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Application of artificial neural network for predicting performance of solid desiccant cooling systems – A review

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ABSTRACT

In present study, an attempt has been made to review the applications of artificial neural network (ANN) for predicting the performance of solid desiccant cooling systems. Different types of neural networks are applied to model the solid desiccant cooling systems. With use of experimental data, an ANN model was developed which is based on different algorithms. Available experimental data were divided into two categories for training and testing of the ANN model. Later on, trained ANN model was tested for predicting the performance of system based on various input and output parameters such as air stream flow rates, temperatures and humidity ratios, pressure drop, dehumidifier effectiveness, cooling capacity, regeneration temperature, power input, coefficient of performance etc. So, present review proposes the use of ANN based model to simulate the relationship between inlet and outlet parameters of the system. The ANN predictions for these parameters usually agreed with the experimental values with higher correlation co-efficient. The previous studies show that ANNs can be used with a higher precision in guessing the performance of solid desiccant cooling systems. This review is useful for making opportunities to further research of ANNs and its feasibility which is becoming common in the coming days.

1. Introduction

The performance of solid desiccant cooling systems is evaluated in terms of energy analysis (first law) and exergy analysis (second law) of thermodynamics using conventional approaches i.e. analytical, numerical and experimental methods. The conventional analytical and numerical approaches involve complex equations and assumptions, whereas experimental studies are rigorous and costlier. During last two decades, the use of artificial intelligence systems in the field of space cooling is increasing gradually to solve the complicated problems. Artificial intelligence systems include areas such as artificial neural network (ANN), genetic algorithms, fuzzy logic and various hybrid systems, which combine two or more techniques. The main advantage of ANN as compared to the other artificial intelligent systems is its accuracy, speed, simplicity and ability to model a multivariable problem for solving complex relationships between the variables and establishing non linear relationships by means of training network. ANN model can forecast the desired output of the system using limited training data. Moreover, ANN overcomes the limitations of traditional approaches by extracting the required information using training data, which has not required any specific analytical equations or exhaustive experimental study. So, manufacturers may employ the ANN technique for evaluating the performance of solid desiccant cooling that can save both engineering effort and funds. Earlier many review studies were reported with applications of ANN in the field of drying processes [1], forecasting [2], atmospheric sciences [3], solar photovoltaic systems [4] and modeling of energy systems [5–7]. Ding [8] summarized various simulation techniques for modeling and performance estimation of conventional VCR systems.

Following the cited literature, it is seen that there is no specific review has been reported on applications of ANN for solid desiccant cooling systems. The present review set out more broadly about up to date study covering the applications of ANN in the performance forecasting of solid desiccant cooling systems by prediction of parameters in terms of cooling capacity, dehumidifier effectiveness, regeneration temperature, power input and COP of the system. Moreover, the limitations with ANN models are also highlighted. The present review can be impacted in term of application of ANN for performance estimation of desiccant cooling system requiring less formal statistical training, ability to implicitly detect complex nonlinear relationships between dependent and independent variables, ability to detect all possible interactions between predictor variables and the availability of

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Nomenclature

a	actual output
ANN	artificial neural network
b	bias
COP	coefficient of performance
COP_H	thermal coefficient of performance
COP_T	total coefficient of performance
COP_w	total work coefficient of performance
C_p	specific heat (J/kg K)
DEC	direct evaporative cooling
E_t	total energy consumption (kW)
EC	evaporative cooling
h	enthalpy (kJ/kg)
MRR	moisture removal rate (kg/h)
MSE	mean square error
$\dot{m}$	mass flow rate of air stream (kg/s)
p	predicted output (network output)
Q_{cc}	cooling capacity (kW)
Q_r	regeneration heat (kW)
R	correlation coefficient
RH	Relative humidity (%)
RHSF	room sensible heat factor
RMSE	Root mean square error
SHR	Sensible heat ratio
T	temperature (K)
TANSIG	Tan-sigmoid transfer function
TRAINLM	Levenberg–Marquardt backpropagation
VC	vapor compression
VCOP	coefficient of vapor compression
VCR	vapor compression refrigeration
VCS	vapor compression system
W	humidity ratio (g/kg)
W_c	compressor work (kW)
w	synaptic weights
$w_{j,i}$	the weight between input layer vectors and hidden layer vectors
X	input signal
Y	output signal

Greek letters

ε	effectiveness
ϕ	relative humidity
$\upsilon_{k,j}$	the weight between hidden layer vectors and output layer vectors
Δm	moisture removal rate (kg/h)

Subscript

a	dry air
amb	ambient air
DW	desiccant wheel
d	desiccant
DEC	desiccant enhanced evaporative cooler
HRW	heat recovery wheel
in	inlet
i,j,k	the number of nodes
p	process air
r	regeneration air
wb	wet bulb
1,2, etc.	reference state points

multiple training algorithms. The objective of the present review is to aware about an introduction of an application of artificial neural network in the field of space cooling energy modeling as a powerful data-driven, self-adaptive, flexible computational tool having the capability of capturing nonlinear and complex underlying characteristics of any physical process with a high degree of accuracy. Moreover, it is found that artificial neural network is very suitable for inverse energy modeling when the numerical relations between input and output variables are unknown, and can't be established. Thus, this review is useful for making opportunities to further research of use of artificial neural network in performance prediction of solid desiccant cooling systems and its feasibility which is becoming common in the coming days.

2. Overview of solid desiccant cooling

2.1. Brief history of solid desiccant cooling

Different configurations of solid desiccant cooling system have been proposed earlier by many researchers so far to attain better system performance in terms of maintaining a thermal comfort. The earliest form of solid desiccant cooling cycle was proposed by coupling desiccant dehumidifier with heat source and evaporative cooler [9]. Similar cycle was proposed later by Dunkle [10] using desiccant wheel

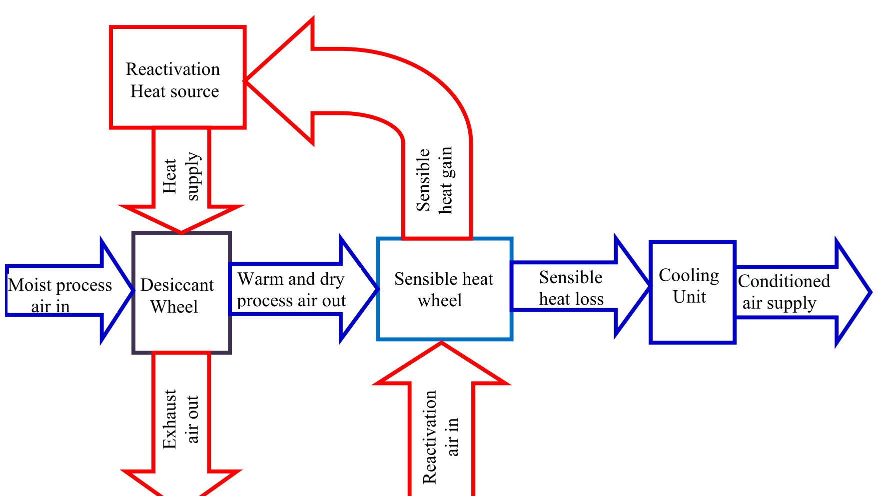

Fig. 1. Principle of solid desiccant cooling.