DESIGN OF CAR AIR CONDITIONING USING EXHAUST GAS

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Abstract - *The main objective of using vapor absorption refrigeration (VAR) system is the recovery of waste heat in engine exhaust to produce cooling effect, which reduces power requirement from engine by eliminating compressor from the system. The refrigeration units currently used in road transport vehicles are predominantly of the vapor compression refrigeration (VCR) type. In such a unit, the compressor requires an input of energy in the form of work. Although in smaller systems, the compressor can be belt driven from the main propulsion engine, enlarge systems, it is normally driven by a dedicated internal combustion (IC) engine. In order to obtain refrigeration, the use of vapor absorption refrigeration (VAR) systems utilizing the waste heat in the exhaust gases from the main propulsion unit of the vehicle was experimentally investigated and proved possible. Hence, there is no need for the IC engine and compressor of the VCR system. Money can therefore be saved, and there is a reduction in the weight of the unit. Additionally, the VAR system runs quietly and is almost maintenance-free., and the primary energy used to drive the independent engine of the VCR system can be saved.*

Key Words**: Waste Heat, Refrigeration, Vapour absorption System and Internal Combustion Engine.**

1. INTRODUCTION

In 21st century every field in this world is developing rapidly to fulfill the demand of increasing population. And energy is the basic need for this development. Also conventional energy sources are limited and non-conventional energy sources are still in primary stages with comparatively high cost and need to develop more so as to become less expensive. So it is very much essential to use the available energy carefully. One of the way to save the energy is recovery of waste energy. In automobile the exhaust heat recovery is an important aspect in waste energy recovery. An automobile engine utilizes only about 35% of available 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. Keeping these problems in mind, a car air conditioning system can be run by 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. The exhaust heat from the four stroke four cylinder engine is sufficient to run the VARS system of 1 TR capacity for air conditioning. The use of VARS system recovers waste heat of engine exhaust and uses it as a heating source to generator of VARS

1.1 Simple Ammonia-Water Vapor Absorption Refrigeration System

The absorption cycle is a process by which refrigeration effect is produced through the use of two fluids and some quantity of heat input, rather than electrical input as in the more familiar vapour compression cycle. Both vapour compression and absorption refrigeration cycles accomplish the removal of heat through the evaporation of a refrigerant at a low pressure and the rejection of heat through the condensation of the refrigerant at a higher pressure. The method of creating the pressure difference and circulating the refrigerant is the primary difference between the two cycles. The vapour compression cycle employs a mechanical compressor to create the pressure differences necessary to circulate the refrigerant. In the absorption system, a secondary fluid or absorbent is used to circulate the refrigerant. Because the temperature requirements for the cycle fall into the low-to-moderate temperature range, and there is significant potential for electrical energy savings, absorption would seem to be a good prospect for geothermal application. Following fig. 2.2 shows the schematic diagram of a vapor absorption system. The absorption refrigeration system differs fundamentally from vapor compression system only in the method of compressing the refrigerant. An absorber, generator and pump in the absorption refrigerating system replace the compressor of a vapor compression system. Ammonia vapors produced in the generator at high pressure from the strong solution of NH_3 by an external heating source. The water vapor carried with ammonia is removed in the rectifier and only the dehydrated ammonia gas enters into the condenser. High pressure NH_3 vapor is condensed in the condenser.

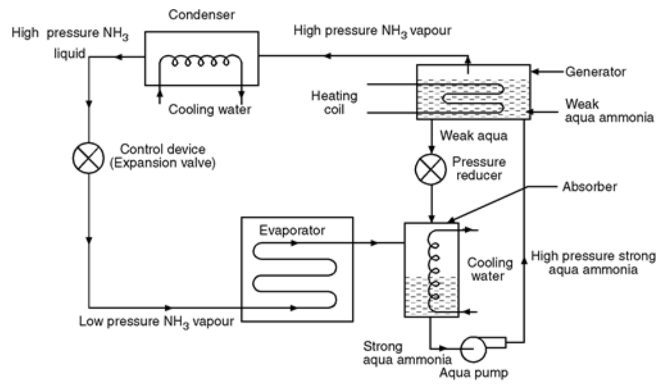


Figure 2.2 Schematic diagram of simple vapor absorption system

1.2 Different components of Vapor Absorption Refrigeration System:

- Condenser
- Expansion valve
- Evaporator
- Capillary tube
- Generator
- Absorber
- Dryer
- Strainer

2. Refrigerant – solvent properties

Some of the properties desired for a solvent are:

(1) Great affinity to absorb the refrigerant used.

(2) Low surface tension to facilitate absorption of refrigerant used.

(3) To remain liquid through its cycle.

(4) Low vapour pressure at generator temperature and stable at highest temperature of the cycle.

(5) Low specific heat and low viscosity for better heat transfer and minimum pump work.

(6) Suitable pressure temperature concentration relationship to meet the actual practical conditions needed in various components of the system.

2.1 Characteristics of Ammonia (NH_3) (R717):

(1) Since ammonia is most commonly used refrigerant in vapour absorption system for domestic and industrial applications, its solubility properties would prove useful in understanding the working of these systems later. These are :

(2) Its boiling point is −33.4°C at atmospheric pressure, therefore, temperatures below zero can easily be obtained.

(3) It has low volumetric displacement, low cost, large latent heat of vaporisation, therefore, needs less mass per ton of refrigeration.

(4) Leaks are easily detected due to its strong smell.

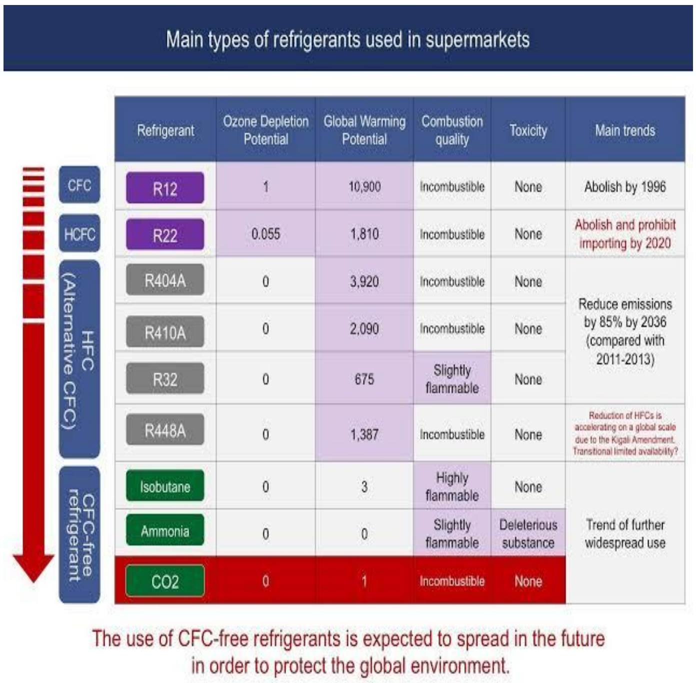
(5) Water has large capacity to absorb ammonia vapour e.g. water at 13°C is capable to dissolve 1000 times of own volume of ammonia vapour.

(6) Amount of NH_3 vapour that water can absorb increases with increase in pressure and decreases with increase in temperature.

(7) During dissolution of ammonia vapour in water, heat is liberated.

(8) Water can be induced to give up dissolved ammonia by heating since the boiling temperature of ammonia is much lower than that of water at any pressure.

(9) Since NH_3 attacks non-ferrous metals in presence of water, therefore copper and brass are never used in the system.


Main types of refrigerants used in supermarkets

	Refrigerant	Ozone Depletion Potential	Global Warming Potential	Combustion quality	Toxicity	Main trends
CFC	R12	1	10,900	Incombustible	None	Abolish by 1996
HCFC	R22	0.055	1,810	Incombustible	None	Abolish and prohibit importing by 2020
HFC (Alternative CFC)	R404A	0	3,920	Incombustible	None	Reduce emissions by 85% by 2036 (compared with 2011-2013)
	R410A	0	2,090	Incombustible	None	
	R32	0	675	Slightly flammable	None	
	R448A	0	1,387	Incombustible	None	Reduction of HFCs is accelerating on a global scale due to the Kigali Amendment. Transitional limited availability?
CFC-free refrigerant	Isobutane	0	3	Highly flammable	None	Trend of further widespread use
	Ammonia	0	0	Slightly flammable	Deleterious substance	
	CO2	0	1	Incombustible	None	

The use of CFC-free refrigerants is expected to spread in the future in order to protect the global environment.

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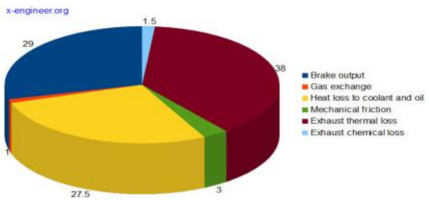
3. LITERATURE REVIEW

As we studied the refrigeration units currently used in road transport vehicles are predominantly of the vapour compression refrigeration type but this work represents study of air conditioning based on ammonia water vapour absorption system.

This is new technique to be used in air conditioning system of automobile and system especially in food preservation this design is couple the vapour absorption system cycle with automotive air conditioning system instead of vapour compression cycle. Considering the environmental changes and the atmospheric depravation including the factors such as excessive energy loss .



With the quickly environmental changes and atmospheric consequences the air conditioning of the moving vehicle has become a necessity in this paper an exploration has been done to research the possibility of the waste heat recovery and its subsequently utilization in air conditioning system of vehicle without increasing the expensive, weight, number of component and brings improvement in vehicle by making luxurious

The attempt to have a vapour absorption system on lithium bromide may prove to be advantageous alternative.it will not require a power input from the cars engines well. Instead the exhaust gas heat may be used to run the system

Colbourne [5] summarized a study analyzing over 50 published technical documents comparing the performance of fluorinated refrigerants and HCs. A significantly higher number of tests showed an increase in performance when using HCs as compared to using fluorinated refrigerants.

Colbourne and Suen [6].Similarly, Colbourne and Ritter [7] investigated the compatibility of non-metallic materials with HC refrigerant and lubricant mixtures. They performed experiments in compliance with European standards for the testing of elastomeric materials and ASHRAE material compatibility test standards.

Maclaine-Cross and Leonardi[8] compared the refrigerant performance of HCs based on refrigerant properties and concluded that the COP improvements, commonly reported in literature, were consistent with better thermodynamic properties of HCs. R600a properties and their influences on system performance were discussed.

COP of the system:

The net refrigerating effect in the system is the heat extracted in the evaporator.

Total energy required to operate the system is equal to the sum of work energy

Required to operate the aqua pump and the heat energy supplied to the generator.

IMPLEMENTATION METHODOLOGY

Estimation of exhaust heat:

To get exhaust heat data, the engine is allowed to run at different throttle position (one-fourth and half) considering engine speed as running parameter. The mass flow rate of air, mass flow rate of fuel and temperature of exhaust gas is measured as given in Table 3.2 For measuring the required data with circular orifice of 32 mm diameter, inclined tube manometer, burette for petrol measurement and thermocouple for exhaust temperature measurement in installed on engine.

Design conditions:

1) Refrigeration capacity=1TR
2) Outside conditions: 36^0c DBT
3) Condenser temperature=45^0c (18 bar)
4) Evaporator temperature=5^0c (5 bar)

Length of condenser coil for varying condenser temperatures.

condenser temperature(^{0}c)	coil length(m)
41	10.48
42	8.73
43	7.49
44	6.55
45	5.82
46	5.24
47	4.76
48	4.36
49	4.03
50	3.74

Throttle Position opening	Engine Speed rpm	Air Pressure mm of H_2O	Time for consumption of 25 c.c. fuel second	Exhaust Temperature ⁰c	Mass of Fuel Kg/s (10^{-5})	Mass of Air Kg/s (10^{-4})	Useful exhaust heat Kg/s
1/4th	3500	7.4	40	622	46	64	3.98
	3000	7.9	57	605	32	67	3.91
	2500	7.2	48	566	38	64	3.50
	2000	5.6	42	623	44	56	3.49
	1500	4.9	41	582	45	52	3.05
half	3500	14.8	34	669	54	91	6.02
	3000	15.9	29	615	63	94	5.74
	2500	12.3	24	648	77	83	5.47
	2000	9.4	32	595	57	73	4.31
	1500	6.8	39	588	47	62	3.61

Table 4.1 Length of condenser coil for varying condenser temperatures.

RESULTS AND ANALYSIS

Below figure shows that with increase in evaporator temperature evaporator coil length also increases. But this result in increase in pressure ratio, hence optimum condenser temperature should be selected by compensating coil length and pressure ratio.

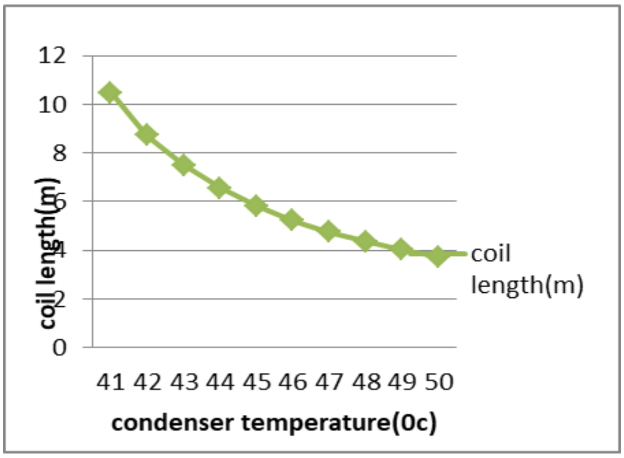
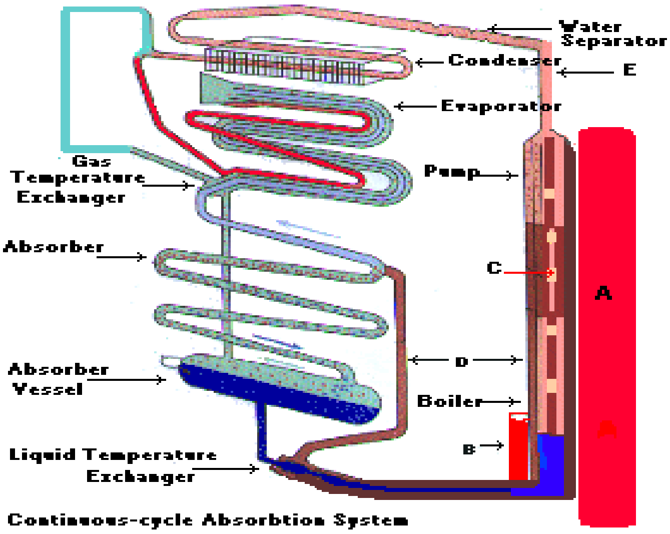


Figure 4.1 Graph of condenser coil length against condenser temperature.



CONCLUSION AND FUTURE SCOPE

Conclusion

The theoretical analysis is verified by experiments. This work results from a prototype which will have to be improved for further development. The claim that is made from this work is that it has shown the feasibility of such a system in a positive frame. It can be concluded that:

1) Vapour compression refrigeration requires a significant supply of work from an electric motor or other source of mechanical power. Absorption refrigeration is an alternate approach to cooling that is largely thermally driven and requires little external work.

   This form of refrigeration is growing in importance as energy conservation considerations demand closer scrutiny of the disposition of heat rejection from thermal processes. Absorption refrigeration provides a constructive means of utilizing waste heat or heat from inexpensive

2) Sources at a temperature of a few hundred degrees, as well as directly from fossil fuels.
3) It is possible to produce cooling effect by recovery of exhaust heat through vehicle.
4) In the exhaust gases of motor vehicles, there is enough heat energy that can be utilised to power an air-conditioning system. Therefore, if air-conditioning is achieved without using the engine's mechanical output, there will be a net reduction in fuel consumption and emissions.
5) Once a secondary fluid such as water is used, the aqua-ammonia combination appears to be a good candidate as a working fluid for an absorption car air-conditioning system. This minimises any potential hazard to the passengers. The low COP value is an indication that improvements to the cycle are necessary.

Future scope:

The use of VAR in road transport vehicles has the advantage of reducing the dedicated IC engine, refrigerant compressor, unit weight, capital cost, fuel costs, maintenance, atmospheric pollution and noise pollution.

Experimental results proved that it is possible to drive a vapour absorption refrigeration system using the exhaust gases from a diesel engine. This suggests that such a system could be used in road transport vehicles. However, further consideration is required with respect to the following:

The design of a heat exchanger to extract waste heat without excessive pressure drops in the exhaust systems, the effect of increased back pressure on the engine performance, the corrosion effect of the exhaust gases on the heat exchanger material, the fluctuations in the cooling capacity due to variations in vehicle speed, and alternative energy input while vehicle is stationary, the effect of varying ambient conditions on the system performance, and accommodating the system on the vehicle. This area of study is worth pursuing in terms of energy and cost savings, and suggests that a prototype design study be undertaken.

One more difficulty on which further study and research required is that when a vehicle be at rest or in very slow moving traffic conditions. In either of these conditions the resulting reduction in heat input to the generator would cause a corresponding drop in the cooling effect of the system.

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PHOTOGRAPH OF OUR MODEL

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