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Comparison of the Performances of NH_3-H_20 and Libr-H_2O Vapour Absorption Refrigeration Cycles

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ABSTRACT

Developments in absorption cooling technology present an opportunity to achieve significant improvements on micro-scale to buildings, cooling, heating and power systems for residential and light commercial buildings. Their resultant effects are effective, energy efficient and economical. This study therefore contributes an important knowledge and method in the development, fabrication and application of an absorption refrigerator as a better alternative to the commonly used compressor refrigerators. Two fluid gas absorption refrigerators use electric based heater installed generator and no moving parts, such as pumps and compressors, and operate at a single system pressure. In this paper the performances analysis of the NH_3-H_2O and possible alternative cycles as lithium bromide-water are compared in respect of the (COP) and different operating conditioning. The highest COP was found as a function of the absorber, generator, condenser, and evaporating temperature. This paper compares the performance of vapour absorption refrigeration cycles that are used for refrigeration temperatures below 0°C. Since the most common vapour absorption refrigeration systems use ammonia-water solution with ammonia as the refrigerant and water as the absorbent, research has been devoted to improvement of the performance of ammonia-water absorption refrigeration systems in recent years.

Keywords: Absorption refrigeration, coefficient of performance, NH_3-H_20, Libr-H_20, VARS.

I. INTRODUCTION

Currently widespread efforts are underway to utilize available energy resources efficiently by minimizing waste energy and develop replacements for the traditionally refrigerants (HCFCs and CFCs), which contribute to ozone depletion and greenhouse warming. The NH_3-H_2O mixture is environmental friendly, which is the only working pair currently used for refrigeration purposes in absorption systems, and despite of the new mixtures under investigation, the ammonia- Water mixture is the only one with a clear future [1]. The principle of the absorption is providing the necessary pressure difference between the Vaporizing and condensing processes, which alternately condenses under high pressure in the condenser by rejecting heat to the environment and vaporizes under low pressure in the evaporator by absorbing heat from the medium being cooled operating. Refrigeration has become an essential

Part of the way we live our life. Almost everyone has a household refrigerator, but not many know of the process required to produce the drop in temperature that we know as refrigeration. Nature works much like a heat engine, heat flows from high temperature elements to low temperature elements. As it does this, work is also done to its environment. The refrigeration process is, in essence then, a reverse heat engine; where heat is taken from a cold element to be transferred to a warmer element, generally by adding work to the system. In a heat engine, work was done by the system; so in order to do the reverse; work must be done to the system.This work input is traditionally mechanical work, but it can also be driven by magnetism, lasers, acoustics, and other means. Several different types of refrigeration systems which utilize different work input were considered for this work.

They are: the vapour-compression system, and the absorption refrigeration system. In recent developments of thermal engineering the Refrigeration technologies play an important role in today's industrial applications [2].But as far as COP of this refrigeration system is concerned, it is always a challenge to the researchers to significantly increase the COP for these systems. The most popular refrigeration and air conditioning systems at present are those based on the vapour absorption systems. These systems are popular because they are reliable, relatively inexpensive and their technology is well established.

The natural alternative is of course the absorption system, which mainly uses heat energy for its operation. Moreover, the working fluids of these systems are environment friendly [3]. The cycle efficiency and operation characteristics of an absorption refrigeration system depend on the properties of refrigerant, absorbent and their mixtures.

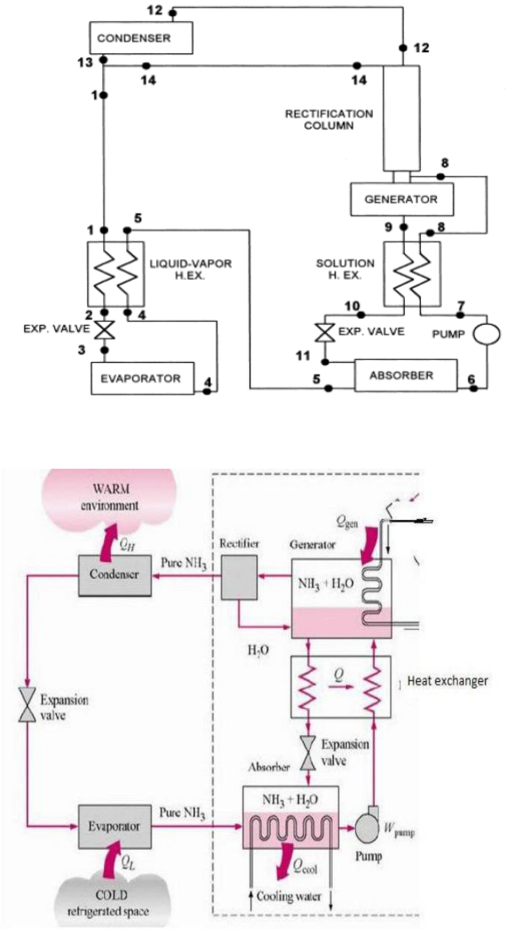

Fig.1. Vapour Absorption Air Conditioning System (NH_3-H_2O)

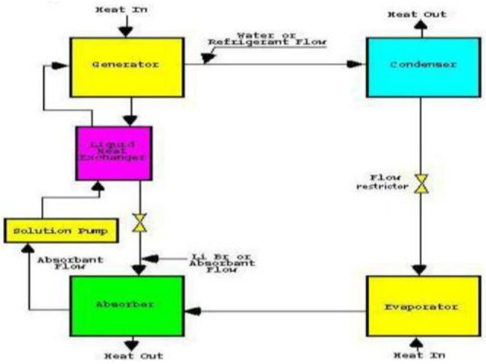

Fig.2. Vapour Absorption Air Conditioning System (LiBr-H_2O)

II. LITERATURE REVIEW

Ref. [1] Nairn discovered Absorption refrigeration in 1777, though in 1823 by Ferdinand Carré the firstcommercial refrigerator was only built and patented and between 1859 and 1862that also got lots of patents from introduction of a machine which is operating on ammonia–water.

Ref. [2]SohailCux, A.c. Tiwari (6) works on the topic of natural refrigerants based automobile air conditioningsystem and presented and published on international journal of emerging science and engineering 7, may 2014 and conclude that the crystallization occurs in lithium bromide –water ,lithium chloride –water absorption refrigeration system and toxic properties of ammonia.

Ref. [3] H.H.Masjuki, M.A.Kalam, M.A.Hazrat (5) worked on the topic of liquid absorption and solid absorption system for household, industrial and automobile applications and published paper on science-direct and conclude that liquid absorption is more common in household and industry applications, while solid absorption systems are suitable for moving automobiles, owing to the limitations of liquid handling, with the recycling of waste heat and the utilization of clean solar energy.

Ref. [4]Khaled S. Alqdah (3) worked on the topic of performance and evaluation of water- ammonia auto air conditioner system using exhaust waste heat and published on paper in science-direct and also conclude that the water-ammonia vapour absorption automobile air conditioner is an economical and friendly concept for utilizing exhaust waste heat, because most of the heat input comes from the exhaust gases, only with small electric power required to operate the pump.

Ref. [5]S.Lakshmi Sowjanya (4) worked on the topic of Thermal analysis of air conditioning system based on an vapour absorption refrigeration cycle using energy from exhaust gas of an internal combustion engine and published the paper in an international journal - advanced engineering and applied sciences and concluded that by observing the analysis results, thermal flux is more for aluminium alloys 204 than copper.

III. REFRIGERANT-ABSORBENT COMBINATIONS FOR VAPOUR ABSORPTION REFRIGERATION SYSTEM (VARS)

VARS are commercially available today basically in two configurations. For applications above 50ºC (primarily air-conditioning) the cycle uses LiBr/H_2O. For applications below 50ºC, ammonia/water cycle, is employed withNH_3 as the refrigerant and H_2O as the absorbent.

3.1 Desirable Properties of Refrigerant Absorbent Mixture

Refrigerant-absorbent mixtures for VARS should possess some desirable properties of the refrigerant should be more volatile than the absorbent, in other words the boiling point of refrigerant should be much lower than the absorbent), so that the solution in the Generator need only to be heated to the temperature required boiling off only the refrigerant. This ensures that only refrigerant (pure) circulates through refrigerant circuit (evaporator-condenser-expansion valve). The refrigerant should exhibit high solubility with solution in the absorber. The absorbent should have a strong affinity for the refrigerant. This will minimize the amount of refrigerant to be circulated. Operating pressures should be preferably low so that the walls of the shells and connecting pipes need not to be thick. It should not undergo crystallization or solidification of the system. Because crystallization will block the free flow of solution in the line. The mixture should be safe, chemically stable, noncorrosive, and inexpensive and should be available easily. The refrigerant should have high heat of vaporization [12], [13].

3.2 Water-Lithium Bromide (H2O-LiBr) System

For moderate temperatures (50ºC and above) applications specifically air conditioning. Here H_2O is the refrigerant and LiBr is the absorbent.

3.3 Ammonia-Water (NH3-H2O) System

For low temperature (less than 50^{o}C) refrigeration applicationswith NH_3 as refrigerant and H_2O as absorbent. The Lithium Bromide-Water pair satisfies majority of the above-listed properties. For these reasons Li-Br and Water systems are becoming more popular. Comparison of Lithium Bromide-Water system and Ammonia-Water System

IV. SYSTEM ANALYSIS

The thermodynamic properties of each state in the cycle, the amount of heat transfer in each component and flow rates depends on the following input parameters:

(a) Generator temperature T_g (^{0}C),
(b)Evaporator temperature T_e (^{0}C),
(c)Condenser temperature T_c (^{0}C),
(d)Absorber temperature T_a (^{0}C),
(e)Refrigeration load Q_e (kW)

The above set can be determined from the actual running measurements. Here pressure drop in components are neglected. The theoretical COP of Vapour Absorption Refrigeration System is the above set can be determined from the actual running measurements. Here pressure drop in components are neglected. The theoretical COP of Vapour Absorption Refrigeration System is as follows,

Theoretical COP = T_g-T_c/T_g x T_e/T_c-T_e

The basic equation to calculate the hot gas stream is calculated by,

$Q_g= m\ C_p\ \Delta T.$

For a given speed, computer program calculates the exhaust mass flow and temperature,

$Q_{ex}= m \text{ x } C_p \text{ x } (T_{out}-T_{in,ex}) \text{ x } 0.97$

Where, m is mass flow rate kg/sec., C_p is average specific heat. T_{in} is the inlet gas temperature to the heat exchanger, T_{out} is the outlet gas temperature to the heat exchanger, 0.97 is the transmission loss. Charge air due to cooling incorporated in the system. Therefore the energy transfer from the charge air is,

$Q_{ip} = m \text{ x } C_p \text{ x } (T_o-T_i)$

V. EXPERIMENTAL SECTION

A vapour absorption refrigeration system was studied using the electric generator. Humidity and temperature inside the refrigerator were measured by using thermocouple. All the system are connected through the electric supply based on the electric based generator we made the vapour absorption refrigeration system and finally by using water-ammonia concentration as a refrigerant and calculated COP of that system. System is shown in fig.2 and related result is taken out in result table. Now planning is that the same system wants to run by using exhausts gas by heat recovery to replacing the electric generator to the exhaust based generator and finding the same COP. For that we have to design all the components'based on the exhaust gas as the source of energy. Source of energy in this project is multi-cylinder C.I Engine. Two thermocouples were installed in the refrigeration system for the measurement of the exhaust gas temperature. For the measurement of temperature and ambient pressure a liquid- in-bulb thermometer and a barometer were used. For the tests of four-cylinder automotive multi-cylinder C.I engine with multipoint electronic fuel injection was used. Based on the exhaust gas temperature and engine also featured, the enthalpy was taken from thermodynamic tables.

Fig.3. Experimental setup

VI. OBSERVATION TABLES

TABLE I. Observation Table of Nh_3-H_2o

Sr no.	Mixture		VL	TG ^{0}C
1	NH_3 5%	& H_2O 95%	3	45
2	NH_3 5%	& H_2O 95%	6	55
3	NH_3 5%	& H_2O 95%	9	65
4	NH_3 10% & H_2O 90%		3	55
5	NH_3 10% & H_2O 90%		6	65
6	$NH_3$10 %	& H_2O 90%	9	45
7	$NH_3$15 %	& H_2O 85%	3	65
8	$NH_3$15 %	& H_2O 85%	6	45
9	$NH_3$15 %	& H_2O 85%	9	55

TABLE II. Observation Table of Libr-H_2o

Sr. no	Mixture		V	TG
1	LiBr 5%	& H_2O 95%	3 L	75
2	LiBr 5%	& H_2O 95%	6 L	85
3	LiBr 5%	& H_2O 95%	9 L	95
4	LiBr 10% & H_2O 90%		3 L	85
5	LiBr 10% & H_2O 90%		6 L	95
6	LiBr10%	& H_2O 90%	9 L	75
7	LiBr15%	& H_2O 85%	3 L	95
8	LiBr15%	& H_2O 85%	6 L	75
9	LiBr15%	& H_2O 85%	9 L	85

VII. CALCULATIONS & RESULT

Calculation Related To Electric Based Generator VARS

COP= $[T_e/T_g]\ [(T_g-T_O)/\Delta T]$

1. Water = 90% and ammonia=10%,
Te=26ºC,
COP = [26/80] [(80-34)/8]=0.6
2. Water=80% and ammonia=20%,
Te=24ºC,
COP = [24/80[(80-34)/10] =0.76
3. Water=70% and ammonia=30%,
Te=22ºC,
COP = [22/80][(80-34)/12]=0.8

TABLE III. Result Table Of Electric Based Generator Vars

Concentration		Evaporator Temp	Generator Temp	Surr. Temp	Temp Diff.	COP
H_2O	NH_3					
90%	10%	26	80	34	8	0.6
80%	20%	24	80	34	10	0.76
70%	30%	22	80	34	12	0.82

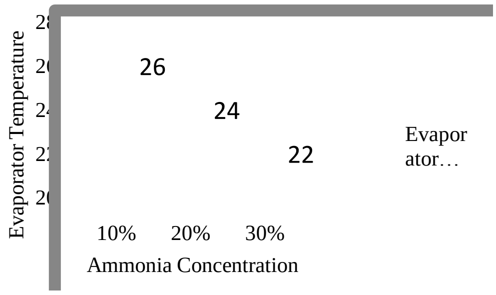

Fig.4. The effect of evaporator temperature with NH_3 concentration

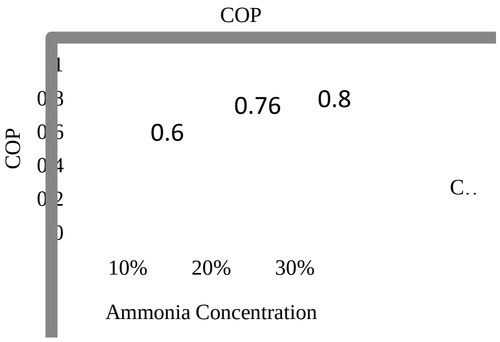

Fig.5. The effect of COP with NH_3 concentration

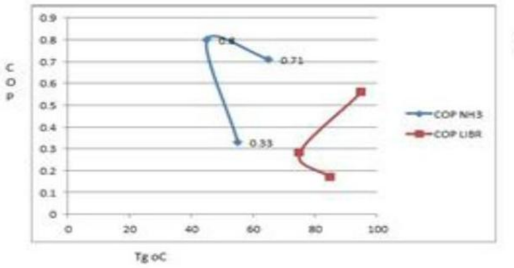

Fig.6. The effect of Generator temp on the COP

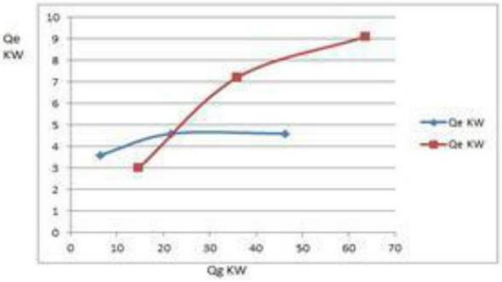

Fig.7. The effect of Generator heat on the Evaporator Heat

VIII. CONCLUSIONS

In this paper we observed an Electric based VARS and finding the COP for mixture of lithium bromide –water and ammonia-water. The same COP can we get by using exhaust gas as a source of energy and it is observed that COP depends on the working conditions such as, condenser, absorber, evaporating temperature, and generator. The water-ammonia vapour absorption automobile air conditioner is suitable and an economically best concept for utilizing exhaust waste heat, because most of the energy input comes from exhaust gases, only to operate the pump very small electric power used. The engine exhaust gas is confirmed as a potential power source for VARS automobile air conditioner system. When the absorption refrigeration system will be installed in the exhaust gas overall, carbon monoxide emissions will decrease. Since, the absorption cycle has the economic advantages of having few high precision components, therefore reduces manufacturing costs. Available in exhaust gas the waste heat energy is directly proportional to speed of the engine and exhaust gas flow rates. The results is shown in the graph is related to the electric based vapour absorption refrigeration system. The same results are expected in the exhaust heat recovery based VARS system. COP of the system varies from 0.3-0.8.

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