International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 6, Nov-Dec--2021, ISSN (Online): 2395-566X

A Review on Thermal Performance Analysis of Single Effect Vapour Absorption System

M. Tech. Scholar Sanjay Sharma, Prof. Deenoo Pawar
Department of Mechanical Engineering,
LNCT, Bhopal,MP,India

Abstract- Cooling and refrigeration demand accounts for a significant portion of global energy consumption. Alternative cooling systems, including absorption and adsorption cooling systems, received more attention than before because mechanical vapour compression systems demand high-grade energy to operate. Conventional cooling methods outperform absorption and adsorption cooling systems it terms of overall performance. Today's world is confronted with two major environmental issues. The energy problem and the greenhouse impact are indeed the two issues at hand. Scientists were attempting to find a solution to this issue. That fact underpins the majority of today's inventions. The lithium-bromide and water-driven absorption refrigeration cycle is indeed an excellent illustration of just this idea since it often reduces fossil fuel use and hence CO2 emissions. Still, it also makes use of the low-grade heat of various businesses and data centers. Accordingly, in this paper, a review on thermal performance analysis of single effect vapour absorption system has been done.

Keywords- Thermal performance, single effect vapour absorption system, lithium-bromide.

I. INTRODUCTION

An absorbent refrigerant combination will be used as the principal working pair inside of an absorption refrigerator that is a chemically powered refrigeration device. In the case of a LiBr+water combination, the LiBr solution acts as an absorbent, while the water acts as both a refrigerant.

The following are the essential features that make this combination useful as both a working pair [2]:

- The refrigerant must be more volatile than the absorbent, i.e., the refrigerant's boiling point ought to be lower than just the absorbent's. This characteristic was easily followed by the working pair LiBr+water.
- Their boiling temperatures may range significantly, making it easier to separate them with in generator. This guarantees that perhaps the refrigerant circuit is filled with pure refrigerant (condenser, expansion valve and evaporator). This pair also follows that characteristic since LiBr solution does have a considerably greater boiling point that refrigerant water.
- The refrigerant water seems to have a significant affinity again for LiBr solution.
- LiBr+water is a low-cost, environmentally friendly, & non-toxic solution.

This working pair seems to be more user-friendly and environmentally beneficial to utilise inside the absorption refrigeration cycle because of the aforementioned qualities. However, there are many limiting factors that must be considered carefully when utilizing this pair, otherwise it will result in a larger difficulty [5].
The following are some of them: Because the working absorbent is an electrolyte solid on solution form, a greater concentration can cause crystal formation, that can clog the pipes, therefore a high pressure in the condenser or generator are required to prevent crystal there at working temperatures. To solve the problem, anti-crystallizers are utilized [4]

- Since the refrigerant utilised here seems to be water, a vacuum condition in the evaporator was required to decrease its boiling point of water. Maintaining this vacuum is indeed a significant task.
- Corrosion is another major issue. These systems are susceptible to metallic corrosion because water contains dissolved oxygen. This may be avoided by constructing the system using anti-corrosive materials.

II. LIBR + WATER BASED ABSORPTION REFRIGERATION SYSTEM

In around 1930s, LiBr + Water were first used in an absorption refrigeration system. The non-volatility of both the absorbent, LiBr, is amongst the most notable properties of a LiBr+water system. The usage of such a rectifier, like in the Ammonia+ water-based absorption refrigeration system, is really no longer necessary.

Another advantage seems to be the high heat of vaporisation of the refrigerant, which in this case was water. However, using water as such a refrigerant limits its usage in low-temperature applications.These refrigeration systems has a greater COP than ammonia + water-based refrigeration systems.
In the LiBr + Water system, the thermodynamic analysis entails determining key parameters such as enthalpy, mass

flow rates, coefficient of performance (COP), heat and mass transfer, and crystallisation.

These assumptions are used in the thermodynamic analysis:

- Steady state and steady flow
- No pressure drops due to friction
- Pure refrigerant comes out from the generator through the refrigerator circuit in form of vapour.

For the vapour absorption cycle, refrigerant absorbent systems should have some desirable features.

The please find below the details:

- The refrigerant should be much more volatile than just the absorbent, i.e., the refrigerant's boiling point ought to be lower than just the absorbent's.
- There should be a substantial difference in both boiling points so that they'll be separated inside the generator. This guarantees that now the refrigerant circuit is filled with pure refrigerant. (condenser, expansion valve and evaporator)
- The refrigerant must be highly soluble in the absorbent's solution, and the absorbent must have a strong affinity for such refrigerant; this one will reduce the amount of refrigerant that must be circulated.
- The operating pressure should have been low, therefore the pipe walls do not need to be thick.
- It does not crystallise since it will clog the pipes and cause flowrates to vary.
- The combination must be chemically stable, safe, and affordable.

Fig.1.1 The working concept of the vapour-absorption refrigeration cycle is presented. Rather than a compressor, the vapour absorption refrigerator has an absorber and a generator, as even the name suggests (which is an integral part in vapour compression system).

The following are the various components of a vapour absorption refrigerator:-

- Evaporator
- Absorber
- Generator
- Condenser

The evaporator receives water at such a low temperature and pressure. Water is really in a vapour-liquid form here. The water refrigerant absorbs heat from of the cooled material then evaporates completely. Due to a high boiling point of the refrigerant, the operation is carried out under low pressure or near vacuum. This low pressure or vacuum situation aids in lowering the refrigerant's boiling point temperature.
The water refrigerant may vaporise at 3-4 ° C. The water vapour would then be injected into the absorber portion at a steady pressure. In the absorber, there seems to be a concentrated LiBr solution. Water vapour was absorbed that through this concentrated solution, diluting it, because water has extremely soluble in LiBr solution.

At about this point, it can be claimed that now the chemical absorption saves the electricity consumed by the compressor, making the system more energy efficient and environmentally beneficial. A pump transports a dilute solution of LiBr+water from in this absorber towards the generator. The generator seems to be the part that separates the refrigerant and absorbent.

Heat is applied towards the solution here. This heat is typically waste heat from data centres, steam power plants, hotels, or large residential buildings. The dilute LiBr+water solution becomes concentrated again and goes to the absorber as water vaporises from the solution & moves towards the condenser. The water vapour then condensed into liquid water using a condenser block.

This could be accomplished simply circulating conventional cooling water or air. In most cases, a valve is utilised to lower the evaporator's necessary pressure.

The lithium bromide/water absorption method has gained popularity in refrigerated air conditioning throughout recent times.

It does have a number of advantages over the other types of absorption systems, including: At same cycle temperatures, it will have the highest capacity factor (COP) when compared to other single-stage absorption units.

It really is comparable to simplifyr components even though it is capable of working even without rectification columns. According to the nonvolatility of the absorbent (LiBr), a simple generator was adequate, enabling just water vapour to be pushed off the generator.

Resulting from the operation at vacuum pressures, less pump effort is required compared to comparable units. The lithium bromide/water absorption method, but at the other hand, does have certain disadvantages, including: Because the refrigerant contains water, it is confined to a rather high evaporation temperature. That indicates that an evaporation temperature over 00C was required in most cases to prevent freezing.

At moderate concentrations (>0.65 kg LiBr/kg solution), crystallisation of LiBr salt will tip beyond cycle range of operation.

Because they function at vacuum pressures, these systems must be constructed as hermetically sealed units. If there was a leak of air into in the system, this would result in inappropriate operation.

Despite its disadvantages, the LiBr/water unit has still been regarded the most cost-effective for this type of refrigeration.

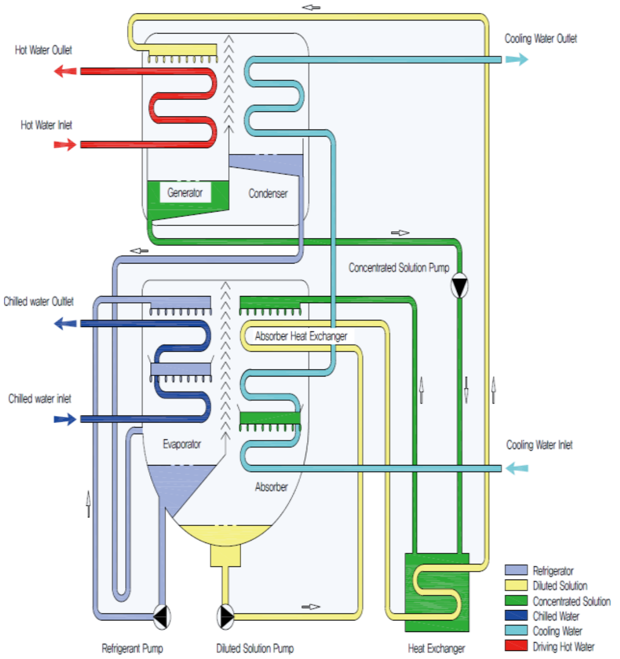

Fig 1. Vapour absorption refrigeration system. [3]

The computer modelling of these kinds of units is described and analysed in this work. The modelling technique has been expanded to allow individuals involved with the usage or assessment of cycles that use this material to save time and effort on calculations. Due to India's tropical climate, the majority of refrigeration and HVAC applications include cooling of air, water, various fluids, or goods.

Inside the northern regions of the nation and at high elevations, heating is still only needed for a brief period with in winter.

In many manufacturing businesses, refrigeration & air conditioning account for a considerable part of energy usage "(like chemicals, pharmaceuticals, dairy, food etc.), agricultural & horticultural sectors (mainly cold stores) and commercial buildings (like hotels, hospitals, offices, airport, theatres, auditoria, multiplexes, data processing centers, telecom switching exchanges, etc.)" Refrigeration and air conditioning, as well as air conditioning systems, are used to cool a wide range of applications, utilising either conventional or custom-made equipment.

Process cooling with chilled water or brine, ice plants, cold stores, freeze drying, and air conditioning systems are one of the most common uses.

III. PAST STUDIES

Altunet al. (2020) The TRNSYS programme was used to model a solar-powered absorption cooling system. The system's performance was evaluated utilizing dynamic modelling in Mugla, Trabzon, Izmir, Konya, Canakkale, and Istanbul. To obtain more realistic results, the absorption chiller model's external catalogue data file was produced.

Jainet al. (2020) based on to its thermo-economic viability, developed a unique structure of Trans critical vapour compression-absorption integrated refrigeration system (TVCAIRS). In the suggested design, a 5 °C sub cooling is achieved by combining a single effect vapour absorption refrigeration system (VARS) (with H2O-LiBr fluid couple) with a Tran's critical vapour compression refrigeration system (TVCRS) (with R744 refrigerant). As a result, the total COP and exergetic efficiency of TVCAIRS are 28.6% and 26.9% higher, respectively, than just a standalone TVCRS with optimal gas cooler pressure & generator temperature. Furthermore, the TVCAIRS requires 12.3% less external cooling water for such gas cooler, absorber, and condenser cooling than that of the corresponding TVCRS.

Merajet al. (2020) Interconnected N number of totally covered semi-transparent photovoltaic thermal integrated concentrator collectors with single effect vapour absorption refrigeration system were explored. The suggested system was investigated using a constant mass flow rate of collecting fluid. The temperature of the absorption unit's generator also has been calculated using mathematical formulas as a function of the both design and operational factors.

Jonathan et al. (2020) Water vapour was separated from an aqueous LiBr solution using a hydrophobic membrane desorber. The H2O/LiBr solution and cooling water temperatures was studied and evaluated as influencing factors. A solar collector system is modelled on a bigger scale using the experimental data, using a 1 m2 membrane.

Kanti et al. (2020) for the operation of a cold storage facility, a single-effect or a double vapour absorption system were compared in terms of performance. A grid-interactive solar photovoltaic system and parabolic trough collectors are used to power the planned cold storage. First and second laws of thermodynamics are used to create a thermal model of VAR systems.

Venkataramanet al. (2020) presented a current overview of heat-driven absorption refrigeration/air-conditioning systems designed particularly for transportation applications. The debate then moves on to the key obstacles of adopting one such technology in the transportation sector, the manner in which that technology may be further improved, "or why heat-driven refrigeration/air conditioning systems might be a game changer in the automotive industry.

Alhamidet al. (2020) At the University of Indonesia in Depok, Indonesia, a solar-gas powered absorption cooling system was constructed and tested in a real setting. The university's Mechanical Research Center building receives chilled water from the cooling system. A single/double-effect water/Lithium Bromide absorption chiller with a nominal cooling capacity of 239 kW is used in the same system. The system also includes evacuated tube solar collectors (with a total aperture area of 181 m2) and fan coil units placed inside the building.

Liuet al. (2020) to fully use low-grade waste heat, a LiBr/H2O absorption chiller and a Kalina integrated in cascade were described. The influence of major operating factors such as turbine-inlet pressure, turbine-outlet pressure, ammonia concentration, segment temperature, and refrigeration temperature was investigated using a parametric approach. In respect of turbine-outlet pressure & net power generation, the linked system is compared to a Kalina cycle without an absorption chiller. Furthermore, the temperature-entropy diagram depicts the comparisons between two systems.

Azhar et al. (2019) Provided exergy studies of single to triple impact direct and indirect fired vapour absorption systems based on lithium bromide and water. The results of many investigators' investigations just on exergy of absorption cycles have already been addressed. Optimization for single to triple impact direct and indirect fired absorption cycles has been done over a wide variety of operating circumstances to bridge the knowledge gap on exergy destruction rate with in absorption system.As a result, ideal parameters for maximum exergy coefficient of performance and minimal exergy destruction rate within different components of both the systems have already been established.

IV. CONCLUSION

The growth of CO_2 concentration in atmosphere and environment toxicity are prominently disused these days worldwide. The increment in continuous demand of refrigeration and air-conditioning with load on power generation are responsible for the ozone depletion and as well as for carbon emission.Fossil fuels are on the verge of depletion, and the world energy consumption is in constant progression, resulting in veryserious concerns about environmental issues.

Mechanical refrigeration based on vapor compression principle uses high gradeelectrical energy, and refrigerant fluid with a global worming and ozone depletion potentials.Absorption machines using solarthermal energy are excellent alternatives to mechanical refrigeration. Absorption cooling systems are mature technologies thatproved their abilities to provide clean cooling with the use of low grade solar and waste heat.

REFERENCES

[1] Altun, A. F., and M. Kilic. "Economic feasibility analysis with the parametric dynamic simulation of a single effect solar absorption cooling system for various climatic regions in Turkey." Renewable Energy 152 (2020): 75-93.

[2] Altun, A. F., and M. Kilic. "Economic feasibility analysis with the parametric dynamic simulation of a single effect solar absorption cooling system for various climatic regions in Turkey." Renewable Energy 152 (2020): 75-93.

[3] Jain, Vaibhav, and D. Colorado. "Thermo-economic and feasibility analysis of novel transcriticalvapor compression-absorption integrated refrigeration system." Energy Conversion and Management 224 (2020): 113344.

[4] Meraj, Md, M. E. Khan, and MdAzhar. "Performance Analyses of Photovoltaic Thermal Integrated Concentrator Collector Combined With Single Effect Absorption Cooling Cycle: Constant Flow Rate Mode." Journal of Energy Resources Technology (2020): 1-28.

[5] Ibarra-Bahena, Jonathan, Eduardo Venegas-Reyes, Yuridiana R. Galindo-Luna, Wilfrido Rivera, Rosenberg J. Romero, Antonio Rodríguez-Martínez, and Ulises Dehesa-Carrasco. "Feasibility analysis of a membrane desorber powered by thermal solar energy for absorption cooling systems." Applied Sciences 10, no. 3 (2020): 1110.

[6] De, Ramen Kanti, and AritraGanguly. "Performance comparison of solar-driven single and double-effect LiBr-water vapor absorption system based cold storage." Thermal Science and Engineering Progress 17 (2020): 100488.

[7] Venkataraman, Vikrant, Ahmad El-Kharouf, Bhargav Pandya, ErideiAmakiri, and Robert Steinberger-Wilckens. "Coupling of engine exhaust and fuel cell exhaust with vapour absorption refrigeration/air conditioning systems for transport applications: A Review." Thermal Science and Engineering Progress (2020): 100550.

[8] Alhamid, M. I., Alberto Coronas, ArnasLubis, Dereje S. Ayou, Kiyoshi Saito, and Hajime Yabase. "Operation strategy of a solar-gas fired single/double effect absorption chiller for space cooling in Indonesia." Applied Thermal Engineering 178 (2020): 115524.

[9] Liu, Zhiqiang, Nan Xie, and Sheng Yang. "Thermodynamic and parametric analysis of a coupled LiBr/H2O absorption chiller/Kalina cycle for cascade utilization of low-grade waste heat." Energy Conversion and Management 205 (2020): 112370.

[10] Azhar, Md, and M. Altamush Siddiqui. "Exergy analysis of single to triple effect lithium bromide-water vapour absorption cycles and optimization of the operating parameters." Energy conversion and management 180 (2019): 1225-1246.

[11] Mishra, R. S. "Thermal performances (first law efficiency, exergy destruction ratio &exergetic efficiency) of cascade single effect ammonia-water (NH3-H20) vapour absorption refrigeration system coupled with vapour compression refrigeration using ecofriendly refrigerants in the low temperature cycle of VCRS system." International Journal of Research in Engineering and Innovation 3 (2019): 1-5.

[12] Mishra, R. S. "Performance evaluation of solar assisted half effect Li/Br vapour absorption refrigeration system cascaded with vapour compression refrigeration system using eco-friendly refrigerants." International Journal 7, no. 2 (2019): 156-161.

[13] Pandya, Bhargav, Nishant Modi, Ravi Upadhyai, and Jatin Patel. "Thermodynamic performance and comparison of solar assisted double effect absorption cooling system with LiCl-H2O and LiBr-H2O working fluid." In Building Simulation, vol. 12, no. 6, pp. 1063-1075. Tsinghua University Press, 2019.