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Implementation of Vars in Automobile AC System By Utilizing Exhaust Heat Energy

C Anil Kumar Reddy[1], D.R Abhinay Kumar[2]
[1]*PRRM Engineering College*

Abstract: The refrigeration units currently used in road transport vehicles are predominantly of the vapour compression refrigeration (VCR) type but this work represents study of air conditioning in automobile based on ammonia water solution in vapour absorption system using hot exhaust gases as an energy source. In the study an experimental set up is designed and fabricated to use low grade heat energy i.e. exhaust gases as input heat to the system.

The thermal efficiency of an IC engine ranges between 25-30% when in pristine condition. From this about 10% used to run compressor of AC system. Major commercial refrigerant chlorofluorocarbons (CFCs) are going to be phase out shortly and they caused the phenomenon called greenhouse effect which causes depletion of ozone layer. The cooling effect is achieved by recovering waste thermal energy from the exhaust gases. This new system is less energy conserving, environment-protective, low-carbon, and high efficient.

Keywords: Vapour absorption system, Automobile air-conditioning, hot exhaust gases; etc.

I. INTRODUCTION

In gasoline operated vehicle approximately 10% of the energy available at the crankshaft is used for operating the compressor of the vehicle's air conditioning system. This is a huge loss if one takes into account the fact that the thermal efficiencies of most gasoline operated vehicles range from 20-30% when in pristine condition. The bottom line is that a great deal of fuel is consumed to generate electricity. In addition to this, alternating current via an alternator is necessary for the operation of the conventional a/c system. To prevent this Energy from the exhaust gas of an internal combustion engine is used to power an absorption refrigeration system to air-condition an ordinary automobile. In the present project we are going to introduce vapour absorption refrigeration system instead of vapour absorption refrigeration system.

Vapour Absorption Refrigeration Systems (VARS) belong to the class of vapour cycles similar to vapour compression refrigeration systems. However, unlike vapour compression refrigeration systems, the required input to absorption systems is in the form of heat. Hence these systems are also called as heat operated or thermal energy driven systems. Since conventional absorption systems use liquids for absorption of refrigerant, these are also sometimes called as wet absorption systems. Similar to vapour compression refrigeration systems, vapour absorption refrigeration systems have also been commercialized and are widely used in various refrigeration and air conditioning applications. Since these systems run on low-grade thermal energy, they are preferred when low-grade energy such as waste heat or solar energy is available. Since conventional absorption systems use natural refrigerants such as water or ammonia they are environment friendly.

A. Objectives Of The Project

Major objectives of our project are

1) To make a simple design for the fabrication of a prototype for the implementation of vapour absorption refrigeration systems in an automobile air conditioning system by utilizing exhaust heat energy.
2) To analyze the performance of refrigeration system and find it's COP.
3) Conclude the project with the remarks to be overcome for the implementation into the actual applications.

II. HISTORY

A. Overview of vars

A company in Newyork city in the United States first offered installation of air conditioning for cars in 1933. Most of their customers operated limousines and luxury cars.

In 1939, Packard became the first automobile manufacturer to offer an air conditioning unit in its cars. These were manufactured by Bishop and Babcock Co, of Cleveland. Ohio. The "Bishop and Babcock Weather Conditioner" also incorporated a heater. Cars ordered with the new "Weather Conditioner" were shipped from Packard's East Grand Boulevard facility to the B&B factory where the conversion was performed. Once complete, the car was shipped to a local dealer where the customer would take delivery.

Packard fully warranted and supported this conversion, and marketed it well. However, it was not commercially successful for a number of reasons

1) The main evaporator and blower system took up half of the trunk space (though this became less of a problem as trunks became larger in the post-war period).
2) It was superseded by more efficient systems in the post-war years
3) It had no temperature thermostat or shut-off mechanism other than switching the blower off. (Cold air would still sometimes enter the car with any movement as the drive belt was continuously connected to the compressor later systems would use electrically operated clutches to remedy this problem.)
4) The several feet of plumbing going back and forth between the engine compartment and trunk proved unreliable in service.
5) The price, at US $274 ($4,692.12 in 2014 US dollars), was unaffordable to most people in post-depression/pre-war America.

B. Growth in demand

Air-conditioning for automobiles came into wide use from the late twentieth century. Although air conditioners use significant power; the drag of a car with closed windows is less than if the windows are open to cool the occupants. There has been much debate on the effect of air conditioning on the fuel efficiency of a vehicle.

Factors such as wind resistance, aerodynamics and engine power and weight must be considered, to find the true difference between using the air conditioning system and not using it, when estimating the actual fuel mileage. Other factors can affect the engine, and an overall engine heat increase can affect the cooling system of the vehicle.

The innovation was adopted quickly and new features to air conditioning like the Cadillac Comfort Control which was a completely automatic heating and cooling system set by dial thermostat was introduced as an industry first in the 1964 model year. By 1960 about 20% of all cars in the U.S. had air-conditioning, with the percentage increasing to 80% in the warm areas of the Southwest. American Motors made air conditioning standard equipment on all AMC Ambassadors starting with the 1968 model year, a first in the mass market, with a base price starting at $2,671. By 1969, 54% of domestic automobiles were equipped with air conditioning, with the feature needed not only for passenger comfort, but also to increase the car's resale value.

III. DESIGN OF VARS CYCLE

A. Vapour absorption refrigeration system

An absorption refrigerator is a refrigerator that uses a heat source (e.g., solar energy, a fossil-fueled flame, waste heat from factories, or district heating systems) to provide the energy needed to drive the cooling process.

Absorption refrigerators are often used for food storage in recreational vehicles. The principle can also be used to air-condition buildings using the waste heat from a gas turbine or water heater. Using waste heat from a gas turbine makes the turbine very efficient because it first produces electricity, then hot water, and finally, air-conditioning
(called cogeneration/regeneration).The standard for the absorption refrigerator is given by the ANSI/AHRI standard 560-2000.

B. Ammonia as a refrigerant

As per the nomenclature of refrigerants it is denoted as R717. Because of ammonia's vaporization properties, it is a useful refrigerant. It was commonly used prior to the popularization of chlorofluorocarbons (Freon’s). Anhydrous ammonia is widely used in industrial refrigeration applications and hockey rinks because of its high energy efficiency and low cost. Along with its use in modern vapor-compression refrigeration it is used in a mixture along with hydrogen and water in absorption refrigerators. The Kalina cycle, which is of growing importance to geothermal power plants, depends on the wide boiling range of the ammonia–water mixture. Ammonia coolant is also used in the S1 radiator aboard the International Space Station in two loops which are used to regulate the internal temperature and enable temperature dependent experiments. In our present project we used aqueous ammonia solution

C. Analysis of vars

Water-Ammonia is an absorption fluid that has been used since the late 1800s at which time it was used for ice production prior to the introduction of vapour compression technology (Harold et al., 1996). Ammonia is highly soluble in water where the solubility increases as the water temperature decreases at constant pressure. In this system, ammonia will act as the refrigerant which will take the heat from the specific environment while the water becomes the absorbent that absorbs the ammonia vapour into a solution and makes it possible to be circulated by the pump. The vapour pressure of a water-ammonia solution is less than that of pure ammonia, at the same temperature. The low volatility ratio between ammonia and water requires a high operating pressure compared to the lithium bromide system. Utilizing ammonia which has a lower freezing temperature (-77.7°C) than water as the refrigerant will give the advantage of working at a much lower refrigeration temperature, although its toxicity level limits the use of ammonia to a well ventilated area or outdoors. The most common material for the construction of a water-ammonia system is steel or stainless steel.

A water-ammonia absorption cycle is similar to a lithium bromide-water cycle except for some important differences in working fluid properties such as:

1) Ammonia has a lower latent heat than water;
2) The different pressure and range of solubility.
3) The latent heat of ammonia is only about half that of water, so, for the same duty, the refrigerant and absorbent mass circulation rates are roughly double that of water-lithium bromide (ASHRAE, 2005).

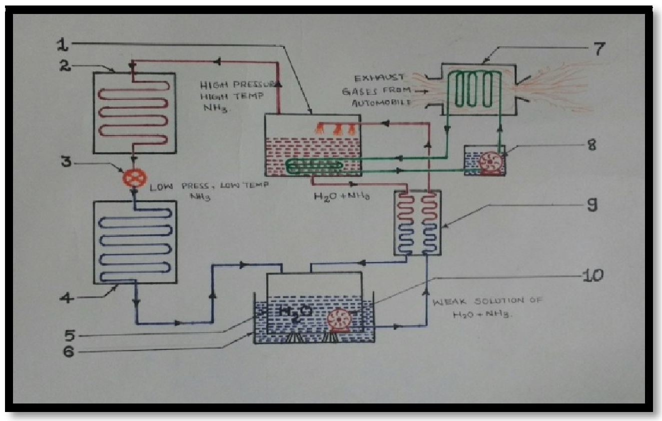

Fig.3.1. H2O-NH3 Absorption Refrigeration System.

Different components in Fig.4.3 are,
1)Generator, 2)Condenser,
3)Throttling device, 4)Evaporator,
5)Absorber, 6)Cooling jacket,
7)Heat exchanger, 8)Heat exchanger pump,
9)Counter flow heat exchanger, 10)Absorber pump.

IV. IMPLEMENTATION OF VARS

A. Working process of vars

As our prototype cycle consists three sub cycles in following paragraphs we explained the working of all cycles individually. The explaining sequence is as follows,

1) Extracting heat energy in heat exchanger and supplying it to the solution present inside the generator.
2) Supplying the heat energy of high temperature weak water-ammonia solution which flows from generator to absorber and the low temperature solution which flows from absorber to generator.
3) Providing the cooling effect inside the evaporator chamber.

a) Working of heat exchanger cycle:

The main function of heat exchanger is to extract heat from the exhaust gases and supply it to the water ammonia mixture present inside the generator vessel. As our heat exchanger is made up of copper tubes and sufficient insulation is done, it is very easy to extract the heat from exhaust gases of the automobile.

Main parts in this cycle are,

i. Heat exchanger,
ii. Heater coil and
iii. Pump.

b) Working of counter flow heat exchanger cycle:

It is very important that the water ammonia solution which enters the absorber should be sufficiently cool. Otherwise absorption capacity of absorbent present inside the absorber will decrease continuously. This leads to stop allowing ammonia refrigerant to be absorbed by the water. This results a blockage in our cycle.

Another problem is strong water ammonia mixture which enters into the generator should be sufficiently cool. Otherwise it decreases the desorbing capacity of the generator.

c) Working of air conditioning cycle

We will get our final output of the prototype in this cycle. in this cycle we are going to provide the cooling effect in the evaporator chamber by utilizing the exhaust heat which was initially extracted from the exhaust gases of the automobile. This cycle mainly consists of following components.

i. Generator,
ii. Condenser,
iii. Throttling device,
iv. Evaporator and
v. Absorber.

Initially the heat energy rejected by the water from heat exchanger is absorbed by the water ammonia mixture present inside the generator tank. As the boiling temperature of ammonia solution at atmospheric pressure is 23°C it will easily evaporates and forms a rich high temperature, high pressure ammonia gas in the generator. Below reactions takes place in generator tank and absorber tank respectively

$$NH_4OH(aq) \stackrel{\Delta}{=} NH_3(g) + H_2O(l)$$

$$NH_3(g) + H_2O(l) = NH_4OH(aq)$$

V. CONCLUSION

Whole work of our project "implementation of VARS in an automobile by utilizing exhaust heat energy" can be concluded as,

A. By utilizing exhaust heat energy for air conditioning in automobile, the work required to drive the compressor can be easily eliminated.
B. As the refrigerant used in VARS is ammonia, an eco friendly refrigerant it does not harm the environment.
C. Even though the COP of the refrigeration system is very low, we can implement it due to its high capacity of refrigeration.

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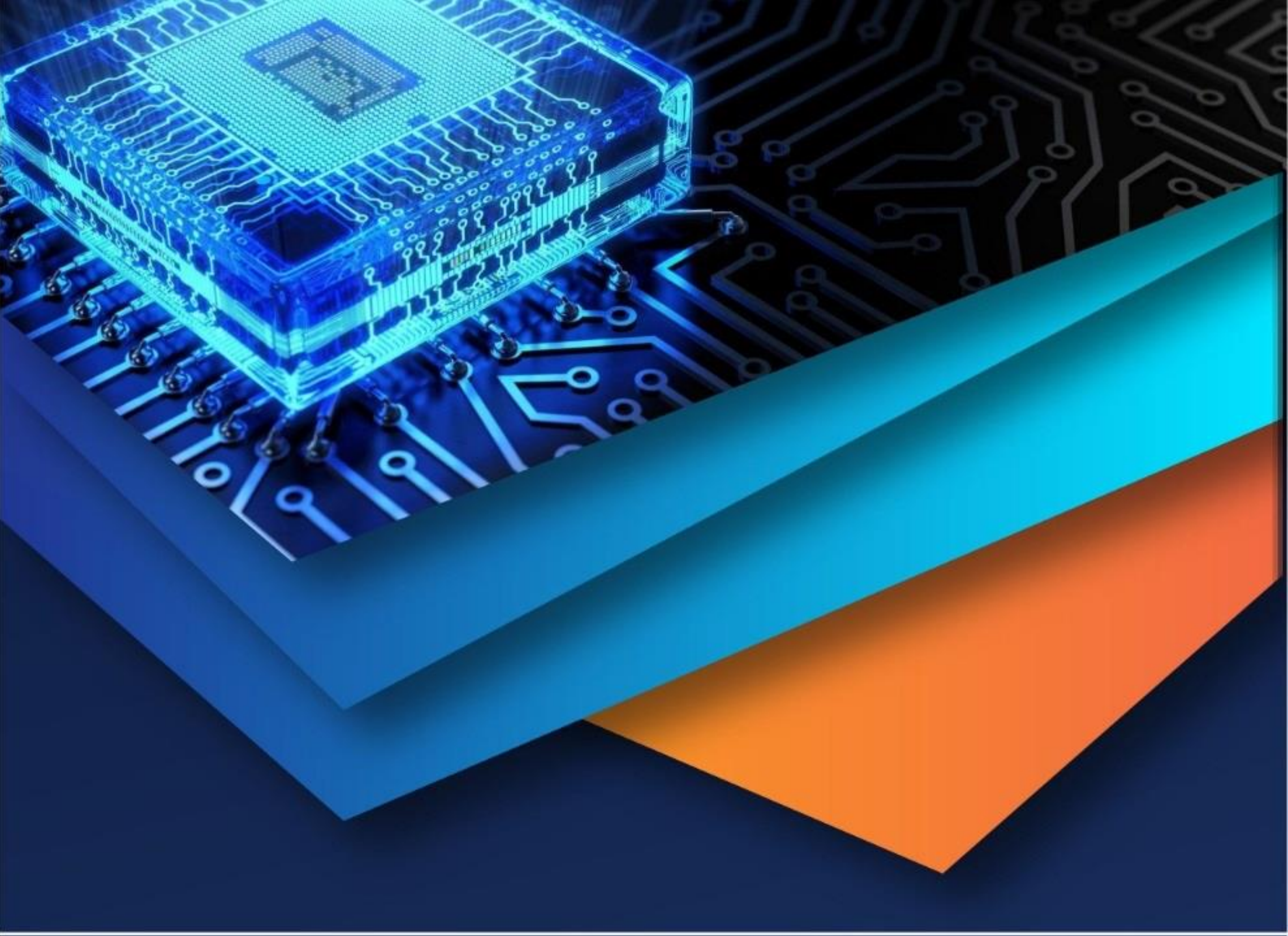

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