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ANFIS Prediction Model of a Modified Active Greenhouse Dryer in No-Load conditions in the Month of January

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Abstract

In this study, an attempt is made to a make soft computing prediction model for modified greenhouse dryer under active mode in no-load conditions. Adaptive Neuro Fuzzy Inference system (ANFIS) is use to predict the behaviour of the system. In this prediction model, weather conditions are taken as input parameters such as ambient temperature, ambient relative humidity, global radiation and time of experimentation and the output parameters are greenhouse air temperature and relative humidity which are important factor for drying. ANFIS shows excellent prediction ability for the greenhouse dryer.

Keywords

ANFIS, active mode, Modified greenhouse dryer, Prediction model

1. Introduction

A greenhouse is a complicated structure to provide ideal conditions for plant growth, drying and others throughout the year. The inside atmosphere of the greenhouse is controlled by other external factors. The greenhouse is used in the following applications namely crop cultivation, low temperature crop drying, soil solarisation, poultry and aquaculture [1].
The temperature inside atmosphere of the greenhouse dryer is more than ambient temperature and relative humidity is less than ambient conditions, which is very ideal situation for crop drying. Products are placed inside the tray of the dryer for the removal of the moisture.

2. Literature Review

There is considerable interest in the field of solar drying as drying is very energy intensive process. Prakash and Kumar have presented comprehensive review of the various existing solar dryers [2]. It is concluded that low temperature drying is suitable for the various crops. Greenhouse dryer is highly recommended for bulk drying of the crops in low temperature drying.

In order to examine the dryer, one need to perform two type of test namely with load and no-laod conditions. Kumar and Tiwari have made thermal model of the greenhouse dryer for jaggery drying under natural and force convection mode [3, 4]. Predicted resulted is validated with experimental results. However the result is further improved for passive mode by the ANFIS modeling as recommended by the Prakash and Kumar [5]. Thermal test in no-load conditions would provide thermal behavior of the dryer. Based on this, suitable dryer will be selected for the crops for the effective drying. Barnwal and Tiwari proposed the hybrid greenhouse dryer [6]. They investigated in the no-load condition in both active and passive mode. Singh and Kumar proposed the no-load performance index for the various solar dryer [7]. It is proved highly informative for the researcher and industrialist.

In solar greenhouse dryer, the major loss of the solar radiation takes through the north wall of the dryer. So now a day, lots of research is going on to minimize this loss through the north wall so that crop drying time can be reduced. Sethi and Arora have applied inclined north wall reflection (INWR) under active and passive mode in the convectional greenhouse dryer [8]. This improved the drying performance of the dryer. Berroug et al., have applied phase change material in the north wall of the conventional greenhouse dryer [9]. It has improved the inside temperature of the greenhouse air and decrease the relative humidity of the greenhouse air.

The main objective of this communication is as following: (i) to do experimentation in the no-load conditions of the modified greenhouse dryer in active mode. (ii) to do ANFIS modeling of the proposed dryer.

3. Experimental Procedure

The proposed greenhouse dryer is of roof even type under active mode. The exhaust fan is connected to solar cell through solar charge controller. The north wall of the greenhouse dryer is made opaque by the application of mirror as shown in Fig 1. The dimension of the dryer is of 1.5×1.0 m^2. Experiment was conducted hourly basis from 10.00 -17.00 hrs on the concrete floor in the Maulana Azad National Institute of Technology, Bhopal (India) in the month of January 10, 2013 in winter season. The solar intensity is measured by the solar power meter; the relative humidity, wind velocity and temperature by the Lutron temperature/ hygrometer with least count 0.1.

Fig.1: Photograph of the modified active greenhouse dryer

4. Adaptive Neuro Fuzzy Inference Systems (ANFIS)

The ANFIS model is totally on a 1^{st} order of the Takagi–Sugeno model [10]. It improved fuzzy controllers due to self-learning ability which leads to lowest steady state error.

The Sugeno fuzzy model applicable to complex nonlinear and dynamic systems. A standard rule in a model is given in below.
If x is Z and y is U Then z = f(x,y)
Here Z and Q are fuzzy sets and z = f(x, y) is a crisp function from Z and U, which contains two rules namely
Rule 1. If x is Z_1 and y is U_1, Then $f^1 = a^1x + b^1y + c^1$
Rule 2. If x is Z_2 and y is U_2, Then $f^2 = a^2x + b^2y + c^2$
where [x, y] is an input variables vector as shown in Fig. 2.

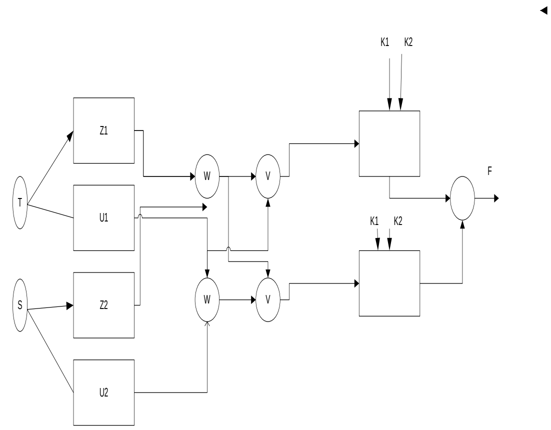

Fig. 2: ANFIS Architecture

Here w_1 and w_2 are firing strengths, which is the product of the membership grades and output function (f) is the mean weight of each rule.

Layer 1: The output function of Node i(Oi^1):
$Oi^1 = \mu_1 Zi(x)$; i = 1, 2 (1.1)
$Oi^1 = \mu_1$ Ui(x) ; i = 1, 2 (1.2)

Layer 2: In this layer, each node is a circle node with labelled W, which product the incoming signals and generate output.
$O_i^2 = w_i$; i = 1, 2 (1.3)

Layer 3: In this layer, calculate the ratio of the i th rule's of the firing strength to the total of all firing strength of the system
$Oi^3 = w1_i$; i= 1, 2 (1.4)

Layer 4: In this layer, the calculation of the i th rule toward the overall output takes place
$Oi^4 = w1_i f_i$, i = 1, 2 (1.5)

Layer 5: In the fifth layer, overall output is computed:
$Oi5 = \Sigma w1_i f_i$, i = 1, 2 (1.6)

5. Result and Discussion

Fig 3 represents the variation of the global radiation during the experimentation. Experiment was conducted in the clear sky condition. The average value of the solar intensity is 767.17 W/m^2.

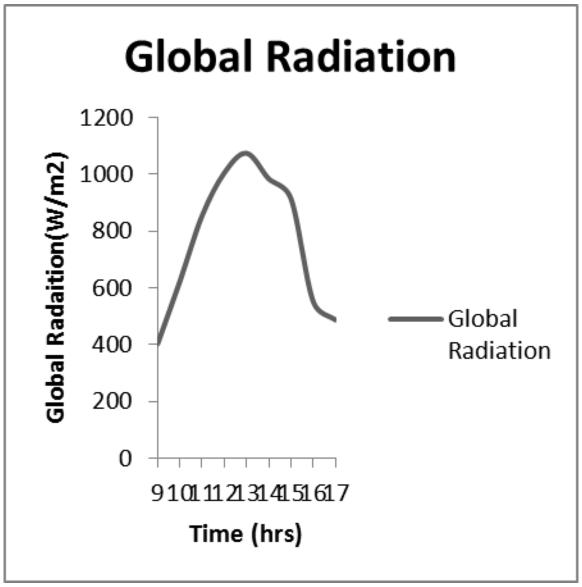

Fig. 3: Variation of solar radiation with time of the day

Fig. 4 reveals the variation of the ambient and greenhouse room temperature. Experiment results shows that the average temperature of the greenhouse air temperature is 11.82 ^{o}C is more than ambient temperature which is highly preferable for the crop drying.

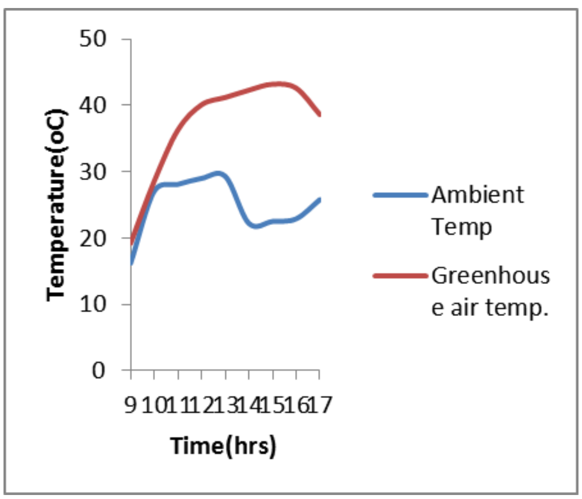

Fig. 4: Variation of temperature with time of the day

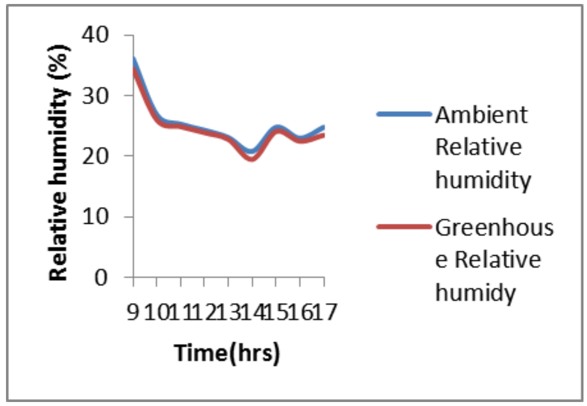

Fig. 5: Variation fo ambient and greenhouse relative humidity

Fig. 5 represent the fluation of the ambient relative humidity and greenhouse air relative humidity. It is observed that greenhouse air relative humidity is always less than ambient relative humidity which is very good for drying.

ANFIS model for dryer is trained by using experimental data. The total error is only 0.026 for the prediction of the greenhouse room temperature. This is hybrid algorithm. Its computation takes less time than other does. Fig. 6 shows the training snapshot for the greenhouse air temperature and Fig 7 shows the rule viewer of this model.

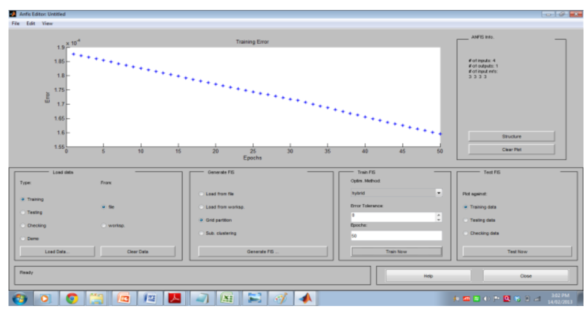

Fig. 6: Training of the ANFIS Model

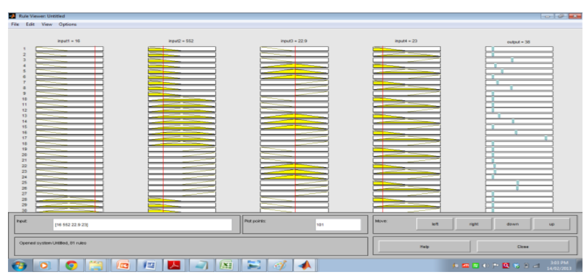

Fig.7: Photo of rule viewer

The prediction error of ANFIS model for the greenhouse air relative humidity is 0.12, which is correlated with the experimental result.

6. Conclusion &Future Work

In this communication, an attempt is made to make ANFIS model for the modified active greenhouse dryer under no-load condition. ANFIS model was successfully validated with the experimental data. This work will be highly useful for the researcher to do analysis without conducting the tedious experimental work. It will save time of the experimentation. Researcher can examine in the other season also.

References

[1] G. N. Tiwari, Greenhouse technology for controlled environment, Narosa Publishing house, New Delhi. (2003).
[2] O.Prakash , A. Kumar Historical Review and Recent Trends in Solar Drying Systems. International Journal of Green Energy, 2012 Online.
[3] A. Kumar, G.N. Tiwari, Thermal modeling of a natural convection greenhouse drying system for jaggery: an experimental validation, Solar Energy 80 (2006)1135–1144.
[4] A. Kumar, G.N. Tiwari, Thermal modeling and parametric study of a forced convection greenhouse drying system for jaggery: an experimental validation, International Journal of Agricultural Research 1 (2006) 265–279.
[5] O.Prakash, A. Kumar ANFIS modeling of a natural convection greenhouse drying system for jaggery: an experimental validation. International Journal of Sustainable Energy, 2012 Online.
[6] P.Barnwal,G.N. Tiwari. Grape drying by using hybrid photovoltaic-thermal (PV/T). greenhouse dryer: An experimental study. Solar Energy 82 1131–1144,(2008).
[7] S.Singh, S.Kumar, Testing method for thermal performance based rating of various solar dryer designs Solar Energy 86 (2012) 87–98.
[8] V.P.Sethi,S.Arora,Improvement in greenhouse solar drying using inclined north wall reflection, Solar Energy 83, 1472–1484,(2009).
[9] F. Berrouga, E.K. Lakhala, M. E Omaria, M. Faraji, H. E Qarniac, Thermal performance of a greenhouse with a phase change material north wall, Energy and Buildings 43,3027–3035, (2011).
[10] T. Takagi, T. Sugeno, Fuzzy identification of system and its applications to modeling and control, IEEE Transaction on Systems, Man and Cybernetics 15 (1985).

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