STUDY OF HEAT PIPE BASED AUTOMOBILE AIR CONDITIONING SYSTEM

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ABSTRACT

A heat pipe is a heat-transfer device which is used for the efficient transfer of heat between two solid interfaces. The refrigerant currently used in refrigeration industry has significant impact on the environment. Therefore, it is unmet need to come up with alternatives having less or no adverse impact on environment. Vapour absorption system is one of the alternative with zero impact on the GWP (Global warming potential) and ODP(Ozone depletion potential) when water and ammonia is used as refrigerant. Although vapours absorption refrigeration system has less COP (Coefficient of Performance) than vapour compression refrigeration system but it has advantage of utilizing the waste heat from the exhaust gases of automobile. This reduces the heat loss of the engine with no further power required to run the system in comparison to the VCRS (Vapour compression refrigeration system) which needs the mechanical power to run the compressor of the refrigeration system.

The vapour absorption system needs bigger setup and more time in order to be effective as VCRS system. This limitation of vapour absorption system can be overcome by incorporating heat pipe along with the evaporator in the air conditioning system. It reduces the load on evaporator hence less amount of NH_3 need to be circulated through the system. In nutshell use of vapour absorption system in combination with heat pipes can serve as next generation refrigeration technology for automobile with no detrimental effect on the environment.

Heat pipe increases the dehumidification of air and heating of downstream air of evaporator without the loss of any mechanical power generated by the Engine. Therefore, output can be utilized to run the vehicle and engine components.Heat pipe reduce the air temperature by 5^oF to 20^o F before it enters the cooling coil (evaporator) and heat the downstream air of the evaporator by 5^oF to 20^o F. It results in increased dehumidification of the air and further heating result in increased in human comfort without increasing the flow of refrigerant through the system (evaporator coil). Hence heat pipe may substantial reduce the system size with increase effectiveness of the air conditioning system, though with low COP of vapour absorption refrigeration system. In the current review we summarise the working, components and advantages of heat pipe vapour absorption system.

Keyword: - *Heat pipe, Dehumidification, Vapour Absorption System, Environment Impact*

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1. INTRODUCTION

The working fluids of the absorption refrigeration plants consists of water and ammonia, Lithium-Bromide and water, and Tetra-Ethylene Glycol Dim ethyl-Ether (TEG-DME) and R-22. Among all these combination water and ammonia do not show any detrimental effect on the environment and it is preferable choice for absorption refrigeration plants. In addition to being eco-friendly water and ammonia combination has following advantages: Firstly,water has the highest latent heat of vaporization at 0^o C. However, its combination with LiBr can cause crystallization due to unstable temperature conditions caused by fluctuations of exhaust gases flow rates.Secondly, Freon-22 is a well-known refrigerant, but in combination with its absorbent the plant becomes less economical. Thirdly, ammonia is highly soluble in water and this ensures low solution circulation rates and both constituents are available at minimal cost.

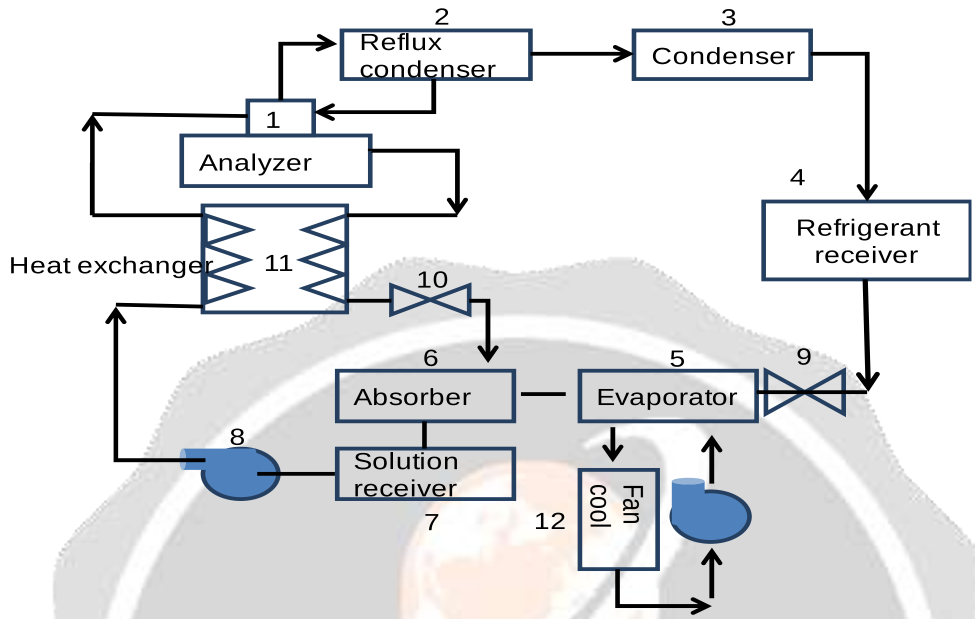

Fig -1: Working fluids for absorption refrigeration plant

Contrary to the several advantages, the choice of ammonia-water combination can attack copper and its alloys when it has been hydrated. Therefore, it is important to make all the components from mild steel or stainless steel. The working fluid of the absorption refrigeration plant has been shown in **Figure 1**. The American National Standards Institute (ANSI) **(King, 1977)** classified refrigerants into three groups according to their safety. Ammonia falls into the group 2 due to its toxicity meaning it cannot be used in the air-conditioning systems in direct expansion in the evaporator coil. Therefore, equipment must be installed outside the inhabitant space. In order to circumvent the toxicity problem, water or glycol is used as a secondary fluid to transfer the heat from the passenger space to the evaporator. This prevents the chance of ammonia getting in contact with the passengers.

Heat energy required for the vapor absorption refrigeration system can be provided by waste heat extracted from the generator sets and other process. The electrical energy in absorption systems is required only for running pumps. Depending on the power cost and temperature required it may even be economical to generate heat / steam to operate the vapour absorption system.

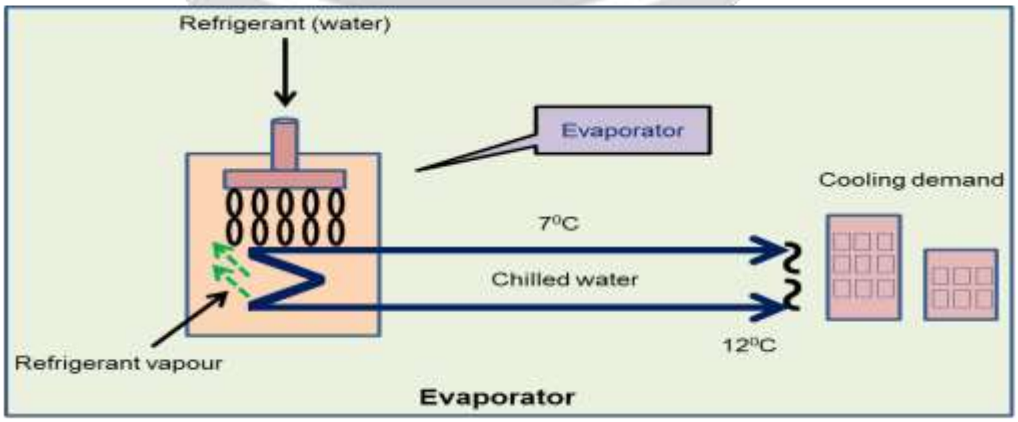

Fig -2: Evaporator

In the evaporator the refrigerant (water) evaporates at around 4^0C under the high vacuum condition of 754mm Hg. As the water evaporates, the latent heat of vaporization utilizes the heat from incoming chilled water. This latent heat of vaporization is sufficient to cool the chilled water which runs into the heat exchanger tubes in the evaporator by transfer of heat to the water. In order to keep running the evaporation, the refrigerant vapor must be discharged from the evaporator and water (refrigerant) must be supplied. The refrigerant vapor is absorbed into lithium bromide solution. It is convenient to absorb the refrigerant vapor in the absorber. The continuous cooling water is utilized to neutralize heat generated in the absorption process. This process of absorption also maintains the vacuum inside the evaporator. The evaporator is shown in the figure 2.

In order to keep running the evaporator, the refrigerant vapour must be discharged from the evaporator into the absorber where water absorbs the ammonia vapour , since water has great affinity to ammonia, convenient absorb the refrigerant vapour in the absorber. The continuous cooling water is utilized to neutralize heat generated in the absorption process. This process of absorption also maintains the vacuum inside the evaporator. Working dynamics of absorber of vapour absorption system is shown in **Figure 3.** Due to continuous vapour ammonia coming from evaporator to the absorber, the absorber temperature rises cooling water is supplied to maintain the temperature in the absorber. With the affinity of water to absorb the ammonia vapor is reduced as the temperature of the aqueous solution increases.

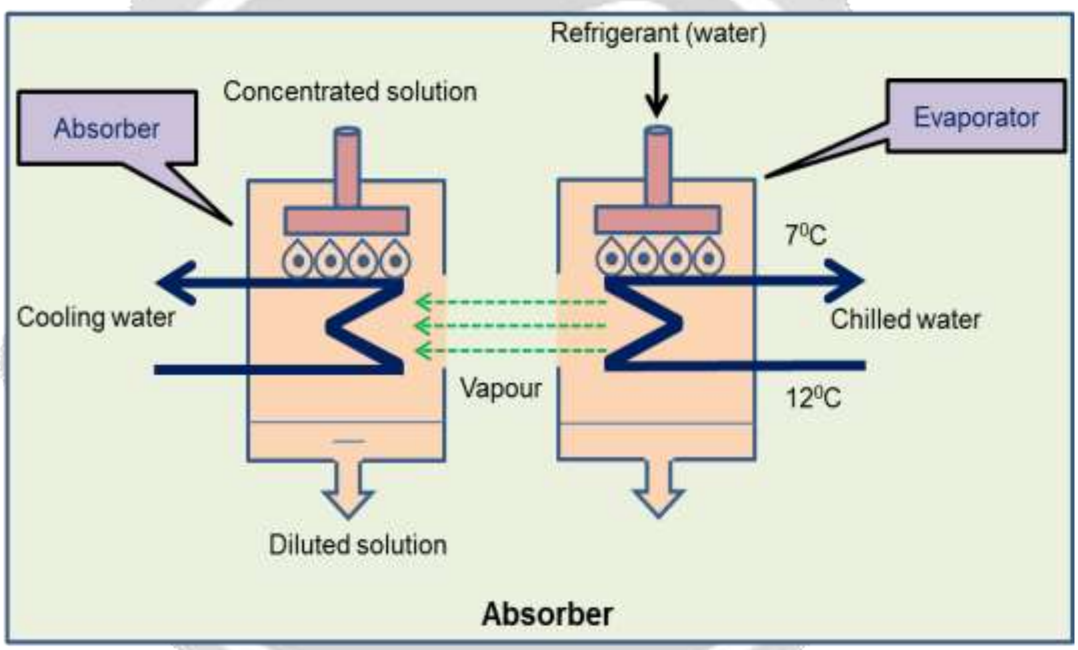

Fig -3: Absorber

Concentrated aqueous solution of water and ammonia is supplied to the generator through the pump which consume small power from the engine where heat is supplied to the generator from the exhaust gases discharged to the atmosphere and refrigerant is evaporated quickly in the generator and some part of water also get evaporated along with ammonia vapour, to separate the ammonia vapour from water vapour a device is fitted above the generator. A separator and rectifier is provided to remove the water vapour from refrigerant vapour since water is allowed to enter the evaporator will chock the evaporator. At low temperature the water will freeze and will block the pipe line, hence water is not allowed to enter the evaporator. Higher pressure is shown in Figure – 4

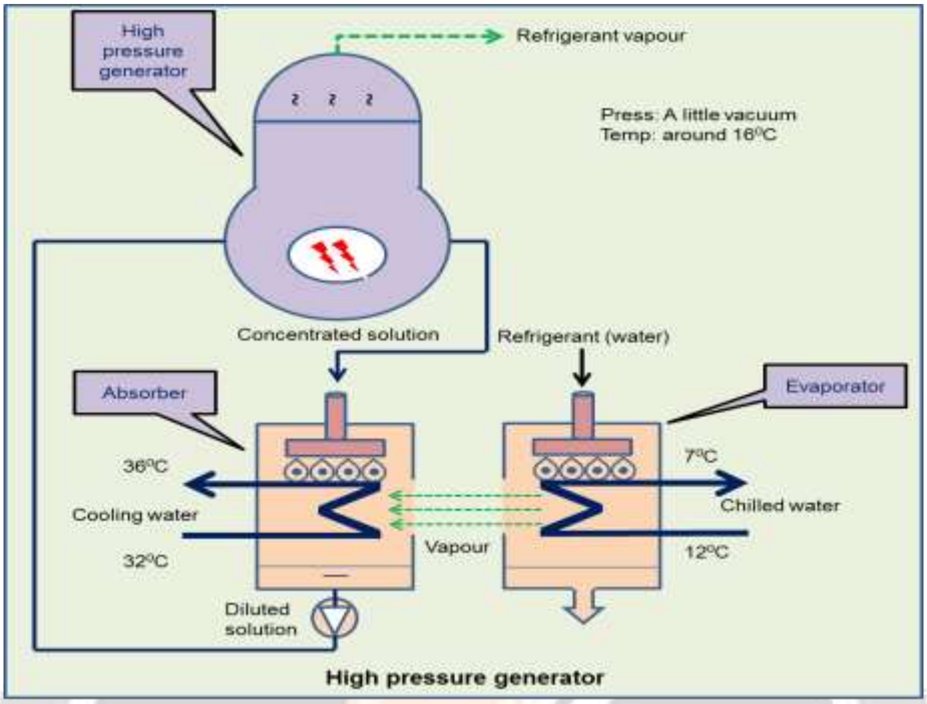

Fig -4: Higher Pressure Generators

The vapour ammonia is supplied to the condenser to remove the heat from refrigerant ammonia vapour and convert in liquid ammonia .And liquid ammonia is supplied to the evaporator where ammonia absorb heat from surrounding and liquid ammonia is converted to vapour, result in cooling of surrounding. This ammonia vapour is directed in to the absorber again and continuous process is repeated in cyclic order. Condenser is shown in figure -5.

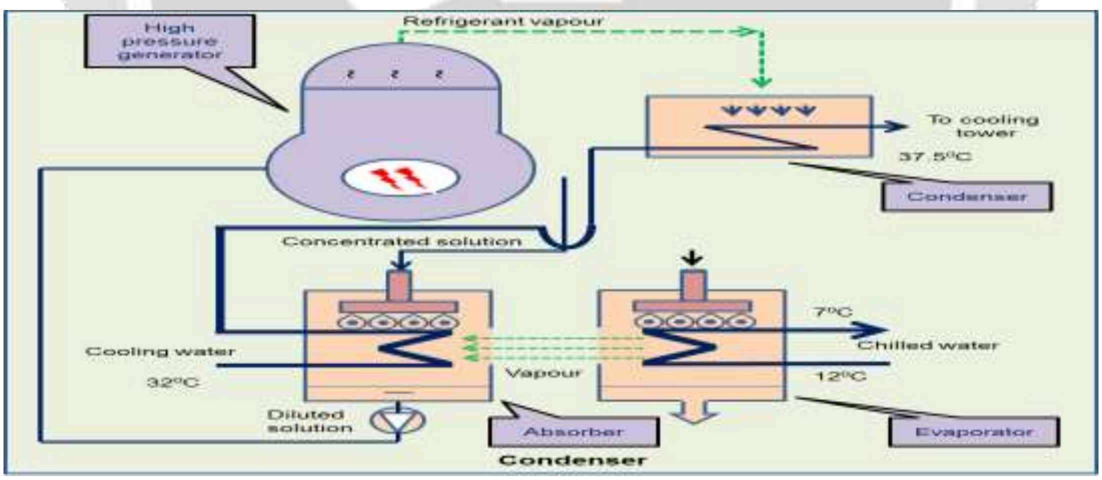

Fig -5: Condenser

1.1 Design Issues for 100% outside Air Systems

The sensible-to-latent load ratio drops below conventional equipment limits if the buildings become tighter and more energy efficient. Outside air requirements have expanded to address ventilation effectiveness at the occupant level in comparison to airflow at the system level. Conventional mixed air systems are inadequate and inefficient for humidity control and for effectively ventilating with verifiable outside air quantities. The solution to this problem is a successful design for the treatment and distribution outside the ventilation air with separate equipment and ductwork – a Dedicated outside Air System (DOAS). ADOAS is designed to satisfy 100% of the outside air (OA) ventilation requirements, as established by ASHRAE 62.1 This is done by using a separate cooling / heating / filtration and distribution system. Air supply from a DOAS can be introduced directly into the conditioned space to mix with air from the re-circulating HVAC system. It can also be ducted to mix with re-circulating air, and the mixed air is discharged into the space. Use of a DOAS has advantage of smaller and simpler re-circulating HVAC system.

DOAS application requires designing of a wrap-around heat pipe. Desired relative humidity and discharge air temperature can be achieved by either modulating the refrigerant flow in the heat pipe, or the air flow through the pre-cool and reheat sections. This design flexibility allows the modulation of discharge conditions, including neutral air, in a variety of configurations. Neutral air is conditioned ventilation air supplied at the space dry bulb temperature. At a dew point low enough to maintain the space at the desired relative humidity, when allowing for latent loads generated in the space and from building envelope infiltration.

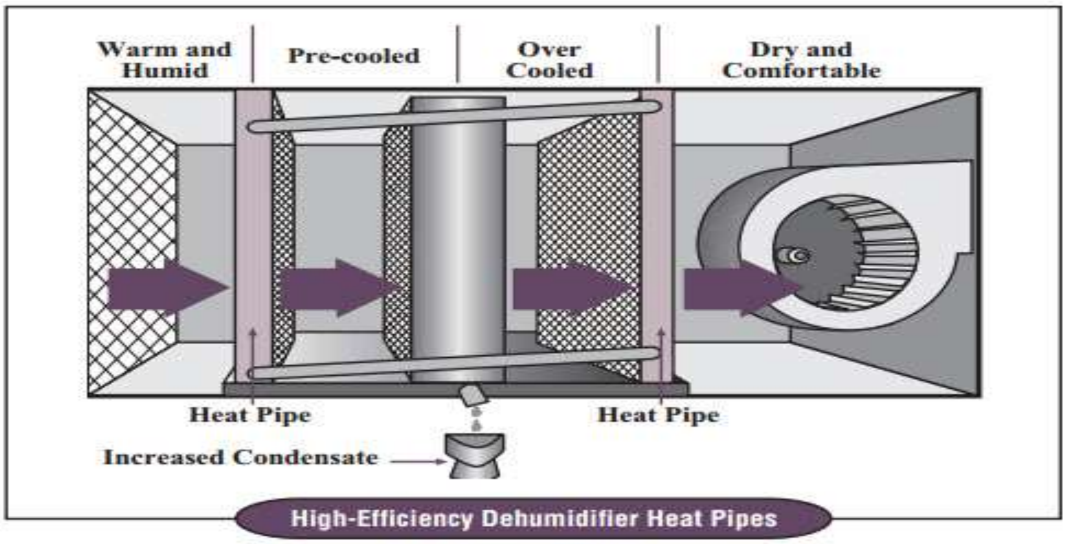

Fig -6: Wrap-around Dehumidifier Heat Pipe Schematic

DOAS designs have several operating characteristics:

Heat pipe can significantly increase dehumidification with the only additional energy usage being the fan energy needed to force air through the pre cool and reheat sections of heat pipe.

2. Conclusion

Vapour absorption refrigeration system run on the waste heat of engine and do not consume the power generated by engine therefore it will be efficient in automobile air conditioning, industrial refrigeration and air conditioning system. Especially in food preservation COP is further increased with incorporation of heat pipe along with evaporator provided heat loss is curbed down to minimum.

The heat required in generator is supplied from the exhaust gases of the engine which is up to 33% of the fuel supply to the engine. By using hot exhaust gases as an energy source high grade energy of engine output can be saved. The decrease in the temperature of evaporator and the load on the engine increases in case of the V R C S and in the V A R S. More supply of aqueous solution required therefore again pump load increases or the increase in temperature of generator, the COP of the system decrease respectively. The minimum condenser temperature increases the refrigerating effect of the automobile air conditioning system.The review on the use of heat pipe for air conditioning applications shows that heat pipes are very efficient heat transfer devices which can be easily implemented as heat exchangers in air conditioning systems to ensure the energy saving and effective dehumidification. Thrust must be given on the heat pipe for air conditioning applications by modifying heat pipe parameters such as working fluid, wick structure and geometry.

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BIOGRAPHIES (Not Essential)

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