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Signature : …………………………………….

Supervisor’s Name : Datuk Prof. Dr. Mohd Ruddin bin Ab Ghani

Date : …………………………………….

FUZZY LOGIC CONTROLLER TO MAINTAIN PARABOLIC DISH (PD) RECEIVER TEMPERATURE WITHIN SAFE OPERATING RANGE

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

I declare that this report entitle “Fuzzy Logic Controller to Maintain Parabolic Dish (PD) Receiver Temperature Within Safe Operating Range” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …………………………………….

Name : Muhammad Faez Bin Ali

Date : …………………………………….

To my beloved mother and father

ACKNOWLEDGEMENT

First of all, I am greatly thankful to ALLAH SWT on His blessing to make this project successful.

I would like to express my gratitude to my supervisor, Datuk Prof. Dr. Mohd Ruddin bin Ab Ghani for his valuable guidance, enthusiasm and motivation given throughout the progress of this project.

I would also like to thank my parents for always being there to support me at all times and for giving me the courage and strength that are necessary to carry on with this project. Thanks for their encouragement, love and emotional supports that they had given to me.

I would also like to thank all my friends who had given me the advice, courage and support in completing this Thesis. Their views and tips are very useful.

Last but not least, I would like to thank all the lecturers who have been very friendly and helpful in providing me with necessary information for my project.

ABSTRACT

Advancing the utilization of Renewable Energy (RE) assets has gotten to be one of the top government motivations all through the world. However, in order to develop RE, for example, Concentrating Solar Power (CSP) in Malaysia, a few key factors that influence the execution of this framework should be totally investigated. The RE resource such as solar energy from the sun is random and intermittent during daily operation depend on weather. With focusing on the one of the CSP technologies which is Parabolic Dish (PD) System, this project aims to investigate on the fuzzy logic controller in order to maintain PD receiver temperature within the safe operating range. Based on research of the previous work, this project proposed fuzzy logic as a control method that maintains the temperature of the PD receiver to the desired point or the maximum temperature for the receiver. By using MATLAB simulation software, the fuzzy logic control (FLC) designed, tested, and tuned to control the system. The simulations of block diagram of the system designed in Simulink and evaluate in terms of speed of response to the desired setting value, overshoot in fixed set point. By the end of this research, the FLC that implement to the system should be neglected overshoot value and steady state error in other to maintain the temperature within safe operating range.

ABSTRAK

Memajukan penggunaan Tenaga Boleh Diperbaharui (RE) telah menjadi salah satu motivasi tertinggi kerajaan semua melalui dunia. Walaubagaimanapun, dalam usaha untuk membangunkan RE, sebagai contoh, menumpukan tenaga solar (CSP) di Malaysia, beberapa faktor utama yang mempengaruhi pelaksanaan rangka kerja ini perlu sama sekali diambil kira. Sumber RE seperti tenaga solar daripada matahari adalah rawak dan terputus-putus semasa operasi setiap hari bergantung kepada cuaca. Dengan memberi tumpuan kepada salah satu teknologi CSP iaitu Sistem 'Parabolic Dish' (PD), kajian ini bertujuan untuk mengkaji pada pengawal logik fuzzy untuk mengekalkan PD suhu penerima dalam julat operasi yang selamat. Berdasarkan kajian kerja yang lepas, projek ini dicadangkan 'Fuzzy logic' sebagai kaedah kawalan yang mengekalkan suhu penerima PD ke tempat yang dikehendaki atau suhu maksimum bagi penerima. Dengan menggunakan perisian simulasi MATLAB, kawalan fuzzy logik (FLC) yang direka, diuji, dan ditala untuk mengawal sistem. Simulasi gambarajah blok sistem direka dalam Simulink dan menilai dari segi kelajuan tindak balas kepada nilai tetapan yang dikehendaki, terlajak di titik set tetap. Pada akhir kajian ini, FLC yang melaksanakan sistem boleh diabaikan nilai terlajak dan ralat keadaan mantap di tempat lain untuk mengekalkan suhu dalam julat operasi yang selamat.

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CHAPTER 1

INTRODUCTION

This chapter will discuss on the background of the fuzzy logic controller to maintain PD receiver temperature within safe operating range; problem statement, objective and scope.

1.1 Motivation

Solar, biomass and wind is the example of Renewable Energy (RE) resources has become increasing in production and make the future recourses less dependent on fossil fuel. Solar energy is the great potential of the RE because of the energy resource most plentiful on earth[1]. To convert solar energy to electrical energy, it can be done by Photovoltaic (PV) system or CSP system.

PV and CSP gather various part of solar resource and to develop their power plants they have theirs generation capacities as well as different region. These two structures use various advances to generate electricity. CSP technologies use mirrors or lenses to track the solar radiation for heat up the fluid inside receiver and creating steam; the steam then generate electricity by drives a turbine generator similarly as the conventional power plants.

Interestingly, CSP can generate electricity even during cloudy or after sunset when equipped with thermal storage system. CSP technologies have four types which are Parabolic Troughs system, Linear Fresnel system, Parabolic Dish System and Power Tower system.

(a)

(b)

(c)

(d)

Figure 1.1: Photo of (a) Parabolic troughs system, (b) linear Fresnel system, (c) parabolic dish system and (d) power tower system. [2]

In general, CSP gives commercial advantages which might give a significant contribution to develop more sustainable energy, green responsive and fuel cost efficiency of generating energy with no fuel cost. On the other hand, creating CSP Plant in Malaysian environment draws, public worries on visual effects especially the land area requirements for the brought together plant. More land is required for the plant in order to generate high electrical energy. Nevertheless, impacts of area use can be decreased by picking lands low population density. Furthermore, among the CSP technologies, PD system is suitable for little scale plant and they are measured. PD is suitable for small area with each unit commonly producing yield of 3 to 25 kW and can possibly get to become one of the least expensive sources of RE. In addition, the area of the CSP plant particularly the PD is littler than the area of the PV plant [1].

Parabolic dish system is one of the CSP technology, have been investigate and developed for global uses that permits to achieve maximum temperatures by concentrating the solar radiation in a centre [3]. Parabolic dish system tracks the sun and focus solar energy into receiver and transfers it to a generator for generates electrical power from the energy absorb. [3].

A concentrator in PD system, concentrations solar light on the central point of the concentrator in Stirling engine where hot end is installed which mirror of the parabolic shaped. Then, solar energy with high temperature is switched to the heat exchanger of the engine. A schematic for a stirling engine associated to the concentrator illustrates in Figure 1.1. Acceptable to have the concentrated solar energy when the sun moves during the times, the concentrator is equipped with a sun tracker which available to tracks the sun. Henceforth, the concentrated solar energy is consumed and exchanged to the working fluid in the engine [4].

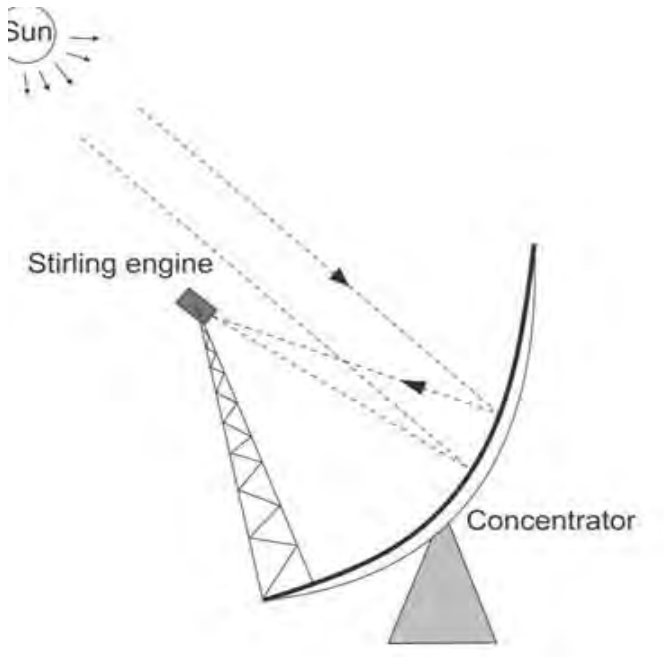

Figure1.2: Schematic of a PD system[4].

The overall efficiency of a PD system, the solar-to-mechanical efficiency, depends on the following parameters; Solar, radiation concentration, intercept factor, thermal receiver efficiency and engine efficiency[5].

For controller development, different controllers like Proportional Integral Derivative (PID) and Fuzzy logic controller that widely used to control the system. Smart control of computer based on fuzzy set theory is fuzzy control. The basic block diagram as fuzzy language variables and fuzzy logic inference is shown as in Figure 1.2 [6].

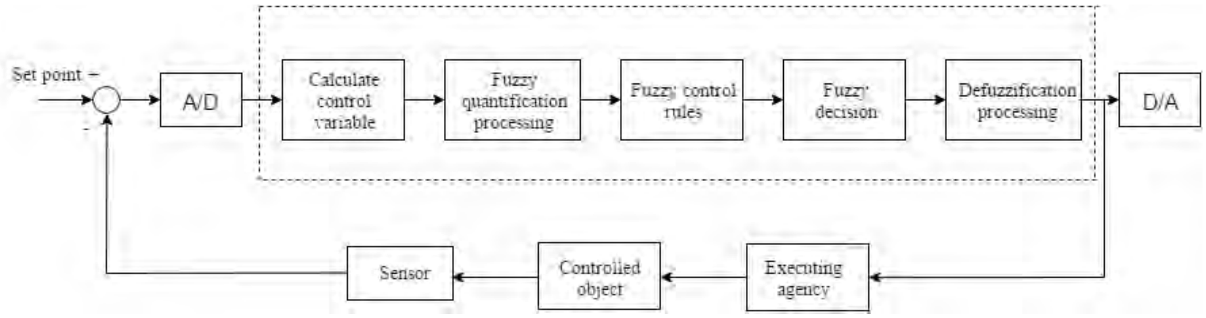

Figure1.3: The fuzzy control basic block diagram[6].

1.2 Problem Statement

The input thermal energy from the sun is rather unpredictable and intermittent during daily operation. Meanwhile, the temperature must be kept high to exploit the thermal efficiency. Besides, the temperature increase will exceed the threshold safe operating will damage the receiver material. A fuzzy logic controller needed in order to maintaining the temperature to be within the safe region.

1.3 Objective

The aim of this project is:

1) To develop fuzzy logic controller for PD receiver temperature.
2) To analyze the performance of PD receiver.
3) To maintain the PD receiver temperature.

1.4 Scope

The scopes for this project the fuzzy logic controller for temperature control system design by using Matlab Simulink. Then analyze the system response before and after implementing the controller. Beside, maintain the temperature within safe operating region in 1000 Kelvin.

1.5 Expected project outcome

The expected result for this project is fuzzy logic controller developed for PD receiver temperature. Moreover the performances of the PD receiver improve after implementing the controller. Besides, the temperature of PD receiver could be maintained within safe operating region.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss on research of preceding research related with the project, the concept of literature and suggested model.

2.1 Journal Literature

The comparison of the preceding research related to project such as temperature control system for CSP, industrial and heater application. All the previous work very useful, giving a great deal of though and information which can execute and apply to the project.

2.1.1 Temperature Control System for CSP

In 2014, Bertinho A. Costa and Joao M. Lemos [7] proposed material derivative based control for temperature control of a CSP parabolic trough system. The speed of the fluid is used as the manipulated variable to control the temperature. In these cases the control The controller is able to adjust to volumetric flow rate to control the temperature at the pipe outlet. Results are improved and also show that the control system is able to compensate large sun power perturbations.[7]

In 2014, Raúl Morales, Felipe Valencia, Doris Sáez and Matías Lacalle [8] presented fuzzy predictive controller in supervisory mode for a solar-concentration-based power plant, with cylindrical-parabolic solar collectors. A model predictive control (MPC) is added in order to maximize the use of the available solar thermal energy for energy production. From the development, it is possible to conclude that the supervisory control enhance the plant performances. The improvement done in the achievement of higher temperatures in the outlet oil, and in the power produced increasing associated with the higher outlet oil temperature. From the control theory, by adding the supervisory control loop also provided some improvements in the closed-loop behaviour.[8]

In 2015, Y. Li, S. S. Choi, C. Yang, and F. Wei [9] advanced dynamic model of the dish-Stirling (DS) system through controlling the Stirling engine speed shows that maximum solar energy harness can be achieved. Besides, the adopted fuzzy supervisory control method is appeared to be compelling in controlling the temperature as the speed changes of the receiver in the DS system. A supervisory fuzzy control scheme has been recognized as a suitable means because it can successfully relieve the effects on the DS receiver temperature of the engine speed differences.[9]

2.1.2 Temperature Control System for Industrial Application

In 2006, Woosung Choi, Woojong Yoo, and Sangchul Won [10] recognized an programmed temperature control system in blast furnace operation. By utilizing Takagi-Sugeno (TS) fuzzy model based on input-output data, the temperature control model for blast furnace. Programmed temperature control techniques based on model predictive control (MPC) techniques, in view of modeling error, the outcomes improved after GA advancement.

The modeling result turns out more precise as repetitions go on, the modeling error is about zero and the model is over fitted.[10]

In 2010, Jiang Wei [11] proposed based on fuzzy self-tuning PID on the temperature control system of vacuum smelting process. The fuzzy self-tuning PID controller has nearly no overshoot and a shorter alteration time of the characteristic, and has the improved dynamic response and steady-state characteristic, compared with the conventional PID controller. The control precision of fuzzy self-tuning PID control is higher than and PID control.[11]

In 2014, Wei Wang, Han-Xiong Li, and Jingtao Zhang [12] presented power plant boiler control system by using intelligence-based hybrid control to incorporate low-level machine control and complex supervision of the power plant boiler for the steam temperature and water level procedures.[12]

2.1.3 Temperature Control System for Heater Application

In 2013, M. Alla [13] proposed using fuzzy logic as a means of retaining control of the heating temperatures, such as ovens and incubators simulate the desired spot. The Fuzzy Logic Controller (FLC) performance is assessed in a few circumstances in terms of speed of response to the desired setting value by comparing it with conventional PID controller, overshoot in static set point and robustness against interference. Compare to PID, FLC has quick response to the set, and more constant against external interference. Further, both of FLC and PID have eliminate overshoot value and steady state error, however FLC has discernible deviation in high set points.[13]

In 2012, Om Prakash Verma and Himanshu Gupta [14] presented control design strategy uutilizing FLC based non-linear control for water shower temperature to get the desired output water temperature of water shower and to actualize them in true environment.[14]

In 2012, Isizoh A. N., Okide S. O., Anazia A.E. and Ogu C.D. [15] recognized temperature control utilizing fuzzy logic method. The system is aimed at regulating the temperature of an state by adaptable a heater and the rate of a fan.[15]

2.1.4 Conclusion

From the table 2.1, the controller development related with temperature control system in three main field which controlling temperature in CSP, industrial and heater application. After the comparison had been made, the fuzzy logic controller is proposed controller apply to the project in order to maintain the PD receiver temperature within the safe operating range.

Table 2.1: The summary of all the previous work related to the project and the proposed controller that implement to the project studied all the previous work.

	Year	Journal Title	Controller	Description	Result
CSP	2014	Material Derivative based Control of a Solar Parabolic Trough Field	Derivative Based Control	The controller is able to adjust to volumetric flow rate to control the temperature at the pipe outlet.	Results are improved
	2015	Design of Variable-Speed Dish-StirlingnSolar–Thermal Power Plant for Maximum Energy Harness	Fuzzy supervisory control	Controlling the temperature of the receiver in the DS system.	Effectively mitigate the impacts of the engine speed variations
	2014	Supervisory Fuzzy Predictive Control for a Concentrated Solar Power Plant	Supervisory Fuzzy Predictive Control	Design and evaluation of the performance of fuzzy predictive controller in supervisory mode for a solar-concentration-based power plant, with cylindrical-parabolic solar collectors.	
Industrial	2006	Development of automatic temperature control system in blast furnace	Fuzzy/ MPC	Temperature control model for blast furnace by using Takagi-Sugeno (TS) fuzzy model based on input-output data.	
	2010	Research on the Temperature Control System Based on Fuzzy Self-tuning PID	Fuzzy Self-tuning PID	Compared to the conventional PID controller, the fuzzy self-tuning PID controller has almost no overshoot and a shorter adjustment time of the characteristic, and has the better dynamic response and steady-state characteristic.	The control accuracy of fuzzy self-tuning PID control is higher.
	2002	Intelligence-Based Hybrid Control for Power Plant Boiler	Hybrid classical/fuzzy	A hybrid classical/fuzzy control methodology is presented to integrate low-level machine control and high-level supervision for the steam temperature and water level processes of the power plant boiler.	
Heater	2013	PID and Fuzzy Logic in Temperature Control System	PID, Fuzzy Logic	Uses fuzzy logic as a control method that maintains the temperature of simulated heater(oven and incubator) to the desired point.	FLC has fast response to the setting with compare to PID.
	2012	Fuzzy Logic Based Water Bath Temperature Control System	Fuzzy Logic	Control design method using Fuzzy Logic Controller (FLC) based non-linear control for water bath temperature.	
	2012	Temperature Control System Using Fuzzy Logic Technique	Fuzzy Logic	The system is aimed at controlling the temperature of an environment by regulating a heater and the speed of a fan.	
The proposed controller apply to the project after studied all the previous work					
Proposed Controller	2015	Controller Development for Maximizing Thermal Efficiency of the Stirling Engine Based on the Concentrator Solar Power (CSP) with Focusing on Parabolic Dish Type in Malaysia Environment	Fuzzy Logic	To maximize the thermal efficiency of the Stirling engine.	