INTERNATIONAL JOURNAL OF INNOVATION IN MECHANICAL CONSTRUCTION AND ENERGY

Vol. 1 No. 3 (2024), 148-155

IJIMCE

https://ijimce.ppj.unp.ac.id/index.php/ijimce
University of Negeri Padang

International Journal of Innovation in Mechanical Construction and Energy

ISSN: 3046-9112 e-ISSN: 3046-9104

Increasing Quail Egg Hatching Production with 2 Sliding Rack Hatching Machine with Temperature Control and Motor Drive Using Ardurino Uno Microcontroller

Adriansyah[1], Nusyirwan[2], Fajar Pradana[3], Fharel Abdillah[4], Ruzita Sumiati[5*]

[1]Mechanical Engineering Department, Politeknik Negeri Padang
Limau Manis Pauh, Padang, 25142, INDONESIA

[2]Mechanical Engineering Department, Politeknik Negeri Padang
Limau Manis Pauh, Padang, 25142, INDONESIA

[3]Mechanical Engineering Department, Politeknik Negeri Padang
Limau Manis Pauh, Padang, 25142, INDONESIA

[4]Mechanical Engineering Department, Politeknik Negeri Padang
Limau Manis Pauh, Padang, 25142, INDONESIA

[5]Mechanical Engineering Department, Politeknik Negeri Padang
Limau Manis Pauh, Padang, 25142, INDONESIA

*Corresponding Ruzita Sumiati, ruzita.sumiati@gmail.com

Received 09 September 2024; Accepted 04 November 2024; Available online 28 November 2024

Abstract

This study aims to design and develop an automated incubator for quail egg hatching, utilizing an Arduino Uno microcontroller to regulate temperature and control the egg-turning mechanism. The hatching process requires precise environmental conditions, particularly consistent temperature control and regular egg rotation, to maximize hatching success. The Arduino Uno system integrates temperature sensors and motor drivers to automate these critical functions. The incubator's performance was evaluated to assess the stability of the system and its capability to maintain the required incubation parameters. Results indicate that the automated control system effectively sustains optimal temperature and performs timely egg rotation, contributing to an increase in hatching rates. This research presents a cost-effective and accessible solution for small-scale quail egg incubation, enabling farmers to reduce the cost of acquiring quail chicks by up to 30%. This device is adaptable for use on small, home-scale farms.

Keywords: automated incubator, Arduino Uno, microcontroller, quail egg hatching

INTRODUCTION

An egg incubator is a critical device in poultry farming and egg production industries. Its primary function is to hatch large quantities of eggs simultaneously by creating and maintaining optimal temperature and humidity conditions necessary for the growth and development of embryos. This process minimizes the risk of hatching failure and enhances productivity [1]. In an egg incubator, temperature and humidity are two crucial factors. Most incubator heating systems utilize light bulbs as a heat source. The egg chamber is equipped with fresh water to maintain humidity levels between 50-65% [2] With advancements in technology, egg incubators have evolved from simple manual systems consisting of racks, light bulbs, and analog thermometers into fully automated, digital, and computerized systems. Innovations such as automatic temperature control and egg-turning mechanisms have greatly enhanced the accuracy, efficiency, and success rates of the hatching process. Numerous studies have contributed to the development of these advanced egg incubators, particularly through the integration of microcontrollers for temperature regulation and automatic motor-driven mechanisms. For instance, Fadlin Rahman explored the use of an ESP8266 microcontroller-based automatic egg incubator with digital thermostats and DHT11 sensors for temperature control [3]. Indra Aditia investigated the application of DHT11 sensors for controlling temperature and humidity directly via an Arduino Uno microcontroller [4]. Ferry Budhi Susetyo developed an automatic sliding rack system powered by a hybrid motor for use in automated egg incubators [5]. Erika Putra designed an automatic egg incubator incorporating an AC motor to facilitate egg rotation. These studies highlight the ongoing technological innovations in egg incubation, contributing to improved system performance and hatchability outcomes in both small- and large-scale applications [6].

In this study, no egg incubator was found that combines the use of a two-tier sliding rack system powered by a single motor with an integrated automatic temperature control system, all within a single unified unit. To address this limitation, the researchers developed a quail egg incubator equipped with two racks operated by a single motor for the egg-turning process. This incubator also features an automatic temperature control system using an Arduino Uno microcontroller, ensuring the temperature remains within the optimal range for hatching. The design of this machine aims to enhance productivity and hatching efficiency, making it suitable for both industrial and small-scale farming applications. Additionally, it reduces reliance on third-party services and strengthens the economic resilience of small-scale farmers by providing an affordable, self-sustained solution for egg incubation. This integrated approach represents a significant advancement in the field of egg incubation technology, offering both technological innovation and economic benefit.

RESEARCH METHODS

The method employed in the development of this quail egg incubator is a design and construction approach that focuses on temperature control and motor operation. The system is automatically controlled using an Arduino Uno microcontroller, which functions to drive the motor for turning the quail eggs and maintaining a stable temperature range of 37-39°C. The following flowchart in **Fig.1** illustrates the methodology utilized in this study.

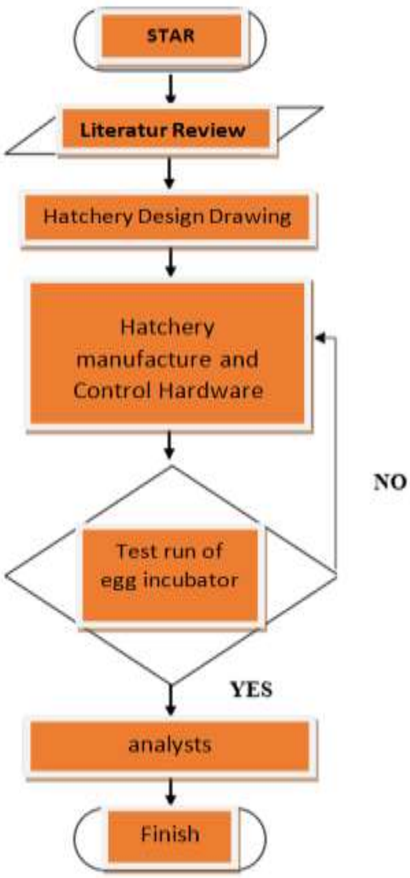

Fig.1. Flow char step of reserach

In the testing of the motor drive system, the servo motor demonstrated that it completes a single rotation when receiving a "HIGH" input signal and ceases movement when the input signal is "LOW." The motor is programmed to operate twice daily, rotating from 0° to 90° and then returning to its initial position. This adjustment effectively resulted in smoother and more stable motor operation, facilitating consistent egg rotation and promoting uniform heat distribution throughout the incubation process. Deviation measurements were performed by calculating the difference between the planned angle degrees and the actual angle measured manually using an angle-measuring instrument. The temperature sensor testing procedure involved comparing measurements from the DHT11 sensor to those obtained from a manual temperature sensor placed within the incubator. The resulting data were analyzed to calculate the percentage error. If the error remained within acceptable standards, the sensor was considered suitable for application in the incubation process.

RESULTS AND DISCUSSION.

The construction of the quail egg incubator is presented in **Fig. 2** below

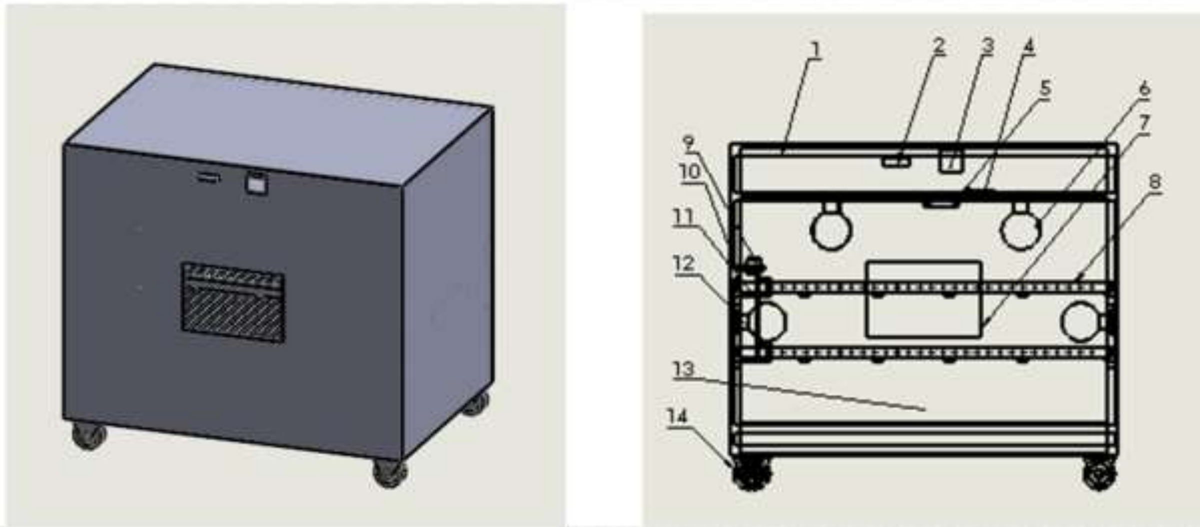

Fig. 2. Construction of the quail egg incubator

In the design of the incubator box, plywood was used with dimensions of 1003 mm in length, 800 mm in height, and 640 mm in width. These dimensions were chosen to accommodate the planned capacity of 1000 eggs. Plywood was selected as the material due to its thermal properties, which help retain warmth around the eggs. Additionally, plywood is cost-effective, widely available, and easy to shape into a box or other desired structures, making it a practical choice for this application.

The quail egg incubator is designed with racks made of hollow aluminum, measuring 600 mm x 890 mm, chosen for their strength and durability. These racks are operated by a servo motor, which moves them forward and backward within the incubator box. The forward movement of the racks automatically rotates the eggs contained within, ensuring that each egg is evenly exposed to the temperature from all sides. This process is essential for maintaining uniform embryonic development, a critical factor in optimizing hatch success.

The servo motor is controlled by a program specifically designed to operate within a set time interval, ensuring that the frequency and duration of the rack movement align with the incubation requirements. Additionally, the incubator is equipped with eight incandescent bulbs that provide optimal heat to create the ideal environment for the hatching process. The internal temperature of the incubator is maintained within the range of 37-39°C, which is the optimal condition for quail egg incubation.

To ensure temperature stability, the system is equipped with sensors that continuously monitor the internal temperature. If the temperature falls below 37°C, the incandescent bulbs automatically activate to raise the temperature. Conversely, if the temperature exceeds 39°C, the bulbs are switched off to prevent overheating. The temperature data is displayed in real time on an LCD screen, allowing the user to easily monitor the incubation conditions, **Fig. 3** is a drive design with a 2-rack system with a servo motor drive.

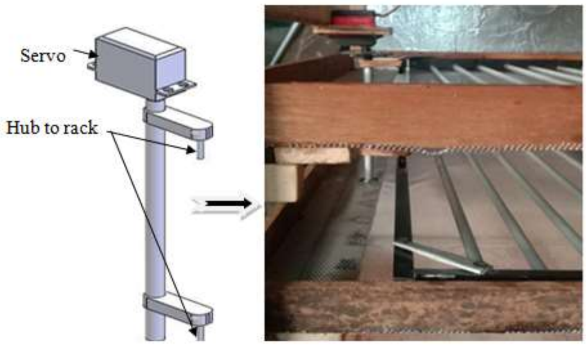

Fig. 3. With a 2-rack system with a servo motor drive

The wiring diagram for the temperature control and motor drive system, which has been designed and implemented in the hardware development, is presented in **Fig. 4.**

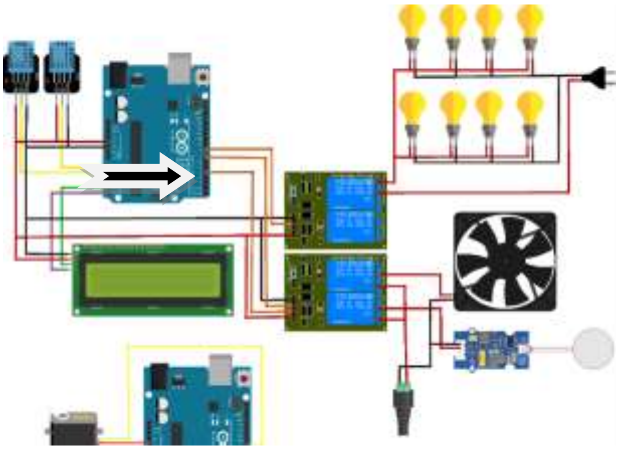

Fig. 4. **Temperature Control Wiring Diagram**

The motor control utilizes the wiring diagram shown in **Fig. 5**, following a series of operational steps. First, the pins are connected, and the Arduino program is uploaded. Upon initialization, the Arduino Uno is programmed to rotate the motor from 0° to 90° and vice versa. The motor's operation has been configured to run once every 12 hours, or twice daily, in accordance with the programmed settings.

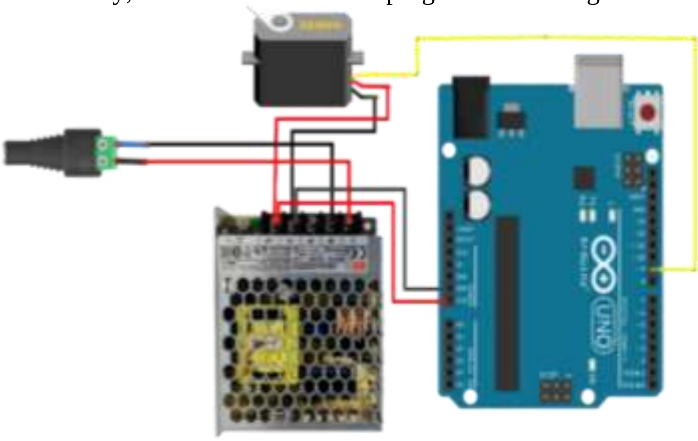

Fig. 5. The motor control utilizes the wiring diagram

Fig. 6. Program listing for the incubator machine

The software design utilizes the Arduino IDE, where the programming is done using the C programming language. The Arduino program is commonly referred to as a "sketch." Each sketch contains two main functions, beginning with the initialization of the specific pins that will be used by the system. The code for the Arduino Uno is shown in Figure 6.

In this software design, the control program for temperature and motor operation will be developed to ensure the optimal performance of the quail egg incubator. For temperature control, the software will be programmed to maintain a stable temperature within the incubator, ranging from 37°C to 39°C, which is the ideal range for quail egg incubation. The system will continuously monitor the temperature in real-time and automatically adjust the internal conditions to ensure the temperature does not exceed or fall below the specified range.

Meanwhile, the motor will be programmed to automatically rotate the quail eggs once every 12 hours. This movement is crucial to ensure even heat distribution across all parts of the eggs, supporting optimal embryo development and preventing hatch defects. Thus, the program is designed not only to maintain environmental stability within the incubator but also to enhance the efficiency and overall success rate of quail egg hatching

Incubator Machine Testing

The temperature control testing using the DHT11 sensor demonstrated that when the temperature exceeds 39°C, the automatic misting system is activated, and the heating light turns off to maintain the incubation temperature within the range of 37–39°C. The program operates as designed, linking the sensor to the misting system. The test also revealed a 3°C temperature difference between the DHT11 sensor and the room thermometer, with an average error of 0.78%, calculated using the Equation 1.

$$\%\text{Error} = \frac{\text{Read value} - \text{Actual value}}{\text{Read value}} \times 100\% \quad (1)$$

In the motor drive testing, the servo motor demonstrated that it rotates once upon receiving a "HIGH" input and stops when the input is "LOW". The motor is configured to rotate twice daily, moving from a 0° position to 90° and back. This modification successfully achieved more stable and smooth motor movement, ensuring proper egg rotation and even heat distribution. The position of the motor's movement is illustrated in **Fig. 7**.

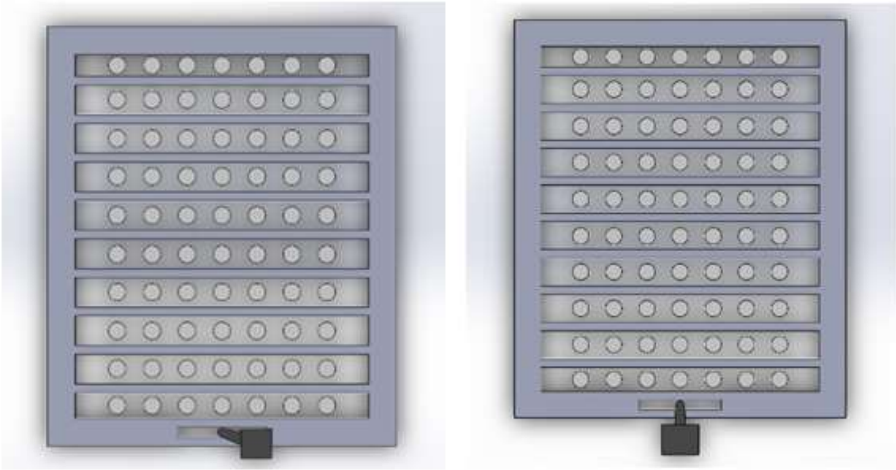

Fig. 7. Positions 0° and 90° on the servo motor

This table records the results of testing the servo motor using the Arduino Uno, where the desired angle column indicates the angle set in the code, and the actual angle column shows the angle observed on the servo motor during the test. **Table 1**. shows the test results of the servo motor against the desired angles.

Table 1. Shows the test results of the servo motor against the desired angles.

No	Planned angle (°)	Read angle (°)
1	0	1
2	45	45.3
3	90	89
4	135	138
5	180	178

Testing was conducted on a sample of 250 eggs evenly arranged on the rack. **Table 2.** presents the stages of the hatching process in the incubator.

Tabel 2. The stages of the hatching process

No.	Day	Description	Testing Figure
1	Day 1 - 3	The eggs are placed in the automatic egg incubator with the temperature maintained at 37-39°C and left for 3 days without operating the rack rotation servo	
2	Day 2	Examining quail eggs	

3	Day 4 – 13	The egg turner rack is activated consistently twice a day	
4	Day 14 – 16	The rack is turned off because the eggs are about to hatch	
5	Day 16	The egg shell begins to crack.	
6	Day 17	The eggs have hatched and become quail chicks	

Testing of 250 fertilized quail eggs demonstrated that maintaining a stable temperature and humidity between 37–39°C during the first 3 days is crucial for optimal development. From days 2 to 7, embryonic development became observable, and by day 16, the eggshells began to crack, with hatching occurring on day 17. Out of the 250 eggs, 202 successfully hatched, while 48 did not. The hatching percentage from the test results is 80%. Therefore, the incubator's performance is assessed as satisfactory in executing the hatching process.

CONCLUSIONS.

The modification of the quail egg incubator effectively addressed the issues related to temperature regulation and motor operation. The enhanced system activates an automatic fogging mechanism when the internal temperature exceeds 39°C. Additionally, the incorporation of a motor with a torque of 20 kg, powered by a 5V 5A power supply, ensures the consistent and stable movement of the egg rack. Experimental results demonstrated that the temperature remained stable within the range of 37-39°C, with an average deviation of 0.78% between the DHT11 sensor readings and a reference thermometer. The servo motor performed reliably, though an angle discrepancy of 280% was observed. This modification enhances both the efficiency and reliability of the quail egg incubator system.

ACKNOWLEDGEMENT

This paper was supported by Penelitian Terapan Unggulan (PTU) grant from Politeknik Negeri Padang. The author wishes to express her gratitude for the support given to this work.

REFERENCES

[1] Constantini:F & Lacy. E. 1986. Perkembangan Embrio. A. Borantory Manual. Cold Spring Harbair Laboratory. New York.

[2] Adiptya, Muhammad Yan Eka, Dkk. 2013. Sistem Pengamatan Suhu Dan Kelembaban Pada Rumah Berbasis Mikrokontroller Atmega8. Jurnal. Universitas Negeri Semarang.

[3] F. Rahman, S. Sriwati, N. Nurhayati, and L. Suryani, “Rancang Bangun Sistem Monitoring Dan Kontrol

Suhu Pada Mesin Penetas Telur Otomatis Berbasis Mikrokontroler Esp8266," ILTEK J. Teknol., vol. 15, no. 01, pp. 5–8, 2020, doi: 10.47398/iltek.v15i01.499.

[4] Aditia, R. Ilham, and J. P. Sembiring, "Penetas Telur Otomatis Berbasis Arduino dengan Menggunakan Sensor DHT11," J. Ilm. Mhs. Kendali dan List., vol. 3, no. 1, pp. 113–119, 2022, [Online]. Available: https://doi.org/10.33365/jimel.v1i1availableonlineat:http://jim.teknokrat.ac.id/index.php/teknikelektro/index

[5] F. B. Susetyo, I. W. Sugita, B. Basori, M. N. Rifqi, R. Wardiana, and J. Prasetyo, "Rancang Bangun Rak Penetas Telur Otomatis Pada Mesin Tetas Bertenaga Hybrid," J. Ilm. Giga, vol. 23, no. 2, p. 69, 2020, doi: 10.47313/jig.v23i2.915.

[6] Sebagai, S. Satu, S. Untuk, M. Gelar, and S. Teknik, "Skripsi rancang bangun alat penetas telur otomatis berkolaborasi motor ac dengan sistem kontrol thermostat," 2023.

[7] Hendri. (2015). Pengenalan Tentang Pengertian Arduino UNO. http://belajardasarpemrograman.blogspot.co.id/2013/03/arduino-uno.html.

[8] Aldy Razor. " Gambar Arduino Uno HD ",https://www.aldyrazor.com/2020/04/gambar-arduino-uno.html#toc-1, diakses pada 28 Juli 2023

[9] Indomaker.com. "Cara penggunaan module 2 channel arduino", http://indomaker.com/product/blog/cara-penggunaan-module-relay-2- channel-arduino/, diakses pada 28 Juli 2023.

[10] Tokopedia "Thermostat digital" https://www.tokopedia.com/westsideshare/10a-thermostat-control-switch-probe-new-220v-digital-led-temperature. diakses pada 20 Juli 2024.

[11] Artolite. "Lampu pijar(Bohlam)", http://share- pangaweruh.blogspot.com/2015/01/apa-perbedaan-lampu-pijar-bohlam- lampu.html. Diakses pada 28 Juli 2023.

[12] Amazon. " Arduino I2C LCD", https://www.amazon.com/arduino-i2c- lcd/s?k=arduino+i2c+lcd. diakses pada 28 Juli 2023.

[13] Narin Laboratory. "antar muka sensor suhu dan kelembaban udara menggunakan arduino", https://tutorkeren.com/artikel/tutorial-antarmuka-sensor-suhu-dan-kelembaban-udara-menggunakan-arduino.htm, diakses pada 28 Juli 2023.

[14] Bukalapak "Digital LCD Thermometer Hygrometer " https://www.bukalapak.com/p/kamera/aksesoris-kamera/hygrometer/131jqig-jual-termometer-thermometer-higrometer-hygrometer-digital-pengukur-suhu-dan-kelembaban-kelembapan-dengan-kabel-sensor. diakses pada 20 Juli 2024.

[15] Robu.in. "servo motor", https://www.tokopedia.com/rekomendasi/10456412100?srsltid =AfmBOopNb_VeMue0Afx0WyQCtWwSAYMmvqZ_eOfWbEeQejmNPI0zFCOA2hg

[16] DigiWare"https://digiwarestore.com/id/adaptor/switching-power-supply-mean-well-lrs-35-5-5v-7a-644193.html ". diakses pada 20 Juli 2024.

[17] N. Iksan, L. Hidayati, T. Andrasto, and K. Fathoni, "Sistem Kendali Suhu dan Kelembapan pada Alat Penetas Telur Berbasis Fuzzy Logic Controller," *J. Edukasi dan Penelit. Inform.*, vol. 8, no. 2, p. 245, 2022, doi: 10.26418/jp.v8i2.53246.

[18] Isma, M. T. S., Purba, T. M., & Sinaga, J. (2021). Rancang Bangun Mesin Penetas Telur Otomatis Kapasitas 50 Butir. Jurnal Teknologi Mesin Uda, 2(2), 67–75.