International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Efficiency of a Two-Stage LiBr-Water Vapor-Absorption Refrigeration System Determined by Artificial Neural Network Modeling

Sundarsingh Dodwa [a], ***Ashish Patidar*** [a]

[a] *Department of Mechanical Engineering, Patel College of Science and Technology, Indore (MP), India*

A B S T R A C T

Vapor absorption systems employ waste heat and mild energy to run the pump and recycle the solution. Because the fluid flow is a mixture of coolant (water) and absorbent (lithium bromide), enthalpy will depend on temperature and concentration, making this research difficult. Thus, water and absorbent form the fluid flow (lithium bromide). We used artificial neural network models to simplify this procedure. Neuron training allows ANN to calculate COP for a double-stage VAR system by determining enthalpy levels from multiple input variables.

Keywords: Artificial Neural Network, Vapor Absorption Refrigeration, Lithium Bromide, Coefficient of Performance, Single Stage Refrigeration, Double Stage Refrigeration, Enthalpy.

INTRODUCTION

Using the waste heat from other sources, such as power plants, has made vapor absorption systems quite common. Condensation's latent heat is not wasted in a two-stage VAR system. Instead, it is put to use inside the system, which raises the COP. As a result, it makes use of the energy that is accessible at a high temperature but is typically wasted by a single-stage VAR system. The authors have attempted to provide evidence for this hypothesis by estimating the COP for a two-stage process using an Artificial Neural Network model. Because the working fluid in a vapor absorption refrigeration system is a combination of two fluids, the analysis is time-consuming because the enthalpy is now a function of both temperature and concentration. The mass flow rate is determined by the mass and energy balance, which is computed with the aid of ANN. Mass flow rate and enthalpy measurements may be used to derive COP. Parameters for a theoretical issue are taken from [4], where they were arbitrarily selected.

DESCRIPTION OF DOUBLE STAGE SYSTEM

The two-stage, LiBr-water absorber operates at three distinct pressures. Between the high temperature condenser and the low temperature generator is a heat exchanger. The absorber takes in the refrigerant, and the weak solution is sent to the high temperature generator, where it receives further heat at high temperatures, thereby separating the water and LiBr. The latent heat of condensation is transferred from the high-pressure condenser to the low-pressure generator through an internal heat exchanger. This means that in double stage refrigeration, the refrigerant and absorbent are separated making use of the latent heat of condensation and the high accessible energy of the heat source that is rejected to the environment in single stage refrigeration (in low pressure generator). Therefore, a high COP value may be expected from a double-stage VAR system.

METHODOLOGY

- Because there is no simple formula for determining the value of Enthalpies at different temperatures and concentrations, ANN modelling with Neuron Training is useful for constructing such equations.
- Mass balancing for the various VAR system parts allows for the determination of the mass flow rate.
- Heat transfer in different parts may be easily determined by employing energy balance if enthalpy and mass flow parameters are known.
- At last, we can evaluate the relative merits of single- and double-effect COPs.
- Temperature dependence of the COP value may be investigated by changing the temperature of a particular component while holding the others constant.

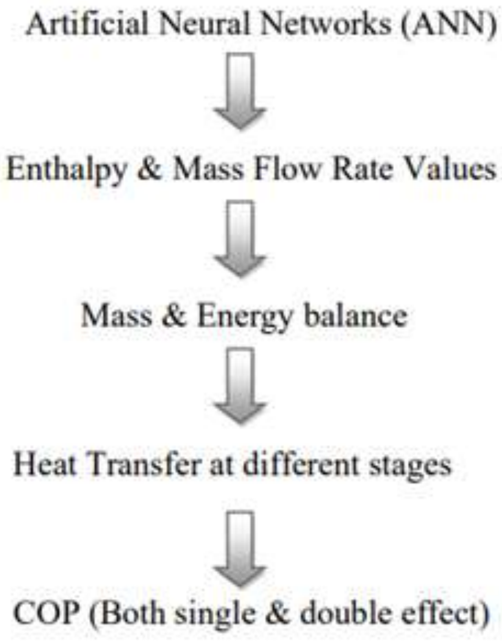

Fig. 1 - Methodology

ANN MODELING

The Following equations are derived by using ANN for calculation of Enthalpy

$$T = \frac{t}{195} \quad (1)$$

$$X = \frac{x}{45} \quad (2)$$

Where 'x' is the concentration of LiBr solution &'t' is the temperature of the solution

$$F1 = -11.5488X - 0.6817T + 11.4856 \quad (3)$$

$$E1 = \frac{1}{1+e^{-F1}} \quad (4)$$

$$F2 = 16.9463X + 0.8378T - 13.014 \quad (5)$$

$$E2 = \frac{1}{1+e^{-F2}} \quad (6)$$

$$F3 = 2.3912X + 2.2963T - 3.0169 \quad (7)$$

$$E3 = \frac{1}{1+e^{-F3}} \quad (8)$$

$$F4 = 4.8857X + 2.0131T - 4.6151 \quad (9)$$

$$E4 = \frac{1}{1+e^{-F4}} \quad (10)$$

$$F5 = 3.6592X + 2.2086T - 3.9311 \quad (11)$$

$$E5 = \frac{1}{1+e^{-f5}} \quad (12)$$

$$E6 = \frac{1}{1+e^{-F6}} \quad (13)$$

$$F6 = -7.5657X + 7.1979T - 9.3693 \quad (14)$$

$$F7 = 2.3363X + 2.7299T + 3.4399 \quad (15)$$

$$E7 = \frac{1}{1+e^{-F7}} \quad (16)$$

$$F8 = -1.2910X + 1.2079T - 3.3782 \quad (17)$$

$$E8 = \frac{1}{1+e^{-F8}} \quad (18)$$

$$F9 = -7.0444X - 10.6850T + 0.3046 \quad (19)$$

$$E9 = \frac{1}{1+e^{-F9}} \quad (20)$$

$$F10 = 40.2470X - 39.5940T + 38.6564 \quad (21)$$

$$E10 = \frac{1}{1+e^{-F10}} \quad (22)$$

$$F11 = -0.5185E1 + 0.0542E2 + 1.8249E3 + 1.4896E4 - 3.0273E5 + 13.1462E6 + 8.1132E7 + 13.0727E8 + 0.0474E9 - 16.8067E10 + 8.9624 \quad (23)$$

$$\text{Enthalpy} = [(\frac{2}{1+e^{-2F11}}) - 1] \times 750 \quad (24)$$

5. RESULTS

The data of enthalpy and refrigerant mass flow rates at various areas of the VAR system were useful in estimating the heat load for both the single stage and the double stage of the system. This was true for both the single stage and the double stage of the system. The following is a tabular representation of the calculated values for heat load:

Table 5.1 Heat load for various components of single stage VAR system

S. No	Thermodynamic Property	Values in kW
1	Circulation Ratio (Δ)	9.94 (dimensionless)
2	Qe	7.011
3	Qc	7.413
4	Qg	9.594
5	Qa	9.624

Similarly heat load table can be obtained for double stage VAR system

Table 5.2 Heat load for double-stage VAR system components

S. No	Thermodynamic Property	Values in (kW)
1	Circulation Ratio (Δ)	5.73 (dimensionless)
2	Qe	354.39
3	Qc2	190.965
4	Qg1	179.8
5	Qg2	291.73

COP equation for single stage is $$COP = \frac{Qe}{Qg + Wp} \quad (47)$$

COP equation for double stage is $$COP = \frac{Qe}{Qg_2 + Wp} \quad (48)$$

So, on using thermodynamic property table and COP equation, the results for single stage are tabulated as follows

Table 5.3 COP comparison for single stage

S. No	Parameter	Magnitude
1	COP (by ANN model)	0.7305
2	COP [1]	0.720
3	Percentage Variation	1.458

Similarly results obtained for double stage LiBr-water VAR system are as follows

Table 5.4 COP comparison for double stage

S. No	Parameter	Magnitude
1	COP (by ANN MODEL)	1.263
2	COP [1]	1.325
3	Percentage variation	4.67

6. CONCLUSION

The writers of this study work attempted to employ ANN as a tool for modelling, and at the end of the work, they came to the conclusion that

- The value of computed COP is in close agreement with COP of the issue that was picked.
- ANN, which is often utilized for condition monitoring, is also capable of being applied in the areas of mathematical modelling and the determination of the thermodynamic parameters of fluid mixes.
- When compared to single stage, the COP of a VAR system with two stages is significantly greater.

References

Arora C.P. 2000, 'Refrigeration and air conditioning', McGraw-hill Education

Arun, M.B., Maiya, M.P., Murthy, S.S., 2001.'Performance comparison of double effect parallel flow and series flow water lithium bromide absorption systems' Applied Thermal Engineering 21, 1273–1279.

Chua, H.T., et al., 2000. Improved thermodynamic property fields of LiBr-H2O solution. International Journal of Refrigeration, 23 (1), 412–429.

Herold K.E., Radermacher R. and Klein S.A., 1996, "Absorption Chillers and Pumps",CRC PRESS London.

Iyer P.S.A, Murthy S.S., Murthy M.V.K. 1990 'Analysis of three pressure vapour absorption refrigeration system' Renewable energy volume 1.

Kaushik S.C., Arora A, 2009 'Energy and Exergy Analysis of series flow Double Effect water-lithium bromide absorption systems', International Journal of Refrigeration.

Kaita, Y 2001.'Thermodynamic properties of LiBr water solutions at high temperatures.' International Journal of Refrigeration, 24 (1), 374–390.

Lee, S.F. and Sheriff, S.A. 1999. Second Law analysis of multi effect lithium bromide water absorption chillers.ASHRAE Transactions,105 (1), 256–266.

Misra, R.D., Sahoo, S., and Gupta, A., 2003 'Thermoeconomic optimization of a single effect water-LiBr vapours absorption refrigeration system' International Journal of Refrigeration, 26 (2), 158–169.

Patel H., Patel L.N., 2015.`Energetic Thermodynamic Analysis of Single Stage LiBr-H2O Refrigeration System' . 3rd International Conference on Innovations in Automation and Mechatronics Engineering 488-495.

Seraj M, Siddiqui M.A, 2013, 'Performance Analysis of Single and Double Effect Absorption Cycles', International Journal of Innovative Research in Science, Engineering and Technology.

Singh D.V.,Maheshwari G., 2011, 'Energy analysis of single-stage LiBr–water vapour absorption refrigeration system using artificial neural network approach', International Journal of Ambient Energy.

Talvar L , Padha M , 2015, 'Performance Assessment Of Large Vapour Absorption System', International Journal of Innovative Research in Science, Engineering and Technology.

Singh, Dheerendra Vikram, et al. "Exergy approach in decision-based design of absorption refrigeration system using artificial intelligence and simulink." Journal of Thermal Analysis and Calorimetry 145.3 (2021): 1227-1253.

Singh, Dheerendra Vikram, and Tikendra Nath Verma. "Energy and exergy analysis of LiBr-H2O-operated vapour absorption refrigeration system using the ANN approach." International Journal of Ambient Energy 43.1 (2022): 905-917.