Jurnal Asiimetrik: Jurnal Ilmiah Rekayasa Dan Inovasi
Accredited "**SINTA 3**" based on the Decree of Dirjendiktiristek, Number: 225/E/KPT/2022
Volume 7 Number 2, July 2025, Page 257-266
Website : http://journal.univpancasila.ac.id/index.php/asiimetrik/

p-ISSN 2655-1861
e-ISSN 2716-2923

Performance Analysis of H_2O-LiBr Absorption Refrigeration Systems for Future Cars

Analisis Kinerja Sistem Pendinginan Absorpsi H_2O-LiBr untuk Mobil Masa Depan

Darwin Rio Budi Syaka[1*], Ragil Sukarno[1], Jeff Michael Johanes[1], Gaguk Margono[2]
[1]Department of Mechanical Engineering, Universitas Negeri Jakarta, 13220, Indonesia
[2]Department of Mechanical Engineering Education, Universitas Negeri Jakarta, 13220, Indonesia

Article information:

Received:
25/05/2025
Revised:
30/06/2025
Accepted:
11/07/2025

Abstract

There has been an increase in the development of electric cars in recent decades, driven by the global need to reduce greenhouse gas emissions and air pollution. The use of refrigeration systems in electric cars is one of the largest consumptions of electric power. Therefore, this study used an absorption refrigeration system with a working fluid in the form of a combination of water as a refrigerant and lithium bromide salt as an absorption compound (H2O-LiBr) as an alternative refrigeration system. However, the use of water as a refrigerant lead to the required components being larger. This study focuses on analyzing the work performance of absorption refrigeration systems. The results of the analysis of the performance of the absorption refrigeration system state that to get the optimal performance value in operating the designed H2O-LiBr absorption refrigeration system, the generator outlet temperature is required to be a minimum of 75°C, which produces a performance stated in COP of 0.705. In the meantime, the analysis of the generator outlet temperature's impact on the refrigeration system's performance value revealed that the higher the generator outlet temperature, the higher the performance value.

Keywords: absorption, alternative, H2O-LiBr, performance, refrigeration.

***SDGs*:**

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Abstrak

Perkembangan mobil listrik dalam beberapa dekade terakhir mengalami peningkatan, didorong oleh kebutuhan global untuk mengurangi emisi gas rumah kaca dan polusi udara. Penggunaan sistem pendingin pada mobil listrik merupakan salah satu konsumsi daya listrik yang terbesar. Oleh karena itu, penelitian ini menggunakan sistem refrigerasi absorpsi dengan fluida kerja berupa kombinasi air sebagai refrigeran dan garam litium bromida sebagai senyawa absorpsi (H_2O-LiBr) sebagai sistem refrigerasi alternatif. Akan tetapi, penggunaan air sebagai refrigeran menyebabkan komponen yang dibutuhkan menjadi lebih besar. Penelitian ini difokuskan pada analisis kinerja kerja sistem pendingin absorpsi. Hasil analisis kinerja sistem pendingin absorpsi menyatakan bahwa untuk mendapatkan nilai kinerja yang optimal dalam mengoperasikan sistem pendingin absorpsi H_2O-LiBr yang dirancang, diperlukan temperatur outlet generator dengan minimum 75°C, yang menghasilkan kinerja yang dinyatakan dalam COP sebesar 0,705. Sementara itu, analisis dampak suhu *outlet* generator terhadap nilai kinerja sistem pendinginan mengungkapkan bahwa semakin tinggi suhu *outlet* generator, semakin tinggi pula nilai kinerjanya

Kata Kunci: absorpsi, alternatif, H_2O-LiBr, kinerja, pendingin.

*Correspondence Author
email : drbsyaka@unj.ac.id

1. INTRODUCTION

The desire to lower greenhouse gas emissions and air pollution worldwide has accelerated the development of electric vehicles in recent decades (Alanazi, 2023). The use of refrigeration systems in electric cars is one of the largest consumers of electric power. In electric cars, the average energy consumption of the refrigeration system accounts for 30-40% of the total energy provided by the battery during regular use, depending on mileage and the size of the refrigeration system. In extreme conditions, such as when the outside temperature is very hot, this percentage can increase even higher, as the refrigeration system must work harder to maintain cabin comfort (Zhang *et al.*, 2018; Budi, Qiram and Sartika, 2021). In fact, the use of a refrigeration system in a car is certainly very important for the comfort of the driver and passengers when in a closed space (car cabin) (Sukarno *et al.*, 2023), the temperature of the car cabin reaches 52.6°C, which will certainly greatly disturb the comfort of the driver and passengers. Thermal comfort is one of the quality aspects of comfort in enclosed spaces (Jasman, Nasaruddin and Tee, 2019). Thermal comfort is affected by air temperature, air humidity, and airflow in the environment (Budi, Qiram and Sartika, 2021). In addition, the boarding car's temperature and humidity levels have an impact on the machine's performance and durability, thus, the design of the air conditioning and refrigeration systems is also crucial (Setiyo *et al.*, 2021; Santoso, 2023).

Defines thermal comfort as a psychological state indicating contentment with one's thermal surroundings (ASHARE, 2013). Thermal comfort is often associated with heat equilibrium, where heat equilibrium is a condition of the body when the heat produced is proportional to the heat released from the body (Ruliandini, 2016). Disabling the refrigeration system to save electricity consumption in the car is very unlikely because it will have an impact on the comfort of the driver or passengers. Therefore, the use of LiBr absorption refrigeration systems is one potential solution for reducing electrical energy consumption in electric cars.

An absorption refrigeration system utilizes solar heat and exhaust heat as its primary energy sources, making it an energy-efficient refrigeration option (Hashim and Kassim, 2021). The absorption refrigeration system is also known as a cycle that operates using heat (heat-operated cycle). In addition, the absorption refrigeration system also uses an environmentally friendly working fluid (refrigerant) without the potential for global warming or ozone depletion. In the LiBr absorption refrigeration system, the working fluid consists of two components: water serves as the refrigerant, while LiBr acts as the absorbent (Rudiyanto, 2015; Xu and Wang, 2016).

The LiBr absorption refrigeration system is in line with the application of the absorption refrigeration cycle. This is one of the oldest types of refrigeration machines. According to John Leslie's 1810 research on absorption refrigeration, the basic idea of the cycle has been around since the early 1800s. To cool the wine, John Leslie employed water vapor as the refrigerant and sulfuric acid as the absorbent (Hashim and Kassim, 2020). However, the first absorption refrigeration engine was invented in France by Ferdinand Carré in 1858 and patented in 1860 (Lestari, 2020). The absorption refrigeration cycle is considered a type of alternative refrigeration engine that is more economical than the vapour compression refrigeration cycle because the absorption refrigeration cycle uses generators and absorbers instead of compressors. The absorption refrigeration cycle requires heat as the main energy source to obtain the cooling effect. This cycle uses the ability to bind and release chemical pairs between refrigerants and absorbents (Wulandari and Dhiyaulhaq, 2022).

Nevertheless, absorption refrigeration systems using H_2O-LiBr pairs are substantially used in medium and large-capacity refrigeration systems installed in buildings (Sitotaw, 2022). There have been several studies on H2O-LiBr absorption refrigeration systems installed in buildings that have been studied by researchers. Yusuf conducted a performance analysis on the H2O-LiBr absorption refrigeration system that uses solar thermal energy in an office building (Yusuf, 2016).

Like the study, Prasetyo et al. examined how well the Sanggar Ksatria Liema Bogor building's H_2O-LiBr absorption refrigeration system worked (Prasetyo, Sukamto and Arda Rahardja, 2020). El Haj Assad et al.'s research investigates the operation of the geothermal-powered H_2O-LiBr absorption refrigeration system that will be used in residential buildings (Assad *et al.*, 2021). Meanwhile, the potential of waste heat from gas power plants (PLTG) as a power source for the H_2O-LiBr absorption refrigeration system will be utilized in the room within the building surrounding the PLTG while also figuring out the absorption refrigeration system's capability and arrangement (Suntoro *et al.*, 2019). Conversely, the study conducted by Soliman et al., focused on the design of a generator for an H_2O-LiBr absorption refrigeration system that utilizes phase change materials (PCMs) harnessed from vehicle exhaust heat (Soliman *et al.*, 2021). Additionally, the research included an assessment of the operational performance of the absorption refrigeration system to variations in vehicle engine speed (Soliman *et al.*, 2021).

According to the existing body of research, the the absorption cooling system with solar heat source design and analysis is intended for building structures or if for vehicle applications using exhaust gas heat sources, with solar heat source design and analysis is intended for building structures or if for vehicle applications using exhaust gas heat sources, there is a notable deficiency of studies addressing the application of H_2O-LiBr the absorption cooling system with solar heat source design and analysis is intended for building structures or if for vehicle applications using exhaust gas heat sources, in electric vehicles. Consequently, this study is intended to evaluate the operational performance of the H_2O-LiBr absorption refrigeration system within the context of electric car refrigeration with solar heat sources, where the generator temperature is observed to range from 70°C to 90°C.

2. METHODOLOGY

2.1. H_2O-LiBr Absorption Refrigeration Systems

The absorption refrigeration cycle is considered as a more efficient alternative type of cooling machine compared to the vapor compression refrigeration cycle because the absorption refrigeration cycle uses a generator and absorber instead of a compressor. The absorption refrigeration cycle requires heat as the main energy source to obtain a cooling effect. This cycle uses the ability to bind and release chemical pairs between the refrigerant and the absorbent (Wulandari and Dhiyaulhaq, 2022). Currently, the refrigerant and absorbent pair used is a lithium bromide (LiBr) salt pair, which is an extremely hygroscopic compound that functions as an absorbent, and water (H_2O) acts as a refrigerant (Jones, 1987). To help this research, the following has been made: a research scheme of the H_2O-LiBr refrigeration cycle shown in Figure 1.

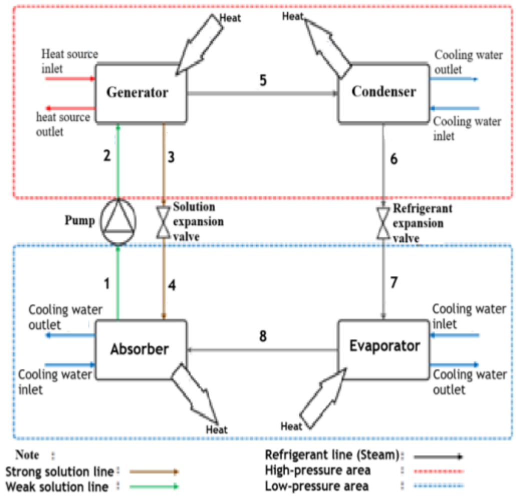

Figure 1. H_2O-LiBr absorption refrigeration cycle scheme.

In Figure 1, the H_2O-LiBr Absorption refrigeration cycle working principle begins with the application of heat through a heater in the generator, which causes the refrigerant to evaporate and separate from the solution. The refrigerant has evaporated towards the condenser, and there is a phase change from vapor to liquid due to the release of heat. The liquid refrigerant transitions from the condenser to the evaporator via an expansion valve, which regulates both the pressure and temperature to lower levels. Within the evaporator, heat absorption occurs, resulting in the evaporation of the refrigerant, which subsequently transitions to the absorber. The residual solution within the generator passes through the expansion valve to the absorber, where it subsequently mixes with the refrigerant vapor. This interaction results in an increase in temperature and pressure. It is imperative that the pressure within the absorber be maintained at a level lower than that of the evaporator. Consequently, a pump is required to facilitate the circulation of the solution from the absorber back to the generator.

2.2. Fundamental Assumptions

The fundamental assumptions governing the calculations and thermodynamic analysis of absorption refrigeration systems utilizing an H_2O-LiBr solution are outlined as follows:

1) The system is in a steady-state state.
2) Pressure drop and heat loss are negligible.
3) The expansion valve operates under adiabatic conditions, while the pump functions isotropically.
4) The temperature, pressure, and concentration conditions of lithium bromide (LiBr) are homogenous across each component.
5) Both the volumetric flow rate of the fluid and the heat transfer coefficient of the components are considered to be constant.
6) LiBr/water from generators and absorbers is considered saturated, and the vapor in the evaporator is superheated.
7) The strong LiBr mass fraction (X_s) has low pressure and absorber outlet temperature respectively P_1 = 3.17 kPa and T_1 = 51.43°C and the weak LiBr mass fraction (X_w) has high pressure and generator outlet temperature respectively P_h = 7,385 kPa and T_3 = 90°C
8) The LiBr mass fraction is strong (X_s) 62% and weak (X_w) 52%.

In addition, there are also the initial conditions of the design:

1) Generator outlet temperature (T_3) and (T_5): 90°C.
2) Evaporator outlet temperature (T_8): 25°C.
3) Condenser outlet temperature (T_6): 40°C
4) Pump mass flow rate $\dot{m}_1$: 0.001 kg/s.

2.3. Energetic Analysis of Vapor Absorption Refrigeration System

Thermodynamic calculations are conducted through the application of mass balance and energy balance equations pertinent to each component. In accordance with the fundamental assumptions employed, it is imperative to utilize the steady-state flow condition alongside the overall mass balance equation and the overall energy balance equation. The subsequent section delineates the general mass balance equation (Holman, 2009).

$$\Sigma \dot{m}_{in} = \Sigma \dot{m}_{out} \quad (1)$$

Then, in a steady-state flow system $dE_{cv}/dt = 0$ It is stated that "the average of the energy transfer to a control volume through a heat transfer and work during a steady flow is equal to the difference between the rate of outgoing and incoming energy flow and mass". Thus, with a steady flow, the typical equation for energy balance is as follows (Boles and Cengel, 2014).

$$\Sigma \dot{E}_{in} = \Sigma \dot{E}_{out} \quad (2)$$

$$\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} = \Sigma_{out}\, \dot{m}\left(h + \frac{V^2}{2} + gz\right) - \Sigma_{in}\, \dot{m}\left(h + \frac{V^2}{2} + gz\right) \quad (3)$$

Based on the equations (1) and (3), the equation of the balance of time and energy in each component can be analyzed and stated. First, the equation that occurs in the generator is as follows:

$$\dot{m}_2 = \dot{m}_3 + \dot{m}_5 \quad (4)$$

$$\dot{m}_2 x_2 = \dot{m}_3 x_3 \quad (5)$$

$$Q_g = \dot{m}_3 h_3 + \dot{m}_5 h_5 - \dot{m}_2 h_2 \quad (6)$$

Next, there is an equation that occurs in the condenser based on equations (1) and (3):

$$\dot{m}_5 = \dot{m}_6 \quad (7)$$

$$Q_c = \dot{m}_5 h_5 - \dot{m}_6 h_6 \quad (8)$$

The equation that occurs in the evaporator also refers to equations (1) and (3), as follows:

$$\dot{m}_7 = \dot{m}_8 \qquad (9)$$

$$Q_e = \dot{m}_7 h_7 - \dot{m}_8 h_8 \qquad (10)$$

The last is the equation that occurs in the absorber based on general equations (1) and (3), as follows.

$$\dot{m}_1 = \dot{m}_4 + \dot{m}_8 \qquad (11)$$

$$\dot{m}_1 x_1 = \dot{m}_4 x_4 \qquad (12)$$

$$Q_a = \dot{m}_4 h_4 + \dot{m}_8 h_8 - \dot{m}_1 h_1 \qquad (13)$$

Additionally, the system's Coefficient of Performance (COP) has been calculated using the following formula :

$$COP = \frac{Q_e}{Q_g + W_p} \qquad (14)$$

3. RESULTS AND DISCUSSION

3.1. Performance Analysis of LiBr Absorption Refrigeration System

In this study, the performance of the absorption refrigeration system was analyzed based on temperature variations. The varied temperature is the temperature at which the generator goes to the absorber (T_3) and the temperature at which the generator goes to the condenser (T_5), where T_3=T_5. Based on the calculation of the COP value on the research matrix carried out, several variable values change due to changes in the input value of the output temperature in the generator shown in Table 1.

Table 1. Refrigeration system performance analysis.

Temperature Out Generator (°C)	Xs (%)	$\dot{m}_{water}$ (kg/s)	Enthalpy (h) (kJ/kg)	Qg (kW)	Qe (kW)	COP
90	0.62	0.001613	2668.8	4.684	3.837	0.7603
85	0.6	0.001333	2659.3	3.827	3.172	0.7571
80	0.575	0.000957	2649.8	2.722	2.276	0.7377
75	0.555	0.000631	2640.3	1.765	1.5	0.705
70	0.53	0.000189	2630.8	0.5185	0.4489	0.5092

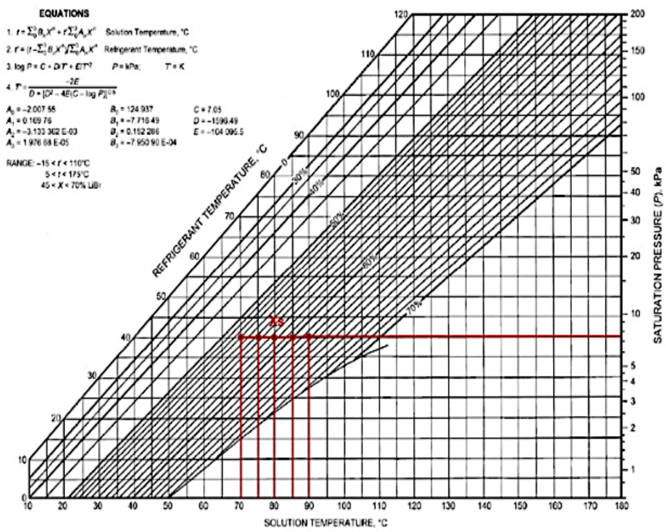

Figure 2. Strong LiBr mass fraction based on temperature variation.

Changes in the output temperature value of the generator affect the value of the strong LiBr mass fraction in the absorption refrigeration system. The value of the strong LiBr mass fraction is obtained from the temperature and pressure determined using the pressure-temperature-concentration diagram of the H_2O-LiBr solution. The effects of the generator's exit temperature on the strong LiBr mass fraction value is shown in Figure 2.

Based on equations (4) and (5), the changes that occur in the LiBr mass fraction strongly affect the flow rate of water vapor mass and are shown in Figure 3. In Figure 3, it is evident that the higher the LiBr mass fraction value, the higher the water mass flow rate.

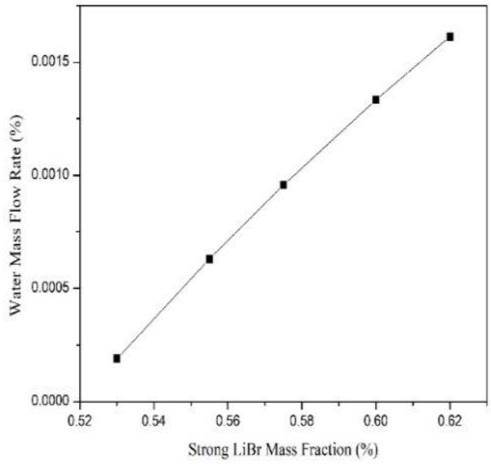

Figure 3. Graph of the effect of strong LiBr mass fraction on water mass flow rate.

The temperature of the generator outlet affects the enthalpy value and the value of the mass flow rate produced. As a result, variations in the temperature at the generator's output influence the heat transfer rate in both the generator and the evaporator. Figure 4 illustrates how the temperature at the generator's exit impacts the heat transfer rate within the generator and evaporator.

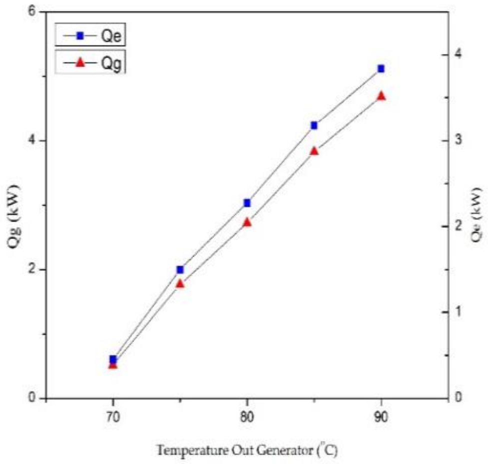

Figure 4. Graph of the relationship between generator outlet temperature and heat transfer rate value.

The correlations examined using equation (14) demonstrate that the generator exit temperature has an impact on the performance value attained. Figure 5 illustrates how the generator's outlet temperature affects the performance value, where it can be stated that the change in the output temperature of the generator is directly proportional to the change in the performance value obtained. Therefore, the higher the temperature output in the generator, the higher the performance value will be.

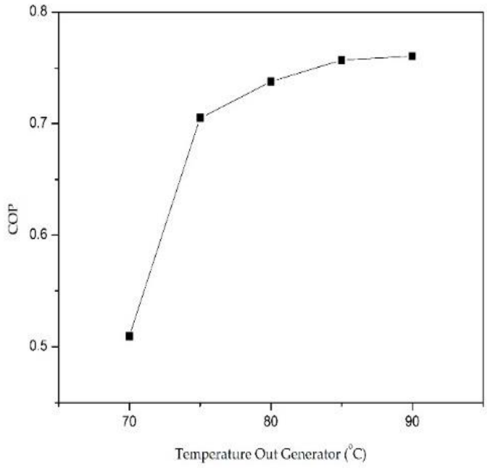

Figure 5. Refrigeration system performance analysis graph.

When the generator is run at 70°C, Figure 5 shows a noticeable change in performance values. This happens because when the temperature reaches 70°C, the value of the strong LiBr mass fraction is obtained at 0.53. Based on the value of the strong LiBr mass fraction, a water mass flow rate value of 0.000189 kg/s can be produced using equations (4) and (5). The mass flow rate value causes a significant decrease in the heat separation rate value produced in the generator and evaporator, so there is a significant decrease in the performance value obtained, which is 0.5092. Meanwhile, when the generator outlet temperature is 75°C, a performance value of 0.705 is obtained. Therefore, to get the optimal performance value in operating the designed H_2O-LiBr absorption refrigeration system, it is necessary to have a generator outlet temperature of at least 75°C.

Figure 6 shows a picture of the absorption refrigeration cycle with H2O refrigerant (refrigerant numbering is referred to as R-718) in the P-h diagram at its optimal performance when the generator outlet temperature is 75°C.

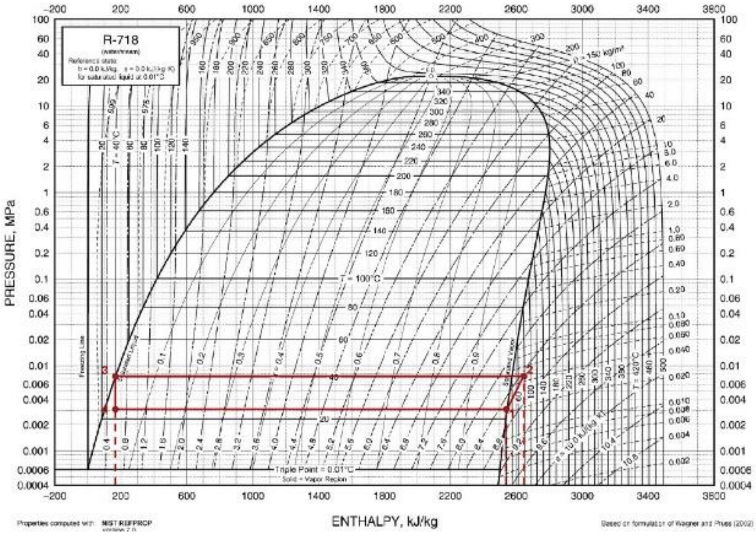

Figure 6. P-h diagram of H_2O (R-718) absorption refrigeration cycle at generator temperature 75°C.

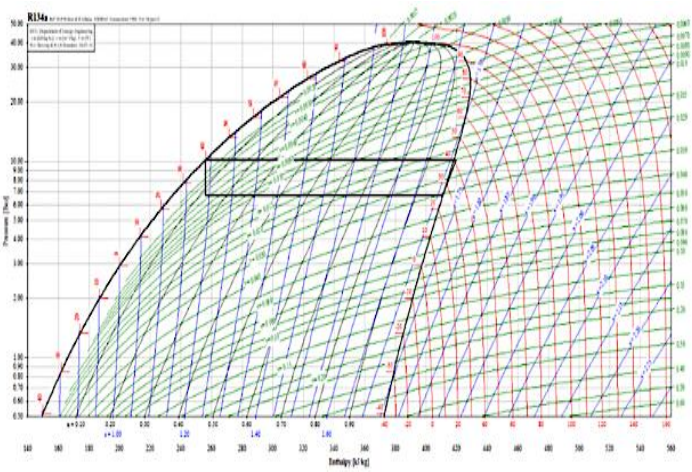

Figure 7. P-h Diagram of R134a refrigerant vapor compression refrigeration system.

3.2. Feasibility of H_2O-LiBr Absorption Refrigeration System

The feasibility test of the designed H_2O-LiBr absorption refrigeration system was conducted by comparing it with a commercial refrigeration system. The commercial refrigeration system used as a comparison is a vapor compression refrigeration system with R134a refrigerant. In the feasibility test, a comparison was made between the performance values using the same temperature conditions in the designed H_2O-LiBr absorption refrigeration system.

The vapor compression refrigeration system using R134a refrigerant is depicted in the P-h diagram to facilitate the calculation of performance values and the power produced. Using the CoolPack software, the P-h diagram for a vapor compression refrigeration system with R134a refrigerant is shown in Figure 7.

By using CoolPack software, a performance value of 17.88 was obtained. Meanwhile, the power required for the vapor compression refrigeration system is based on the designed evaporator capacity of 0.262 kW. Furthermore, an evaluation was carried out on the performance of the developed H_2O-LiBr absorption refrigeration system.

In the designed H_2O-LiBr absorption refrigeration system, the heat source used in the generator is obtained from the sun's heat. Therefore, the performance value is calculated by ignoring the heat transfer rate in the generator.

The performance value obtained is 10.57, with a power in the pump of 0.363 kW. Based on data obtained under the same temperature conditions, it is known that with a power of 0.363 kW, the performance value of the H_2O-LiBr absorption refrigeration system designed is 10.57. Meanwhile, with a power of 0.262 kW, the performance value of the vapor compression refrigeration system with R134a refrigerant is 17.88. Thus, based on the comparisons that have been made, further research is needed to obtain better performance values for the H_2O-LiBr absorption refrigeration system.

4. CONCLUSION

From the research that has been carried out, it is concluded that to get the optimal performance value in operating the designed H_2O-LiBr absorption refrigeration system, the generator outlet temperature is required to be a minimum of 75°C, which produces a performance stated in COP of 0.705. Meanwhile, the analysis of the generator outlet temperature's effect on the refrigeration system's performance value revealed that the higher the generator outlet temperature at 90°C, the greater the performance value obtained at COP 0.7603.

ACKNOWLEDGMENTS

The State University of Jakarta's Faculty of Engineering provided funding for this study through a grant from the Penelitian Dasar Fakultas Teknik 2024, under Chancellor's Decree No. 325/UN39/HK.02/2024.

REFERENCES

Alanazi, F. (2023) 'Electric Vehicles: Benefits, Challenges, and Potential Solutions for Widespread Adaptation', *Applied Sciences*, 13(10), p. 6016. Available at: https://doi.org/10.3390/app13106016.

ASHARE (2013) *2013 ASHRAE Handbook: Fundamentals*. UK: American Society of Heating, Refrigerating and Air-Conditioning Engineers. [Print].

Assad, M.E.H. *et al.* (2021) 'Space Cooling Using Geothermal Single-Effect Water/Lithium Bromide Absorption Chiller', *Energy Science & Engineering*, 9(10), pp. 1747–1760. Available at: https://doi.org/10.1002/ese3.946.

Boles, M.A. and Cengel, Y.A. (2014) *Thermodynamics: An Engineering Approach*. 8th edn. India: McGraw-Hill Education. [Print].

Budi, A.N.S., Qiram, I. and Sartika, D. (2021) 'Pengaruh Prosentase Kepekatan Kaca Film Terhadap Distribusi Termal dan Pencahayaan Kabin Kendaraan', *V-MAC (Virtual of Mechanical Engineering Article)*, 6(1), pp. 1–4. Available at: https://doi.org/10.36526/v-mac.v6i1.1293.

Hashim, N.A. and Kassim, M.S. (2020) 'A Comparative Study About Lithium Bromide-Water and Lithium Chloride-Water Solutions in Pumpless Absorption Solar Cooling Systems in Iraqi Circumstances', *Journal of Engineering and Sustainable Development*, 24(4), pp. 79–88. Available at: https://doi.org/10.31272/jeasd.24.4.9.

Hashim, N.A. and Kassim, M.S. (2021) 'Experimental Study of A LiCl-H2O Bubble Pump Solar Absorption Cooling System', in *IOP Conference Series: Materials Science and Engineering. 1st International Conference on Sustainable Engineering and Technology (INTCSET 2020)*, Baghdad, Iraq: IOP Publishing Ltd, p. 012017. Available at: https://doi.org/10.1088/1757-899X/1094/1/012017.

Holman, J.P. (2009) *Heat Transfer*. Colombia: McGraw-Hill Education. [Print].

Jasman, M.E.S.M., Nasaruddin, A.N. and Tee, B.T. (2019) 'Analysis Of Indoor Environment Condition Towards Thermal Comfort Level In An Air-Conditioning Office Building', in *IOP Conference Series: Earth and Environmental Science. 2019 Theory and Technique International Aerosol Conference and Malaysia Air Quality Annual Symposium*, Malacca, Malaysia: IOP Publishing Ltd, p. 012015. Available at: https://doi.org/10.1088/1755-1315/373/1/012015.

Jones, J.W. (1987) *Refrigerasi Dan Pengkondisian Udara*. Jakarta, Indonesia: Erlangga. [Print].

Lestari, K. (2020) *Sistem Pendinginan Dan Pompa*. 1st edn. Jakarta, Indonesia: Lembaga Penerbitan UNAS. [Print].

Prasetyo, N.B., Sukamto, AP.E. and Arda Rahardja (2020) 'Analisa Kinerja Sistem Absorption Chiller di Gedung Sanggar Ksatria Liema Bogor', in *Prosiding The 11th Industrial Research Workshop and National Seminar (IRWNS). The 11th Industrial Research Workshop and National Seminar (IRWNS)*, Bandung, Indonesia: Politeknik Negeri Bandung, pp. 349–354. Available at: https://doi.org/10.35313/irwns.v11i1.2029.

Rudiyanto, B. (2015) 'Potensi Pemanfaatan Membran Untuk Regenerasi Refrigeran Dari Absorber Pada Sistem Pendingin Absorpsi Lithium Bromide-H2O', *Rona Teknik Pertanian*, 8(1), pp. 1–9. Available at: https://doi.org/10.17969/rtp.v8i1.2682.

Ruliandini, R. (2016) 'Mengukur Nilai Kenyamanan Termal Pada Mobil Dengan Kaca Film Berteknologi (Engineered Window Film)', *AME (Aplikasi Mekanika dan Energi): Jurnal Ilmiah Teknik Mesin*, 2(1), pp. 14–14. Available at: https://doi.org/10.32832/ame.v2i1.348.

Santoso, H. (2023) 'Installation of Refrigeration and Air Conditioning Systems in The Production Facility on PT. X to Maintain the Performance and Durability of Machine Components', *Jurnal Asiimetrik: Jurnal Ilmiah Rekayasa & Inovasi*, 5(2), pp. 243–250. Available at: https://doi.org/10.35814/asiimetrik.v5i2.4683.

Setiyo, M. *et al.* (2021) 'Cooling Effect And Heat Index (HI) Assessment On Car Cabin Cooler Powered By Solar Panel In Parked Car', *Case Studies in Thermal Engineering*, 28, p. 101386. Available at: https://doi.org/10.1016/j.csite.2021.101386.

Sitotaw, N. (2022) 'Energy and Exergy Analysis of Single Effect Water-LiBr Vapour Absorption Refrigeration System', *International Journal of Advanced Science Computing and Engineering*, 4(3), pp. 175–187. Available at: https://doi.org/10.62527/ijasce.4.3.94.

Soliman, A.S. *et al.* (2021) 'Design Of An H2O-Libr Absorption System Using PCMS And Powered By Automotive Exhaust Gas', *Applied Thermal Engineering*, 191, p. 116881. Available at: https://doi.org/10.1016/j.applthermaleng.2021.116881.

Sukarno, R. *et al.* (2023) 'Experimental Study Of Thermoelectric Cooling System For A Parked Car With Solar Energy', in *Journal of Physics: Conference Series. 12th International Physics Seminar 2023*, Jakarta, Indonesia: IOP Publishing Ltd, p. 012052. Available at: https://doi.org/10.1088/1742-6596/2596/1/012052.

Suntoro, D. *et al.* (2019) 'Utilization of Waste Heat From Pesanggaran Bali Gas Turbine Power Plant for Air Conditioner Using Absorption Chiller', *Ketenagalistrikan dan Energi Terbarukan*, 18(1), pp. 29–40.

Wulandari, D.A. and Dhiyaulhaq, N.R. (2022) 'Utilization of Exhaust Heat from Diesel Powered Vehicle for Absorption Refrigeration System: A Review', *Jurnal Konversi Energi dan Manufaktur*, 7(2), pp. 123-133. Available at: https://doi.org/10.21009/JKEM.7.2.7.

Xu, Z.Y. and Wang, R.Z. (2016) 'Absorption Refrigeration Cycles: Categorized Based On The Cycle Construction', *International Journal of Refrigeration*, 62, pp. 114–136. Available at: https://doi.org/10.1016/j.ijrefrig.2015.10.007.

Yusuf, Y. (2016) 'Analisa Performa Sistem Pendinginan Absorpsi Menggunakan Energi Panas Matahari Pada Sebuah Gedung Perkantoran', *Jurnal Energi dan Manufaktur*, 9(2), pp. 150–153. Available at: http://ojs.unud.ac.id/index.php/jem.

Zhang, Z. *et al.* (2018) 'The Solutions To Electric Vehicle Air Conditioning Systems: A Review', *Renewable and Sustainable Energy Reviews*, 91, pp. 443–463. Available at: https://doi.org/10.1016/j.rser.2018.04.005.