International Journal of Innovative Research in Science and Engineering
Vol. No.2, Issue 04, April 2016
www.ijirse.com
ISSN: 2454-9665

UTILIZATION OF ENGINE'S WASTE HEAT IN A.C. SYSTEM OF AN AUTOMOBILE

Joel P John[1], Hepsiba Seeli[2] Sriharsha Dorapudi[3]

[1,2]Mechanical Engineering, Pydah Kaushik College of Engineering, (India)

[3]Mechanical Engineering, MVGR College of Engineering (A), (India)

ABSTRACT

The exponential increase in cost of conventional fuels, component costs and maintenance costs associated with vehicle; shifts the interest towards the use of alternative as well waste energy sources. With the rapid changing environment and atmospheric effect, the air conditioning of the moving vehicle has become a necessity. An exploration has been done to research the possibility of waste heat recovery and its subsequent utilization in air conditioning system of a vehicle without increasing the component cost, weight, number of component and bring improvement in vehicle by making it luxurious. Instead of VCRS, if VARS is used in vehicles the refrigeration system could be operable in a vehicle without adding running cost for air conditioning. Keeping these in mind, an A.C. System is proposed which recovers the engine waste heat using radiator water as source / generator for VARS. An analyze in the performance of a process steam operated vapor absorption system for cooling and heating applications using ammonia-water as working fluids based on first and second law of thermodynamics is done. The results obtained from the simulation studies can be used to optimize different components of the system so that the performance can be improved significantly.

Keywords: A.C. systems, Triple fluid VARS, VCRS, Waste Engine Heat

I. INTRODUCTION

At present, all industries are trying for various tools and techniques by combining factors like quality, cost, flexibility, responsiveness, and innovation. Also In today's global market, there is a constant increase in pressure to make products more quickly, with more variety, at the lowest possible cost. The A/C system adds nearly 35 % extra cost in fuel expenses. Reducing the A/C load decreases A/C fuel consumption. But they have been traditionally designed to maximize capacity, not efficiency. An automobile engine utilizes only about 35% of available energy and rest is lost to cooling and exhausts. Conventional air conditioner in car also decreases the life of engine and increases the fuel consumption. Even for small cars, the 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 from recovery of engine waste heat using radiator water as source / generator for VARS. Air conditioning of a vehicle can be done by Vapour Compression Refrigeration System (VCRS) and Vapour Absorption Refrigeration System (VARS). Presently, VCRS is in use in most of the vehicles. If, VARS is used in vehicles the refrigeration system could be operable in that case without adding running cost for air conditioning. The objectives of this study on the subject are to:

1. Identify the form of "muda" (waste) in traditional VCRS.
2. Compare the key characteristics of traditional VCRS and proposed VARS
3. Differentiate between existing refrigeration cost and proposed target cost
4. Identify data and tools useful for planning and assessing strategies in refrigeration quality in vehicle by use of SWOT analysis.

II. VAPOUR COMPRESSION REFRIGERATION SYSTEM

It is an improved type of air refrigeration system, which condenses and evaporates at temperatures and pressures close to atmospheric conditions. Heat flows naturally from a hot to a colder body. But, in refrigeration system there is opposite phenomena i.e. heat flows from a cold to a hotter body. This is achieved by using a substance called a refrigerant. The refrigerant absorbs heat and hence evaporates at a low pressure to form a gas. This gas is then compressed to a higher pressure; such that it transfers the heat it has gained to ambient air or water and turns back (condenses) into a liquid. Thus, heat is absorbed, or removed, from a low temperature source and transferred to a higher temperature source. The refrigerants usually used for this process are ammonia (NH_3), carbon dioxide (CO_2) and sulphur dioxide (SO_2). The refrigeration cycle can be broken down into the following stages, shown in Fig. 1:

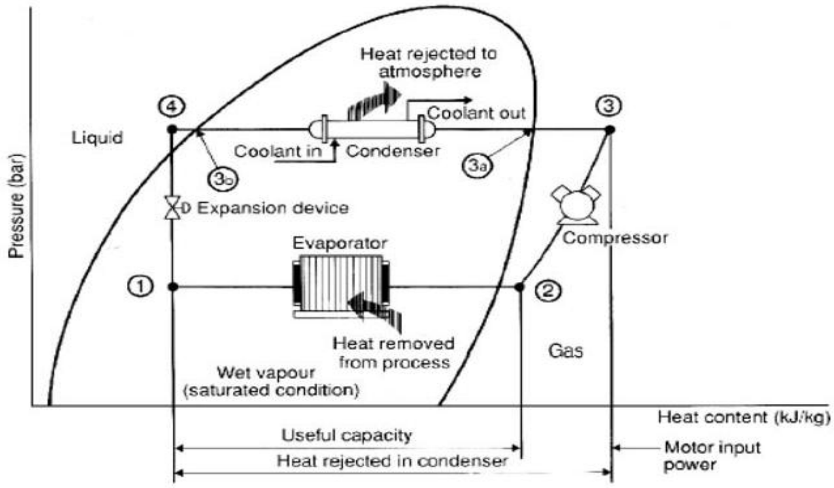

Fig.1: Schematic diagram of a Basic Vapour Compression Refrigeration System

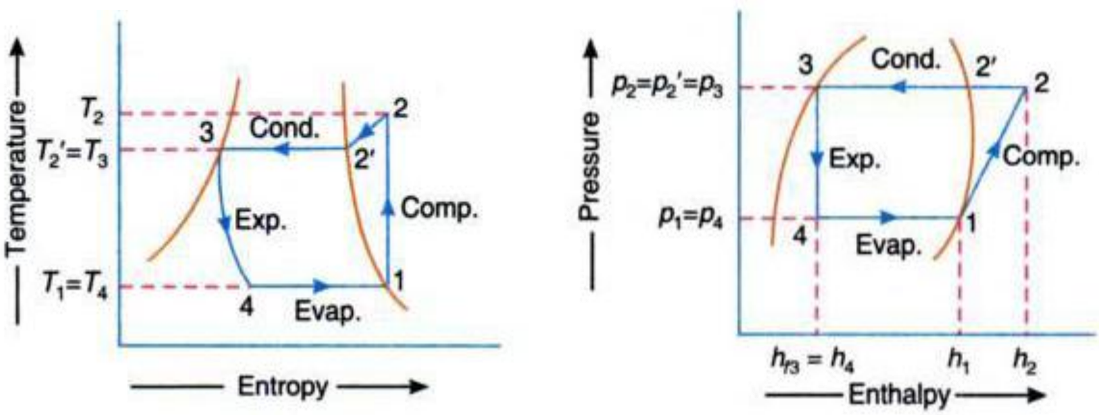

Fig. 2: T-s and p-h diagram

The graphical representation of Temperature-Entropy & Pressure- Enthalpy is shown in Fig. 2. It can be observed that the condenser has to be capable of rejecting the combined heat inputs of the evaporator and the compressor. There is no heat loss or gain through the expansion device. The Compressor is run by the power from engine crankshaft, thus reducing the efficiency of the engine. Use of refrigerant increases the cost. Much attention is being given to increase the coefficient of performance in this cycle. The existing refrigeration system in a vehicle is shown diagrammatically in Fig.3:

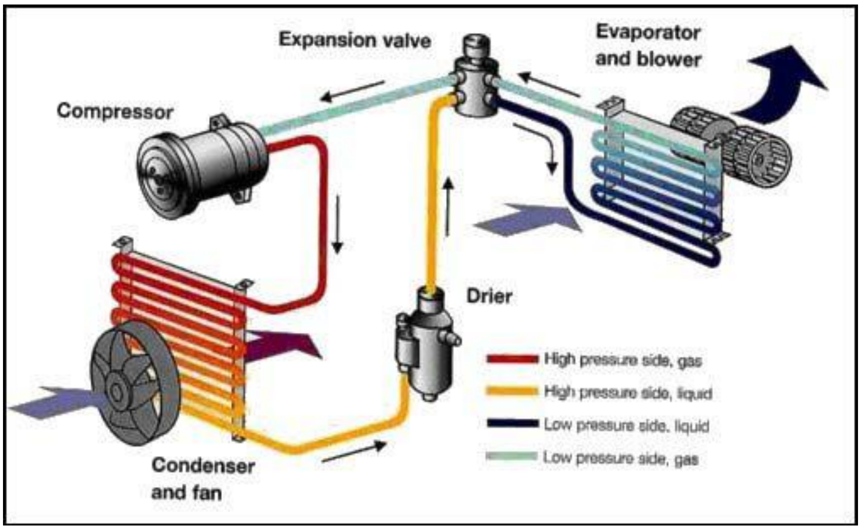

Fig.3: Existing Refrigeration system in automobiles

III. ABSORPTION COOLING SYSTEMS

Absorption is the process of attracting and holding moisture by substances called desiccants. Desiccants are sorbents, i.e., materials that have an ability to attract and hold other gases or liquids, which have a particular affinity for water. During absorption the desiccant undergoes a chemical change as it takes on moisture. The characteristic of the binding of desiccants to moisture makes the desiccants very useful in chemical separation processes.

Ammonia-water combination possesses most of the desirable qualities which are listed below:

•1m^3 of water absorbs 800m^3 of ammonia (NH_3).

•Latent heat of ammonia at-15°C = 1314 kJ/kg.

•Critical temperature of NH_3 = 132.6°C.

•Boiling point at atmospheric pressure = -33.3°C .The NH_3-H_2O system requires generator temperatures in the range of 125°C to 170°C with air-cooled absorber and condenser and 80°C to 120°C when water-cooling is used. These temperatures cannot be obtained with flat-plate collectors. The coefficient of performance (COP), which is defined as the ratio of the cooling effect to the heat input, is between 0.6 - 0.7.

Ammonia is highly soluble in water and this ensures low solution circulation rates. Both constituents are obtainable at minimal cost. The choice of Ammonia water combination is not made without considering certain Disadvantages: ammonia attacks copper and its alloys when it has been hydrated. Therefore, all components are made from mild steel or stainless steel. Fig. 4 shows VARS module.

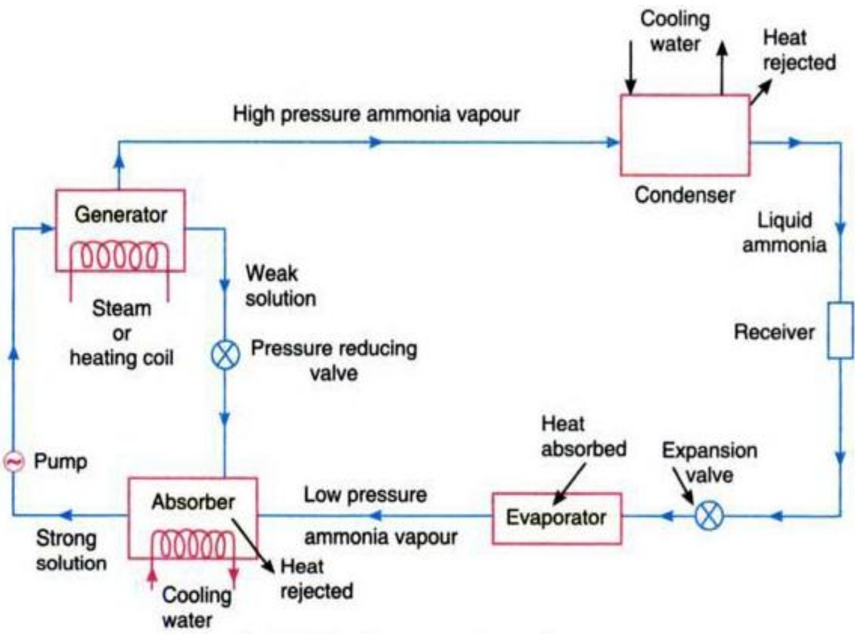

Fig. 4: Schematic diagram of Vapour Absorption Refrigeration System

IV. ENGINE COOLING SYSTEM

The cooling system on liquid-cooled cars circulates a fluid through pipes and passageways in the engine. Temperatures in the combustion chamber of the engine can reach 4,500 F (2,500 C), so cooling the area around the cylinders is critical. As this liquid passes through the hot engine it absorbs heat, cooling the engine. After the fluid leaves the engine, it passes through a heat exchanger, or radiator, which transfers the heat from the fluid to the air blowing through the exchanger. The engine in car runs best at a fairly high temperature. When the engine is cold, components wear out faster, and the engine is less efficient and emits more pollution. So another important job of the cooling system is to allow the engine to heat up as quickly as possible, and then to keep the engine at a constant temperature. To handle this heat load, it may be necessary for the cooling system in some engines to circulate 4,000 to 10,000 gallons of coolant per hour. The water passages, the size of the pump and radiator, and other details are designed as to maintain the working parts of the engine at the most efficient temperature within the limitation imposed by the coolant. The fluid that most cars use is a mixture of water and ethylene glycol ($C_2H_6O_2$), also known as antifreeze. By adding ethylene glycol to water, the boiling and freezing points are improved significantly. Even with ethylene glycol added, these temperatures would boil the coolant, so something additional must be done to raise its boiling point. Typical radiator cap pressure raises the boiling point of the engine coolant.

It does not exert any pressure and does not boil off when heated. So the refrigerant water vapour boiled off from the absorbent solution in the generator leaves as pure refrigerant vapour. Thus there is no need of rectifier to separate out the absorbent vapour from the refrigerant vapour. The heat rejection of an absorption system is higher and so requires higher flow rate of the coolant (air or water) than the mechanical system. The cooling tower capacity for an absorption machine therefore should be much more than that of a mechanical vapour-compression system of the system capacity.

V. COMPARISON BETWEEN VAPOUR ABSORPTION AND VAPOUR COMPRESSION SYSTEMS

S No:	Absorption System:	Compression System:
1.	Uses low grade energy like heat. Therefore, may be worked on exhaust systems from I.C Engines, etc…	Using high-grade energy like mechanical work.
2.	Moving parts are only in the pump, which is a small element of the system. Hence operation is smooth.	Moving parts are in the compressor. Therefore, more wear, tear and noise.
3.	The system can work on lower evaporator pressures also without affecting the COP.	The COP decreases considerably with decrease in evaporator pressure.
4.	No effect of reducing the load on performance.	Performance is adversely affected at partial loads.
5.	Liquid traces of refrigerant present in piping at the exit of evaporator.	Liquid traces in suction line may damage the compressor.
6.	Automatic operation for controlling the capacity is easy.	It is difficult.

VI. REVIEW OF LITERATURES

There are various works available on the absorption cooling with exhaust heat of engine.

According to Palm, most HFC refrigerants have a relatively high global warming potential (GWP) though it is non-ozone depleting; which is also being regulated by the Kyoto Protocol.

Suzuki theoretically studied the effects of UA (overall heat transfer coefficient) on SCP of a passenger car waste heat absorption air conditioning system. However, in the case of automobile waste heat cooling, mechanical simplicity and high reliability will prevail on efficiency. And the waste heat recovery cannot affect the mechanical energy output from the engine. So a two-bed basic zeolite-water absorption cycle is considered in this study.

Melinder reported the performance of aqueous secondary fluids and non-aqueous secondary fluids for indirect system. Compared to all the water solutions, the non-aqueous fluids such as diethyl benzene mixtures, hydrocarbon mixtures, hydro fluoroether and polydimethylsiloxan require a much larger volume flow rate under the same refrigeration capacity and temperature change.

Ure ascertained several requirements that any secondary refrigerants must satisfy:

- Low viscosity
- High specific heat
- Good thermal conductivity
- Good chemical corrosion inhibiting
- Chemically stable, no separation or degrading

• Non-toxic

• Non-flammable

• Food grade for food refrigeration

Zhao studied two combined absorption/compression refrigeration cycles using ammonia and water as the working fluid. The combined cycle with one solution circuit was a conventional absorption chiller with a mechanical compressor, using both the work and heat output from an engine. The combined cycle with two solution circuits was a generalized version of the previous cycle, which condenser and evaporator were replaced by a second absorber and a second generator. The primary energy ratio, defined as the ratio of the design cooling capacity and the total energy input to the engine, increased considerably for the combined cycles compared to a conventional engine driven compression cycle working with pure ammonia.

VII. PROPOSED METHODOLOGY

The proposed model is based on three fluids vapour absorption systems. It will contain basic components needed for vapour absorption system as shown in Fig. 5:

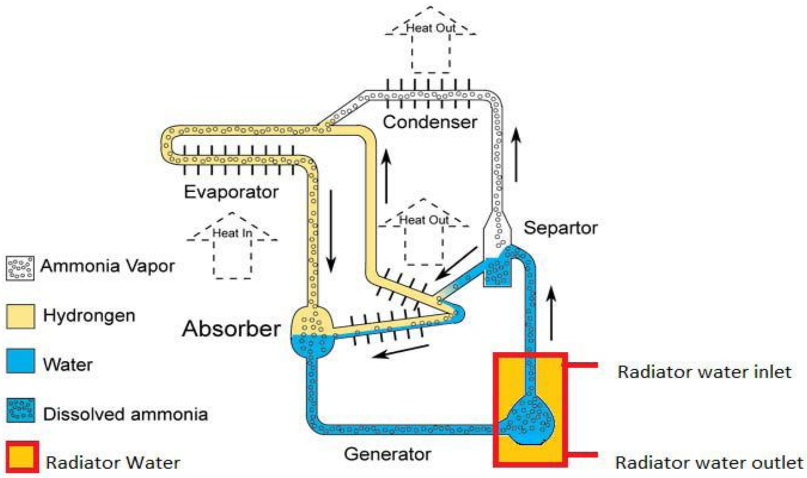

Fig. 5: Schematic of a triple fluid vapours absorption refrigeration system

a. The three fluid used in this system will be ammonia, water and hydrogen. The use of water is to absorb ammonia readily. The use of hydrogen gas is to increase the rate of evaporation of the liquid ammonia passing through the system.

b. Even though ammonia is toxic, but due to absence of moving part, there will be little chance for the leakage.

c. The hot radiator water will be used to heat the ammonia solution in the generator. To remove water from ammonia vapour, a rectifier will be used before condenser. The ammonia vapour is condensed and flows under gravity to the evaporator, where it meets the hydrogen gas. The hydrogen of gas, which is being feed to the evaporator, permits the liquid ammonia to evaporate at low pressure and temperature.

d. During the process of evaporation, the ammonia will absorb the latent heat from refrigerated space and produces cooling effect. The mixture of ammonia vapour and hydrogen will be passed to the absorber where ammonia will be absorbed while hydrogen raises the top and flows back to the evaporator.

VIII. CONCLUSION

The study reveals that it comprises four heat exchanges, namely, an air finned forced convection condenser, an air finned forced convection evaporator, and a pair of shell and tube type absorbers, plus four one-way refrigerant valves, an expansion valve, and an exchange valve. For a refrigerant system the following things are needed

- Specific Cooling Power (SCP)
- Coefficient of Waste Heat Recovery (CWHR)
- Coefficient of Waste Heat Cooling (CWHC)

At present, for an automobile waste heat absorption cooling system, the demand for CWHC can be easily met, but for SCP, further research is needed.

IX. ACKNOWLEDGEMENT

I'd like to thank all my faculty members and Lab Technicians, especially Miss. Hepsiba Seeli and Sir Sriharsha for helping me throughout working on the paper.

REFERENCES

[1] Dr. Terry J. Hendricks, Valerie H. Johnson, Heat-Generated Cooling Opportunities, Center for Transportation Technologies and Systems Golden, Colorado

[2] Abhilash Pathania, Dalgobind Mahto, Recovery of Engine Waste Heat for Reutilization in Air Conditioning System in an Automobile: An Investigation, Global Journals Inc. (USA), Volume 12 Issue 1 Version 1.0 January 2012

[3] R.S. Khurmi, J.S. Gupta, A textbook of Refrigeration and Air Conditioning (Eurasia Publishing House, Ram Nagar, New Delhi, 2007)

[4] S. Anand, A. Gupta, Use of process steam in vapor absorption refrigeration system for cooling and heating applications: An energy analysis, Cogent OA, Cogent Engineering

[5] Palm B, 2008, Hydrocarbons as refrigerants in small heat pump and refrigeration systems – a review. Int. J. Refrigeration 31,552–563.

[6] M. Suzuki, Application of absorption cooling systems to automobiles. Heat Recovery Systems & CHP 13, 335- 340 1993.

[7] Melinder A, 2004, Secondary Fluids for Low Operating Temperatures, Gustav Lorentzen Conference on Natural Working Fluids, Glasgow, United Kingdom, August 29

[8] Ure, Z, 2003, Secondary refrigeration, European Experiences, Ashrae Trans. 109

[9] Zhao Y, Shigang Z, Haibe Z, Optimization study of combined refrigeration cycles driven by an engine, Appl. Energy 2003; 76:379–89.