system as shown in Fig. 1. The three fluid used in this system are ammonia, water and hydrogen. Although ammonia is toxic, but due to absence of any moving part there is a little chance for the leakage. The hydrogen gas is used to increase the rate of evaporation of the liquid ammonia passing through the system. The water is used because it has the ability to absorb ammonia readily.

The exhaust gas is used to heat the ammonia solution in the generator. A rectifier is used before condenser, which removes water from ammonia vapor. The ammonia vapor is condensed and flows under gravity to the evaporator where it meets the hydrogen gas. The hydrogen of gas, which is being feed to the evaporator, permits the liquid ammonia to evaporate at low pressure and temperature. During the process evaporation the ammonia absorbs the latent heat from refrigerated space and produces cooling effect. The mixture of ammonia vapor and hydrogen is passed to the absorber where ammonia is absorbed while hydrogen raises the top and flows back to the evaporator.

The arrangement of various components of this proposed air conditioning system is also a challenge because of the fix size of cars. In the proposed model condenser and evaporator are arranged same as the conventional unit. However, absorber is fitted immediately below radiator and extends to one of the fenders. The dephlegmator is fitted against to the condenser as the latter has been so designed to make place for both the other units. The generator is mounted as close to the exhaust manifold as possible to save on heat losses from the gases before they are routed through the generator heat exchangers. Since the generator is actually a fairly large size unit. It can only be placed below the engine and slightly to the rare dynamo.

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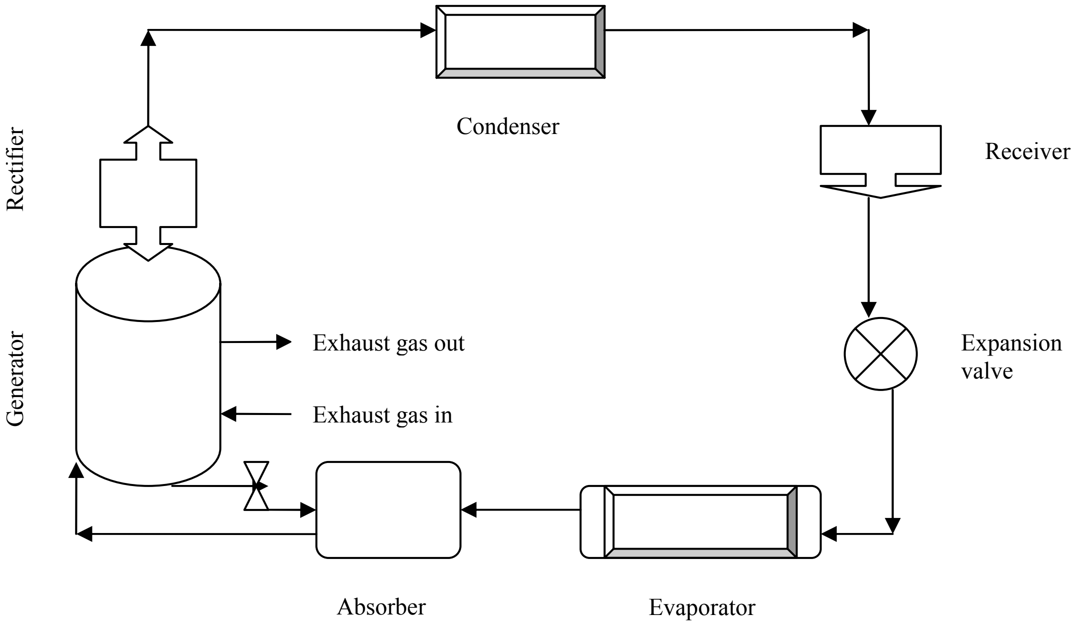

Fig. 1 Schematic diagram of three fluid vapor absorption system

3. MEASURED DATA AND HEAT LOAD CALCULATION

To generate base line data, the engine is allowed to run at different throttle position (one-fourth and half) considering engine speed as running parameter. The mass flow rate of air, mass flow rate of fuel and temperature of exhaust gas is measured as given in Table 1.0. For measuring the required data plenum chamber (1 m^3) with circular orifice of 32 mm diameter, inclined tube manometer, burette for petrol measurement and thermocouple for exhaust temperature measurement in installed on engine.

The determination of actual load becomes very difficult in car air conditioning because of the variation of the load in the climatic conditions when the car is exposed during the course of long journey.

The cooling load of a typical automobile is also considered at steady state conditions. The cooling capacity is affected by outdoor infiltration into car and heat gain through panels, roofs, floors etc. The cooling load considered in this analysis is given in Table 2.0 The table shows that heat load inside the car is 2.2 kW. Therefore, one ton air conditioning unit is sufficient to fulfill the cooling requirement.

Table 1 Measured data and exhaust useful heat

Throttle Position opening	Engine Speed	Air Pressure	Time for consumption of 25 c.c. fuel	Exhaust Temperature	Mass of fuel	Mass of air	Useful exhaust heat
	rpm	mm of H_2O	second	^0C	Kg/sec (10^{-5})	Kg/sec (10^{-4})	KJ/sec
1/4th	3500	7.4	40	622	46	64	3.98
	3000	7.9	57	605	32	67	3.91
	2500	7.2	48	566	38	64	3.50
	2000	5.6	42	623	44	56	3.49
	1500	4.9	41	582	45	52	3.05
half	3500	14.8	34	669	54	91	6.02
	3000	15.9	29	615	63	94	5.74
	2500	12.3	24	648	77	83	5.47
	2000	9.4	32	595	57	73	4.31
	1500	6.8	39	588	47	62	3.61

Table 2 Heat load considered in the analysis

Heat Load	Amount of heat (KJ/hr)
Solar radiation (roof, walls, glasses)	300
Normal heat gain through glass	1200
Normal heat gain through walls etc.	4300
Air leakage	1000
Passenger including driver	1200
Total	8000 KJ/hr or 2.22 KJ/sec

4. RESULTS AND DISCUSSION

The measured data as given in Table 1.0 is used to calculate mass flow rate of air, mass flow rate of fuel and maximum useful heat available in exhaust gas at 25% & 50% throttle opening position, considering speed of engine as running parameter.

The Table 1.0 shows that useful heat available in exhaust gas varies 3.05 KJ/sec at 1500 rpm to 3.98 KJ/sec at 3500 rpm when throttle opening is $1/4^{th}$ and with half throttle opening the amount of exhaust heat varies from 3.61 KJ/sec at 1500 rpm to 6.02 KJ/sec at 3500 rpm. This shows that useful heat is about double when throttle position becomes half. In this way at full opening of throttle valve significant heat can be obtained from the exhaust gases.

For installing one ton air conditioning unit operating between 45^0C condenser temperature and 5^0C evaporator temperature the heat required for generator unit is about 3.02 KJ/sec. The useful heat available in the exhaust gas is more than the heat required in the generator and able to run air conditioning unit.

5. CONCLUSION

In the proposed analysis it is shown that useful heat available in the exhaust gas is sufficient to generate ammonia vapor from ammonia solution for one ton air conditioning unit. Since this system does not use direct energy of engine, therefore, it does not affect fuel consumption, life and efficiency of the engine.

6. REFERENCES

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