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A Cooling System for an Automobile Based on Vapour Absorption Refrigeration Cycle Using Waste Heat of an Engine.

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Abstract
Now a days the air conditioning system of cars is mainly uses "Vapour 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 vapour 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 "Vapour 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 Vapour 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: Waste heat from I. C. Engine, Waste heat recovery system for I. C. Engine, car air-conditioning, absorption refrigeration, renewable energy.

I. Introduction

Refrigeration is the process of removing heat from an enclosed or controlled space, or from a substance, and moving it to a place where it is unobjectionable. The primary purpose of refrigeration is lowering the temperature of the enclosed space or substance and then maintaining that lower temperature as compare to surroundings. Cold is the absence of heat, hence in order to decrease a temperature, one "removes heat", rather than "adding cold."

The basic objective of developing a vapour absorption refrigerant system for cars is to cool the space inside the car by utilizing waste heat and exhaust gases from engine. The air conditioning system of cars in today's world uses "Vapour Compression Refrigerant System" (VCRS) which absorbs and removes heat from the interior of the car which is the space to be cooled and further rejects the heat to be elsewhere. Now to increase an efficiency of car beyond a certain limit vapour compression refrigerant system resists it as it cannot make use of the exhaust gases from the engine. In vapour compression refrigerant system, the system utilizes power from engine shaft as the input power to drive the compressor of the refrigerant system, hence the engine has to produce extra work to run the compressor of the refrigeration system utilizing extra amount of fuel.[1] This loss of power of the vehicle for refrigeration can be neglected by utilizing another refrigeration system i.e. a "Vapour Absorption Refrigerant System" i.e low grade heat operated systems. It is well known that an IC engine has an efficiency of about 35-40%, which means that only one-third of the energy in the fuel is converted into useful work and about 60-65% is wasted to environment. In which 28-30% is lost by cooling water and lubrication losses, around 30-32% is lost in the form of exhaust gases and remainder by radiation, etc. In a Vapour Absorption Refrigerant System, a physicochemical process replaces the mechanical process of the Vapour Compression Refrigerant System by using energy in the form of heat rather than mechanical work. The heat required for running the Vapour Absorption Refrigerant System can be obtained from that which is wasted into the atmosphere from IC engine.[2] Hence to utilize the exhaust gases and waste heat from an engine the vapour absorption refrigerant system can be put into practice which increases the overall efficiency of a car.

II. Possibility of heat recovery and availability from I.C. engine.

Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then "dumped" into the environment even though it could still be reused for some useful and economic purpose. This heat depends in part on the temperature of the waste heat gases and mass flow rate of exhaust gas. Waste heat losses arise both from equipment inefficiencies and from thermodynamic limitations on equipment and processes. For example, consider internal combustion engine approximately 30 to 40% is converted into useful mechanical work. The remaining heat is expelled to the environment through exhaust gases and engine cooling systems [3]. It means approximately 60 to 70% energy losses as a waste heat through exhaust (30% as engine cooling system and 30 to 40% as environment through exhaust gas). Exhaust gases immediately leaving the engine can have temperatures as high as 842-1112°F [450-600°C]. Consequently, these gases have high heat content, carrying away as exhaust emission. Efforts can be made to design more energy efficient reverberatory engine with better heat transfer and lower exhaust temperatures; however, the laws of thermodynamics place a lower limit on the temperature of exhaust gases [4].

III. Possible way of using heat recovery system.

Today's modern life is greatly depends on automobile engine, i.e. Internal Combustion engines. The majority of vehicles are still powered by either spark ignition (SI) or compression ignition (CI) engines. Small air-cooled diesel engines of up to 35 kW output are used for irrigation purpose, small agricultural tractors and construction machines whereas large farms employ tractors of up to 150 kW output. Water or air-cooled engines are used for a range of 35-150 kW and unless strictly air cooled engine is required, water-cooled engines are preferred for higher power ranges. Earth moving machinery uses engines with an output of up to 520 kW or even higher, up to 740 kW. Marine and locomotive applications usually employ engines with an output range of 150 kW or more. Trucks and road engines usually use high speed diesel engines with 220 kW output or more. Diesel engines are used in small electrical power generating units or as standby units for medium capacity power stations [5].

Table : Various Engine and There Output

S.N	Engine Type	Power Output (kW)	Waste Heat
1.	Small air cooled diesel engine	35	30-40 % of energy waste loss from IC engines
2.	Water air cooled engine	35-150	
3.	Earth moving machineries	520-720	
4.	Marine applications	150-220	
5.	Trucks and road engines	220	

IV. Working principle: Vapour absorption refrigeration system.

The vapour-absorption cycle is similar to the better known vapour-compression cycle in that it employs a volatile refrigerant, e.g. ammonia, which alternately condenses under high pressure in the condenser by surrendering heat to the environment and vaporizes under low pressure in the evaporator by absorbing heat from the medium being cooled. The principal difference between the absorption and the vapour-compression cycles is the mechanism for circulating the refrigerant through the system and providing the necessary pressure difference between the vaporizing and condensing processes. The vapour compressor employed in the vapour-compression cycle is replaced in the absorption cycle by an absorber and a generator or boiler, which compress the vapour as required. The energy input required by the vapour-compression cycle is supplied to the compressor in the form of mechanical work but In the absorption cycle, the energy input is mostly in the form of heat supplied to the generator. In the present case the heat source is the exhaust heat of an internal combustion engine.

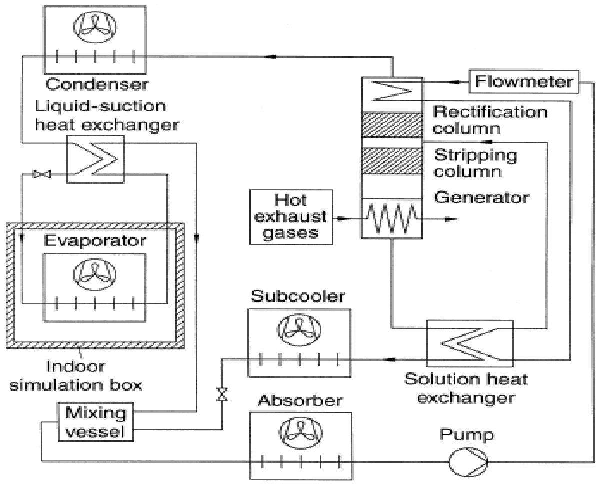

Figure : The essential components of the air-cooled absorption system.

The boiling point of ammonia is lower than that of water, so it vaporizes, separating the refrigerant from the absorbent. Since the vapour is not a pure ammonia gas, it must be purified as it flows through a stripping and rectification column. The heat exchangers of the generator rectification system were designed as compact plate-fin heat exchangers and the column was filled with stainless steel Pall rings.

In Vapour absorption refrigeration system, generator portion is designed for utilizing exhaust gas from internal combustion engine.[6] Type of engine and also details of engine parameters are given below.

1.	Engine Make	Kirloskar
2.	Engine Type	Single Cylinder
3.	Power	3.7 kW
4.	Speed	1500 rpm
5.	Bore Diameter	80 mm

6.	Stroke Length	110 mm
7.	Room Temperature	29 ℃
8.	Exhaust Gas Temperature Range	125℃ to 260℃

Table : IC Engine specifications.

Temperature of an exhaust gas in kirloskar engine by an heat balance on engine by using electrical loading. Fuel used in engine is high speed diesel. Exhaust gas temperature range is varied depends upon the type and also amount load acting on the engine.

V. Refrigerant used for the Absorption Refrigeration Systems

A fundamental requirement of absorbent/refrigerant combination is that, in liquid phase, they must have a margin of miscibility within the operating temperature range of the cycle. The mixture should also be chemically stable, non-toxic, and non-explosive. In addition to these requirements, the following are desirable[7-8]:

a. Refrigerant should have high heat of vaporization and high concentration within the absorbent in order to maintain low circulation rate between the generator and the absorber per unit of the cooling capacity.

b. Transport properties that influence heat and mass transfer, e.g., viscosity, thermal conductivity, and diffusion coefficient should be favourable.

c. Both refrigerant and absorbent should be non-corrosive, environmental friendly, and economical. There are some 40 refrigerant compounds and 200 absorbent compounds available. However, the most common working fluids are water/ammonia and LiBr/water. Since the invention of absorption refrigeration systems, water/ammonia has been widely used for both cooling and heating purposes.

The main properties are:

a. Ammonia (refrigerant) and water (absorbent) are highly stable for a wide range of operating temperature and pressure.

b. Ammonia has a high latent heat of vaporization, which is necessary for efficient performance of the system. Its latent heat of vaporization at -15℃ is 1315kJ/Kg.

c. Its boiling point at atmospheric pressure is -33.3 ℃ & freezing point is -77 ℃ .

d. It has highest refrigerating effect per Kg of refrigerant.

e The leakage of this refrigerant may be quickly & easily detected by the use of burning sulphur candle which in the presence of ammonia will form white fumes of ammonium sulphite.

f. It is environmental friendly.

VI. Advantages

- Uses Engine heat as source of energy hence enhances the efficiency of engine.
- Moving parts are only in the pump, which is a small element in the system hence operation becomes smooth and also wearing and tearing is reduced.
- The system works at low evaporator pressures without affecting the COP of the system.
- Environmental friendly, no release of CFC derivatives.
- Helps in protecting OZONE layer from depletion.
- Helps engine to cool, as it extracts heat from engine.
- Low running cost.
- Higher engine power efficiency.

VII. CONCLUSION

It is possible to design an automobile air conditioning system using engine heat based on Vapour Absorption Refrigeration System.

Also from the Environmental point of view this system is Eco-friendly as it involves the use of Ammonia as a refrigerant which is a natural gas and is not responsible for OZONE layer Depletion. In this way we can concluded, technically, that Out of the total heat supplied to the engine in the form of fuel, approximately, 30 to 40% is converted into useful mechanical work; the remaining heat is expelled to the environment through exhaust gases and engine cooling systems, resulting in to entropy rise and serious environmental pollution, so it is required to utilized waste heat into useful work. The recovery and utilization of waste heat not only conserves fuel (fossil fuel) but also reduces the amount of waste heat and greenhouse gases damped to environment. The study shows the availability and possibility of waste heat from internal combustion engine, also describe loss of exhaust gas energy of an internal combustion engine. Possible methods to recover the waste heat from internal combustion engine and performance and emissions of the internal combustion engine. Waste heat recovery system is the best way to recover waste heat and saving the fuel.

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