TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol. x, No. x, April 2013, pp. 1 ∼ 5
DOI: 10.11591/telkomnika.vXiY.abcd

Implementation of PID Controllers to Maintain Water Temperature in Hydroponics Assistant IoT

Agung Suryana*, M. Nurkamal Fauzan , and M Harry K Saputra
Politeknik Pos Indonesia
Jalan Sariasih No.54, Sarijadi, Sukasari, Kota Bandung, Jawa Barat 40151, (022) 2009562
*Agung Suryana, e-mail: agungsuryana66@gmail.com

In today's population and building growth is very difficult to control [1] for example in the city of Bandung, Bandung is the capital of West Java province with a population of 2014 is 2,490,622 people, with a population density 22.089 soul / km2 with a growth rate of 0 , 37-0.71% per year (Central Bureau of Statistics of Bandung city 2014) [2] with high level of activity [3], With increasing population affecting green areas in Bandung experiencing reduction of 3932 ha (1.4%) per year [4], while vegetable needs are increasing [**?**] and if unmet needs eat import increase will increase whereas Calculation results show that import growth negatively impact economic growth in Indonesia [**?**]. Also, there are other disturbances such as extreme temperatures that make crop failure[5]. The increase in temperatures occurring from 2011-2015, called the hottest in history, has begun to cause problems, especially in the agricultural sector, [6] High temperatures damage the enzymes so that metabolism does not work. Low temperatures also cause inactive enzymes and metabolism to cease [7], Water temperature is considered one of the most important parameters affecting growth rate and development of sea cucumber and its distribution in it [8]

Based on some literature, the plant's response to temperature rise depends on the temperature value of [9], temperature is one of the factors that significantly determine the growth and development of the plant [10], the ideal temperature for the plant phase, e.g. sprouts ranging from 25-30°-30°C, while the ideal temperature for fruit color formation ranges from 24-28°-30°C [11], temperature control is an interesting variable in the growth of healthy aquatic plants [12], low temperature allows plants to have constraints on the growth of [13]

Therefore, a technique or method is needed to overcome the problem, by making a temperature control device where there are a heating and cooling device which will respond to the temperature in a container where if the water temperature does not match the specified set point then the system will calculate the error and reduce the error, this method is called the PID (Proportional Integral Derivative) method, PID is the most widely used controller in industry [14] [15], PI and PID controller settings often selected by using methods designed for recurrent controllers [16], In PID control, derivative terms are used to reduce overshoot and improve responses [17]. Proportional Control-Integral Derivatives (PID) offer the simplest yet most effective solution to address many real-world control issues [18]

1. Related Works

Hydroponics is the cultivation of plants by utilising water and not using it as a planting medium, but rather the suppression of nutrient requirements for plants [19]. NFT techniques are techniques that use nutrient solutions to drain into the root area. Nutritional solutions are essential to the defined success of hydroponic cultivation[20]. IOT is recognised as one of the most important areas of technology of the future and gained wide attention from various industries[21]. Temperature is one of the main factors affecting plant growth[22].Water temperature is considered to be one of the important parameters affecting growth rates and plant development and distribution within the ponds[8].The daily growth is calculated from air temperature measurements and is a can often use weather to describe the biological process time[23]. The response of the plant to temperature rise depends on the temperature value [9].Temperature is one of the factors that significantly determine the growth and development of plants[10]. Low temperatures allow plants to

Received May 9, 201x; Revised August 3, 201x; Accepted August 16, 201x

have constraints on growth[13]. The ideal temperatures for plant phases such as sprouts range from 25°-30°C, while the ideal temperature for fruiting colouration ranges from 24°-28°C[11]. Temperature control is an attractive variable in the growth of healthy aquatic plants[12]. Temperature control is a very general sight in industrial control[24].Temperatures that maintain water temperatures at specified values will be attached to water which is a container[25]. In the traditional temperature control technology, heating and cooling are often discrete[26]. Temperature control has a very important role in industrial / home applications and is difficult to implement through ordinary control techniques[27].

Proportional Integral Derivatives (PIDs) are the most widely used controllers in the industry[14][15][28]. PI and PID controller settings are often selected using methods designed for recurring controllers [16]. In PID control, the term derivative is used to reduce overshoot and improve response[17]. The PID controller is an electrical element to reduce the error value between the desired setpoint and the actual process variable measured [29].The advantage of the PID coefficient was set from the lowest value to the coefficient of the best response[30]. PIDs in modern control systems such as "ants in the colony" [31]. With PID tuning controller the performance of the system is increasing and stable but the resolving time is increasing[32]. PID controllers are the basic and most widely used modules in discrete control systems. Over 90 control loops were designed with the PID method [33].The Proportional-Integral Control Derivative (PID) control offers the simplest yet most effective solution to addressing many real-world control issues[18]. In the PID literature, it proved stronger in performance[34]. PID controller automatic tuning is a useful feature for users who do not have the time, knowledge, or desire to set up their loop controls manually[35].Basic PID Algorithm:

$$u(t) = K\left(e(t) + \frac{1}{T_i}\int_0^t e(\tau)d\tau + T_d\frac{de(t)}{dt}\right),$$
$$e(t) = y_r(t) - y(t),$$

Figure 1. PID Formula

Where u is the control signal, e signal error, yr from the signal signal, variable y process, K gain, Ti integration time, and Td At the time of its derivatives [36].

$$u(t) = k\left(by_r(t) - y_f(t)\right) + k_i\int_0^t \left(y_r(\tau) - y_f(\tau)\right)d\tau$$
$$+ k_d\left(c\frac{dy_r(t)}{dt} - \frac{dy_f(t)}{dt}\right)$$

Figure 2. Rumus PID

Di sini k, ki, dan kd adalah keuntungan controller, b dan c bobot setpoint, dan yf adalah disaring variabel proses sedemikian rupa sehingga Here k, ki and kd are the controller advantages,

$$Y_f(s) = G_f(s)Y(s) = \frac{1}{(1+sT_f)^n}Y(s),$$

Figure 3. Rumus PID

b and c the setpoint weights, and yf are filtered process variables such that where Y (s) is the Laplace transform of the process variable y (t). Tf is a constant-time filter measurement and n filter sequence. Usually, n equals one or two[37].

In previous research based on the existing literature, the study was carried out by maintaining the temperature of the room and using the indoor temperature sensor while in the observation of the maintained temperature, not the temperature of the air temperature increase, this research aims to make the water temperature stable at 25°-26°C by using sensor temperature and heating device and the coolant will react according to the temperature obtained at a water reservoir used for hydroponics due to the Bandung city temperature ranging from 18-26°C to 30-26°C with an average of 23-26°C. This research designed and artificial tool to stabilize the temperature based on Arduino Uno microcontroller and from theoretical control literature it is clear that PID controller is the ideal method for controlling system, first the system set up the temperature set point then PID process it and if the outout value does not match the set value specified feeding PID will return the error value and fix the error until finally, the temperature value is stable. The purpose of this system built to provide convenience in the process of stabilising water temperature and is expected to make a better harvest

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