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Article

Baby Incubator Temperature Control With PID System

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Abstract : A Baby incubator is one of the right instruments to overcome problems in handling newborn babies. An important parameter to control is the temperature of the baby incubator room. A study has been conducted on the Design of Baby Incubator Temperature Control with a PID System using a DHT22 sensor for the incubator room temperature sensor and a DS18B20 sensor for the baby's skin sensor. The microcontroller used is ATmega328. The temperature is maintained at 36 °C. There is a heater component to heat the Baby Incubator if the temperature is >36 °C, a blower as a cooler if the temperature is <36 °C. The temperature condition is displayed on the Nextion 4.3" LCD in real time using touchscreen technology. After being compared with the Incubator Analyzer, the overshoot value on the Incubator Analyzer was 0.74% while on the device made it was 0.20%. While the error value on the Incubator Analyzer was 0.02%, on the device made it was 0.01%. So it can be concluded that the tool operates properly according to what was planed.

Keywords: PID, Atmega328, DHT11, DS18B20.

1. Introduction

Based on UNICEF data from the United Nations, premature babies in Indonesia are still fifth in the world with 13,370 babies born prematurely (Qoyima, 2020). Maintaining the body temperature of premature babies is very important, because the body of premature babies does not yet have good body temperature regulation. Premature babies need a room temperature of 36.5 °C – 37.5 °C to maintain their body health. In general, providing warm body temperature to premature babies is by using the Kangaroo Mother Care (KMC) method, which is a method of caring for premature babies by placing the baby in the mother's arms to channel warmth to the baby. However, this method cannot be done when the mother has to abandon her baby. So currently, using an Incubator, a warming device for the baby that can provide warmth according to the temperature required by premature babies (Sugihatmoko, 2015).

In the current Baby Incubator devices, many use a setpoint system, so that temperature and temperature control are still relatively unstable. Based on these problems, in this study, the author will make a design for the Baby Incubator temperature control using the PID system. PID is a controller that is a combination of proportional, integral, and derivative controllers. The combination of the three controllers is expected to produce stable system outputs because they can cover each other's shortcomings. The advantage of PID controllers is that the system is simple, so it is faster to make a decision. So it is hoped that with the use of PID, the system performance will be stable and the system reaction will be fast, the system output will be as desired. From some of the advantages of the PID controller, it is hoped that the premature baby incubator will have stable and automatic temperature control as desired.

2. Theoretical Studies

Literature Review

In the research on making Baby Incubator Temperature Control with the PID Method, it cannot be separated from previous research. The research was conducted by Muhtarom in 2021 with the title "Implementation of Temperature Control Using the PID Method in Infant Warmers Incubator

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Applications". In this study, adjusting to room temperature, where the temperature of the baby in the womb is 34 °C to 37 °C. In the design of the system it is divided into three parts, mechanical, hardware and software,

Mechanical system is designed with a height of 90 cm, and a width of 45 cm, for planning The hardware includes ATmega8, PLC and HMI microcontrollers. The system that was built uses the PID method, this method aims to accelerate the system's response in reaching a set of temperature points that have been set, where this temperature varies, where this is caused by different baby weights (Muhtarom, et al., 2021).

Supporting Theories

In this study, the author also uses several theoretical bases that will be used in the process of making Baby Incubator Temperature Control Using the PID Method. The theories needed are about Premature Babies, Baby Incubators, Theories about PID and ATmega 328 microcontrollers.

Premature Babies

Premature babies are babies born at less than 37 weeks gestation. Where the birth of a normal baby is usually in the period of 37 to 41 weeks. Premature babies weigh less than 2500 grams so they are very susceptible to the surrounding temperature. If the room temperature is too cold, it can lower the body temperature of premature babies so that babies can experience cold. Where the normal temperature of newborns (neonates) is around 36.5°C - 37.5°C (Aceh Health Office, 2023.

Baby Incubator

Baby Incubator/Incubator is one of the electromedical equipment used to provide protection for premature newborns or have Low Birth Weight (BBLR) by providing stable temperature and humidity and oxygen needs according to the conditions in the mother's womb. This device has controlled circulation or has relative humidity and insulation to protect the baby from air contamination from the outside. This is necessary for premature babies, because they are very prone to respiratory problems and problems related to the baby's health. The temperature needed in the care of this baby is between 32°C - 36°C (Harseno, 2017). Figure 1 shows a picture of the Baby incubator:

Figure 1. Baby Incubator

Apart from being a warmer, the Incubator also serves to protect babies from the dangers of infection. In the incubator, there is moisture control as a condition for the baby's skin so that it is not too dry or moist, because the skin texture is indeed very thin from the baby. Usually, babies in the incubator will be left naked to make it easier to monitor, so that they can be seen from their breathing movements and skin color.

PID (Proportional, Integral, Derivative) Control

PID (Proportional, Integral, Derivative) controllers are a combination of Proportinal, Integral, Derivatife controllers that overlap. By using these three as Proprtional, Integral, Derivative controlling elements respectively as a whole it aims to accelerate the reaction system, use offsets and produce large initial changes. The PID controller calculates the error as the difference between the measured process variable and the desired set of points. PID controllers try to minimize errors by adjusting the control process inputs. The calculation of the PID controller involves three parameters. By tuning the three parameters in the PID controller algorithm, the controller can provide control actions designed for specific process needs.

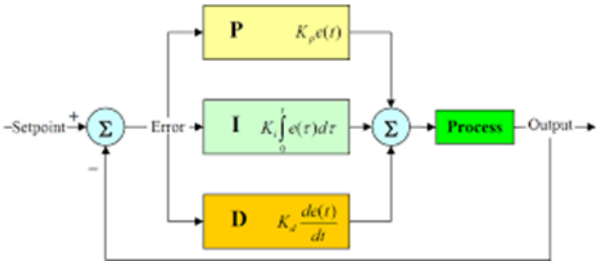

Figure 2. PID System Block diagram

In continuous time, the output signal of the PID controller can be formulated as follows:
u(t) = Kp e(t) + Ki ∫ e(t)dt + Kd Description:

u(t) Kp = Controller output signal (PID control output)
= Proportional Constant
Ki = Integral Constant
Kd e(t) = Derivative Constant
= Error signal

Characteristic controller PID very Influenced by contribution big of the three controlling parameters or constants (Kp, Ki, and Kd). Kp, Ki, and Ki tuning

Kd will result in the prominence of the properties of each controller. In general, the step that must be taken in the design of a PID control design is to determine the values of the Kp, Ki, and Kd parameters. Proportional controls that excel in fast rise times, Integral controls that eliminate errors and Derivative controls that can reduce overshoots.

Atmega 328 Microcontroller

The Atmega 328 microcontroller that serves as a processor for the Arduino board. Consisting of 28 pins, of these 28 pins the input can be controlled by transmission and receive input to an external device. Also consists of pulse width modulation (PWM),

This PWM is used to transmit the entire signal in pulse modulation. The IC is composed of analog and digital inputs, used for specific application processes. The Atmega 328 microcontroller consists of analog input pins, these analog inputs can be named A0 to A5. From these 6 analog input pins we can do the process using analog inputs, used in the operating range of 0 to 5V. Analog signals are considered continuous time signals, where these analog signals can be used in applications. This is also referred to as a non discrete time signal.

3. Research Methods

The type of research carried out is applied type research. Applied research is research that is carried out by applying the theories that have been obtained by the author into direct practice with the stages of literature study, field studies and data analysis. This study aims to design a baby incubator temperature control using the PID method, the block diagram in this study is shown in the following image.

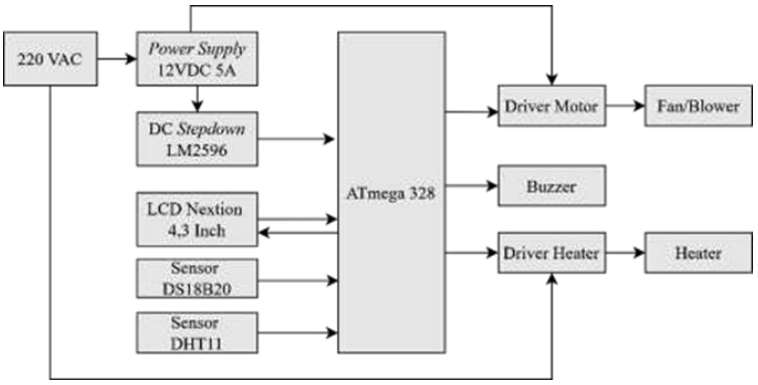

Figure 3. Block Diagram Tool

The design in this study uses the ATmega328 microcontroller as a controller between input and output, while this controller uses the PID (Proportional, Integral, Derivative) method that regulates the process between the sensor and the driver. The sensors in this series use DS18B20 as the sensor skin and DHT11 as the temperature and humidity sensors in the incubator chamber. For the Heater driver circuit using the Triac BT136 component, the function of this component is to regulate the AC voltage output coming from the PLN 220 VAC meshes then to control the heat output from the Heater. The motor driver circuit in this study uses the Mosfet IRF520 component, the function of this component is to regulate the DC voltage coming from the 12VDC power supply circuit and then used to regulate the speed of the Blower. Nextion's LCD with a size of 4.3 Inch functions to control the temperature setting of the baby incubator and displays the existing temperature results, on this LCD display is equipped with a graph that functions to monitor temperature changes that occur in the incubator room with the reading results from the DHT11 sensor. The function of this Buzzer component is as an alarm indicator when the temperature is overshoot or exceeds the predetermined setting limit.

Then for the workflow of the baby incubator temperature control device with the PID method shown in the following image:

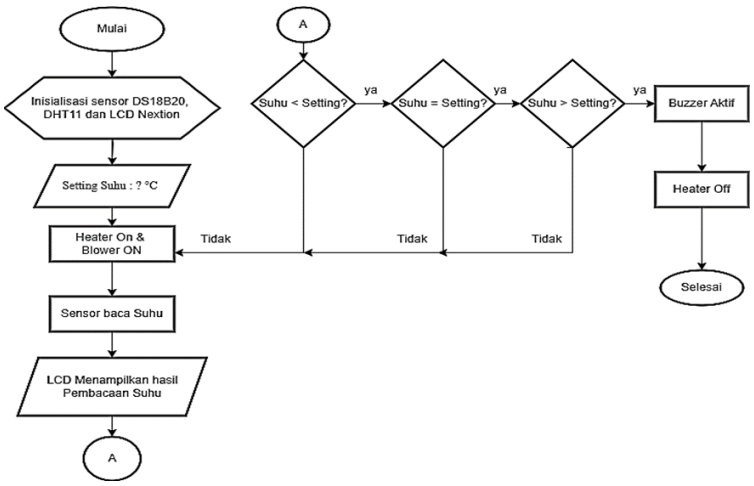

Figure 4. Tool Flowchart

The following are the results of the tool function test made in the form of a graph, with 30 measurements.

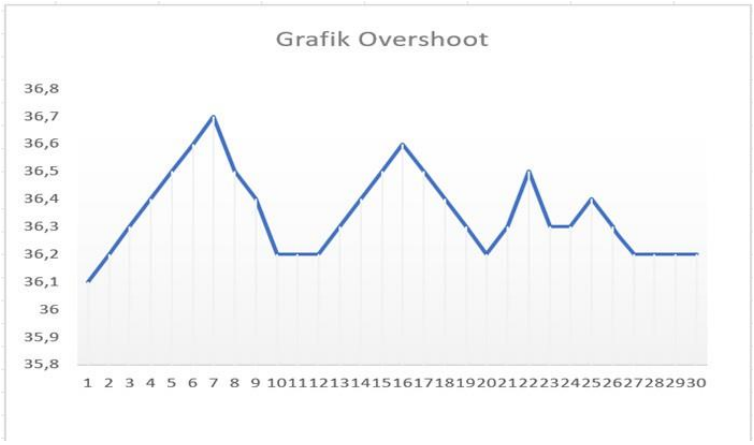

Figure 5. PID system overshoot graph

From Figure 5. above, it can be seen that on tools made with the PID system, i.e. at a setting of 36-37°C with the permissible tolerance (±0.2 °C). In this condition, the buzzer will illuminate when the temperature is more than ±0.2° from the specified setting.

The system starts when the tool is turned on and then sets the desired temperature, after the temperature setting is done, namely the heater and blower will work to heat the incubator room according to the settings that have been done, the sensor begins to read the room temperature on the incubator and the results of the temperature reading will be displayed on the Nextion LCD. When the temperature is less than the setting, the heater will still be on, if the temperature has been reached the heater will turn off, and when the temperature exceeds the predetermined setting limit (overshoot) then the buzzer will activate as an alarm for the over temperature indicator, and the system is finished. The following wiring diagram for PID control system:

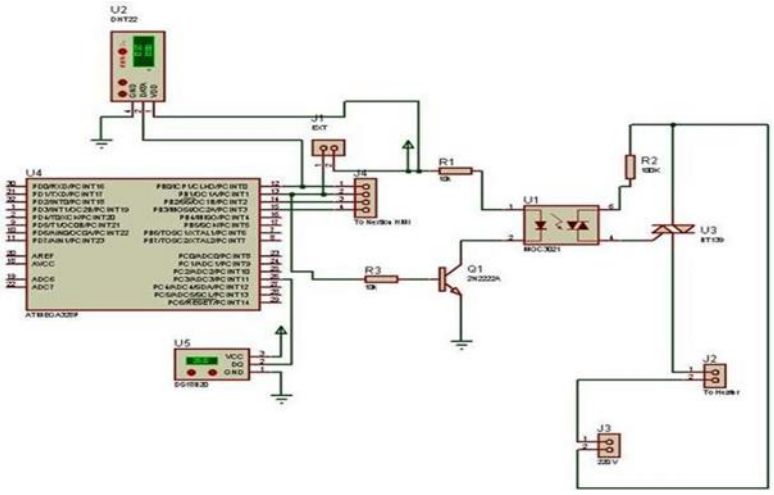

Figure 6. wiring diagram PID

4. Results and Discussion

The results and discussions in this study include the function test and installation of the Baby Incubator Tool available at PT. BARTEC UTAMA MANDIRI (BUMA) and calibration results on the tool by comparing the Incubator Analyzer with the FLUKE brand INCU II type. The way to place the incubator analyzer calibrator is by placing temperature sensor probes with a total of 5 pieces (T1-

T4), with a distance between probes of 10 CM, and also on the T5 probe is the result of reading from the skin sensor. The map of the probe placement point is shown in the following image.

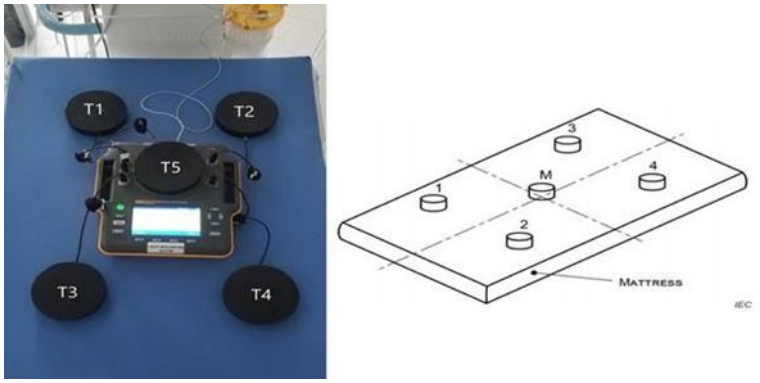

Figure 7. Probe Fixation of the Incubator Analyzer

The following are the results of testing and installation of the Baby Incubator Temperature Control device with the PID Method on the baby Incubator device (6), and calibration tests were carried out using the incubator analyzer

Figure 8. Results on the Analyzer

Figure 9. Display on LCD

The results of temperature measurement on the tool made with the PID system in Table 1. Below:

Table 1. Results of baby incubator temperature measurement with incubator

No.	Set. Temper-ature (°C)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	Difference (°C)	*Error (%)*
1	36	36.20	36.20	36.20	36.20	36.80	0.32	0.01
2		36.00	36.00	36.00	36.00	36.80	0.16	0.00
3		36.20	36.20	36.20	36.20	36.40	0.24	0.01
4		36.00	36.00	36.00	36.00	36.60	0.12	0.00
5		36.00	36.00	36.00	36.00	36.30	0.06	0.00
6		36.20	36.20	36.20	36.20	35.90	0.14	0.00

7		36.20	36.20	36.20	36.20	35.90	0.14	0.00
8		36.20	36.20	36.20	36.20	35.90	0.14	0.00
9		37.70	37.70	37.70	37.70	35.90	1.34	0.04
10		36.20	36.20	36.20	36.20	35.60	0.08	0.00

From the table above, to see if the temperature remains at the preset conditions, it is necessary to create an overshoot graph or control map consisting of the Upper Control Limit (UCL), Lower Control Limit (LCL), and permissible tolerance (±0.2 °C)

5. Conclusion

The conclusions of this study include:

1. An overshoot was obtained in the incubator analyzer of 0.74%. Meanwhile, the overshoot on the tool with the PID system is 0.20%. Thus, the PID controller can lower the overshoot value.
2. An error in the analyzer incubator was obtained of 0.2%. Meanwhile, the error in the tool with the PID system is 0.1%. Thus, the PID controller can reduce the error value.

From the design and research carried out, there are several shortcomings, so it is necessary to develop in the medical field. The author's suggestions in the future so that the tools made are even better, including:

1. Increase the settint point of 32°C because it is in accordance with the Calibration Method for Baby Incubator using temperature parameters of 32°C and 36°C.
2. Increase the calculation of the time it takes for the system to reach a steady state.
3. Added an Internet of Things system to be controlled remotely.

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