DESIGN AND FABRICATION OF A.C. SYSTEM USING EXHAUST GAS OF VEHICLE

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ABSTRACT

Now days the air conditioning system of cars is mainly uses "Vapour Compression Refrigerant System" (VCRS) which absorbs and removes heat from the interior of the car that is the space to be cooled and rejects the heat to atmosphere. In Vapour compression refrigerant system, the system utilizes power from engine shaft as the input power to drive the compressor of the refrigeration system, hence the engine has to produce extra work to run the compressor of the refrigerating system utilizing extra amount of fuel. This loss of power of the vehicle for refrigeration can be neglected by utilizing another refrigeration system i.e. a "Vapour Absorption Refrigerant System". As well-known thing about VAS that these machines required low grade energy for operation. Hence in such types of system, a physicochemical process replaces the mechanical process of the Vapour Compression Refrigerant System by using energy in the form of heat rather than mechanical work. This heat obtained from the exhaust of high power internal combustion engines.

Keywords— Vapour Absorption Cycle, COP, Thermal conductivity, Ammonia, Generator.

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I. INTRODUCTION

The vapour absorption refrigeration system is one of the oldest methods of producing refrigerating effect. The principle of vapour absorption was first discovered by Michael Faraday in 1824 while performing a set of experiments to liquefy certain gases. The first machine was based on Vapour Absorption Refrigeration machine was developed by a French scientist, Ferdinand Carry, in 1860. This system may be used in both the domestic and large industrial refrigerating plants. The refrigerant commonly used in vapour absorption system is Ammonia.

An automobile engine utilizes only about 35% of available energy and rests are lost in the form of heat and mechanical losses to cooling and exhaust system. If one is adding conventional air conditioning system to automobile, it further utilizes about 4-5% of the total energy. Therefore automobile becomes costlier, uneconomical and less efficient. The conventional air conditioning system in car decreases the life of engine and increases the fuel consumption, further for small cars compressor needs 3 to 4 bhp i.e. a significant ratio of the power output. Keeping these problems in mind, a car air conditioning system is proposed which is using exhaust heat. The advantages of this system over conventional air-conditioning system are that it does not affect designed efficiency life and fuel consumption of engine. Thus to have the more economical air conditioning and more efficient engine in the automobile the need of this system arises.

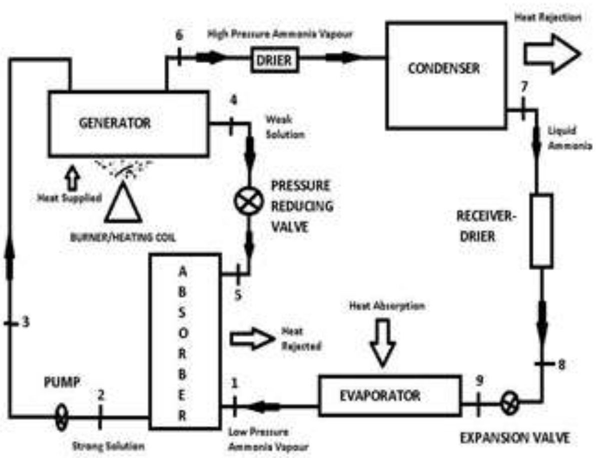
NEED

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. And hence makes the running of the engine efficient and economical.

II. LITERATURE SURVEY

To provide air cooling for the driver of a truck is never given importance in India, the basic reason is the use of available methods of air cooling affects the fuel consumption and the initial cost of the truck. For automobile air conditioning normally vapour compression refrigeration cycle is used. The cycle run on engine power and consumes around 10% of the total power produced by the engine and thereby increases the fuel consumption shown by Lambart and Jones, 2006 [2]. Till date, 1 TR VAR system has been neither built practically nor simulated for analyzing the performance of the system because of its low COP (Jakob et al, 2007) [3]. Due to this reason, no information is available regarding the performance of 1 TR VAR system. The work carried out in this project holds significance not only because it shows the practicability of fabricating a 1 TR VAR system for providing cabin cooling of truck by using engine exhaust but also it makes available the information about the performance of such a system under different operating conditions.

III. WORKING PRINCIPLE OF VAS CYCLE



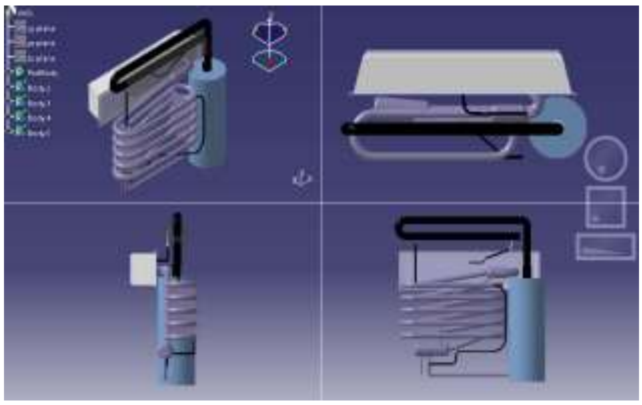
An Absorption Cycle can be viewed as a mechanical vapor-compression cycle, with the compressor replaced by a generator, absorber and liquid pump. Absorption cycles produce cooling and/or heating with thermal input and minimal electric input, by using heat and mass exchangers, pumps and valves. The absorption cycle is based on the principle that absorbing ammonia in water causes the vapor pressure to decrease.

The basic operation of an ammonia-water absorption cycle is as follows. Heat is applied to the generator, which contains a solution of ammonia water, rich in ammonia. The heat causes high pressure ammonia vapor to desorb the solution. Heat can either be from combustion of a fuel such as clean-burning natural gas, or waste heat from engine exhaust, other industrial processes, solar heat, or any other heat source. The high pressure ammonia vapor flows to a condenser, typically cooled by outdoor air. The ammonia vapor condenses into a high pressure liquid, releasing heat which can be used for product heat, such as space heating. The high pressure ammonia liquid goes through a restriction, to the low pressure side of the cycle. This liquid, at low pressures, boils or evaporates in the evaporator. This provides the cooling or refrigeration product. The low pressure vapor flows to the absorber, which contains a water-rich solution obtained from the generator. This solution absorbs the ammonia while releasing the heat of absorption. This heat can be used as product heat or for internal heat recovery in other parts of the cycle, thus unloading the burner and increasing cycle efficiency. The solution in the absorber, now once again rich in ammonia, is pumped to the generator, where it is ready to repeat the cycle.

IV. PROPERTIES OF AMMONIA AND SAFETY CONCERN

Ammonia is a naturally occurring substance that is produced and used in large quantities (in the US alone 20 million tons per year IPCS, ammonia health and safety guide, publ. World health org. Programmed on chemical safety, Geneva, 1990) for agriculture as fertilizer and as the source material for fibers, plastics and explosive .consequently it is shipped in large quantities by rail and ship. Ammonia is also used as a cleaning and de - scaling agent and food additives. Ammonia is a colourless gas of flow density at room temperature with a pungent smell. It has relative molecular mass of 17.03 and is lighter than air and atmospheric conditions. It can be stored and transported as a liquid under a pressure of 1 MPa 25 0c. The critical point of ammonia is at 132.30c and 11.3 MPa. The critical density is 235 kg/m3 Since ammonia is highly soluble in water generating NH_4^+ and OH^- ions, it reacts very quickly with mucus membranes. However, it is not absorbed through the skin. It can be smelled by humans in concentration of very few ppms at about 50 ppm, the odor is almost unbearable. This is also the concentration range (25 ppm) to which long-term exposure is limited from an occupational health point of view, (IPCS,1990,ammonia health and safety, Geneva)at high dosages ammonia exposure can be lethal. Ammonia is flammable and explosive in the range of 16 to 25 vol. % (IPCS, 1990, ammonia health and safety, guide, publ. World health org. Programmed on chemical safety, Geneva) in air. The strong odour of ammonia can be seen as an asset. It is self-alarming. Even very small leak in system are easily noticed and therefore a significant incentive exists for early repairs and consistent maintenance.

V. CATIA DESIGN



VI. CALCULATIONS

DESIGN CONSIDERATION OF AUTOMOBILE AIR CONDITIONING UNIT BASED ON VAPOUR ABSORPTION REFRIGERATION SYSTEM (CAPACITY=1TR)

	Temperature (^{0}C)	Temperature (K)	Pressure (bar)	Specific Enthalpy (kJ/kg)		Specific Entropy (kJ/kg K)		Enthalpy (kJ/kg)
				Liquid (h_f)	Latent (h_{fg})	Liquid (s_f)	Vapour (s_g)	(h_g)
Absorber (T_A)	0	273	4.29586	181.20	1263.25	0.7151	5.3405	1444.45
Generator (T_G)	100	373	11.66896	323.08	1145.79	1.2037	4.9842	1468.87
Condenser (T_C)	30	303	11.66896	323.08	1145.79	1.2037	4.9842	1468.87
Evaporator (T_E)	0	273	4.29586	181.20	1263.25	0.7151	5.3405	1444.45

(For ease of calculation and compactness of the model we have made all of our calculations, taking Capacity = 1TR)

$$W_{input} = \frac{Capacity \times 210\ kJ/min}{COP} kJ/min$$

$$= \frac{1 \times 210}{2.4397} kJ/min$$

$$= 86.0769\ kJ/min$$

$$= 1.4346\ kW$$

$$Mass\ of\ Refrigerant\ Flowing = \frac{Hgc - Hfc}{Capacity \times 210} kg/min$$

$$= \frac{1468.87 - 323.08}{1 \times 210} kg/min$$

$$= 5.4561\ kg/min$$

$$= 0.0909\ kg/sec$$

$$Volume\ of\ Refrigerant\ Flowing = \frac{Mass\ Flow\ Rate}{Density}$$

$$= \frac{5.4561}{640.10} m^3/min$$

$$= 0.0085\ m^3/min$$

$$= 0.0001\ m^3/sec$$

$$Power\ Required\ to\ Drive\ Suction\ Pump$$

$$= \frac{Volume\ flow\ Rate\left(\frac{m^3}{sec}\right) \times (P_g - P_a) \times 10^5}{\eta_{pump}}$$

$$= \frac{0.0001 \times (11.66896 - 4.29586) \times 10^5}{0.85} W$$

$$= 260.1531\ W$$

$$Amount\ of\ Heat\ Required\ in\ Generator = (W_{in} \times 1000 - P_{pump})Watts$$

$$= (1.4346 \times 1000 - 260.1531)W$$

$$= 1174.4623\ W$$

$$= 1174.4623 \times \frac{60}{1000} kJ/min$$

$$Amount\ of\ Heat\ Rejected\ by\ Refrigerant$$

$$= Mass\ of\ Refrigerant\ Flowing\ in\ Cycle$$

$$\times Sp.Heat\ of\ Refrigerant \times (Temp.Condenser - Temp.Absorber)$$

$$= 5.4561 \times 4.635 \times (30 - 0)\ kJ/min$$

$$= 758.6767\ kJ/min$$

$$= 12.6446\ kJ/sec$$

VII. FURTHER IMPROVEMENT POSSIBLE

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 suggested to couple this system electronically by the use of various ammonia detecting sensors, which when detect any leakage (which is hardly possible) will bring down the closed windows of the vehicle so the possibility of any damage will be eliminated, and will enable the driver to get aware of any problem and will release the leaked gas in to the atmosphere and thus the impeding danger will be eliminated.

VIII. CONCLUSION

As per our analysis and references, we have found that, it is possible to design an automobile air conditioning system using engine heat based on Vapour Absorption Refrigeration System. Also from the Environmental point of view this system is Eco-friendly as it involves the use of Ammonia as a refrigerant which is a natural gas and is not responsible for OZONE layer Depletion. Furthermore, it also saves the power of engine as it replaces the compressor by the four components i.e. Absorber, Pump, Generator & Pressure Reducing Valve out of which only the pump consumes some power that too is very feeble as compared to that of the Compressor, and thus helps in saving of fuel. Also this system can be employed to commercial heavy vehicles including those which are involved in the transportation of refrigerated products, as this system can easily provide the refrigeration/air-conditioning of cabin as per the requirements by using the exhaust heat of the vehicle's engine (which is in abundance in such vehicles) thus will not add any additional engine to run the air-conditioning/refrigerating unit in vehicle and hence reduces the operational cost.

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