Dual Power Vapour Absorption Air Conditioning System in Trucks

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Abstract— **The possibility of exploiting waste heat from the automobiles has been of great significance in view of ever increasing energy demand and environmental constraints. Thus to overcome these issues this project bring out a smart hybrid refrigeration system which makes maximum utilization of the waste heat from the engine during working of the engine and uses battery powered heater during rest hours.**

***Index Terms*—Vapour absorption system, Air conditioning, Energy, Transportation.**

I. Introduction

This project focuses on harvesting waste heat from a truck engines and using the same heat to cool the cabin of the truck using Vapor absorption refrigeration system. Ionic liquids are ideal absorbents for vapour absorption refrigeration systems because of their low volatility, and good solubility with different natural refrigerants such as ammonia, water, carbon dioxide, etc. [1]

Following are the main advantages.

1. Refrigeration and air conditioning in truck can be obtained at almost zero running cost.
2. Cost saving on fuel=15.4% (in ideal condition), improves efficiency.
3. Use of electrical heaters for refrigeration system prevents the need of engine idling for air conditioning during rest hours.
4. The heat from the engine as well as the electrical heater output can be seamlessly controlled for best cooling results.

II. Aim & Objective

A. Aim

The basic aim behind the innovative concept of Dual power vapour absorption Air conditioning system in trucks is to improve efficiency of fuel energy by recycling the waste heat as well as to improve comfort by providing air conditioning inside the truck cabin.

B. Objective

To design a hybrid air conditioning system that utilizes waste heat from the automotive engine during working hours and electrical power during rest hours. It uses waste energy hence it does not account for any extra environmental pollution, instead it improves the efficiency of the fuel and provide free refrigeration.

III. Proposed System

The vapour compression refrigeration systems (VCRS) are popular but are being replaced by vapour absorption refrigeration system (VARS) in many places owing to an increased cost and scarcity of electricity. During the course of this study on IC engines and energy management we realized that the IC engines are very inefficient machines with efficiency of almost 35%. [2]

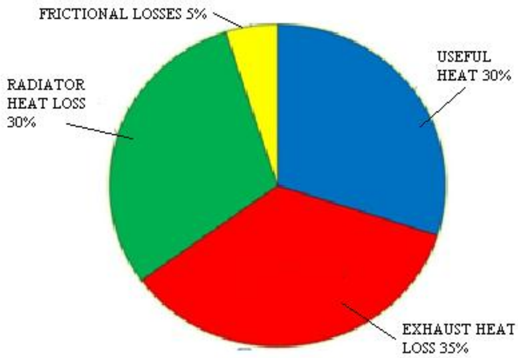

Figure 1: Fuel Energy Distribution in IC engine

This triggered to do more research in this field and obtained the following results.

Total available engine heat=113 kW, Total waste heat =79 kW (considering a 150 BHP engine) the losses are estimated to be 34kw of heat from the engine cooling radiator, 36kw of heat from the engine exhaust. Remaining are losses due to friction. The following results concluded that this waste heat can be utilized for some useful work. [3].

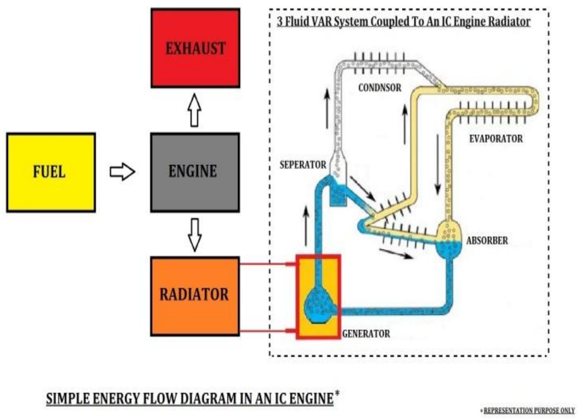

Figure 2: Basic energy flow diagram

Vapour absorption air conditioning system requires only heat to operate, and the waste heat from engine can be successfully utilized for cooling purpose. After a study on

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systems in automobiles, it was found that the heat dissipated from the exhaust & from the radiator is identical but harvesting exhaust heat was costlier in terms of design, manufacturing and maintenance hence radiator heat recovery system was adopted. The system was designed to absorb heat from the engine coolant and produces cooling effect. The main components of vapour absorption system are ammonia (refrigerant), water (solvent) and hydrogen (absorbent).

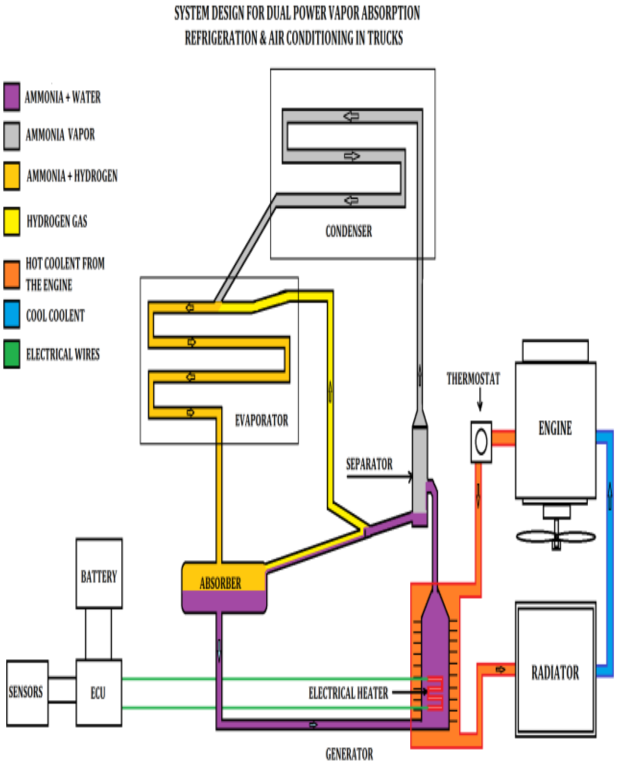

Figure 3: Schematic diagram of hybrid VAR system

Mixture of ammonia and water is heated by using the waste engine heat till boiling point of ammonia. Ammonia vapour enters condenser where it loses heat. In the next stage the vapour enters evaporator along with hydrogen gas, which increases the rate of evaporation and in turn increases the rate of heat absorption. The total amount of heat absorbed by the fluids is equal to the latent heat of evaporation. After absorbing the heat it becomes weak solution and then it enters the absorber chamber where ammonia again mixes with water and hydrogen is re circulated as it is insoluble in water. This cycle continues to produce the desired cooling effect. The next challenge which faced was when the engine is turned off and air conditioning effects still need to be in force, so battery powered electrical heater was introduced in vapor absorption refrigeration system. The battery backup time was limited to 6 hrs, so a secondary battery was added to meet the power demands. The charging expenses are estimated to be 2.22% of the fuel cost. This cost can further be reduced by charging of the battery using 220v ac supply.

IV. Observation

- Table I: Specification of the Engine under consideration

No.	Parameter	Symbol	Value
1.	Engine Power	P	150 BHP
2.	Calorific Value Of The Fuel	CV	42000 kJ/kg
3.	Efficiency Of The Engine	η	30%
4.	Mass Flow Rate(Average)	mf	0.00269 ltr/sec
5.	Actual Heat Available	Q_{actual}	113 kW
6.	Total Heat Rejected	$Q_{rejected}$	79 kW
7.	Approximate Heat Rejected Through Radiator	$Q_{radiation}$	34 kW
8.	Coolant Temperature (Average)	$T_{radiation}$	90 °C

- Table II : cabin cooling requirement during engine working hours(**day time**)

No.	Parameter	Symbol	Value
1.	Cabin Size	L*B*H	2×1.75×1.5m
2.	Cabin Temp	T_{cabin}	35 °C
3.	Solar Radiation (Roof, Walls Glasses)	Q_{solar}	300kJ/hr
4.	Heat Radiated From Engine	$Q_{eng.rad}$	1000 kJ/hr
5.	Air Leakage	Q_{air}	1000 kJ/hr
6.	Passenger Including Driver	Q_{pass}	1200 kJ/hr
*	Total		3500 kJ/hr

- Table III : cabin cooling requirement during rest hours(**Night time**)

No.	Parameter	Symbol	Value
1.	Cabin Size	L*B*H	2×1.75×1.5m
2.	Cabin Temp	T_{cabin}	35 °C
3.	Solar Radiation (Roof, Walls,Glasses)	Q_{solar}	0.00kJ/hr (night)
4.	Heat Radiated From Engine	$Q_{eng.rad}$	0.00kJ/hr (engine off)
5.	Air Leakage	Q_{air}	0.00 kJ/hr
6.	Passenger Including Driver	Q_{pass}	1200 kJ/hr
*	Total		1200 kJ/hr

- Table IV: Specification of 1Tonne VAR system

No.	Parameter	Symbol	Value
1.	Minimum Assumed C.O.P	COP_{min}	0.2
2.	Heat Required For 1tr At 0.2 Cop	Q_{ref}	17.5 kW
3.	Temperature At Generator	T_g	80 °C
4.	Temperature At Evaporator	T_e	5 °C
5.	Temperature At Condensor	T_c	55 °C
6.	Required Cabin Temperature	$T_{c.req}$	24 °C
7.	System Average Pressure	P_{system}	5bar
8.	Maximum C.O.P Obtained	COP_{max}	0.32

This implies the following:

a. The cooling load during rest hours(night time) are less(1200KJ/hr) ,hence the electrical heater of 6 kW is sufficient. The heater runs on 24v dc standard automotive rechargeable battery for an approximate time of 6hrs.(a secondary battery is advised for longer working period)
b. Both the heat source can be simultaneously operated for greater cooling action.

#A small quantity of sodium chromate (1% by weight) was used as anti rust agent.

V. CONCLUSIONS

Based on detailed study and results obtained, we can conclude that Vapor absorption refrigeration system can be effectively used over vapor compression refrigeration system in automobile at almost zero running cost. Thus also use of electrical heaters for refrigeration system prevents the need of engine idling for air conditioning during rest hours. And the heat from the engine as well as the electrical heater can be seamlessly controlled for best cooling results.

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