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Vapour Absorption Air Conditioning by Using Exhaust of Automobile

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ABSTRACT

Now days the air conditioning system of cars is mainly uses "Vapor 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 Vapor 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 "Vapor 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 Vapor 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:- **VAS[Vapor Absorption System],ACS[Air Conditioning System], COP[Coefficient Of Performance], VCRS[Vapor Compression Refrigeration System], LCCP [Life-Cycle Climate Performance]**

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I. INTRODUCTION

The vapor absorption refrigeration system is one of the oldest methods of producing refrigerating effect. This idea of refrigeration system is being utilized in our project for the purpose of air conditioning. 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 different kind 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. 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.

II. LITERATURE REVIEW

Lambart and Jones *et al*.[1].The cycle run on engine power and consumes around 10% of the total power produced by the engine and thereby increases the fuel consumption.

Venkatesh and Praveen *et al*. [2] have suggested that it is possible to drive a vapor absorption refrigeration system for air conditioning of a car using the exhaust gases from the engine. A case study for "Honda city Exi" has been presented in which a cooling potential of 2.5 T has been justified.

Salim Munther*et al* [3] in his theoretical study and analysis has claimed that exhaust heat energy is capable of powering and producing cooling effect up to 1.4 tons of refrigeration using VAC.

Working principle:

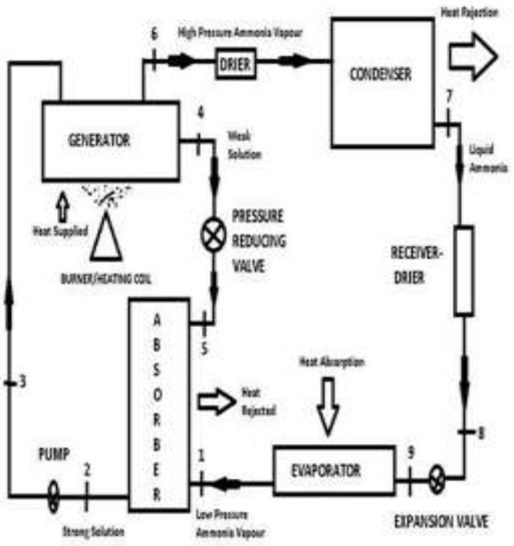


Fig.1 Schematic of VAS system.

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.

The underlying principle is the “Practical Vapor Absorption System” that uses aGenerator, instead of compressor (i.e. used in vapor compression system). This Generator requires a Heat Source to generate Ammonia vapors from Aqueous Ammonia Solution received from Absorber. The above heat requirement is served by the exhaust heat of the engine. Some power is also required to run the Pump, which is used to raise the pressure of Aqueous Ammonia Solution as well as to transmit it from Absorber to Generator. As the pump consumes very less amount of power in comparison to Compressor, it is quite comfortable to drive it from battery power or directly from crank-shaft.Using the above setup, we can relieve the crank-shaft from excess load of compressor; this will help in decreasing the fuel requirement of engine. Thus, increases the fuel efficiency.So,without using any other equipment or source of energy besides the vehicle itself, it is possible to introduce this air-conditioning system in existing automobiles/vehicles. Also it uses Ammonia as refrigerant, which do not affect the ozone layer as well as it does not contribute to the greenhouse effect, and it’s LCCP (Life-Cycle Climate Performance) is also highly favorable.

Methodology:

Generator

Generator is simply type of heat exchanger in which heat is transferred from external sources tovaporizethe ammonia from rich aqua-solution. During the heating process, the ammonia vapor is driven off the solution at high pressure leaving behind the hot weak ammonia solution in the generator. This weak solution flows back to the absorber at low pressure after passing through the pressure reducing valve. The high pressure ammonia vapor from the generator is condensed in the condenser to the high pressure liquid ammonia. This liquid ammonia is passed to theevaporator through expansion valve. In this experimental set up heat is supplied to the generatorfrom electric heater (equivalent to exhaust energy).

Analyzer

When ammonia is vaporized in the generator, some water is also vaporized and will flow into the condenser along with the ammonia vapors in the simple system. If these unwantedwater particles are not removed before entering to the condenser, they will enter to the expansion valve where they freeze and choke the pipeline. In order to remove these unwanted particles flowing to the condenser, an analyzer is used. The analyzer may be built as an integral part of generator or made as a separate piece of equipment. It consists of a series of trays mounted above generator. The strong solution from the absorber and the aqua from the rectifier are introduced at the top of the analyzer and flow downward over the trays and into the generator. In this way, considerable liquid surface area is exposed to the vapor rising from the generate or. The vapor is cooled and most of the water vapor condensed, so that mainly ammonia vapor leaves the top of analyzer. Since the aqua is heated by the vapor, less external heat is required in generator.

Absorber

In the absorber the low pressure ammonia vapor leaving the evaporator enters and is absorbed by the cold water. The water has the ability to absorb very large quantities of the ammonia vapor and the solution thus formed, is known as aqua-ammonia. The absorption of ammonia vapor in water lowers the pressure in the absorber which in turn draws more ammonia vapor from the evaporator and thus raises the temperature of solution. Some form of cooling arrangement (usually water cooling) is employed in the absorber to remove the heat of solution evolved there. This is necessary in order to increase the absorption capacity of water, because at higher temperature waterabsorbs less ammonia water. Absorber is made of galvanized iron sheet and having cylindrical shape by riveting and brazing. On a circular GI pipe the suction and discharge hole with flare nut and union by means of gas welding process are joined and one end of absorber is connected with discharge of evaporator (low pressure ammonia) and another end of absorber is connected with suction of pump (strong ammonia solution). One hole of the absorber connects with pressure reducing valve for taking low pressure vapor ammonia and another hole connects with the valve which controls the pressure of aqua-ammonia solution.

Coil specification

65watt

220v

The IC engine based on which the calculations are done is

$$COP_{cooling} = \frac{|\Delta Q_{cold}|}{\Delta W}$$

ΔQ_{cold} Is the heat moved from the cold reservoir (to the hot reservoir).

ΔW Is the work consumed by the heat pump.

LPT 407 Ex2 EFIP BSIII
No of cylinders, n = 4.
Power, P = 75 bhp at 2800 rpm.
Capacity, V = 2956cc.
No of strokes = 4.
Fuel used = diesel, Air-fuel ratio, A/F =15:1

A. Waste Heat of the Enginethe two main areas through which the heat is exhausted into the atmosphere from the engine are the cooling water and the exhaust gases. It is necessary to calculate the amount of heat energy carried away by the exhaust gases and the cooling water.

Exhaust gas heat:

Volumetric efficiency of the engine, E**voi**= 70% ,Rated speed, N = 2800 rpm
Mass flow rate of air into the cylinder, m**a** = VN E**voi**/2 = 0.002956x2800x0.7/2 m**a**=0.02m3/s.
Mass flow rate of fuel, m**f** = m**a**/ (A/F ratio) = 0.02/15 =0.001335 kg/sec
Total mass flow rate of exhaust gas, m**e**= m**a**+m**f**= 0.021335 kg/s.

Specific heat at constant volume of exhaust gas C**pe**= l kj/kgk.

Temperature available at the engine exhaust, t**e**= 300°C.

Temperature of the ambient air, t**a** = 40°

Heat available at exhaust pipe,

Q**e**= m**e** *C**pe**(t**e**-t**a**) = 0.021335xlx (300-40) =5.5Kw

COEFFICIENT OF PERFORMANCE (COP):

The coefficient of performance or COP, of a refrigeration system is the ratio of the heat
removed from the cold reservoir to input work.

Where

T**e**=evaporator temperature
T**c**=condenser temperature
T**g**= generator temperature

Domestic and commercial refrigerators may be rated

$$\text{Coefficient of Performance (COP)} = \left[\frac{Te}{Tc-Te} \; X \; \frac{Tg-Ta}{Tg} \right]$$

in kJ/s, or Btu/h of cooling. Commercial refrigerators in the US are mostly rated in tons of refrigeration, but elsewhere in kW. One ton of refrigeration capacity can freeze one short ton of water at 0 °C (32°F) in 24 hours.

Based on that:
Latent heat=333.55 kJ/kg
Heat extracted = (2000) (144) / 24 hr.
1 ton refrigeration =3.517 kW
The performance of the vapor absorption refrigeration system is given by the above formula.

Single pressure absorption refrigeration

Fig 2. Actual model of vas system

1. The ammonia (gas) and hydrogen (gas) mixture flows through a pipe from the evaporator into the absorber. In the absorber, this mixture of gases contacts water (technically, a weak solution of ammonia in water). The gaseous ammonia dissolves in the water, while the hydrogen, which doesn't, collects at the top of the absorber, leaving the now-strong ammonia-and-water solution at the bottom. The hydrogen is now separate while the ammonia is now dissolved in the water.

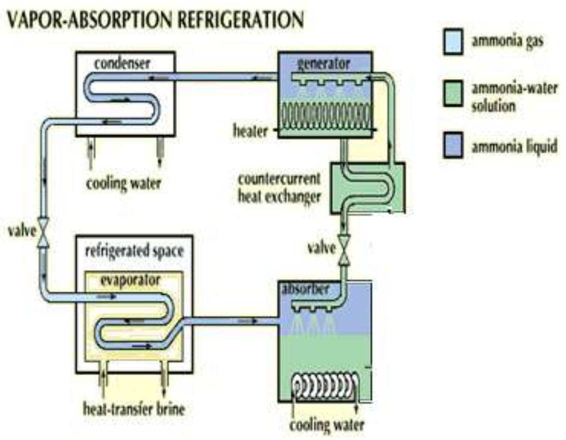
2. The next step separates the ammonia and water. The ammonia/water solution flows to the generator (boiler), where heat is applied to boil off the ammonia, leaving most of the water (which has a higher boiling point) behind. Some water vapor and bubbles remain mixed with the ammonia; this water is removed in the final separation step, by passing it through the separator, an uphill series of

twisted pipes with minor obstacles to pop the bubbles, allowing the water vapor to condense and drain back to the generator.

The pure ammonia gas then enters the condenser. In this heat exchanger, the hot ammonia gas transfers its heat to the outside air, which is below the boiling point of the full-pressure ammonia, and therefore condenses. The condensed (liquid) ammonia flows down to be mixed with the hydrogen gas released from the absorption step, repeating the cycle.

III. DESIGN IMPROVEMENT

a). Design of energy supplying network to the generator.The prime motive behind this project was to utilize low grade thermal energy which is released by many industries and manufacturing units that go unused. This energy should be tapped and supplied to the generator. A proper system should be designed for this purpose. Also the solar energy should be properly supplied as an input to the generator to provide refrigeration and air conditioning for domestic purposes.
b). Design of Solution Heat ExchangerThe efficiency of the system is greatly affected by the enthalpy of solution entering the generator and temperature of the solution entering the absorber. Thus a proper heat exchanger is necessary for enhancement of this refrigeration system.
c). Design of a water Cooled CondenserA properly designed water cooled condenser will reduce the size of the refrigeration system and make it compact, easy to transport and efficient.
d). Design of Generator and AbsorberSince the system is operating under low pressure, the cylinders for generator and absorber can be properly selected so that mass of the system is greatly reduced and making the system cost.



Ammonia/Water Absorption 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.

Properties of Ammonia and Safety Concerns:
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 colorless 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 odor 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. One method of leak detection is to use wet indicator paper, which will quickly change its color once it is exposed to air with a few ppm of ammonia content. However, traditional leak detection devices such soap (or bubble) solutions do not work since the ammonia is dissolved in the water without creating bubbles.

Results and analysis:

EXHAUST GAS ANALYSIS

Sr. no	Speed	Temperature (degree Celsius)	velocity (Cm of water)
1	Idle	96	10
2	Medium	197	40
3	High	377	76

IV. CONCLUSION

It has been concluded that, for providing cabin cooling for automobile using engine exhaust, the vapor absorption systems can be used i.e. ammonia/water vapor absorption cycle. The heat load on the generator can be met very easily by using the engine exhaust for both the systems as available energy rejected by cooling system of automobile engine is more than sufficient. Hence from the discussion, ammonia/ water vapor absorption system is suggested for the application. Though the COP of the system is less but since waste heat is given as input, it is not a matter of concern.

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