ENHANCE THE EFFICENCY OF AUTOMOTIVE AC SYSTEM BY USING EXHUAST HEAT

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ABSTRACT

Most of new automobile engines used all over the world utilize about 30 – 35% of the available energy for developing power. The balance is covered by the cooling and exhaust system etc. conventional air conditioning system of automobile is consumes 15 – 20% of the total energy developed in the engine. As a result it effect for running cost, environment pollution and overall efficiency of automobile. This designed is couple the vapor absorption cycle with automotive air conditioning system instead of vapor compression cycle. Here use exhaust waste heat as power source and it may not consume engine developed power for run the air conditioner. On the other hand in this design used ammonia as a refrigerant. It may be causes to reduce the environmental impact. Existing components other than the compressor can be used as usual with this modification. However an economical heat exchanger/generator should be introduced to proper functioning of the system. This paper presents the overview of test result.

Key words: *Air Condition, Exhaust system, Vapor compression cycle, vaporize Ammonia*

1. INTRODUCTION

With considering AC system of conventional automobile, powered by internal combustion engine is utilized the engine developed power to drive the compressor. This may take around 15 to 20% of engine power to drive the piston or rotary compressor. Approximately it consumes of 20% total fuel consumption on the other hand the R12 used as refrigerant (Or R134a) and it is affected to ozone layer depletion. [1].

However many passenger vehicle engine utilizes only about 35% of total energy and rests are lost to various form of energy losses [2]. If one is adding conventional air conditioning system to automobile, it further utilizes about 15% to 20% of the total energy. Therefore most of existing automobile becomes uneconomical and less efficient [5]. In addition conventional air conditioner is causes to decreases the life time of engine also. Hence considering of the above factors in this research introduce an alternative solution for automobiles AC system as based on ammonia absorption refrigeration cycle using exhaust waste heat of the engine. The advantages of this system over conventional air-conditioning system are that it does not affect original design of the whole system. But overall fuel consumption of engine significant amount reduction & therefore, the running of the engine efficiently and economically. On the other hand it showed comparatively less environmental pollution. Furthermore life time of engine optimized due to less load capacity of engine.

2. METHODOLOGY

Vapor compression system requires mechanically or electrically driven compressor to operate the air conditioning process. But absorption technology is based on heat source to drive the system. Therefore, it can be easily used waste heat of the engine to drive the system. The absorption cycle is similar to vapor compression cycle. Therefore both cycles can use same evaporator, condenser and pipe lines, as a result it is more convenience to new modification and cost effective design and installation. In this modification replaced the compressor with heat exchanger and absorber.

Considering of the heat rage of the exhaust system of an automobiles, identified the maximum possible heat range provided between the exhaust manifold and flexible joint. Hence, the heat exchanger is designed to install in between the exhaust manifold and flexible joint of exhaust system. Aammonia vapor is extracted from the NH_3 strong solution at high pressure in the generator by an external heat source[3]. In the receiver the water vapor which carried with ammonia is removed and dried ammonia gas enters into the condenser and it is condensed. The pressure and temperature of cooled NH_3 is then reducing by throttle valve below the temperature of the evaporator. Then NH_3 at low temperature enters to the evaporator and absorbed the required heat from passenger compartment and leaves as saturated vapor out from the evaporator. The low pressure NH_3 vapor is then passed to the absorber, where it absorbs by the NH_3 weak solution. After absorbing NH_3 vapor by weak NH_3 solution (aqua-ammonia), the weak NH_3 solution becomes strong solution and then it to pump to generator through heat exchanger [6].Heat is supplied to the generator from the exhaust system, which generates ammonia gas from a liquid water ammonia mixture. Ammonia gas flows to the condenser allows the ammonia gas to dissipate its thermal energy and condenses into liquid. The liquid ammonia flows to evaporator via the expansion valve, it is vaporized and cooling load generated by absorbing the heat from the vehicle's passenger compartment.

3. CALCULATION & RESULTS

Table 1: Pressure & Temperature [3]

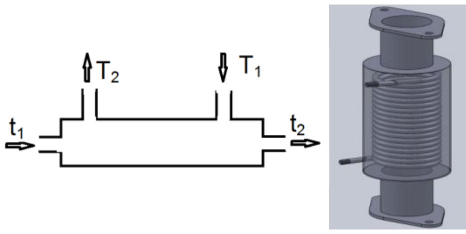
State Points	Temperature in ^oC	Pressure in bars	Specific Enthalpy h in KJ/Kg
1	54	10.7	1135
2	54	10.7	200
3	2	4.7	200
4	2	4.7	1220
5	52	4.7	0
6	52	10.7	0
7	120	10.7	255
8	120	4.7	255

$$Q = UAF(LMTD)$$

Where Q = Total Heat Transfer**,** U = Overall heat transfer coefficient, A = Heat transfer area **and** LMTD = Logarithmic mean temperature difference Mean Temperature Difference (MTD) formulation for this design of heat exchangers. The MTD is related to the logarithmic Mean Temperature Difference (LMTD) by the equation, [6]

$$MTD = F\,(LMTD)$$

Where the LMTD is defined as counter current flow arrangement,



a b

Figure 1: Heat Exchanger

$$LMTD = \frac{(T1-t2)-(T2-t1)}{\ln\left(\frac{T1-t2}{T2-t1}\right)} \qquad F = 1$$

Where T_1 = Inlet temperature of the tube (^0C), t_1 = Inlet temperature of shell side (^0C), T_2 = Outlet temperature of tube (^0C) and t_2 = Outlet temperature of shell side (^0C).

Data

Considering the average size car existing air conditioner capacity and logically comparing the cooling requirement with new design based on the theoretical values,

Required capacity for designed system = 12000 Btu (British Thermal Units)

System designed for the 1500CC four stroke diesel engine vehicle and considers the exhaust smoke at idle speed,

Engine rpm = 720 rpm
= 720 / 60
= 60 rps

Exhaust Volume = (1500 / 4) * 2 * 12
= 9000 cm^3
= $0.9 * 10^{-2}\ m^3/s$

By measuring,

Hot air temperature of exhaust = 200^oC

Per one second hot air produce,

M = dv

Air density = 1.29 Kg/m^3 [8]

According to the equations a MATLAB simulator is designed and using the simulator and assuming the damping co-efficient of the shock absorber varies from 4000 Ns/m to 0 Ns/m, the below values were taken.

Hot air produce = 0.9 * 10^{-2} * 1.29
= 1.16 * 10^{-2} Kg/s

1 KW = 3412.124 Btu/h

∴ Cooling load requirement
= (1/3412.142) * 12000 = 3.5 KW

Neglecting thermal losses and assuming efficiency of the generator is 90%;

Required heat energy to drive the system = 3.8 KW. Therefore, designed the size of the heat exchanger with considering heat transfer requirements;

3.1 Calculating of LMTD;

T_1 = 200°C measured data
t_1 = 52°C by standard data sheet
T_2 = 120°C Theoretical assumption of the cycle
t_2 = 120°C

$$LMTD = \frac{(200-120)-(120-52)}{\ln(\frac{200-120}{120-52})}$$

$$= \frac{(12)}{\ln(1.176)}$$

LMTD = 73.83°C
= 346.83 K

Table 2: Cost Estimation

Component	Status	Cost (Rs.)
Evaporator	Used Existing Unit	-
Condenser	Used Existing Unit	-
Absorber	New requirement	12500.00
Receiver-Drier	Used Existing Unit	-
Pump	New requirement	4500.00
Glass Cloth Tape	New requirement	2000.00
Insulation Foam Tube	New requirement	2500.00
Heating Coil	New requirement	6500.00
Generator	New requirement	15000.00
Connection Tubes	New requirement	7500.00
Other cost		5000.00
Total Cost		55500.00

Overall heat transfer coefficient for unit area;

Assume by considering engineering data;

U = 300 , Q = 3.8 KW

Therefore area of the heat exchanger;

Q = U A (LMTD)

3.8 * 10^3 = 300 * A * 346.83

A = 0.0365 m^2

∴ A = πdl

D = outer diameter of the tube

D = 8 mm , = 8 * 10^{-3} m, l = A/πd

l = 0.0365/ π * 8 * 10^{-3}

l = 1.45 m

4. CONCLUSION

Proposed system has been save considerable amount of power of engine as it replaces the engine driven compressor by absorber and generator with liquid pump which consumes very low power compared with compressor. This also helping to saving fuel and prevent using of engine power to drive the air conditioner. This system also can be introduced to commercial vehicles including which are involved in the transportation of perishable goods such as fruits, fish pharmaceuticals etc (refrigerated vehicles).
At the same time there is some drawbacks also identified and further developments are also introduced to overcome such kind of drawbacks through suitable improvement. However, this is very economically and user friendly design to the automobile air conditioning system to become cost effectively and as energy conserving technology. As the major limitation of the system is the use of ammonia which is a life causing gas if inhaled in large amounts, so to overcome this problem it can be introduce ammonia leak detection system by installing ammonia detecting sensors in passenger compartment. Which detects leakage will occurs inside the passenger compartment and allows operating the power windows automatically or the indication of warning buzzer or the lamp in instrument panel notified the leak to driver and passengers. At initial condition if lack of heat supplied hearing coil will be arranged to maintain high cooling efficiency the operating pressure should be controlled to prevent undue damages to the system, suggest arranging pressure control valves with expansion device. Mixing with some color with ammonia easily detects the leaking points
Where the system and can rectify and prevent some damage to other components.

This research introduces the economical and echo friendly alternative solution to utilize waste energy of automobiles. Cost for the modification is approximately Rs.55,500.00. As reference, theoretical calculation and studies found that it is possible to design alternation an automobile air conditioning system based on vapor absorption refrigeration cycle by utilizing exhaust waste heat. This is also environmentally friendly system. Because the existing air conditioning system of automobile uses the R12 and R134a as the refrigerant and it is subject to Ozone layer depletion and increasing of GWP. This will reduce the cost of fuel about 20% due to none using of engine power to drive the compressor. By considering the calculation and assumptions, the average fuel consumption is 10 KM/L and cost per liter is Rs.121.00, Therefore considering of 20% saving the payback period for the investment is 15 months by considered of average running mileage per month is 1800KM.

5. REFERENCES

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