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Performance analysis of ejector absorption heat pump using ozone safe fluid couple through artificial neural networks

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Abstract

Thermodynamic analysis of absorption thermal systems is too complex because the analytic functions calculating the thermodynamic properties of fluid couples involve the solution of complex differential equations and simulation programs. This study aims at easing this complex situation and consists of three cases: (i) A special ejector, located at the absorber inlet, instead of the common location at the condenser inlet, to increase overall performance was used in the ejector absorption heat pump (EAHP). The ejector has two functions: Firstly, it aids the pressure recovery from the evaporator and then upgrades the mixing process and pre-absorption by the weak solution of the methanol coming from the evaporator. (ii) Use of artificial neural networks (ANNs) has been proposed to determine the properties of the liquid and two phase boiling and condensing of an alternative working fluid couple (methanol/LiCl), which does not cause ozone depletion. (iii) A comparative performance study of the EAHP was performed between the analytic functions and the values predicted by the ANN for the properties of the couple. The back propagation learning algorithm with three different variants and logistic sigmoid transfer function were used in the network. In order to train the neural network, limited experimental measurements were used as training and test data. In the input layer, there are temperature, pressure and concentration of the couples. Specific volume is in the output layer. After training, it was found that the maximum error was less than 3%, the average error was less than 1.2% and the R^2 values were about 0.9999. Additionally, in comparison of the analysis results between analytic equations obtained by using experimental data and by means of the ANN, the deviations of the refrigeration effectiveness of the system for cooling (COP_r), exergetic coefficient of performance of the system for cooling ($ECOP_r$) and circulation ratio (F) for all working temperatures were found to be less than 1.7%, 5.1%, and 1.9%, respectively. Deviations for COP_r, $ECOP_r$ and F at a generator temperature of ~90 °C (cut off temperature) at which the coefficient of performance of the system is

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maximum are 0.9%, 1.8%, and 0.1%, respectively, for other working temperatures. When this system was used for heating, similar deviations were obtained. As seen from the results obtained, the calculated thermodynamic properties are obviously within acceptable uncertainties. The results showed that the use of ANNs for determination of thermodynamic properties is acceptable in design of the EAHP.

Keywords: Artificial neural network; Absorption; Thermodynamic properties; COP; Ozone safe

1. Introduction

Despite a lower coefficient of performance (COP) as compared to the vapor compression cycle, ejector absorption heat pumps (EAHPs) are promising for using waste energy from industrial processes, geothermal energy, solar energy etc. In addition, the EAHPs use natural substances, which do not cause ozone depletion, and have no fossil fuel consumption as working fluids. For these reasons, this technology has been defined as ozone friendly. The application of solar energy for cooling products for preservation purposes, as well as air conditioning in buildings, is a field with high potential in the coming years, and as the technological setbacks are overcome, it may become a highly profitable sector [1].

There are too many parameters affecting the overall performance of the EAHPs. In order to improve the system performance, researches on the design of system components and applications of various configurations on the system have been constantly occurring. One of them is the choice of an appropriate refrigerant/absorbent pair. For example, the utilization of low potential heat sources (50–130 °C) for cooling and refrigeration is limited by the properties of the working fluids. So, the choice of the most appropriate refrigerant/absorbent pair is as important as system design and optimization of parameters. Determination of the thermodynamic properties of fluid couples for absorption systems is also one of the present interests. Continued research in this field depends on analysis of alternative fluid couples that are thermodynamically acceptable and harmless for the environment [2–10]. This work proposes the methanol/LiCl (refrigerant/absorbent) fluid couple, which has zero ozone depletion potential and is not a fossil fuel.

Initially, in the present study, a special ejector, located at the absorber inlet [5,28] instead of the common location at the condenser, was used in the EAHP with the working couple methanol/LiCl. As is well known, ejectors can increase the pressure and do not consume mechanical energy directly, which are the main characteristics of ejectors [6,11,12]. Because of these characteristics, applying an ejector may be simpler and safer technologically than applying mechanical devices, that can increase pressure, such as a compressor, pump etc. Besides the ejector's very simple configuration, the systems combining ejectors and other devices are also very simple [13].

Thermodynamic analysis of the EAHPs is too complex because the thermodynamic properties equations of the fluid couples involve the solution of complex differential equations. Analytical computer codes usually require a large amount of computer power and need a considerable amount of time to give accurate predictions. Instead of complex rules and mathematical routines, ANNs are able to learn the key information patterns within a multi-dimensional information domain. This technique can be used in modeling complex physical phenomena, such as in thermal engineering. The use of artificial neural networks (ANNs) for modeling and prediction purposes is