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Temperature control based on ANFIS

Doaa M. Atia, Hanaa T. El-madany *

Electronics Research Institute, Photovoltaic Cells Department, Giza, Egypt

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Abstract

The greenhouse is a complicated nonlinear system, which provides the plants with appropriate environmental conditions for growing. This paper presents a design of a control system for a greenhouse using geothermal energy as a power source for heating system. The greenhouse climate control problem is to create a favourable environment for the crop in order to reach predetermined results for high yield, high quality and low costs. Four controller techniques; PI control, fuzzy logic control, artificial neural network control and adaptive neuro-fuzzy control are used to adjust the greenhouse indoor temperature at the required value. MATLAB/SIMULINK is used to simulate the different types of controller techniques. Finally a comparative study between different control strategies is carried out.

Keywords: Artificial intelligent; Control; Artificial neural network; Fuzzy logic control; Adaptive neuro-fuzzy

1. Introduction

A greenhouse is an enclosed construction that provides plants with optimally controlled environment for regulation of plants growth conditions, to decrease cost of production and increase crop revenues (Coelho et al., 2005). The greenhouse environment can be improved by adding heating, ventilation and CO_2 supply systems, in order to provide the best environmental conditions. Numerous greenhouses use a conventional control, but this control strategy may not be suitable to guarantee the desired performance (Ghoumari et al., 2002). The recent techniques of artificial intelligence have found application in almost fields of the human knowledge. However, a great emphasis is given to the accurate sciences areas; perhaps the major expression of the success of these techniques is in engineering field. Fuzzy and neural networks are two types of AI techniques. These two techniques neural networks and fuzzy logic are many times applied together which is called adaptive neuro-fuzzy inference system (ANFIS) for solving engineering problems where the classic techniques do not supply an informal and accurate solution (Alhanafy et al., 2010; Ruano, 2005; Khoshnevisan et al., 2014).

* Corresponding author.
E-mail address: hanaa_tolba@yahoo.com (H.T. El-madany).
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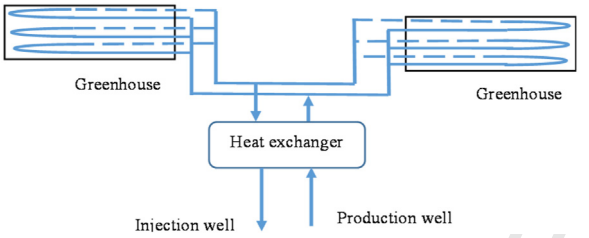

Fig. 1. Greenhouse geothermal heating system layout.

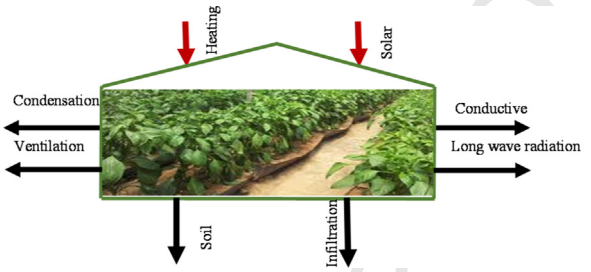

Fig. 2. Greenhouse losses and gain scheme.

In the last decade, a number of researchers addressed the control design of the climatic conditions in GHs. GH modelling and identification have been studied by Ferreira et al. (2002), Cunha (2003), and Bennis et al. (2003). GH climate was developed using intelligent controllers by Arvantis et al. (2000), Lafont and Balmat (2002), Sigrimis et al. (2002), Pasgianos et al. (2003), Bennis et al. (2005), Koutb et al. (2004), Bennis et al. (2003), and Fourati and Chtourou (2004). Numerous strategies and control techniques have been proposed (Márquez-Vera et al., 2016; Revathi and Sivakumaran, 2016; Coelho et al., 2005), model predictive control (Coelho et al., 2005; Piñón et al., 2000), linear quadratic adaptative control (Arvantis et al., 2000), neural networks control (Ferreira et al., 2002), fuzzy control (Lafont and Balmat, 2004).

In this paper, modelling and control problem of greenhouse indoor temperature are studied. Various control techniques (PI control, fuzzy logic control (FLC), artificial neural network control (ANNC) and ANFIS) are presented. Moreover MATLAB/SIMULINK is used to validate the proposed types of controller techniques. Finally a comparison study between the controllers performance is carried out.

2. Geothermal greenhouse layout

Heating greenhouses can be accomplished using different systems and energy sources, such as fossil fuels and geothermal energy. Heating systems utilizing fossil fuels might have low initial cost, but their running costs are high, as well as causing pollution to the environment. On the other hand geothermal energy heating systems might have high initial costs but low running costs and are pollution free which makes these systems highly attractive to farmers (Radojević et al., 2014). Bare tube heating system is considered in this study. It is preferable for the tubing to be located low in the greenhouse. Control of the system may be manual via gate valves or by using automatic control. Ras Sedr-2 well is used as a geothermal source which located on the Suez Gulf. Fig. 1 presents the layout of the greenhouse heating system using geothermal energy.

3. Greenhouse dynamic modelling

The dynamic behaviour of the greenhouse microclimate is a combination of physical processes involving energy transfer and mass balance (Pawlowski et al., 2009). The physical processes involved in estimating the greenhouse climate, can be schematized according to Fig. 2. The heat balance can be expressed (Emeish, 1999; Xu et al., 2006) as:

$$Q_{t_{otal}} = Q_{gain} - Q_{loss} \quad (1)$$

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