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Pid Temperature Controller System for Poultry House System Using Fuzzy Logic

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ABSTRACT: *Poultry house is the place where birds are kept in order to provide a healthy environment and to enhance optimum feeding efficiency for the birds. To get the most productivity in poultry production, it is essential that the thermal environment presents appropriate comfort levels. When thermal environment becomes uncomfortable, the body of the poultry birds will begin to require some physiological adjustments in order to maintain their homoeothermic conditions making them to either retain or dissipate heat* **.** *Effective and efficient temperature control system plays crucial role in providing a comfort indoor environment which could enhance voluntary feed intake, alleviate thermal strain and humidity, as well as maintain an acceptable indoor air quality Providing an optimum temperature controlled environment will increase the profitability, growth rate, adequate feed conversion, reduce diseases, reduce mortality, and ultimately improve the animal product quality. The PID controller and Fuzzy-PID controller for the control of poultry house temperature were designed and was simulated using MATLAB/ SIMULINK package program. The simulation results show that the Fuzzy-PID controller have better performance in terms of both the steady-state error and the settling time than that of PID controller*

Keywords: *Poultry, Fuzzy-PID, Settling Time, Heat, Matlab*

I. INTRODUCTION

Poultry house is the place where birds are kept in order to provide a healthy environment and to enhance optimum feeding efficiency for the birds. To get the most productivity in poultry production, it is essential that the thermal environment presents appropriate comfort levels. When thermal environment becomes uncomfortable, the body of the poultry birds will begin to require some physiological adjustments in order to maintain their homoeothermic conditions making them to either retain or dissipate heat (Czarick et al , 2013). Optimum temperatures allow the poultry birds to convert nutrients into growth ratherthan using the calories for temperatureregulation. At high environmental temperatures, poultry birds consume less feed and convert this feedless efficiently. Poor temperature control in poultry house during hot and humid weather can result in excessive bird mortality (Czarick, 2014).

There are many parameterssuch as temperature, relative humidity and air movement that are needed to be monitored in poultry house. As the thermal environment becomes increasingly stressful, the animal body perceives the risk to life and ceases to prioritize production and reproduction but focus only on their survival (Czarick, 2014). This has made the need for thermal environment control to emerge. One of the most common approaches used to control the thermal environment of the poultry house in the recent time is the use of curtain drops. Another method is lowering the feed intake of the bird in order to reduce the heat stress. However, curtain ventilation requires continuous, 24 hour management if the poultry house environment is to be satisfactorily controlled (Constantin, 2012). The application of Fuzzy-PID controller will help to provide an automated and less monitoring thermal environment for the birds.

II. REVIEW OF RELATED WORKS

Manoj(2011), carried out a research work to evaluate the thermal comfort of broilers reared under two lighting programs in broiler houses with yellow or blue lateral curtains. Six consecutive flocks were housed in four 12 × 10 m broilers houses internally divided into four pens of 200 birds each. The registration of data was accomplished at 3-hour intervals, for 24 hours twice a week. In the center of each pen and outside the house, dry and wet bulb temperatures, black globe temperature, and air velocity were collected. Based on the data collected at each time, air temperature (AT) (ºC), black globe humidity temperature index (BGHTI), radiant thermal load (RTL) (W/m2), and relative air humidity (RH) were determined. Harmonic analysis was used to estimate m, R, and f parameters. The use of side curtains to control ventilation and a drop ceiling (both made of waterproof material) wereused to reduce internal heat losses. However, curtain ventilation requires continuous, 24 hour management if house environment is to be satisfactorily controlled. The constant monitoring of conditions and adjustment of curtains is required to compensate for changes in temperature, humidity, wind velocity and wind direction.

Manjumath(2011), worked on modeling of temperatures in a closed cage for Broiler chickens using Computational Fluid Dynamics (CFD) to apply a supervisory control system in selecting the control mode (PI, PD, PID) temperature and humidity in order to stabilize temperature and humidity in the broiler house so that growth of broiler chickens in the broiler house can be improved. The primary data (floor, wall, room, and roof temperature) was obtained from measurements using electronic measuring devices. The secondary data (external humidity, temperature, radiation) that was also obtained. The simulation result showed the trend of temperature increase at the outlet regions (roof, wall, and floor outlets) of the broiler house. However, the use of artificial-intelligent based control mode such as control fuzzy logic and neural network etc will give a better controlling process for the poultry house.

Neil et al (2012), carried out a research work on resistance furnace temperature control system using Fuzzy-PID controller. In the research work, an optimal fuzzy PID controller was presented. A comparison was made between the conventional PID controller and fuzzy PID controller. From the results of the simulation, it was concluded that Fuzzy-PID controller was more effective than the conventional PID.

III. METHODOLOG

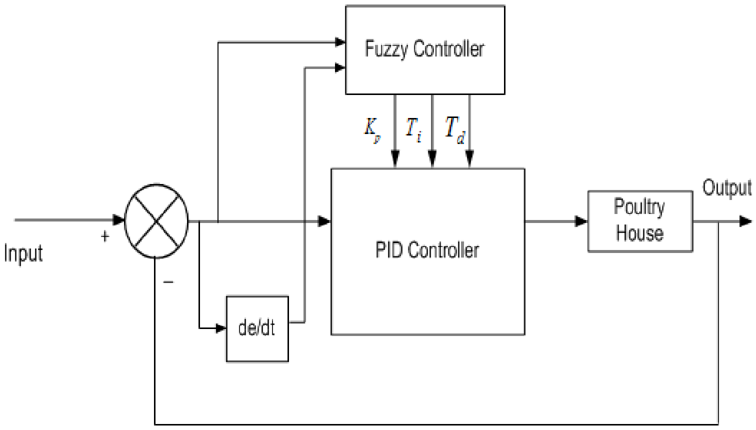

Figure 3.1: Structure of Fuzzy-PID hybrid control system for the Poultry House

The structure of Fuzzy-PID hybrid control system isshown in Figure 3.2. Combining Fuzzy control with PID. In the design, fuzzy controller used the structure of twoinputs and three outputs. Deviation e and deviation rate $\dot{e}$ arethe inputs of the system. Once the fuzzy controller received the input data, it translated it into a fuzzy form and fuzzyprocessed according to IF…THEN rules. The controllerevaluated the table of fuzzy control rules to arrive at a singleoutcome value and then proceeded on defuzzification process toget accurate values of K_p, K_i, $K_d$which are the inputs of PIDcontroller. Similarly, the other tuning techniques which are Cohen-Coon, Chien-Hrones-Reswick, Ziegler-Nichols were used to tune the PID parameters

Poultry House Temperature Control System

This chapter presents the structure of research methodology employed in order to realize the research aim and objectives. The physical realization of poultry house temperature control system is in Figure 3.1. The body temperature of a bird normally runsbetween 39.4°C and 40°C. The thermal neutral zone for chickens to maintain their body temperature is between 18°C and 23.9°C, while for adult broilers is between 26°C and 27°C.The desired poultry housetemperature has been set at 26.5ºC which falls within thethermal neutral zone for adult broilers. The input part of the system includes the setting of the desired temperature using a potentiometer. The temperature sensor and humidity sensor read the present temperature and humidity of the poultry, respectively. The data signals from the sensors were sent to the controller for interpretation and simulation. The controlled signal then triggered the heater switches on when the room temperature rose, and the cooler switches onwhen the temperature fell.

3.2 Poultry House Mathematical Modeling

Considering the following five types of heat that makes thechanges of poultry house temperature namely heat gain fromthe air-conditioner (Q_{aircon}), heat gain from opening thewindow ($Q_{airflow}$), heat gain due to difference in temperaturebetween inside and outside through glass window only (Q_{dth}),heat gain due to solar radiation (Q_{sr}), and the sensible heatgain and latent heat gain by birds (Q_b). Therefore, thedynamic poultry house temperature equation is generated as in equation 3.1

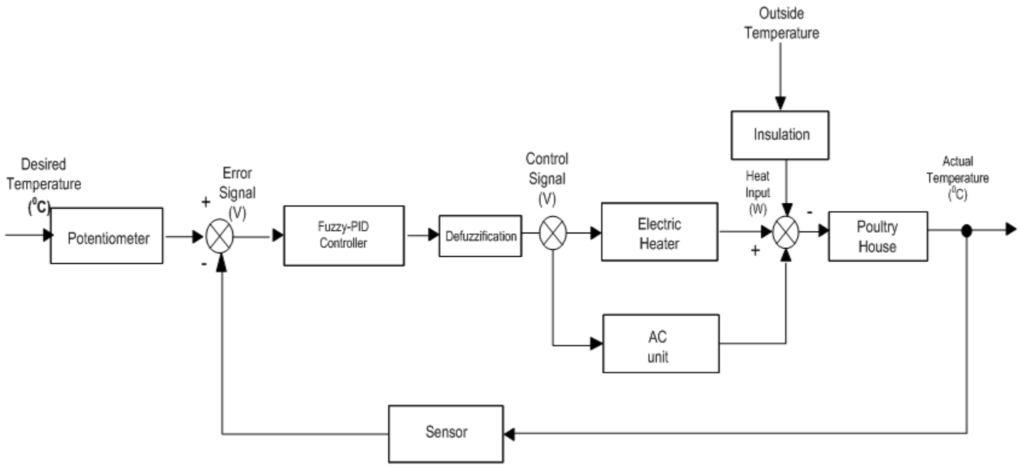

Figure 3.1: Block Diagram of Poultry House Temperature Control

$$\sum Q_{all} - Q_{out} = \beta \frac{d(T_{ph})}{dt} \qquad 3.1$$

Where

$\sum Q_{all} = Q_{aircon} + Q_{airflow} + Q_{dth} + Q_{sr} + Q_b$ and T_{ph} is poultry house temperaturepoultry house temperature. β is defined as in equation 3.2

$$\beta = \rho_{air} V_{ph} C_p \qquad 3.2$$

whereρ_{air} is air density, V_{ph} is the poultry house volume, and C_p is specific heat capacity of the house air. The values of each heat equation in (3.1) are thus computed as follows

$$Q_{aircom} = 1.08 \times \text{CFM} (T_{sa} - T_{ph}) \qquad 3.3$$

where CFM is air volume flow and T_{sa} is setting temperature of air-conditioner

$$Q_{aircom} = V_{airflow} C_p \rho_{air} (T_{so} - T_{ph}) \qquad 3.4$$

WhereT_{so} is the supplied outside temperature and $V_{airflow}$ is the ventilation rate required rate required to remove heat from the occupied space computed as

$$V_{airflow} = A_{op} C_d V_{air} \qquad 3.5$$

whereA_{op} is the surface area of window opening, C_d is effectiveness of air, and V_{air} denote air velocity leaving the opening.

$$Q_{dth} = U_g A_g (T_{out} - T_{ph}) \qquad 3.6$$

whereU_g is U-value for the glass and $A_g$is the surface of glass window.

$$Q_{sr} = F_C F_S A_g q_{sg} \qquad 3.7$$

where$F_C$is air node correction factor, $F_S$is shading factor for double glazing glass, and q_{sg} is cooling load.

$$Q_b = (n \times shg \times clf) + (n \times lhg) \qquad 3.8$$

Where*n* is the number of birds in the poultry, *shg*is sensibleheat gain by the birds, *clf*is cooling load factor for the birdsand *lhg*is latent heat gain by the birds.

$$Q_{out} = M \times C_p \times (T_{ph} - T_{air\ leaving\ ph}) = 0 \qquad 3.9$$

Since $T_{ph} = T_{air\ leaving\ ph}$

Combining equations 3.1, 3.3, 3.4, 3.6, 3.7, and 3.8, an equation of asingle zone poultry house temperature is written as follows:

$$T_{ph} \frac{1}{kV_{ph}} \int [Q_{sum} + kV_{airflow} (T_{so} - T_{ph})] dt \qquad 3.10$$

where $Q_{sum} = Q_{aircom} + Q_{sr} + Q_b + Q_{dth}$ and $k = C_p \rho_{air}$

3.3 Fuzzy Rules for the Temperature Control of the Poultry House

In the design, fuzzy controller used the structure of two inputs and three outputs. Deviation *e* and deviation rate $\dot{e}$ are the inputs of the system. Once the fuzzy controller received the input data, it translated it into a fuzzy form and fuzzy processed it according to IF…THEN rules. The controller evaluated the table of fuzzy control rules to arrive at a single outcome value and then proceeds on defuzzification process toget accurate values of K_P, K_I, $K_D$which are the inputs of PID controller.

The linguistic labels used to describe the fuzzy sets were 'Negative Big' (NB), 'Negative Small' (NS), 'Zero' (ZE), 'Positive Small' (PS), 'Positive Big' (PB). The output is determineddepending on the defined rule base of *e* and $\dot{e}$, as indicated in Table 3.1-3.3 for K_i, K_d and K_p respectively with the aim ofminimizing the error.

Table 3.1: The rule base for K_i, K_d and K_p

e	$\dot{E}$				
	NB	**NS**	**Z**	**PS**	**PB**
NB	PB/Z/PVB	PB/Z/PVB	PM/PS/PVB	PM/PS/PB	PM/PB/PM
NS	PB/Z/PVB	PB/Z/PVB	PB/Z/PB	PM/Z/PB	PS/PS/PM
Z	PM/Z/PB	PS/Z/PB	Z/Z/PM	Z/PS/PS	Z/PB/PS
PS	PM/PS/PM	PM/PS/PS	PS/PS/PS	Z/PB/PS	Z/Z/PS
PB	PS/Z/PS	Z/Z/PS	Z/Z/Z	Z/PS/PZ	Z/PB/Z

IV. RESULT AND DISCUSSION

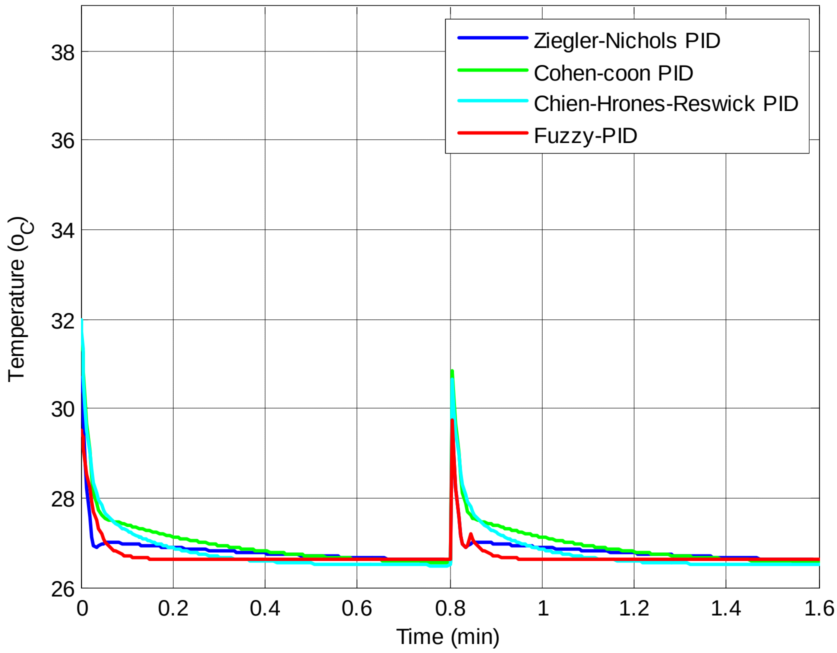

Figure 4.5(e): The Comparison of Fuzzy-PID and Cohen-Coon PID, Chien-Hrones-Reswick-PID, Ziegler-Nichols-PID simulation with overshoot

Figure 4.5(f) shows the performance of Cohen-Coon PID, Chien-Hrones-Reswick-PID, Ziegler-Nichols-PID and Fuzzy-PID before and after an overshoot in temperature. The Fuzzy-PID was able to return to the desired temperature faster than three other methods in both conditions. Fuzzy-PID returned to the desired temperature at shortest time 12sec and 57sec respectively. This made Fuzzy-PID preferable for controlling the poultry house during continuous change in outside temperature for poultry birds.

Figure 4.6(e) shows the performance of Cohen-Coon-PID, Chien-Hrones-Reswick-PID, Ziegler-Nichols-PID and Fuzzy-PID controller when the temperature of the poultry house fell to 22^0C. The settling time, which is the time take for Cohen-Coon PID, Chien-Hrones- Reswisck-PID, Ziegler-Nichols PID and Fuzzy-PID to return to the desire temperature when there was fall in temperature were 54sec, 42sec, 30sec and 18sec respectively. Similarly, their respective temperatures were 27.1°C, 27.0071°C, 27.0064°C and 26.6232°C. Therefore, it could be deduced from the result of the simulation, that the time taken for Fuzzy-PID controller to raise the temperature of the poultry house to the desired temperature is shorter as compared to Cohen-Coon PID, Chien-Hrones-Reswisck-PID, Ziegler-Nichols PID controllers. Additionally, the Fuzzy-PID controller outperformed other controllers as regarding the steady state error because there was no distortion along the settling path when it was used.

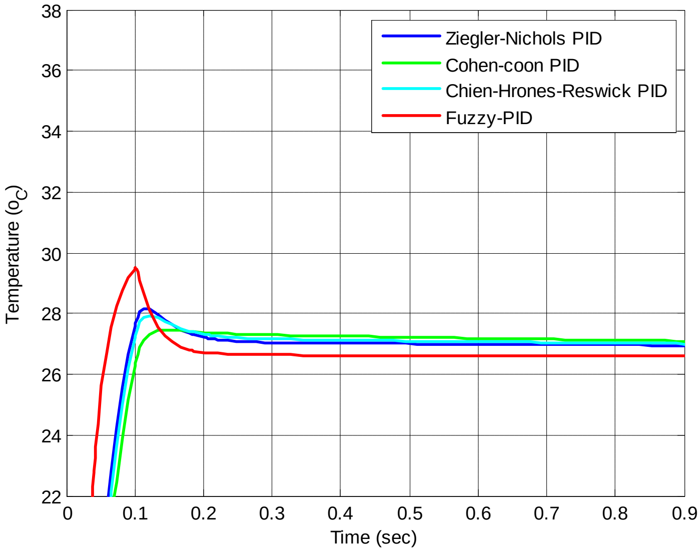

Figure 4.6(e): The Comparison of Fuzzy-PID andCohen-Coon PID, Chien- Hrones- Reswick- PID, Ziegler-Nichols PID simulation with fall in Temperature

Figure 4.7(a) shows the performance of Cohen-Coon PID, Chien-Hrones-Reswick PID, Ziegler-Nichols PID and Fuzzy-PID controller when the bisector defuzification method was used for Fuzzy-PID. The settling time, which is the time taken for Cohen-Coon PID, Chien-Hrones-Reswisck PID, Ziegler-Nichols PID and Fuzzy-PID to return to the final temperature were 51 sec, 54sec, 50 sec, and 27sec. Similarly, the settling temperature for Cohen-Coon PID, Chien-Hrones-Reswisck PID, Ziegler-Nichols PID and Fuzzy-PID were 27.2234^{o}C, 27.146^{o}C, 27.0073^{o}C and 26.621^{o}C respectively. The Fuzzy-PID gave the best performance with the smallest settling time and temperature when bisector method was used.

Figure 4.7(b) shows the performance of Cohen-Coon PID, Chien-Hrones-Reswick-PID, Ziegler-Nichols-PID and Fuzzy-PID controller when the Centroid defuzzification method was used for the Fuzzy-PID. The settling time for Cohen-Coon-PID, Chien-Hrones-Reswisck-PID, Ziegler-Nichols-PID and Fuzzy-PID to return to their final temperatures were 54sec, 50sec, 27sec, and 19sec respectively. Similarly, the settling temperature for Cohen-Coon-PID, Chien-Hrones-Reswisck-PID, Ziegler-Nichols-PID and Fuzz-PID were 27.2234^{o}C, 27.146^{o}C, 27.0073^{o}C and 26.6234^{o}C respectively.

Table 4.1(a) shows the rise time (sec), settling time (sec) and the temperature when there was rise in temperature to 38^{o}C with an overshoot in temperature. From the table, it can be seen that the Fuzzy-PID has the shortest settling time of 57sec after the overshoot in poultry house temperature. Also, it has the smallest overshoot of 1.565% among the others.

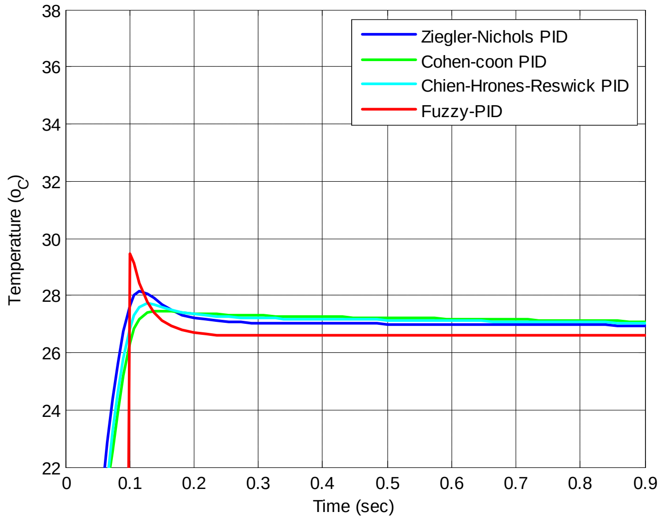

Figure 4.7(c): Poultry House Temperature Control using SOM Method for Defuzification

V. CONCLUSION

This research work is successful in addressing the problem of poor temperature control in the poultry house. This research work emphasized on the effectiveness of controlling temperature of a poultry house with a Fuzzy-PID controller and its merit Cohen-Coon PID, Chien-Hrones-Reswisck PID and Ziegler-Nichols PID. The PID controller and Fuzzy-PID controller for the control of poultry house temperature were designed and was simulated using MATLAB/ SIMULINK package program. The simulation results show that the Fuzzy-PID controller have better performance in terms of both the steady-state error and the settling time than that of PID controller

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