Modeling of Artificial Neural Network for Predicting Specific Heat Capacity of Working Fluid LiBr-H_2O Used in Vapor Absorption Refrigeration System

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Dheerendra Vikram Singh[1], Dr. Govind Maheshwari[2]
[1] Shri Vaishnav Institute of Technology & Science, Indore (M.P.), India
[2] Devi Ahilya University, Vishwavidyalaya, Indore (M.P.), India

***Abstract*—The objective of this work is to model an artificial neural network (ANN) to predict the value of specific heat capacity of working fluid LiBr-H_2O used in vapour absorption refrigeration systems. A feed forward back propagation algorithm is used for the network, which is most popular for ANN. The consistence between experimental and ANN's approach result was achieved by a mean relative error - 0.00573, sum of the squares due to error0.00321, coefficient of multiple determination R-square 0.99961and root mean square error 0.01573 for test data. These results had been achieved in Matlab environment and the use of derived equations in any programmable language for deriving the specific heat capacity of LiBr-H_2O solution.**

***Index Terms*—ANN, LiBr-H_2O Solution, MATLAB, Specific Heat.**

I. INTRODUCTION

ANN's are used in many engineering application for better and quick results in many engineering field especially in thermal engineering field [1-4]. Author study include many research papers on ANN's and some of the examples are: Yasar Islamoglu [1] A new approach for the prediction of the heat transfer rate of the wire-on-tube type heat exchanger—use of an artificial neural network model; Arzu S¸encana, Kemal A. Yakuta, Soteris A. Kalogiroub[5] Thermodynamic analysis of absorption systems using artificial neural network; Adnan Sozen Mehmet Ozalp, Erol Arcaklioglu[6] Calculation for the thermodynamic properties of an alternative refrigerant (R508b) using artificial neural network, which use neural network to solve mechanical problems. After studying these papers we have reached the conclusion that ANN's is a better technique to solve this problem [7]. Hence author has exercised to model or optimize the neural network for specific heat of LiBr-H_2O used in vapour absorption refrigeration system [8] and absorption chillers [9]. Improved properties of LiBr-H_2O working fluid in absorption chillers is evaluated by H.T. Chua, H.K. Toh, A. Malek, K.C. Ng, K. Srinivasan in their experimental work [9].

II. THEORY OF NEURAL NETWORK

Artificial neural network is analogous to the biological neural network. As with a help of biological neural network one can remember the things and apply that knowledge to the randomly generated unknown problem. Similarly, with help of artificial neural network we can create artificial neural network in MATLAB environment for a given specific problem and train it with some previous set of information as imparting knowledge and then using this knowledge to randomly generated problem set to view the result of training. As the biological neural network consists of biological neuron which responds to the signals (as the result of biological transmission) in the similar manner artificial neural network comprises of artificial neuron which responds when the received value (summation of product of input and weight) exceed the threshold value. So, we can say that artificial neural network mimic the behavior of the biological neural network for intelligent computing [10].

For training the artificial neural network we use various algorithms. One of the variant is Back Propagation algorithm. In Back Propagation algorithm if the training network yield wrong result then the error factor is calculated which is back propagated or feed back to the network, so that network can be scaled accordingly to accommodate that error. This is done by adjusting the synaptic weights connecting the artificial neurons [10].

III. ARCHITECTURE OF NEURAL NETWORK

The inputs given to the artificial neural network are temperature and vapour quality and output is specific heat. The network is shown in figure1. The pattern set for training the artificial neural network is shown in table 1. Input range for temperature is between 10 to190 ^{O}C and for vapour quality is 5 to 75 [9].The back propagation learning algorithm with single hidden layer is used in feed forward mode .The algorithm use logistic sigmoidal transfer function as activation function for both hidden and output layer [11]. As the sigmoidal transfer function posses property of asymptotic limits so it is desirable to normalize all input and output data with largest and smallest values of each data pattern.

The range of normalized input and output pairs is between [0.15, 1].the artificial neural network comprises of three layers input layer, hidden layer and output layer. Hidden layer consist of ten neurons for more accurate results. The transfer function is mentioned

$$F(z)=\frac{1}{1+e^{-z}} \qquad (1)$$

IV. RESULT AND DISCUSION

Specific heat capacity of LiBr-H_2O used in vapour absorption refrigeration system is evaluated by ANN model has neural configuration 2-10-1. The maximum value of epochs is 1000. We changed the value of weights for reducing the error and at the conditions where we have found optimized value of errors we set the network for evaluating specific heat capacity value. Author calculates the mean relative error which is very less than 1% and which is very satisfactory [12]. Adnan Sozen Mehmet O zalp a, Erol Arcaklioglu [6] calculated and presented the coefficient of multiple determination R-square value in range of 0.9312 to 0.9708 for their wet vapor region ANN modelling work and authors work has calculated the value of the coefficient of multiple determination R-square 0.9996.

Figure 2 is representing the curve fitting graph between the experimental results and results by ANN.

In table 2, a comparisons is presented between the actual specific heat capacity and the derived from ANN for LiBr-H_2O working fluid and we can see very clearly that error is very less under the acceptable limits.

V. CONCLUSION

In the present modelling, the ANN approach is used to predict the specific heat capacity of LiBr-H_2O working fluid, mostly used in vapour absorption refrigeration system or chillers. Theses calculation gives the support for choosing alternate method for calculation or analysis of thermal properties of any fluids. This study is also the part of computational intelligence which is also recently new research field.

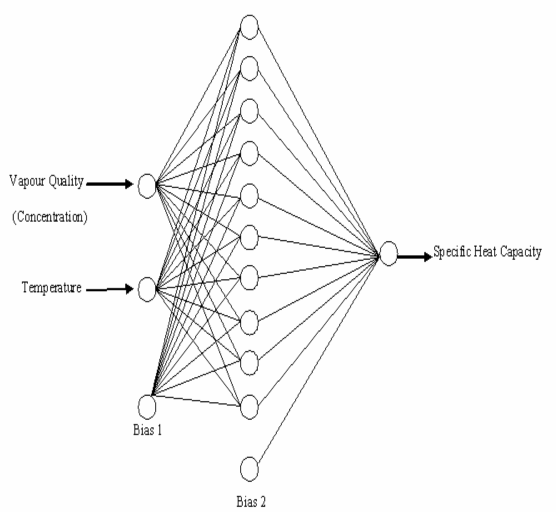

Figure 1. ANN model for predicting Specific Heat capacity of LiBr-H_2O working fluid in vapour absorption refrigeration system

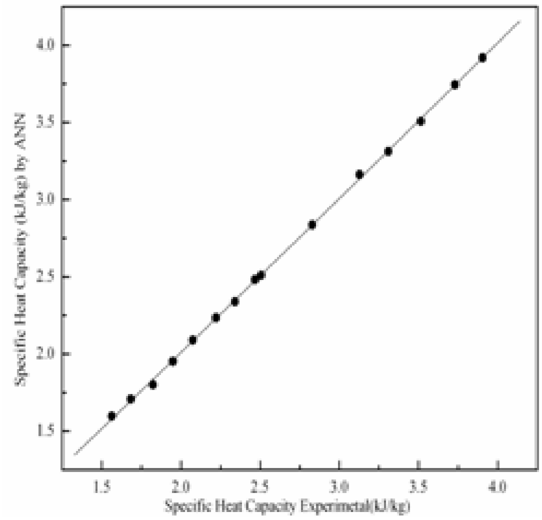

Figure 2. Comparison of experimental and ANN predicted values for specific heat capacity of LiBr-H_2O solution

TABLE I.
EXPERIMENTAL CONDITIONS AND RESULT FOR ANN

Experimental conditions and results [9] prepared for ANN's

	Temperature in (°C)																		
x(wt)%	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
5	3.845	3.852	3.865	3.873	3.881	3.887	3.892	3.904	3.914	3.928	3.945	3.964	3.982	4.000	4.023	4.051	4.077	4.111	4.149
10	3.563	3.579	3.602	3.616	3.628	3.638	3.643	3.659	3.667	3.682	3.696	3.717	3.731	3.750	3.770	3.792	3.817	3.842	3.876
15	3.304	3.329	3.360	3.379	3.396	3.408	3.412	3.432	3.438	3.452	3.466	3.487	3.508	3.515	3.533	3.554	3.572	3.595	3.619
20	3.065	3.097	3.135	3.158	3.179	3.193	3.194	3.218	3.221	3.236	3.249	3.272	3.280	3.294	3.309	3.329	3.341	3.359	3.381
25	2.844	2.882	2.926	2.952	2.976	2.993	2.991	3.018	3.019	3.032	3.051	3.066	3.087	3.086	3.101	3.119	3.128	3.143	3.158
30	2.640	2.685	2.734	2.762	2.788	2.803	2.801	2.831	2.829	2.842	2.856	2.879	2.897	2.893	2.905	2.924	2.930	2.942	2.955
35	2.455	2.506	2.559	2.589	2.616	2.632	2.627	2.659	2.653	2.666	2.678	2.703	2.720	2.714	2.726	2.743	2.747	2.758	2.770
40	2.291	2.347	2.404	2.434	2.462	2.477	2.468	2.502	2.493	2.506	2.519	2.543	2.556	2.552	2.562	2.579	2.583	2.592	2.603
45	2.123	2.208	2.267	2.297	2.324	2.341	2.325	2.360	2.348	2.358	2.370	2.396	2.405	2.403	2.412	2.431	2.432	2.442	2.452
50	1.961	2.077	2.140	2.170	2.196	2.208	2.190	2.223	2.212	2.221	2.233	2.261	2.256	2.263	2.273	2.294	2.292	2.303	2.314
55	1.797	1.925	2.010	2.040	2.065	2.077	2.055	2.089	2.074	2.084	2.095	2.120	2.115	2.124	2.135	2.158	2.156	2.168	2.179
60	-	1.764	1.860	1.896	1.923	1.936	1.908	1.948	1.927	1.936	1.949	1.975	1.968	1.980	1.991	2.016	2.015	2.027	2.040
65	-	-	-	-	1.768	1.782	1.751	1.790	1.769	1.780	1.792	1.824	1.817	1.829	1.841	1.867	1.868	1.883	1.898
70	-	-	-	-	-	-					1.629	1.660	1.654	1.668	1.684	1.717	1.715	1.732	1.749
75	-	-	-	-	-	-								1.511	1.527	1.563	1.563	1.582	1.602

TABLE II.
COMPARE VALUE OF SPECIFIC HEAT CAPACITY FROM EXPERIMENTS AND FROM ANN'S

Compare values of specific heat capacity from experiments [9] and from ANN's

x (wt)%	Temperature(°C)	Specific Heat Capacity (kJ/kg) (Experimental results)	Specific Heat Capacity (kJ/kg) (ANN)	% RE (Relative Error)
5	80	3.904	3.918	-0.0035
10	130	3.731	3.744	-0.0034
15	140	3.515	3.5084	0.0066
20	150	3.309	3.313	-0.0012
25	170	3.128	3.162	-0.0340
30	90	2.829	2.837	-0.0080
35	20	2.506	2.511	-0.0019
40	100	2.468	2.481	-0.0052
45	60	2.341	2.338	-0.0012
50	100	2.221	2.234	-0.0026
55	90	2.074	2.090	-0.0077
60	110	1.949	1.951	-0.0010
65	120	1.824	1.799	0.0137
70	150	1.684	1.709	-0.0148
75	160	1.563	1.597	-0.0217

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AUTHORS

Dr. Govind Maheshwari is with Mechanical Engineering Department of Institute of Engineering and Technology - Devi Ahiliya University, Indore. His research interest includes finite time and exergy analysis of thermodynamic systems and computational intelligence especially with artificial neural network. (email: govind_maheshwari2001@yahoo.com)

Dheerendra Vikram Singh holds Bachelor of Engineering from Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal and a Master of Engineering from Devi Ahilya Vishwavidyalaya, Indore. He is an Assistant Professor with Mechanical Engineering department of Shri Vaishnav Institute of Technology & Science, Indore. (email: dheerendra_mechanical@rediffmail.com)

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