Review on Exhaust Gas Heat Recovery for I.C. Engine Using Refrigeration Systems

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ABSTRACT

Due to green house effect & changing environment and atmospheric effect, the air conditioning of the moving vehicle has become a necessity now a day. As the major percentage of heat energy is rejected by engine exhaust which can be recovered is approximately 30-40% of the energy supplied by the fuel depending on engine load. Waste heat recovery system is the best way to recover waste heat and saving the fuel. Although there are various methods are available for the recovery of waste exhaust gas such as direst methods in which the emf is directly induced by directly called the sea beck effect or indirect methods such as Rankine Cycle , Stirling Cycle & Refrigeration cycles. The present paper discusses the Exhaust Gas Heat Recovery for I.C. Engine using refrigeration systems. As continuous raise in fuel prices and manufacturing cost, the consumers getting many difficulties in maintain the automotive vehicles.

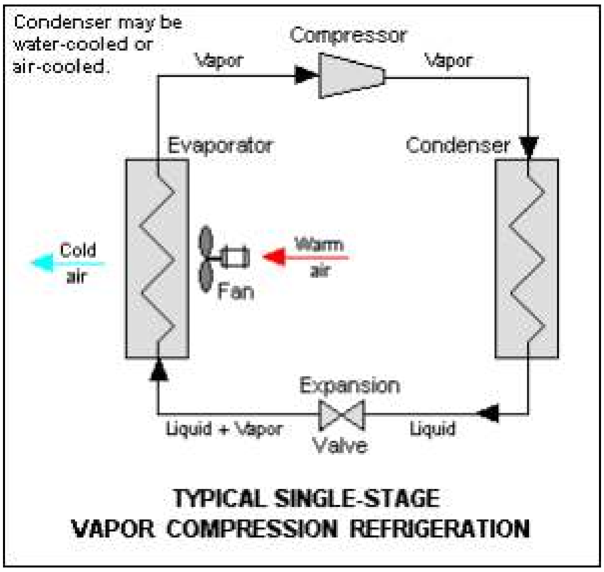
Keywords: Waste Engine Heat, Air Conditioning System, VCRS, VARS, Engine Exhaust

INTRODUCTION

A heat engine is a system that performs the conversion of heat or thermal energy to mechanical work.Examples of everyday heat engines include the steam engine, the diesel engine, and the gasoline (petrol) engine in an automobile. Heat engines are designed to produce useful work only. The efficiency of a modern internal combustion engine is about 37% in a normal passenger car spark ignition engine. The energy in the form of heat is rejected by means of exhaust, circulating cooling water, lubrication oil & radiation. Due to green house effect & changing environment and atmospheric effect, the air conditioning of the moving vehicle has become a necessity now a days. The refrigerating effect is done by either Vapour Compression Refrigeration System (VCRS)and Vapour Absorption Refrigeration System (VARS). Since the COP of higher in VCRS system than VARS but as the point of operating condition the VCRS is more suitable. Due to improvements of comfort and driving performance the electric load of a vehicle is increasing day by day.

A) Vapour Compression Refrigeration System

Generally refrigeration means, removing the heat from a space so that the space becomes colder than the surrounding. In a natural way the heat flows from hot region to cold region. But in a refrigeration system the heat is removed from cold region & rejected into a hot region, hence the cold region becomes colder & hot regions becomes more hotter.



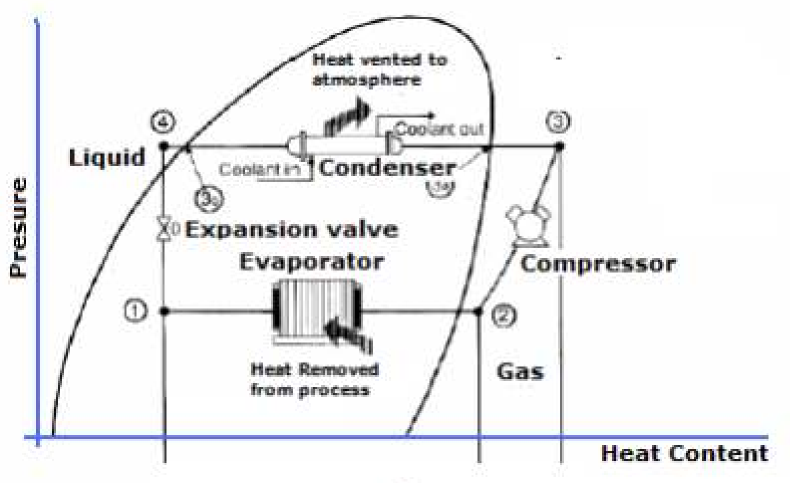


Figure2: p-h diagram for VCR system

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The vapour-compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. Figure1 depicts a typical, single-stage vapour-compression system. All such systems have four components: a compressor, a condenser, a thermal expansion valve (also called a throttle valve), and an evaporator. Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapour and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapour is then in the thermodynamic state known as a superheated vapour and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air. That hot vapour is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cool water or cool air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by either the water or the air (whichever may be the case).

The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The auto-refrigeration effect of the adiabatic flash evaporation lowers the temperature of the liquid and vapour refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated.

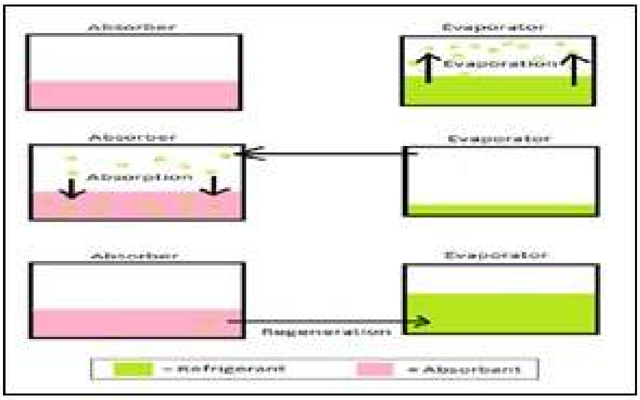
The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapour mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser. To complete the refrigeration cycle, the refrigerant vapour from the evaporator is again a saturated vapour and is routed back into the compressor.

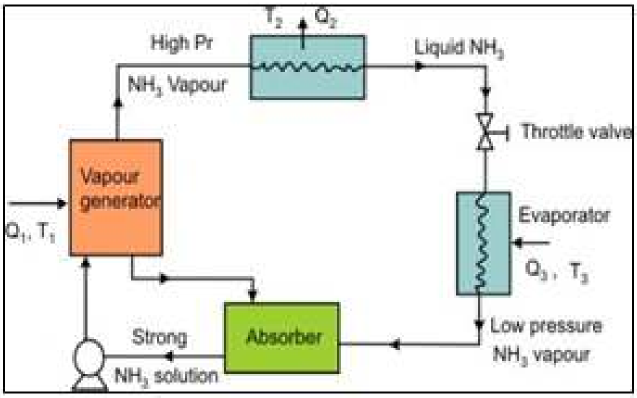
B) Vapour Absorption System

An absorption refrigerator is a refrigerator that uses a heat source (e.g., solar, kerosene-fuelled flame, waste heat from factories or district heating systems) to provide the energy needed to drive the cooling system. In the early years of the twentieth century, the vapour absorption cycle using water-ammonia systems was popular and widely used. Ammonia-water combination possesses most of the desirable qualities which are listed below:

- 1m3 of water absorbs 800m3 of ammonia (Nh3).
- Latent heat of ammonia at-15 C = 1314 kJ/kg.
- Critical temperature of NH3 = 132.6 C.
- Boiling point at atmospheric pressure = -33.3 C

The NH3-H2O 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, which vary between 0.6 to 0.7. Ammonia is highly soluble in water.





SCOPE OF THE WORK

The engine waste heat can be recovered by using radiator water as source /generator for VARS. The arrangement of various components of air conditioning system is also a challenge because of the fix size of cars. In the proposed model condenser and evaporator will be arranged same as the conventional unit.

REVIEW OF LITERATURES

According to Hui Tong Chua and Anutosh Chakraborty [1], The formulation of specific heat capacity of a single component adsorbent + adsorbate system is one of the basic foundations of any adsorbate-adsorbent thermodynamic analysis. This would be useful in the design and analysis of solid-gas absorption in cooling applications such as adsorption chiller, adsorption cryocoolers, infrared detectors cooling.

I.L. Maclaine-cross summarised [2], Usage and risk of hydrocarbon refrigerants in motor cars. He conclude that for fires this is consistent with the ignition probability being hundreds of times less than used in predictions and most R290/600a leaks being effectively non flammable. The actual accident frequency and hence risk of using hydrocarbon refrigerant in motor cars is much lower than predicted when commercial use commenced.

In the paper of V. M. Suryawanshi, K. V. Mali, A. A. Keste & S. D.Wankhede named Performance Assessment of Window A/C under Drop- In Condition Using Propane as Refrigerant [3] showed the COP of the system using R22 & the COP of the system using R190 (propane) are found to be same. It is observed that for same COP, the specific refrigerating effect of R290 is about 40% greater than R22 as R290 has high latent heat of vaporization. But actual cooling capacity of system with R290 is observed 8.86% less as compared to the system with R22. This is due to lower mass flow rate of R290 refrigerant in the system.

CONCLUSION

Waste heat recovery system is the best way to recover waste heat and saving the fuel. Above papers shows the utilization of the waste heat into creating the refrigeration effect. For this purpose the vapour absorption system is most suitable. At present, for an automobile waste heat absorption cooling system, the demand for Coefficient of Waste Heat Recovery can be easily met. Some operational parameters, such as desorption and adsorption temperatures, have significant influence on total performance and refrigeration power. Reasonable design of evaporator and the absorber air-cooling subsystem can remarkably promote the output of refrigeration capacity.

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