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Effect of Evaporator Temperature on Performance of Vapour Absorption Refrigeration

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A B S T R A C T

The paper attempts to simulate a Vapour absorption refrigeration system for by using Lithium-Bromide/water. The complete system is simulated using MATLAB software. The project also attempts to carry out a critical study on the effect of effect of evaporator temperature on performance of the system, concentration, mass flow rates and conductance.The paper ended with the result as increase in the evaporator temperature there is an increases in coefficient of Performance from 0.665 to 0.83. As increase in evaporator temperature there is a decrease in generator load from 18980 to 15075 kJ/hr, absorber load from 18265 to 14459 kJ/hr and condenser load from 13355 to 13256kJ/hr. The evaporator temperature decreases the concentration (x1) from 56% to 49% with the increase. The mass flow rate of weak in refrigerant (Strong solution) decreases from 211.68 to 33.36 kg/hr.

1. Introduction

The advancement in semiconductor technologies resulted in improvement of robust and compact electronic devices. This growth attributed increase in the power density level. Enhancement in the density level resulted in catastrophic failure in devices. Conventional cooling technologies fail to provide the better thermal management under allocated space. Researchers are developing new technologies for device cooling such as minichannel, monolithic thermally activated material, thermal management refrigeration, Nano-technologies etc. Among all these refrigeration shows a candidate solution for the device cooling. Vapour compression refrigeration cycle consists of evaporator, compressor, condenser and capillary tube. Vapour absorption refrigeration cycle consists of evaporator, absorber, generator, condenser and capillary tube. Vapour absorption refrigeration systems are mainly two types Lithium-Bromide/water and Ammonia/water system**.**Tausifahmad et al., (2022) conducted energy analysis for single effect vapour absorption refrigeration system employing two working pairs LiBr-H2O (LiBr-H2O) and lithium chloride-water (LiCl- H2O) under various operating climate circumstances. Performance metrics for both systems, including coefficient of performance (COP), solution concentration, heat load at various components, and optimal operating generator temperature, have been examined. Salem M. et. al. (2017) researched and optimised the vapour-solution interface area (ai) in a small-scale lithium-bromide/water (LiBr-H2O) absorption refrigeration system fitted with an adiabatic absorber for certain absorption rates in the adiabatic absorber. With the help of a horizontal spiral groove formed of perspex plate, a new flow configuration of the LiBr-H2O solution inside the adiabatic absorber was developed.Devendra et al. (2022) researched running refrigeration systems on fossil fuels poses a concern for global warming since carbon dioxide is released during the creation of electricity. On the other side, the use of refrigerants also contributes to ozone layer loss and global warming. Because the combination of the refrigerant and absorbent does not emit any toxic residuals, the vapour absorption refrigeration system (VARS) with water and lithium bromide (LiBr-H2O) could be used. Reynaldo Palacios-Bereche et al. (2012) determined the exergy of LiBr-H_2O solution, which is utilised in absorption heat pumps and absorption heat transformers. Results are provided in the temperature range of 5 to 180°C.K. Edem N. Tsoukpoe et.al., (2012) investigated long-term solar thermal energy storage based on water absorption by a lithium bromide aqueous solution. The evaluation of simulations performed for a low-consumption building in Chambéry the simulation outcomes are used in the design of prototype that is being tested for model validation.

Abdul Khaliq et al. (2012) proposed cogeneration cycle, a LiBr-H_2O absorption refrigeration system is used to combine electricity with an ejector refrigeration system that uses R141b as the working fluid. The suggested cogeneration cycle, according to the results, produces significantly higher

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thermal and energy efficiency than the combined power and ejector cooling cycle that was previously studied.M. Izquierdo et.al., (Jan 2012) Describes a new small air-cooled double-effect LiBr-H_2O absorption prototype with a mean daily coefficient of performance (COP) of about 1.05. Since the absorption prototype doesn't release fluorinated refrigerants, it is a more environmentally friendly option.R. Lizarte et al. (2012) have carried out experimental trials on a novel 4.5 kW LiBr-H_2O absorption chiller prototype that is solar-driven, directly air-cooled, and single effect. Scope and copth had mean values of 0.06 and 0.53, respectively. This research is a component of a broader effort whose goal is to utilise solar energy as a source of heat in residential buildings' air-cooled absorption chiller.Kokouvi Edem N Tsoukpoe et al. (2013) researched on the heat storage using absorption method focuses on building heating. The charging procedure has been shown to be effective. It is also confirmed that absorption occurs during the discharge period. However, various issues with the heat exchanger's design prevented us from seeing the heat release as we had hoped. Lizarte et.al., (Jul 203) carried out trials to compare a prototype directly air-cooled absorption chiller against a commercially available, indirectly air-cooled absorption chiller. The mean daily COPth for single-effect LiBr-H_2O chillers was 0.55 in the commercial chiller versus 0.62 in the prototype. The chiller and prototype had mean daily COPelecs of 3.5 and 5.3, respectively. In both instances, the solar-powered air conditioning facility's average daily scope was roughly 0.08.

Z.Y. Xu et al. (2013)'s varied generator temperatures from 110 °C to 140 °C are insufficient to drive a double effect LiBr-H2O absorption cycle, a special LiBr-H2O absorption cycle with an aghe (absorber generator heat exchanger) is introduced for this. When the generating temperatures are between 85 °C and 93 °C, 93 °C and 140 °C, and 140 °C and 150 °C, respectively, and the cop is between 0.75 and 1.08, the simulation results demonstrate that the innovative cycle may operate in single effect mode, 1.n effect mode, and double effect mode.G. Evola et al. (2013) developed a mathematical model for the dynamic modelling of a single-effect LiBr-H2O. The absorption chiller is shown. Experimental data gathered on a commercial small-capacity water-cooled unit is used to validate the mathematical model. The measurements of the water temperature at the machine's outlet are used to validate the model, and both on a daily and seasonal basis, there is excellent agreement between experimental and simulated findings.Perusal of Literature showed number of researchers investigated the vapour absorption refrigeration with respect to varying the working pair such as ammonia, LiBr-H_2O Licl-H_20 and operating parameters. Less attempt has been made to determine the main parameters that affects the performance of the system. The study aims to investigate the detail analysis of the system by using mathematical model.

2. Results and discussions

2.1 Effect of Evaporator Temperature on COP

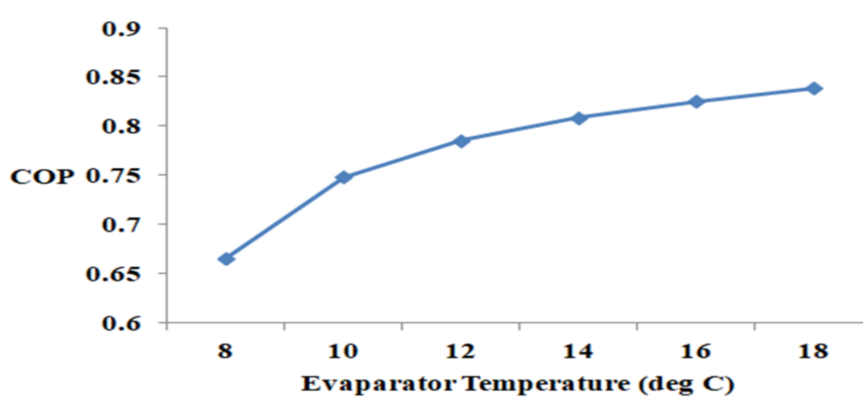

Figure 1:Variation of evaporator temperature on COP,

Figure 1 shows the variation of evaporator temperature on COP, the simulation is carried at generator temperature (Tg) =80 ºC, Condenser temperature (Tc) = 40 ºC, Absorber temperature (Ta) = 40 ºC, Evaporator load =3024kJ/hr and Effectiveness of solution heat exchanger=75%. It is observed from the above figure as evaporator temperature increases from 8ºC to 18ºC at a step of 2 ºC there is an increase in COP from 0.665 to 0.83. This is due to increase in the latent heat of the refrigerant under constant evaporator load. The similar trends are observed in the literature and results corroborates with the available data.

2.2 Effect of Evaporator Temperature on thermal Load

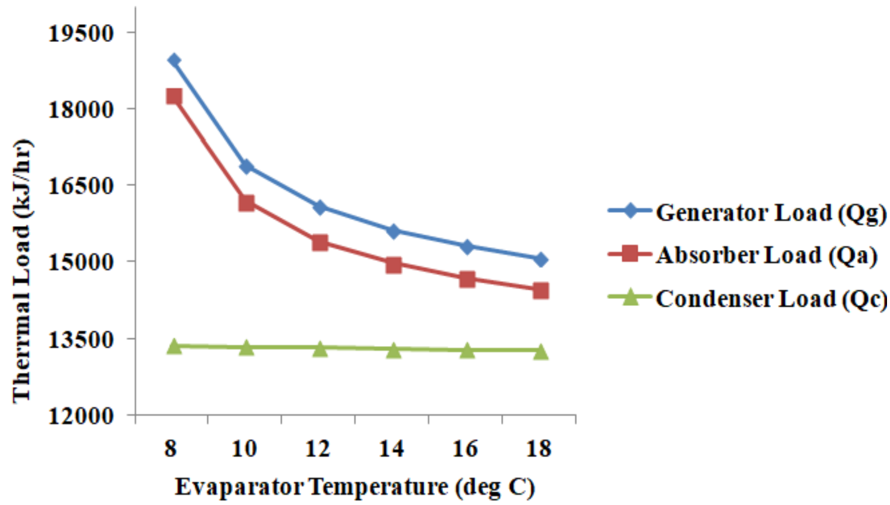

Figure 2: Variation of evaporator temperature on thermal Loads

Figure 2: Shows the variation of evaporator temperature on thermal Loads, the simulation is carried at generator temperature (Tg) =80 ºC, Condenser temperature (Tc)= 40 ºC, Absorber temperature (Ta)= 40 ºC, Evaporator load =3024kJ/hr and Effectiveness of solution heat exchanger=75%. It is observed from the above figure as evaporator temperature increases from 8ºC to 18ºC at a step of 2 ºC there is a decrease in generator load from 18980 to 15075 kJ/hr, absorber load from 18265 to 14459 kJ/hr and condenser load from 13355 to 13256kJ/hr. This is due to decrease in the refrigerant flow rate under constant generator, condenser and absorber temperature. The similar trends are observed in the literature and results corroborates with the available data.

2.3 Effect of Evaporator Temperature on Concentration

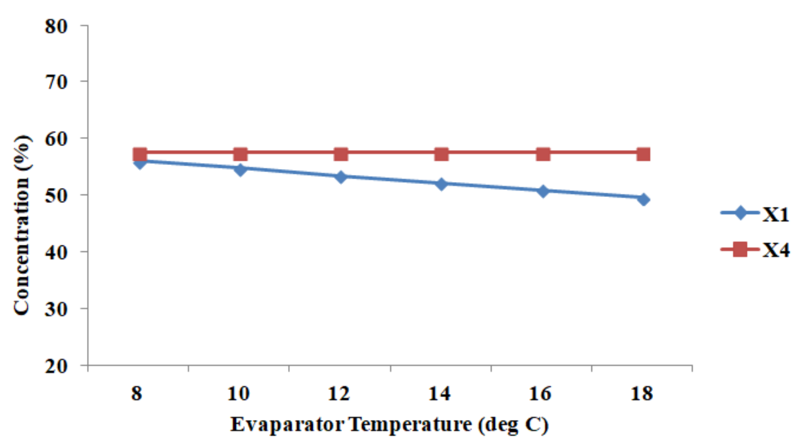

Figure 3: Variation of evaporator temperature on Concentrations

Figure 3: Shows the variation of evaporator temperature on Concentrations, the simulation is carried at generator temperature (Tg) =80 ºC, Condenser temperature (Tc)= 40 ºC, Absorber temperature (Ta)= 40 ºC, Evaporator load =3024kJ/hr and Effectiveness of solution heat exchanger=75%. It is observed from the above figure as evaporator temperature increases from 8ºC to 18ºC at a step of 2 ºC there is a decrease in concentration (x1) from 56% to 49% this is due increase in the evaporator pressure and greater absorption of refrigerant and concentration (x4) remains unchanged at 57.5%. This is due to constant generator temperature. The similar trends are observed in the literature and results corroborates with the available data.

2.4 Effect of Evaporator Temperature on mass flow rate

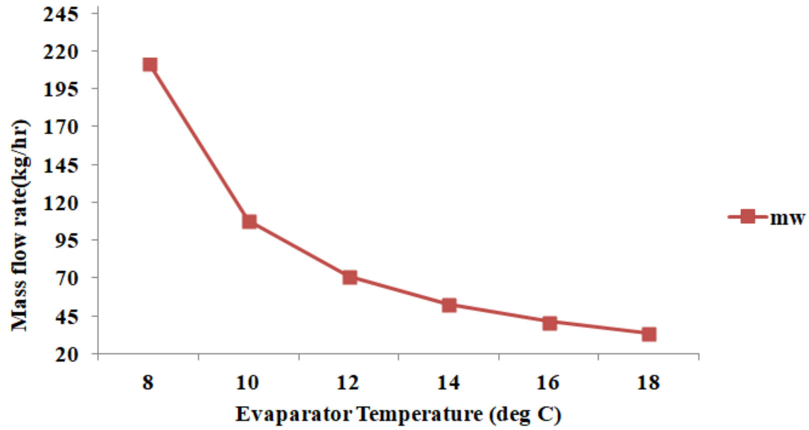

Figure 4: Variation of evaporator temperature on mass flow rate of weak in refrigerant (Strong solution)

Figure 4. Shows the variation of evaporator temperature on mass flow rate of weak in refrigerant (Strong solution), the simulation is carried at generator temperature (Tg) =80 ºC, Condenser temperature (Tc) = 40 ºC, Absorber temperature (Ta)= 40 ºC, Evaporator load =3024kJ/hr and Effectiveness of solution heat exchanger=75%. It is observed from the above figure as evaporator temperature increases from 8ºC to 18ºC at a step of 2 ºC there is a decrease in mass flow rate of weak in refrigerant (Strong solution) from 211.68 to 33.36 kg/hr this is This is due to decrease in the refrigerant flow rate under constant generator temperature. This is due to constant generator temperature. The similar trends are observed in the literature and results corroborates with the available data.

2.5 Effect of Evaporator Temperature on refrigerant flow

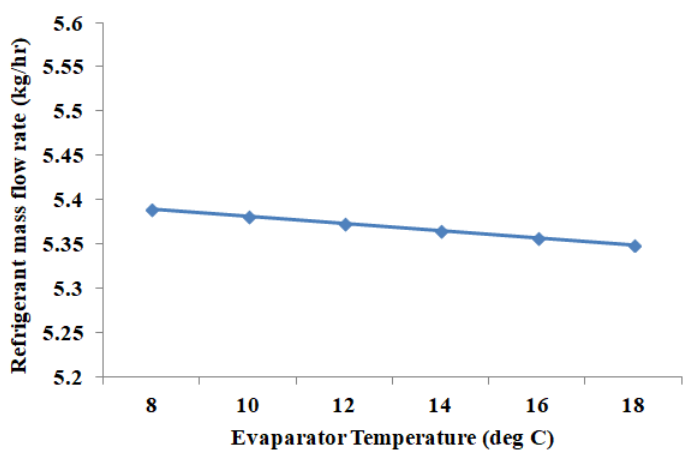

Figure5: Variation of evaporator temperature on refrigerant mass flow rate

Figure5: Shows the variation of evaporator temperature on refrigerant mass flow rate, the simulation is carried at generator temperature (Tg) =80 ºC, Condenser temperature (Tc)= 40 ºC, Absorber temperature (Ta)= 40 ºC, Evaporator load =3024kJ/hr and Effectiveness of solution heat exchanger=75%. It is observed from the above figure as evaporator temperature increases from 8ºC to 18ºC at a step of 2 ºC there is a decrease in mass flow rate of refrigerant from 5.38 to 5.349 kg/hr this is This is due to increase in the evaporator temperature under constant evaporator load. The similar trends are observed in the literature and results corroborates with the available data.

2.6 Effect of Evaporator Temperature on conductance

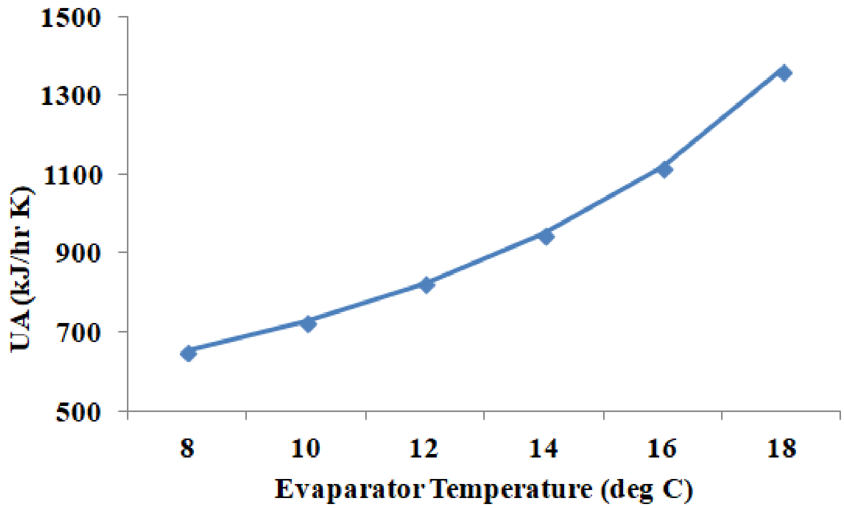

Figure 6: Variation of evaporator temperature on conductance

Figure 6: Shows the variation of evaporator temperature on conductance, the simulation is carried at generator temperature (Tg) =80 ºC, Condenser temperature (Tc) =40 ºC, Absorber temperature (Ta)= 40 ºC, Evaporator load =3024kJ/hr, Effectiveness of solution heat exchanger=75%., Cooling water inlet temperature =25ºC and Cooling water outlet temperature =30ºC. It is observed from the above figure as evaporator temperature increases from 8ºC to 18ºC at a step of 2 ºC there is an increase in conductance from 651 to 1363.6 kJ/hr K this is This is due to increase in the evaporator temperature and latent heat under constant evaporator load. The similar trends are observed in the literature and results corroborates with the available data.

2.7 Effect of Evaporator Temperature on (COP) max

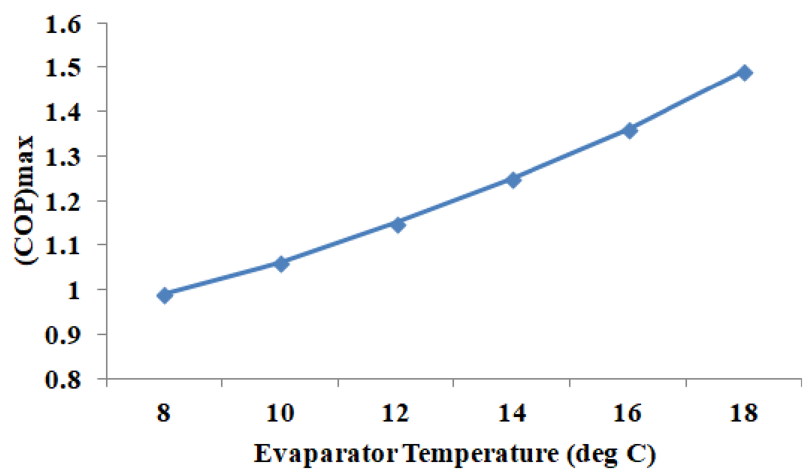

Figure 7: Variation of evaporator temperature on (COP)max

Figure 7 shows the variation of evaporator temperature on (COP)max, the simulation is carried at generator temperature (Tg) =80 ºC, Condenser temperature (Tc) = 40 ºC, Absorber temperature (Ta) = 40 ºC, Evaporator load =3024kJ/hr and Effectiveness of solution heat exchanger=75%. It is observed from the above figure as evaporator temperature increases from 8ºC to 18ºC at a step of 2 ºC there is an increase in (COP)max from 0.99 to 1.5. This is due to increase in the latent heat of the refrigerant under constant evaporator load. The similar trends are observed in the literature and results corroborates with the available data

3. CONCLUSIONS

The paper attempts to simulate a Vapour absorption refrigeration system by using Lithium-Bromide/water. The complete system is simulated using MATLAB software. The paperalso attempts to carry out a critical study on the effect of effect of evaporator temperature on performance of the system, concentration, mass flow rates, conductance, pressure drop and heat transfer coefficient on evaporator.The paperended with the result as increase in the evaporator temperature there is an increases in coefficient of Performance from 0.665 to 0.83. As increase in evaporator temperature there is a decrease in generator load from 18980 to 15075 kJ/hr., absorber load from 18265 to 14459 kJ/hr. and condenser load from 13355 to 13256kJ/hr. The evaporator temperature decreases the concentration (x1) from 56% to 49% with the increase. Mass flow rate of weak in refrigerant (Strong solution) decreases from 211.68 to 33.36 kg/hr. with increase in evaporator temperature.

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