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Performance Analysis of Li-Br H_2O VAR System by Applying Magnetic Field to Liquid Line

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Abstract: Process of industries and automobile vehicles, there is usually a great amount of waste heat available at different temperatures and at the same time, there are cooling or refrigeration demands at different temperatures. In this work, a single effect vapour absorption refrigeration system is to be fabricated. And to perform the optimal matches between heat source temperatures and refrigeration levels of the vapour absorption refrigeration cycle are determined in terms of two indicators, coefficient of performance (COP) and efficiency of the cycle.

In this work the waste heat taken from the automobile exhaust gas and utilized to produce refrigeration effect by using vapour absorption refrigeration system. In automobile exhaust system using the exhaust waste heat of an internal combustion diesel engine as an heat source. Here the Absorber (lithium bromide) and refrigerant (water) used in getting required refrigeration effect. The refrigeration effect will be developed by using the energy available from the engine exhaust gas passed through the generator of the vapour absorption refrigeration system.

After that different pairs of magnets are placed in liquid line and find the performance characteristics of lithium bromide water vapour absorption refrigeration system. The COP was initially measured without application of magnetic field, and then magnetic field applied to liquid refrigerant was increased by increasing the number of the magnetic pairs from 1 to 3. Here we use Alnico rare earth magnets with magnetic strength of each magnetic pair was 650 gauss, and the obtained results are compared with above data.

The results shows that the theoretical COP of an VAR system is maximum for the system operated with two pairs of magnets.

Keywords: Fabrication of Vapour absorption Refrigeration System, VAR, LiBr-H_2O absorption refrigerator, waste heat VAR system.

I. INTRODUCTION

In the early years of the twentieth century, the vapour absorption cycle using water-ammonia systems was popular and widely used. After the development of the vapour compression cycle, the vapour absorption cycle lost much of its importance because of its low coefficient of performance(about one fifth of that of the vapour compression cycle). Today, the vapour absorption cycle is used mainly where fuel for heating is available but electricity is not, such as in recreational vehicles that carry LP gas. It is also used in industrial environments where plentiful waste heat overcomes it's inefficiency. The absorption cycle is similar to the compression cycle, except for the method of raising the pressure of the refrigerant vapour. In the absorption system, the compressor is replaced by an absorber which dissolves the refrigerant in a suitable liquid, a liquid pump which raises the pressure and a generator which, on heat addition, drives off the refrigerant vapour from the high-pressure liquid. Some work is needed by the liquid pump but, for a given quantity of refrigerant, it is much smaller than needed by the compressor in the vapour compression cycle. In an absorption refrigerator, a suitable combination of refrigerant and absorbent is used. The existing review works on heat transformers confirm that water-lithium bromide the most investigated couple for heat transformers. Despite that, they also report many studies researching alternative fluids, due to the high corrosiveness, viscosity and crystallization risk in some operating ranges of the water-lithium bromide pair. Improvements can be achieved by adding additives as ethylene glycol or using mixtures of various salts rather than (Li-Br) alone, but none of the proposed alternatives succeeded in solving all the drawbacks. Donellan et al. in particular express the view that research should investigate different and less corrosive working fluids to reduce size, weight and capital cost of the equipment. Initial cost that is one the main factors hindering heat transformers diffusion in industry.

Marcos, J. D et.al. , Absorption-based refrigeration systems, powered through solar energy, can be a perfect solution to this issue. Use of low-grade solar energy offers dual advantage of primary energy savings and reduced environmental menace. Such prospect has attracted significant volume of research on absorption systems, coupled with solar thermal collectors, working on either NH3–H2O or H2O–LiBr mixtures

Ganguly et al.,They are theoretically designed a stand-alone power system for H_2O–LiBr cooler of 1.75kW rating. Fifty-two PV modules in parallel, each having an area of 1.256 m^2, along with 1200 Ah storage battery were found to be sufficient to power the system satisfactorily over a complete calendar year.

Pongtorn kulpanicha et al., They developed an absorption chiller of 35kW capacity coupled with evacuated tube solar collector. About 19% of thermal energy requirement was found to be met through liquefied petroleum gas (LPG)-fired backup heating unit, which highlights the prime concern for solar thermal-based coolers. Proper thermal energy storage option must be provided to sustain operation beyond daytime, which is not economical at present.

Pandya et al.,They presented the integration of a storage tank and thermal solar collector, which feed the absorption refrigeration cycle working with LiBr–H_2O and LiCl–H_2O.

II. METHADOLOGY

When a solute such as lithium bromide salt is dissolved in a solvent such as water, the boiling point of the solvent (water) is elevated. On the other hand, if the temperature of the solution (solvent + solute) is held constant, then the effect of dissolving the solute is to reduce the vapour pressure of the solvent below that of the saturation pressure of pure solvent at that temperature. If the solute itself has some vapour pressure (i.e., volatile solute) then the total pressure exerted over the solution is the sum total of the partial pressures of solute and solvent.

If the solute is non-volatile (e.g. lithium bromide salt) or if the boiling point difference between the solution and solvent is large ($\geq$ 150^{O}C), then the total pressure exerted over the solution will be almost equal to the vapour pressure of the solvent only. In the simplest absorption refrigeration system, refrigeration is obtained by connecting two vessels, with one vessel containing pure solvent and the other containing a solution. Since the pressure is almost equal in both the vessels at equilibrium, the temperature of the solution will be higher than that of the pure solvent. This means that if the solution is at ambient temperature, then the pure solvent will be at a temperature lower than the ambient. Hence refrigeration effect is produced at the vessel containing pure solvent due to this temperature difference.

In this experiment the exhaust pipe of the engine is connected to the generator shell by using a pipe. Inside this generator shell a generator tank is placed. This generator tank is made up of copper. The generator tank is connected to the condenser.

The condenser is of air flow type condenser. The air is supplied by the fan which is powered by a motor. The condenser is connected to an expansion valve, this expansion valve is connected to evaporator by using copper wire and copper L-bend connectors. The evaporator is bent and wound in a spiral around an eternal sheet. The outlet of the eternal pipe is connected to the absorber tank. The absorber consists of 3 drilled holes.

Fig.1: Generator is connected to engine exhaust manifold pipe

One outlet of the absorber is connected to evaporator outlet, another is connected to a pump, and last outlet is connected to the generator which is connected to the heat exchanger. There is a pipe connecting the generator and pump. Generator second outlet pipe is connected to the heat exchanger which is in connection to a regulating valve which connects the absorber tank. This total equipment is fixed on a frame. A pipe is welded to the absorber for adding absorber.

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Absorber and the refrigerant is filled into the absorber tank in the ratio of 25%(refrigerant) and 75%(absorber). The engine exhaust pipe is mounted on the generator shell. When the engine is started and run for a while the hot exhaust gases of temperature above 150^0C enters the generator shell. The heat from the exhaust gases is absorbed by the generator tank. Inside the generator tank water which is the refrigerant absorbs this heat. The refrigerant evaporates and enters the condenser in the form of vapor.

Fig.2: Experimental setup on VAR system is connected to the diesel engine

This vapor condenses by using air from the fan. The heat removed by the fan from the refrigerant in the condenser. In the condenser the refrigerant changes its phase from vapor to liquid due to the heat lost in the condenser. The liquid refrigerant enters the expansion valve where the temperature and pressure reduces due to the narrow space of the copper pipe (capillary). This cold refrigerant enters the evaporator. This cold refrigerant absorbs the heat from the surroundings of the evaporator creating a cooling effect. This heat absorbed refrigerant then flows into the absorber tank and mixes with lithium bromide forming a weak solution. This weak solution is pumped to the generator tank while passing through a heat exchanger. Simultaneously the lithium bromide separates and falls down into the heat exchanger where it exchanges it's heat with the weak solution and falls down into the absorber tank whereas the water vapor to the condenser there by starting the cycle again. The exhaust gases exchanges its heat given to the generator tank and passed away to the atmosphere.

III.EXPERIMENTAL CALCULATIONS

A. Calculations for 25%Li Br 75% H_2O

1) Heat Rejection from Condenser (Q_r)

Condenser temperature at the inlet (T_1) = 41+273 =314 K
Condenser temperature at the outlet (T_2) = 30.5+273 = 303.5 K
Mass flow rate of air (m) = 1.2 Kg/min
Specific heat of air (C_p) = 1.005 Kj/Kg-k

$$Q_R = m \times C_p \times (T_1 - T_2)$$
$$= 1.2 \times 1.005 \times (314 - 303.5)$$
$$= 12.663 \text{ KW}$$

2) Heat Extract from Evaporator (Q_e)

Evaporator temperature at the inlet (T_2) =16.2+273 =289.2 K
Evaporator temperature at the outlet (T_1) = 21.1+273 =294.1 K
Mass flow rate of refrigerant (Water) (m) = 1.2Kg/min
Specific heat of refrigerant (Water) (C_p) = 4.187 kJ/Kg-k

$$Q_E = m \times C_p \times (T_1 - T_2)$$
$$=1.2 \times 4.187 \times (294.1 - 289.2)$$
$$=24.61 \text{ KW}$$

3) Heat given to Generator (Q_g)

Generator temperature at the inlet (T_2) =118+273 =391k
Generator temperature at the outlet (T_1) = 87.8+273 =360.8 k
Mass flow rate of exhaust gases (m) = 1.2Kg
Specific heat of exhaust gases (C_p) = 1.063 Kj/Kg-k

$$Q_G = m \times C_p \times (T_2 - T_1)$$
$$= 1.2 \times 1.063 \times (391 - 360.8)$$
$$= 36.45 \text{ KW}$$

4) Coefficient of Performance (COP) Actual

$$(COP)\ actual = \frac{\text{Amount of heat extracted from the evaporator}}{\text{Amount of heat given to the generator}}$$
$$= \frac{24.61}{36.45} = 0.675$$

5) Maximum Coefficient of Performance (COP)

$$COP = \frac{Te}{(Tc - Te)} \times \frac{(Tg - Tc)}{Tg}$$

Temperature at evaporator Te =16.2 ^{0}C+273=289.2k
Temperature at condenser Tc =41^{0}C+273=314k
Temperature at generator Tg = 118 ^{0}C+273=393k

$$COP = \frac{Te}{(Tc - Te)} \times \frac{(Tg - Tc)}{Tg}$$
$$= \frac{289.2}{(314 - 289.2)} \times \frac{(393 - 314)}{393}$$
$$COP = 2.344$$

6) Observation and Result of VAR System

Table 1: Experimental observation for VAR System with 25%Li-Br 75% H_2O, Using Water (Refrigerant) and Lithium Bromide (Absorber) is Working Fluid

S. NO	Mixture	Volume in liters	T_g (°C)	T_e (°C)	T_c (°C)	Q_e (kW)	Q_g (kW)	COP
1	25% of lithium bromide and 75% of water	1.5	118	16.2	41	24.61	36.45	0.675

The reading as in above the tabular form is taken from the performance and experimental values of the vapour absorber refrigeration. And observe the COP of the vapour absorption refrigeration(VAR) system by using a working fluid as water and lithium bromide.

IV. RESULTS AND DISCUSSIONS

The results obtained from the absorption refrigeration system using the engine exhaust gas as energy source and widely varying engine speed. The refrigerator average internal temperature at the engine operational conditions. In the first 30–45 min it is observed that the average refrigerator temperature increases with time.

The distinct behaviours of the absorption refrigeration cycle as a function of its generator temperature. when the heat input is too low (t_g=100^{o}C) the evaporator is not effectively cooled and the temperature inside the refrigerator is lowered by only approximately 20^{o}C. At 120^{o}C, rapid cooling is achieved at first, but after the temperature reaches approximately a 15^{o}C minimum, a continuous increase is then observed for 180^{o}C, no refrigeration actually occurs due to the overheating of the water and lithium bromide or ammonia and water solution. for t_g=120^{o}C the temperature initially drops because the water and lithium bromide or ammonia and water solution going through the generator is not yet overheated at the start of the process.

When the water and lithium bromide or ammonia and water solution eventually becomes overheated at the generator (which happens for t_g =120^{o}C after 4 min and for t_g=180^{o}C from the start), the refrigerant is not condensed at the condenser of the absorption cycle and is unable to extract heat from the evaporator. The only condition which produced a steady decrease in temperature throughout the entire duration of the experiments was t_g=110^{o}C.

The results agree with the predictions of previous works, which stated that excessive exhaust gas heat (produced by high engine speeds/torque) lead to poor refrigeration performance justifying the implementation of the control scheme proposed in the present study.

The experiments whose results are present in process will be recorded in the experimental table. Were such the extended periods of time because their objective is to determine the reference values for the generator temperature which was capable of causing the refrigerator to cooling efficiently.

V. CONCLUSION

A. Performance of vapour absorption system using exhaust waste energy from diesel engine has been carried out in this experiment. It is marked that COP strongly depends on working conditions such as generator, absorber, condenser and evaporating temperature.

B. The vapour absorption automobile air conditioner is an economically attractive concept for utilizing exhaust waste heat because most of the energy input comes from the heat available in the exhaust gases, with only small electric power used to operate the pump.

C. For 25% Li-Br 75%H_2O the theoretical efficiency of an vapour absorption refrigeration system is 0.675 and it is 0.609 for 30% Li-Br 80%H_2O, from this we conclude that VAR with 25% Li-Br 75%H_2O gives the best efficiency

D. In the second stage tests were conducted with the 25% Li-Br 75%H_2O and Magnets are connected in liquid line of the refrigerator, here we use anlico (Aluminium Nickel Cobalt alloy) magnets are used for the experimental study.

E. The COP of an Li-Br H_2O vapour absorption refrigeration system is 0.872 for 25% Li-Br 75%H_2O with one pair of magnet, 1.2 with two pairs of magnets and 1.01 for three pairs of magnets. So the maximum COP is 1.2 obtained for 25% Li-Br 75%H_2O with two pairs of magnetic pairs.

F. The engine exhaust gas was confirmed as a potential power source for absorption automobile air conditioner system. In other words, the absorption refrigeration system may be able to take advantage of the exhaust gas power availability and provide the cooling capacity required for automotive air conditioning.

G. Water and lithium bromide, should be considered as a viable alternative to mechanical vapour compression cycle. Appreciable cooling load reduction can be realized by modification on the automobile body and the door and windows design.

H. With flexibility in operation, absence of compressor noise, very low maintenance and high reliability. The waste heat energy available in exhaust gas is directly proportional to the engine speed and exhaust gas flow rates.

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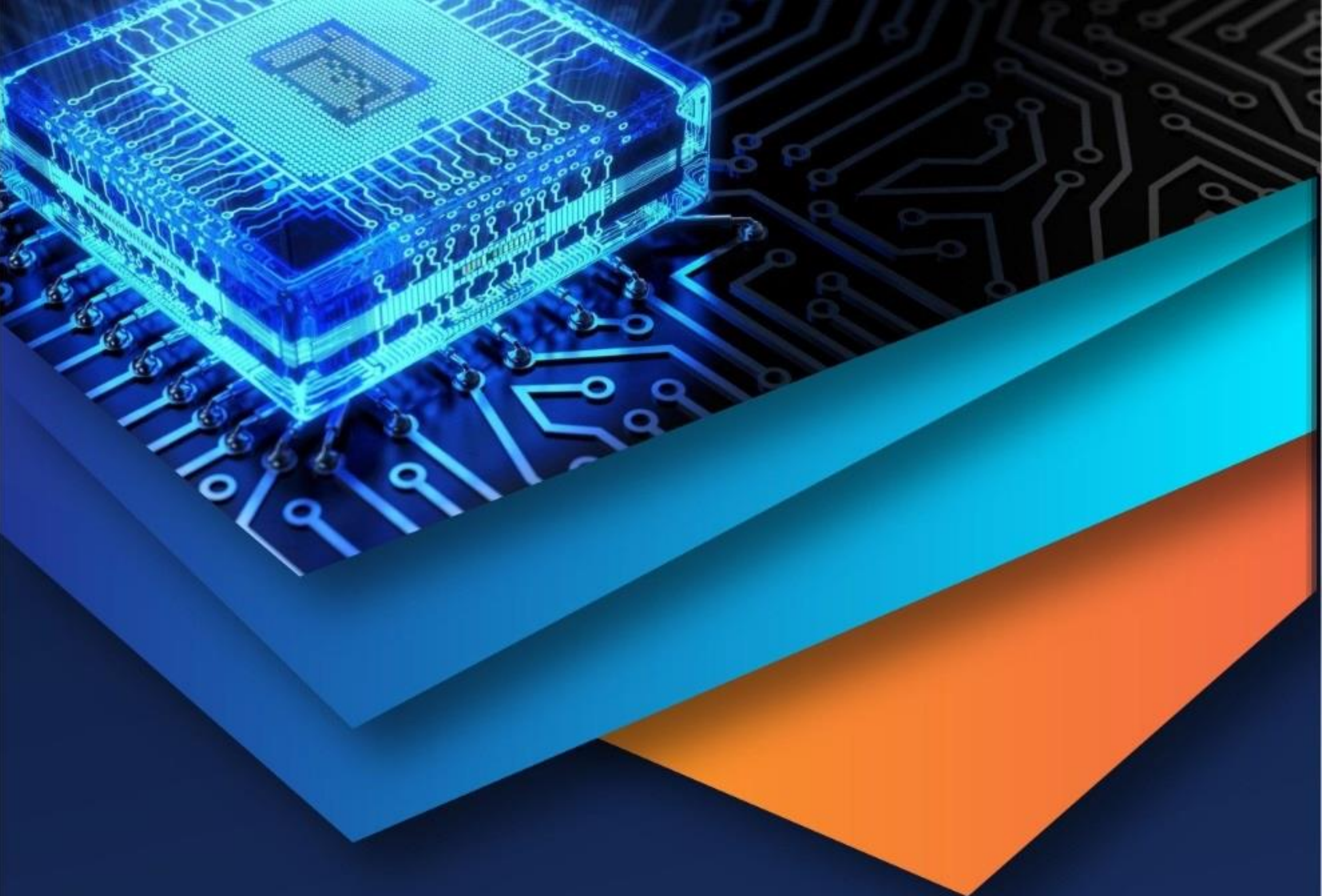

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