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"Waste heat recovery of 80 cc petrol engine for refrigeration with VAC system"

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ABSTRACT— Waste heat recovery is essential for achieving the fuel economy of engine indirectly. In this project vapor absorption refrigeration system is used to utilize the waste heat from engine. The use of recovered heat is made in generator of the vapor absorption system and due to this heat refrigerant gets separated from absorbent. This absorption system uses water as absorbent and R134a as refrigerant. This heat recovery system can be adopted in both traction and non-traction application of engine, in this system heat is recovered from the exhaust gases of engine by passing the exhaust pipe from the generator. In this paper the more focus is given to the design and manufacturing of the system with 80 cc internal combustion petrol engine.

KEYWORDS- R134a, water, generator, absorber, condenser

I. INTRODUCTION

In the vapour absorption refrigeration system, a physicochemical process replaces the mechanical process of the vapour compression refrigeration system by using energy in the form of heat rather than work. The vapour absorption systems have many more favourable characteristics .Typically a much smaller electrical input is required to drive the solution pump, also it is having fewer moving parts means lower level of noise. In this system the compressor is replaced by an absorber, a pump and generator. These installed components performed the same work as that of compressor used in vapour compression system. Generally 35$^{\%}$ of thermal energy generated in the combustion process of engine is lost to the surrounding through the exhaust gas and from other mean. In this work one provision is made to recover the lost heat. So here heat is recovered by passing the exhaust pipe from the generator. The advantage over the conventional air-conditioning system would be that it does not affect the design efficiency, life and fuel consumption of an engine, but it does add some weight. Trucks used for perishable items are commonly equipped with refrigeration systems. Some have a vapour compression machine powered by the engine via pulley and belt or by an auxiliary power unit. Others use expendable liquid nitrogen or carbon dioxide spray systems. In most car engines, waste heat is removed through the radiator using a coolant and then rejected to the ambient. The other significant heat rejection is through the exhaust system. In the case of high-performance engines the exhaust heat is used either for turbo-charging or supercharging. A turbocharger uses a turbine attached to the exhaust system whereas a supercharger is attached directly to the engine to run a compressor.

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Basic absorption systems

In the absorption cycle, the low-pressure refrigerant (e.g., ammonia or lithium bromide) vapour is absorbed in water and the liquid solution is pumped to a high pressure by a liquid pump. The lithium bromide-based absorption chiller has been around commercially since the late 1950's and uses bromide brine with concentrations of about 60%. The ammonia–water absorption system has been around since the early 1900's. Little work input is required to pump the liquid. Another advantage is that they have been around for a long time, such that there is a manufacturing basis for larger systems. A source of heat with temperature ranging from 100 to 200^{0}C must be available for the absorption system. COPs for absorption systems are near 1.There may be some safety related issues in transporting ammonia or lithium bromide in vehicles, which could cause significant resistance to absorption systems in the automobile industry. Another disadvantage is that corrosion in the evaporator can occur. Lithium bromide is highly corrosive. So there is a need to develop an system which does not have any above mentioned haphazard effects. Hence to overcome the disadvantages of a Li-Br Absorption system new absorption system with R134a –H_2O is designed, developed and analyzed in this work.

II. DESIGN OF THE R134A-H_2O SYSTEM

System has been designed by considering below mentioned parameters

1) Temperature at generator, t_g = 90^{0}c

2) Temperature at condenser, t_c = 40^{0}c

3) Temperature at evaporator, t_e = 05^{0}c

4) Temperature at absorber, t_a = 25^{0}c

Equation used

1) $R_E = m_r \times h_{fg}$

2) $LMTD = \frac{[[t_s - t_i] - [t_s - t_0]]}{\ln [\frac{[t_s - t_i]}{[t_s - t_0]}]}$

3) $Gr = \frac{g.\beta.\rho^2 \Delta t.D_0^3}{\mu^2}$

4) $Q = M_r.C_p.(t_g\text{-}t) + M_r . h_{fg}$

5) $Q = UA\Delta T$

6) $Nu = \frac{h.D_o}{K}$

7) $L = \frac{Q}{h \times \pi D_i \times LMTD}$

8) $COP = (\frac{T_e}{T_C - T_e})\ (\frac{T_g - T_C}{T_g})$

9) $\frac{m_a}{m_r} = \frac{X_b}{(X_a - X_b)}$

10) $V = \frac{m}{A\rho}$

Final dimensions of designed parts are

Generator 1)D_0 = 0.012 m

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	2) D_i = 0.01 m
	3) L = 2.905 m
Condenser	1) D_0 = 0.012 m
	2) D_i = 0.01 m
Evaporator	1) Di = 0.01 m
	2) D_0 = 0.012 m
	3) L = 4.87 m
Absorber	1) D_o = 0.30 m
	2) L = 0.409 m

III. EXPERIMENTATION AND SETUP

Basic components

In vapour absorption system, the function of the compressor is accomplished in a three step process by the use of the absorber, pump and generator or re boiler and description of various parts are as follow:

Absorber:-

Absorption of the refrigerant vapour by its weak or poor solution in a suitable absorbent forming a strong or rich solution.

Pump:-

Pumping of the rich solution raising its pressure to the condenser pressure.

Generator or Desorber:-

Distillation of the vapour from the rich solution leaving the poor solution for recycling. Heating of strong solution is done in the generator by means of exhaust gases from engine

Condenser:-

Here latent heat of condensation is rejected to the atmosphere and gaseous phase of refrigerant gets converted into the liquid phase.

Expansion coil:-

Here expansion of refrigerant takes place and its pressure drop to condenser pressure.

Evaporator:-

Here refrigerant takes its latent heat of evaporation from surrounding and starts to evaporate. Following figure shows the block diagram of experimental setup which reflects the working of the system.

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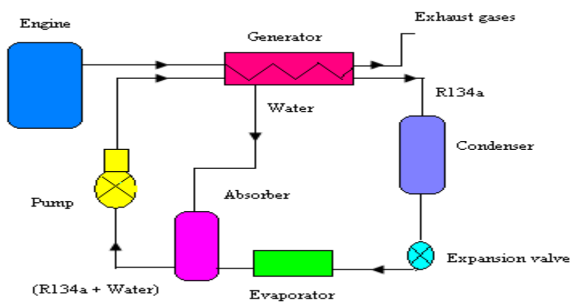

Figure 1 Block diagram of experimental setup

IV. EXPERIMENTAL PROCEDURE

Heat input is given to generator by starting engine. Temperature is measured at various points after achieving steady state. Pressure is also measured after generator and expansion coil. Engine speed is measured with tachometer and by measuring various necessary data COP is calculated at various ambient temperatures. Evaporator and condenser temperature is measured at various speeds of engine.

V.RESULT ANALYSIS

The effects of different engine parameters on the performance of refrigeration system have been investigated, these parameters are the engine speed, exhaust gases temperature and exhaust gas flow rates. The effect of the generator, condenser, absorber and evaporator temperatures on the capacity of refrigeration system has been observed. From the observation it is clear that as the engine speed increases the exhaust gases temperature and energy available will also increases as shown in figures 2 and 3.

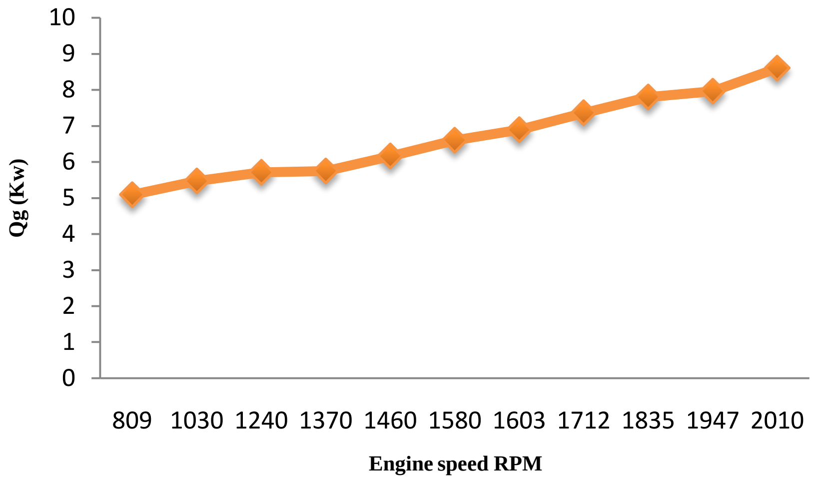

Figure 2.Effect of Engine speed on Exhaust heat generation (Q_g)

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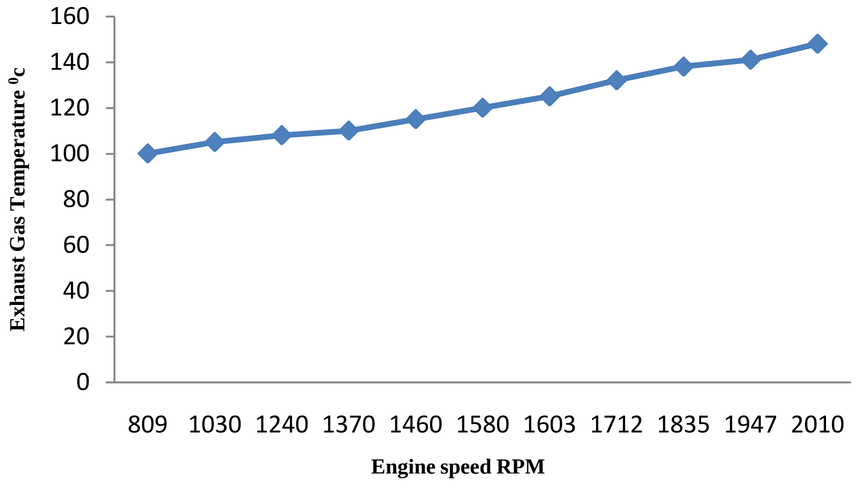

Figure 3.Effect of Engine speed on Exhaust gas temperature

Therefore absorption refrigeration system is able to take advantage of the exhaust gas power availability and thus provides the cooling. Figure 4 shows the variation of COP with evaporator temperature for the generator temperature $T_g = 90^0c$ and condenser $T_C = 40^0c$. After performing trial it is found that the COP increased slightly by increasing the evaporator temperature, this increment is due to the increment of enthalpies and hence increasing the capacity of the evaporator.

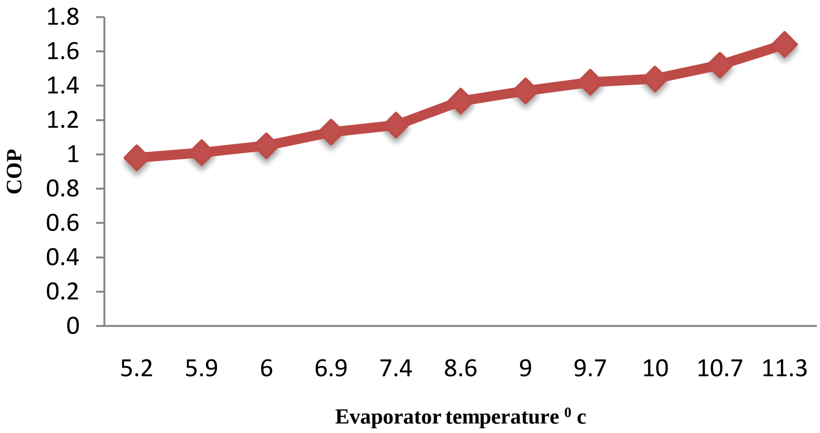

Figure 4 Variation of COP with Evaporator temperature

COP of the system also gets vary with the heat supplied to the generator and figure 5 shows the variation of the COP with heat supplied to the generator, further observations shows that COP of the system get increases with decrease in heat input to the generator.

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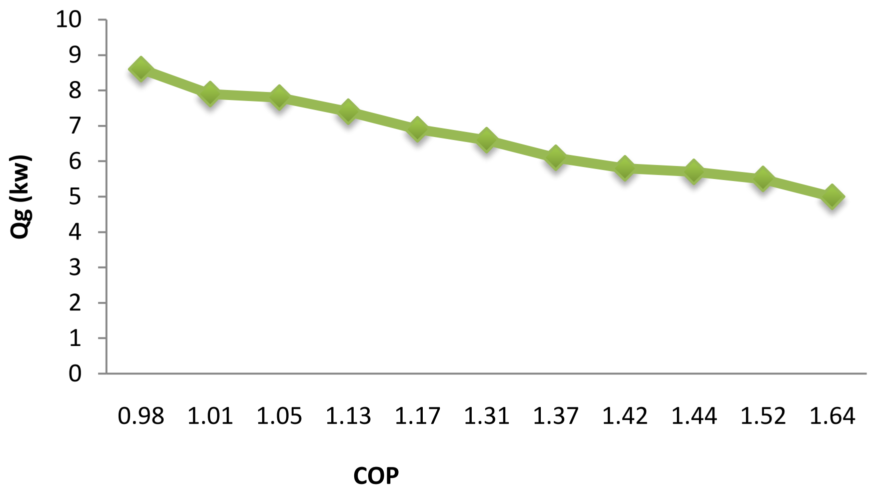

Figure 5 Variation of COP with heat supplied to the generator (Q_g)

VI.CONCLUSIONS

The waste heat recovery system has been analysed and experimentally investigated in this article. In this paper work has been supported by a suitable mathematical model .The study reveals that it comprises two heat exchangers, namely: air forced convection condenser, air forced convection evaporator and absorber, an expansion valve.

The exhaust gas from an 80 cc internal combustion engine was used to run a 0.5 TR vapour absorption system which was designed for hot gas intake. The experiments conducted on the system, prove that the concept is feasible and could be used for refrigeration in traction and non-traction application of engine. The absorption system is having few high precision components, thus it reduces manufacturing costs. This system is having some silent features like high reliability, low maintenance, flexibility in operation and less noise.

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