Duck Egg Hatching Incubator Technology Based on Internet of Things

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Abstract
The egg incubator was originally a simple tool using a lamp to produce heat without other supporting tools, So the incubation process has a big influence on traditional egg hatching through the mother duck incubating the eggs. However, temperature control at the time Incubation of eggs by the parent certainly has certain limitations due to the parent which is difficult to control in order to incubate it which ultimately causes the egg to suffer hatch failure. In the process of hatching duck eggs, you must pay attention to temperature and humidity and egg rotation which must be maintained regularly, is necessary continuous supervision and monitoring so that the eggs can hatch well. By utilizing applicable Internet of Things technology in the field of animal husbandry, it is a solution to monitor the condition of hatching duck eggs automatic and real-time, so it can help farmers in monitoring conditions such as temperature and humidity as well as the condition of the eggs in the hatching room. So A research was conducted entitled "Duck Egg Hatching Incubator Technology Internet of Things" was carried out with the aim of making things easier for breeders monitor temperature and humidity and monitor conditions inside real time drip space.

1. Introduction

The egg incubator was initially a simple tool that only used a lamp to generate heat without any additional supporting tools, and it was only used by traditional farmers with small capacities. However, with the development of technology, this machine has been improved to enhance its capabilities and ease of use in egg hatching (Susetyo et al., 2020).

The high demand from the public for duck eggs makes the reproduction process very important(Ahaya & Akuba, 2018). The incubation process greatly affects the hatching of eggs traditionally through ducks that incubate their eggs. Temperature control during the incubation of eggs by the mother duck certainly has certain limitations because the mother duck is difficult to control during incubation, which ultimately leads to egg hatching failures (Yasir et al., 2023).

Duck eggs have an incubation period of 27-30 days, and the temperature required for duck eggs from 1-30 days is 38˚C. When incubating duck eggs, it is also essential to pay attention to the humidity level. The required humidity is around 75-85% and the rotation of the stepper motor for 8 hours per day (Wirajaya et al., 2020). However, monitoring the incubator is inefficient because it takes a very long time and requires excessive effort.

In this era of rapid technological advancement, one of the fields is electronics, which is applied to ease daily life by utilizing internet of things technology. When implemented in the livestock sector, it becomes a solution for farmers to monitor egg incubators automatically and in real-time. Internet of things is a concept where everyday objects or devices exchange information and data through the internet network. With the existence of a technology called the Internet of Things, monitoring and controlling conditions in the egg incubation room can become efficient and maximally controlled.

In previous research that has been discussed related to egg incubators, among them is the research conducted by (Noviansyah & Abdulrahman, 2022) titled "Design and Development of an Automatic Egg Incubator Using Temperature Sensors Based on Wemos D1 ESP8266 Microcontroller" which transforms a manual egg incubator into an automatic one for egg rotation, temperature, and humidity control, and creates a remote interface using a smartphone to facilitate temperature and humidity monitoring. This automatic egg incubator uses the DHT22 sensor as a temperature and humidity sensor, the MG996R servo motor to move the egg sliding rack, and a 16x2 LCD to display temperature and humidity results. For remote temperature and humidity monitoring, the Blynk application is used. This device has been operating automatically to maintain a temperature range of 37.0˚C - 38.8˚C using a lamp and a humidity range of 63% - 76%.

In the research conducted by (Dwipandita INBS Nugraha, 2022) conducting research on a temperature monitoring device for village chicken egg incubators utilizing Internet of Things technology with an Arduino Uno control system, this device uses a DHT11 sensor that operates when the DHT11 sensor detects the temperature in the machine and the detection results are displayed through a 16x2 LCD, if the room temperature is low, the relay will turn on the heater, conversely, if the room temperature is high, the relay will turn off the heater, this device is equipped with remote monitoring using the Thingspeak application with a NodeMCU ESP8266 module that serves as the internet connection.

In previous research conducted by (Sari et al., 2022) which creates an egg hatching incubator monitoring system based on NodeMCU ESP8266 and Telegram bot using hardware such as NodeMCU ESP8266 as the microcontroller, DHT11 sensor for detecting temperature and humidity in the incubator machine, lamp as the main heater in the incubator, and fan also to cool the temperature in the incubator machine room, jumper wires used to connect the microcontroller to the sensor, while the software uses commands from the Telegram bot that can monitor the incubator remotely, which can be viewed by farmers from anywhere and anytime.

Based on previous research, the author will develop an egg incubator machine that can monitor in real-time and provide information if an egg hatches by utilizing internet of things technology. Thus, the research titled "Duck Egg Hatching Incubator Technology Based on Internet of Things" was created.

1.1 Literature Review

In this study, the author uses 5 literature reviews from previous research that support the study, as shown in Table 1.1 below:

Table 1 Literature review

No. Literature	Authors	Year	Title
Literature 1	Ferry Budhi Susetyo, I Wayan Sugita, Basari, Muhammad Naufal Rifqi, Rois Wardiana, Joko Prasetyo	2020	Design and Development of an Automatic Egg Incubator Rack on a Hybrid-Powered Incubator
Literature 2	Yusuf Noviansyah, Erwin Abdul	2023	Design and Build an Automatic Egg

	Rahman		Incubator Using a Temperature Sensor Based on Wemos D1 ESP8266 Microcontroller
Literature 3	Ferry Sugara, Karsid, Bobi Khoerun	2023	Egg Incubator Automatic Duck Based on Arduino Uno
Literature 4	Hermanto, Susanti, Marina	2016	Automatic Control System for Chicken Coop Temperature Monitoring Based on the Internet of Things
Literature 5	Muhamad Sophian Alwi Ramadhan, Farida Asriani, Agung Mubyarto	2023	Design and Build a TX/RX Communication System for Real-Time Monitoring of Poultry Egg Incubators Based on Web and Telegram

In the research conducted by (Susetyo et al., 2020) creating an automatic egg incubator using the Atmega8535 microcontroller equipped with a thermocontrol as the main sensor for detecting temperature and humidity in the incubator and a timer as a counter for scheduling the rotation time in the incubator, and this machine is powered by a solar cell change control, which uses a battery that can be charged through AC or DC flow via a device called an inverter. This research aims to enhance the capabilities of conventional egg incubators into automatic incubators, making the egg hatching process more practical, efficient, and yielding excellent results. This incubator machine uses 4 incandescent bulbs with a power of 5 Watts as the heat source and a thermocouple as the temperature checking device. In the testing of this machine, chicken eggs were used with a temperature set point between 37°C - 38°C. With a power source of 25 Watts, this incubator can accommodate 120-150 eggs.

In the research conducted by (Noviansyah & Abdulrahman, 2022) developing a conventional egg incubator into an automatic one for egg rotation, temperature, and humidity. The operation of this tool uses the DHT22 as a temperature and humidity sensor, the MG996R servo motor to move the rack on the egg incubator, a 16x2 LCD to display temperature and humidity, and the Blynk application to show temperature and humidity data for remote monitoring. This tool automatically adjusts two 35 Watt incandescent bulbs to be bright and dim within the temperature range of 37.0°C - 38.8°C, and regulates humidity with a fan to 63% - 76%. For egg rotation, it uses an M996R servo motor that moves at an angle of 45° - 180°, allowing the servo to rotate the sliding rack by 6.1 cm.

In the research conducted by (Sugara et al., 2023) making an automatic duck egg incubator based on the Arduino Uno R3 microcontroller to monitor temperature and humidity using the DHT 22 sensor and a stepper motor as the back-and-forth mover of the incubator's swing rack. This research uses the Arduino R3 board as the system controller, the DHT 22 to detect air temperature and humidity, and a 16x2 LCD as the display medium for the temperature and humidity measurements, as well as a stepper motor as the mover and swinger so that the rack can turn the eggs. From the test results, this incubator is capable of generating heat with a temperature and humidity range of 36°C - 38°C. The final results of this device show a success rate of 62%, while the failure rate is 38%.

In the research conducted by (Hermanto et al., 2016) creating an automatic temperature monitoring control tool for chicken coops by utilizing internet of things technology with an Arduino Uno R3 control system using the NodeMCU ESP8266 Wifi module. This tool uses the LM35 sensor as a temperature detector for the coop, which will be displayed on a 2.4" TFT shield LCD. If the temperature is below the specified set point, the relay will turn on the heater; if the temperature is above the set point, the relay will turn off the heater. Additionally, this tool is equipped with a Thingspeak monitoring system for remote monitoring using the NodeMCU ESP8266 module as the internet connection.

In the research conducted by (Alwi Ramadhan et al., 2023) creating a TX/RX communication system to monitor poultry egg incubators in real-time based on Web and Telegram, using hardware and software. For hardware, it includes NodeMCU ESP8266, Arduino Mega 2560, ZMPT101B sensor, ZMCT sensor, RTC sensor, DHT21 sensor, lamp, jumper cables. As for the software, it includes Telegram Bot, MySql Database, Arduino Uno. This egg incubator machine uses the NodeMCU EP8266 microcontroller, Arduino Mega 2560, and ZMCT sensor as the current sensor, ZMPT101B sensor as the voltage sensor, DHT21 sensor as the time sensor, and DHT21 sensor as the temperature and humidity sensor. In this device, a MySql database is used as a storage place for scheduled data, which can later be monitored and controlled through a Telegram Bot.

2. Research Methods

In this research, the author uses the experimental research method (trial), which means this method requires direct implementation at the research site. This research is divided into several stages or parts: the first is literature study, design and development of software and hardware, testing, data collection, and result analysis. The literature study is conducted by gathering information from journal articles, books, and direct interviews at the research site related to this study. By using this experimental method, the author can create a system or tool that can monitor duck egg incubators in real-time and maintain stable temperature and humidity within the incubator room.

2.1 Prototype method

The prototype method is a system development method that, once successful, can be further developed. This prototype method begins with gathering user requirements for the developed device, which is duck egg incubator technology. Then a quick design is created, which will be re-evaluated before being properly produced. A prototype is not something complete, but something that must be evaluated, modified, and optimized ideally. Any changes can occur during the creation of the prototype, which will be made according to user needs, and at the same time, it allows developers to better understand user needs. Here is the prototype image used by the author.

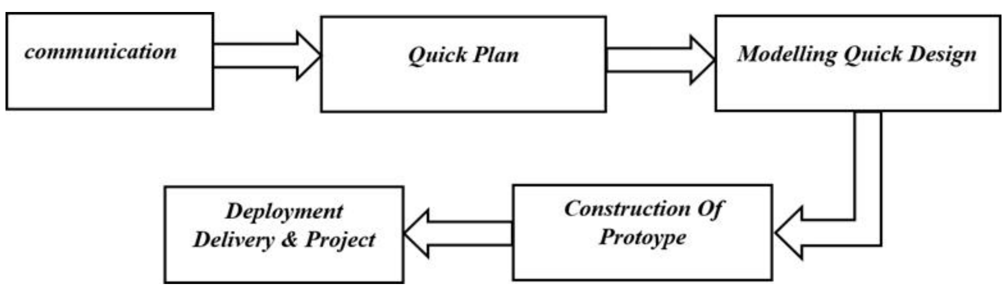

Fig. 1 Prototype Method

1. Commucation, before carrying out technical work, it is essential to have communication between users to understand and achieve the intended goals.
2. Quick Plan, this planning stage involves the rapid design and modeling of a prototype.
3. Quick design modeling, the quick design model at this stage uses an application called "yEd Graph Editor," which is a tool that can be used to create flowcharts to define the functions of the system and tools.
4. Construction Of Prototype, the creation of a prototype in making a quick design based on the representation of aspects of the software that will be seen by users.
5. Deployment Delivery and Feedback is the handover stage that provides feedback on the development of the previously created prototype and offers feedback that will be used to improve the requirements specifications.

2.2 Block diagrams

Block diagrams are the most important aspect in the design of a device, aimed at providing an overview of how the device will work and be used. The block diagram in this research is as follows:

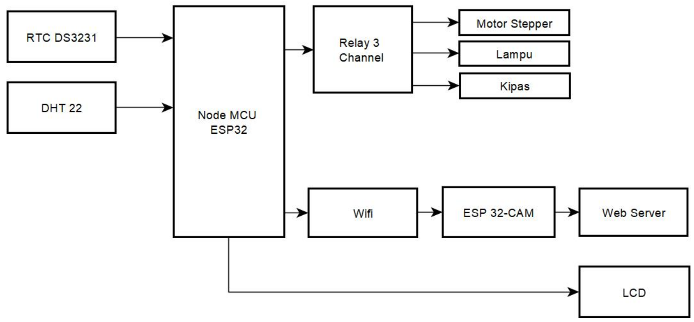

Fig. 2 Block diagrams

The block diagram of the circuit in Figure 2.2 is an example of a block diagram of the circuit that broadly explains the design of this research. The operation of this device uses the DHT22 sensor, which will detect the temperature and humidity in the hatching room. If the temperature in the hatching room is cold, the lamp will turn on to warm the room; if the temperature in the hatching room is hot, the fan will turn on. Then, the RTC DS3231 will schedule the egg rack to rotate every 8 hours, and the readings will be sent via a web server using a local network. Additionally, there is an ESP32-CAM used to monitor the condition of the eggs inside the incubation room. The results of the DHT22 sensor readings can be viewed through the LCD and web server.

2.3 Tool Design

The design of the tool is the architectural design of the tool created visually to understand the physical form of the system being designed. The purpose of the tool design is to understand the outline of the tool that will be designed as a guide in the tool's construction. The following is the design of the tool that the author has researched.

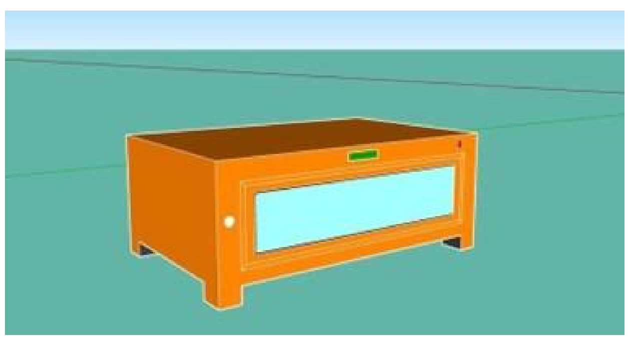

Fig. 3 Tool Design

2.4 Schematic Diagram of the Tool

Below is the schematic diagram of the entire device that will be used by the author, aimed at minimizing errors in component installation and facilitating system testing.

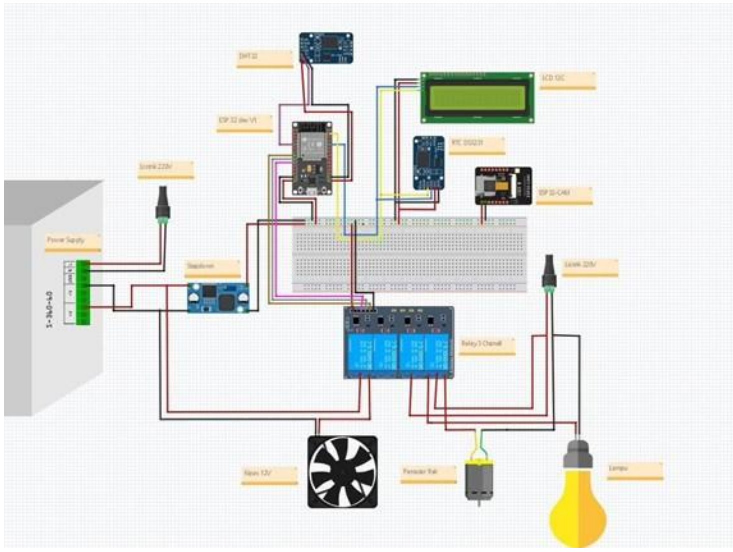

Fig. .4 Schematic Diagram of the Tool

2.5 Implementation

After the collection of materials and tools, the next stage is to implement the design of the tool that has been created. At this stage, the design results that have been made will be implemented into the actual system.

Fig. 5 Implementation

3. Result and Discussion

In this chapter, the author will explain the results of the tool testing that has been designed along with the discussion to determine whether the results, design, and implementation of the tool have met the required data.

3.1 Testing

The equipment testing is a stage conducted directly by the author on the duck egg incubator prototype. This testing aims to determine the success rate of the equipment or system in functioning properly as expected or not.

3.1.1 Testing the DS3231 RTC

The testing of the DS3231 RTC involves a correction process to check if the time is accurate and whether the system operates according to commands. The purpose of this DS3231 RTC testing is to observe and ensure that the system works automatically on schedule for egg incubation rotation.

Table 2. Testing the DS3231 RTC

Time	RTC DS3231	Egg rotation
00:40 AM	00:40 AM	Not moving
01:00 AM	01:00 AM	Moving
07:00 AM	07:00 AM	Not moving
08:40 AM	08:40 AM	Not moving
09:00 AM	09:00 AM	Moving
12:00 PM	12:00 PM	Not moving
15:40 PM	15:40 PM	Not moving
17:00 PM	17:00 PM	Moving
17:40 PM	17:40 PM	Not moving

Based on the test results in table 3.1, the Node MCU ESP32 will read the RTC DS3231 sensor to schedule playback 3 times a day within 8 hours (Mido, 2018) so the system will activate the stepper motor for 3 seconds, moving from left to right, every 8 hours at 01:00 AM, 09:00 AM, and 17:00 PM.

3.1.2 DHT22 Sensor Testing

The DHT22 sensor testing was conducted by placing the DHT22 sensor on the wall of the duck egg incubator and testing whether the temperature detected by the sensor with a thermometer could control the lights and fan to maintain the temperature stability in the incubation room. Here is the experimental table for testing the DHT22 sensor.

Table 3 DHT22 Sensor Testing

No	Time	Thermometer		DHT22 Sensor		Lampu	Kipas
		Temperature	Humidity	Temperature	Humidity		
1	00:00 AM	36.00	56	37.00	58.80	On	Off
2	01:00 AM	37.20	59	38.20	60.80	Off	On
3	05:16 AM	37.50	57	37.70	58.4	On	Off
4	09:00 AM	37.40	56	37.90	57.10	Off	On
5	10:00 AM	35.70	57	36.80	58.60	On	Off
6	11:00 AM	36.70	60	37.70	61.40	On	Off
7	12:22 PM	35.00	59	36.80	60.90	On	Off
8	13:07 PM	35.20	57	36.90	58.70	On	Off
9	17:00 PM	37.30	56	38.10	57.6	Off	On

Based on the test results from the DHT22 sensor in table 3.2, it shows that the DHT22 sensor can accurately detect temperature and humidity in the incubation room. According to (Agusdika & Purwanti, 2019) explains that the ideal temperature is 37˚ - 39˚ and humidity is 55% - 65%, so the test results show that this egg incubator can maintain the stability of temperature and humidity in the incubation room by automatically turning the light and fan on or off using a relay as a switch controlled by the NodeMCU ESP32 microcontroller. The light in the egg incubation serves to warm the incubation room, while the fan functions as a cooler or to lower the temperature of the incubation room.

3.1.3 ESP32 CAM Testing

The ESP32 CAM testing was conducted by placing the ESP32 CAM on the upper right wall of the duck egg incubator and testing whether the ESP32 CAM could monitor the incubation room conditions in real-time. The monitoring results from the ESP32 CAM will be displayed on the web server as shown in figure 3.1.

Fig. 6 ESP32 CAM Testing

Figure 4.8 above is the result of testing the ESP32 CAM in monitoring the hatching room, displaying the current conditions occurring in the hatching room. Monitoring is conducted by accessing the web server by activating localhost or the local network on the desktop device, which will then display real-time monitoring results.

3.2 Web Server Display (GUI)

Next, the sensor data values will be stored in the local network database by activating the local network connected to the internet, and the sensor will read the data in the hatching room and then send it to the local network server. Here is the web server interface using GUI.

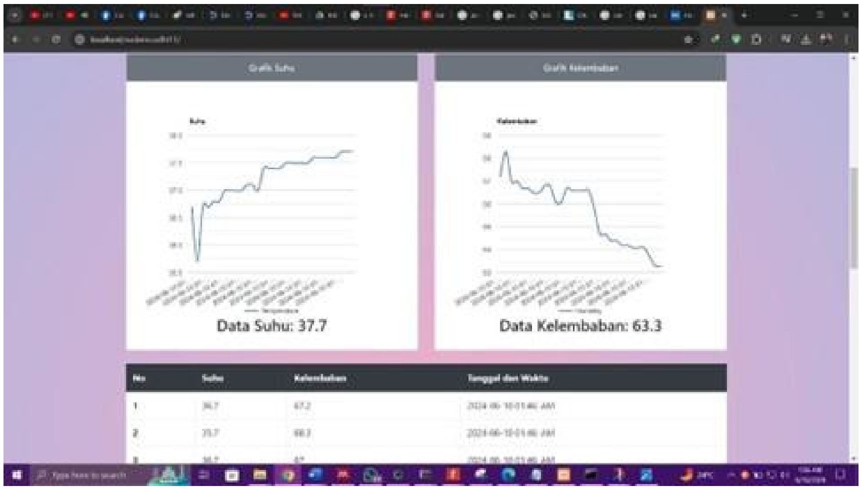

Fig.7 Web Server Display (GUI)

In Figure 3.2, the web server (GUI) interface is used to monitor the temperature, humidity, and egg conditions in the incubation room in real-time using local devices connected to a database that must have an internet connection to connect to the local network server. On this page, users can monitor and check the conditions of the incubation room through a camera displayed live from within the incubation room.

3.3 How the tool works

The operation of the device begins with the DHT22 sensor, which detects temperature and humidity in the egg incubation room. When the temperature in the egg incubation room is below 37˚C, the light turns on to raise the room temperature, and when the temperature in the incubation room is above 38˚C, the fan turns on to lower the room temperature. Then, the RTC DS3231 schedules the egg rack to rotate every 8 hours, specifically at 01:00 AM, 09:00 AM, and 17:00 PM. Additionally, the NodeMCU ESP32 CAM monitors the conditions inside the incubation room, which is connected to the local network and can be monitored directly through the localhost website.

4. Conclusions

Based on the testing results of the components in the Internet of Things-based Duck Egg Incubator Technology, it can be concluded that this device provides an effective solution for farmers in the process of incubating duck eggs that are not brooded by a hen. This tool allows for real-time monitoring of temperature and humidity, enabling farmers to maintain optimal conditions in the incubation machine. Equipped with an RTC DS3231 sensor, this device is capable of scheduling the periodic movement of a stepper motor, which serves to maintain air circulation.

In addition, the DHT22 sensor is used to detect temperature and humidity, where the fan and light systems operate automatically according to environmental conditions. Information related to the hatching process can be accessed in real-time through the web server, while the ESP32-CAM functions to monitor the condition of the eggs in the hatching room. Thus, this tool not only increases the efficiency of the hatching process but also provides convenience for farmers in managing their business.

5. References

Agusdika, A., & Purwanti, D. (2019). Implementasi Sensor Suhu dan Kelembaban sebagai Inkubator Penetas Telur Ayam Lokal Berbasis Web Server. *INAJEEE Indonesian Journal of Electrical and Eletronics Engineering*, *2*(2), 43–47. https://doi.org/10.26740/inajeee.v2n2.p9-13

Ahaya, R., & Akuba, S. (2018). Rancang bangun alat penetas telur semi otomatis. *Jurnal Teknologi Pertanian Gorontalo (JTPG)*, *3*(1), 44–50.

Alwi Ramadhan, M. S., Asriani, F., & Mubyarto, A. (2023). Rancang Bangun Sistem Komunikasi TX/RX Untuk Monitoring Mesin Penetas Telur Unggas Secara Realtime Berbasis Web Dan Telegram. *Jurnal Pendidikan Dan Teknologi Indonesia*, *3*(1), 31–40. https://doi.org/10.52436/1.jpti.210

Dwipandita INBS Nugraha, R. (2022). Sistem Monitoring Suhu Mesin Penetasan Telur Ayam Kampung Berbasis Iot Menggunakan Api Thingspeak. *Jurnal Manajemen Dan Teknologi* , *12*(2), 57–64. https://ojs.mahadewa.ac.id/index.php/jmti

Hermanto, Susanti, & Artiyasa, M. (2016). Sistem Kontrol Otomatis Monitoring Suhu Kandang Ayam Berbasis Internet of Things. *Jurnal Rekayasa Teknologi Nusa Putra*, *3*(1), 53–65. https://doi.org/10.52005/rekayasa.v3i1.177

Mido, A. R. (2018). Rancang Bangun Mesin Otomatis Penetas Telur Berbasis Nodemcu dan Android. *Jurnal Tekno Sains Seri Teknik Komputer*, *01*(1), 1–12.

Noviansyah, Y., & Abdulrahman, E. (2022). Rancang Bangun Inkubator Penetas Telur Otomatis Menggunakan Sensor Suhu Berbasis Mikrokontroler Wemos D1 Esp8266. *Jurnal Teknik Elektro Raflesia*, *2*(1), 21–29. http://ejournal.polraf.ac.id/index.php/JTERAF/article/view/135

Sari, Y., Achmady, S., & Qadriah, L. (2022). Sistem Monitoring Incubator Penetasan Telur Berbasis Nodemcu Dan Bot Telegram. *Jurnal Literasi Informatika*, *1*(1), 1–8. http://journal.unigha.ac.id/index.php/JLI/article/view/851%0Ahttp://journal.unigha.ac.id/index.php/JLI/article/viewFile/851/797

Sugara, F., Karsid, & Khoerun, B. (2023). Mesin Penetas Telur Bebek Otomatis Berbasis Arduino Uno. *Jurnal Rekayasa Energi*, *2*(1), 50–56. https://doi.org/10.31884/jre.v2i1.31

Susetyo, F. B., Sugita, I. W., Basori, B., Rifqi, M. N., Wardiana, R., & Prasetyo, J. (2020). Rancang Bangun Rak Penetas Telur Otomatis Pada Mesin Tetas Bertenaga Hybrid. *Jurnal Ilmiah Giga*, *23*(2), 69. https://doi.org/10.47313/jig.v23i2.915

Wirajaya, M. R., Abdussamad, S., & Nasibu, I. Z. (2020). Rancang Bangun Mesin Penetas Telur Otomatis Menggunakan Mikrokontroler Arduino Uno. *Jambura Journal of Electrical and Electronics Engineering*, *2*(1), 24–29. https://doi.org/10.37905/jjeee.v2i1.4579

Yasir, M., Isa Ibrahim, M. T., & Faisal, M. (2023). Uji Kinerja Alat Penetas Telur Dengan Kapasitas 30 Butir Telur Bebek. *Jurnal Ristech (Jurnal Riset, Sains Dan Teknologi)*, *4*(1), 39–44. http://jurnal.abulyatama.ac.id/index.php/ristech