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Design and Fabrication of Semi-Automatic Incubator for Hatching Performance of Poultry Egg

B. Mano*[1], P. Tamilchelvan[2], S. Praveen Kumar[3], R. Priyanka[4] and R. K. Chandrakas[5]

[1-5] Department of Agriculture Engineering, Paavai Engineering College, Pachal, Namakkal - 637 018, Tamil Nadu, India

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Abstract

In this study, a poultry egg incubator was designed, fabricated and tested to evaluate its hatching performance. The incubator is designed to maintain the optimal temperature and humidity conditions for embryo development, and it is also equipped with an egg-turning mechanism. The temperature or humidity is either too high or too low due to poor regulation. An electrical light is utilized as a heater in this project to keep the egg production for higher rates. The temperature and humidity conditions inside the incubator were maintained within the desired ranges, and the egg-turning mechanism worked effectively. The egg fertilization is one of the major factors to be considered in the poultry farms. It is noted that the percentage of hatching in conventional method is below 70% which is much below comparing with the developed incubator. Also, the newborn chickens in conventional method are unhealthy as they don't get a sufficient amount of heat. The developed incubator is environment friendly because it doesn't produce any by-product that is responsible for harming the environment. The results of this study show that this artificial incubator could be a reliable and effective tool for hatching poultry eggs. The incubator is easy to use and maintain, and it is affordable for local poultry farmers. Future studies should focus on determining the conditions under which the incubator will yield the best results in terms of hatching efficiency.

***Key words*:** Low-cost incubator, Microcontroller, Poultry egg, Hatching performance

A mother hen performs hatching function at low efficiency. Using artificial method, in an incubator, a system simulates the environmental conditions required for such operation is used by poultry farmers within specified temperature and relative humidity range. These range between 36°c-39°c and increases efficiency 50%- 90% [1-2]. Egg fertilization is one of the important factors to be considered when operating a poultry farm. It is possible to hatch eggs at home without the mother chick seating on them. It takes over 21-days to incubate these chicken eggs with difficult control of their temperature, humidity and turning of the eggs. Some eggs got spoiled when some factors such as temperature, humidity and egg turning are not maintained. It is therefore necessary to have a system that can monitor and maintain the factors responsible for hatching in order to keep the eggs healthy. This could be achieved with the use of a programmed micro controller to activate the heater and put the fan in OFF position when the temperature is lower than the reference temperature and to automatically put the heater OFF and the fan ON when the temperature tends to exceed the reference temperature putting the humidity inside the incubator into consideration [3].

Several technological advancements have resulted in the employment of artificial techniques for incubation eggs. This artificial process has been around for thousands of years, and it has only kept improving with time [4]. An incubator is designed to create and maintain specific temperature conditions for optimal embryo development at any given moment. The temperature set-point may be adjusted slightly to suit the conditions. The right temperature provides sufficient heat necessary for embryo development. However, determining the exact temperature required at any given moment of incubation can be challenging due to several factors, including air speed within the incubator, heat distribution in the surrounding air, the nature of thermal conductivities of eggshells, and the different stages of embryo development [5-6]. The research work is based on design and fabrication of a semi-automatic egg incubator capable of maintaining and regulating the temperature, humidity, ventilation and turning system of the eggs throughout the incubation period. This project to assist farmers in hatching eggs and save time by using the egg incubator, which will boost their production and thus their income. The main objective of the present study: Design and fabrication of semi-automatic egg incubator. Fabricate the incubator with more of locally source materials. Hatch eggs in a clean environment. Encourage the youth to venture into agriculture (poultry farm), small and large scale**.**

Sanjaya *et al*. [7] proposed an IoT-based egg incubator system for poultry farming. It incorporates sensors to monitor temperature, humidity, and CO_2 levels. The data is sent to a cloud platform for real-time monitoring and remote control via a mobile app. Radhakrishnan *et al*. [8] developed an egg incubator using an ATmega16 microcontroller. The system automatically maintains optimal conditions for embryo development by using temperature sensors, a heating light

***Correspondence to:** B. Mano, E-mail: manoboominathan1996@gmail.com; Tel: +91 8778562493

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source, and a fan. The temperature is displayed on an LCD, and a gear motor controlled by a timer periodically tilts the egg tray. Atharva Chaskar *et al*. [9] designed an aesthetically pleasing and functional incubator suitable for various egg types. It uses temperature and humidity sensors to maintain ideal conditions. A heating lamp regulates temperature, while humidity is controlled with water and a blower. Cherappa *et al*. [10] created an IoT-based incubator that monitors temperature, humidity, and CO_2 levels. Data is transmitted to the cloud for real-time access, and the system supports remote adjustments through a mobile app. It also features automated egg turning and anomaly alerts. Benjamin Kommey *et al*. [11] focused on designing a low-cost smart incubator to optimize hatching conditions like ventilation, temperature, humidity, and egg turning. Sensor data is processed by a microcontroller, which automates responses. A mobile app is used to relay key information to the farmer.

MATERIALS AND METHODS

Traditional egg incubators often lack real-time monitoring of critical parameters such as temperature, humidity and airflow. This can lead to suboptimal conditions, reducing the hatch rate. The manual monitoring of egg incubators prone to human error. Constant supervision is required to maintain ideal conditions. The inconsistent environmental conditions due to equipment malfunction, power outages, or poor manual adjustment can affect the health and development of the embryos. Problems such as overheating, insufficient humidity, or poor ventilation may go unnoticed until it's too late, leading to egg spoilage or low hatchability.

A Semi-automatic incubator system construction was achieved using various components which consist of the incubator box, fan, 2 pieces of 100 watts tungsten bulbs, electrical component and the egg turning trays. The temperature sensor is an integrated circuit sensor that measures the centigrade temperature and provides an output voltage that is linearly proportional to the temperature. Measures the ambient temperature in an environment. The light Sensor detects light intensity or brightness in the environment. The Humidity sensor measures the moisture level in the air. A fan was incorporated into the design of the incubator to cool and control the amount of air circulating within the incubation system. The bulb generates warmth to maintain the necessary temperature for incubation, especially for hatching eggs or nurturing newborn birds. When used with a thermostat, the bulb helps maintain a stable environment inside the incubator. 100W tungsten electric light bulb, which served as the source of heat, to warm the inner unit to a temperature of 37.5°C. The aluminum tray holds water to help regulate humidity levels inside the incubator, which is essential for egg incubation. The Plastic incubator box can be used to hold eggs to protecting them from direct exposure to heating elements. Plastic provides some thermal insulation, helping maintain a stable temperature inside the incubator.

The fabrication process begins with designing and assembling the incubator frame Preparation the outer casing was selected based on size and insulation requirements. Openings for ventilation and observation glass were created. Installation of heating element was securely fixed inside the incubator and electrical connections were insulated to ensure safety. Temperature and Humidity Sensors were placed at strategic points inside the chamber for accurate readings, to maintain optimal temperatures around 37.5°C, along with temperature and humidity sensors connected to a microcontroller for monitoring and adjustments. A small fan ensures proper air circulation, while a water reservoir helps maintain humidity levels, crucial for successful incubation. The egg tray is designed to securely hold the eggs while allowing airflow, and the entire unit is often equipped with a transparent lid for visibility. All components were connected to the power supply through a circuit board. Safety checks were conducted to prevent short circuits. After assembly, thorough testing and calibration are essential to create a stable environment before introducing the eggs, making this project an engaging blend of engineering and biology.

Testing

The incubator was powered on to test all components. The thermostat and sensors were calibrated to maintain the desired temperature (e.g., 37-39°C for egg incubation). Humidity levels were adjusted by adding water or controlling the humidifier. The fan's operation was verified for uniform air circulation**.** The turning frequency every 2 hours (automated setting) all eggs turned successfully as scheduled and achieved a high hatching success rate. Minor adjustments may be needed for control optimal humidity control, but overall, the incubator meets industry standards for performance and user experience.

RESULTS AND DISCUSSION

The results of our experiments for the proposed monitoring system will be presented and discussed in this section. The temperature and humidity measured data are updated continuously and monitored utilizing the microcontroller application. The fabrication of the incubator was successfully completed, incorporating precise design considerations and material selection to ensure functionality, durability, and cost-effectiveness. Key components, such as temperature and humidity control systems, were tested and optimized for stability and accuracy. Challenges encountered, such as calibration of sensors and structural assembly, were resolved through iterative testing and adjustments. The final prototype demonstrated reliable performance, maintaining the desired environmental conditions for incubation, thus validating the design's practicality and effectiveness. Further improvements could enhance energy efficiency and user interface for broader applications.

Table 1 Testing efficiency and hatching performance of Incubator

S. No.	Analysis	20 Numbers of eggs	
		Conventional method	Artificial method
1.	Temperature control	Frequent	Automated sensor
2.	Time taken	21 days	18 days
3.	Accuracy	65%	90%
4.	Application scale	Small scale	Large scale
5.	Efficiency	65.67%	90.35%

The comparison between conventional and artificial incubation methods based on a sample of 20 eggs demonstrates significant improvements in performance and efficiency with the artificial method.

Temperature control

In the conventional method, temperature regulation is done manually, requiring frequent human intervention. This method is prone to inconsistency due to human error or environmental fluctuations. On the other hand, the artificial method employs automated sensors to continuously monitor and control the internal temperature of the incubator, ensuring stable and optimal conditions for embryo development.

Time taken

Eggs incubated using the conventional method generally require the full incubation period of 21 days to hatch. However, the artificial method shortens this period to around 18 days by maintaining precise environmental conditions, thereby accelerating embryonic development [12].

Accuracy

The accuracy of successful hatching in the conventional method is relatively low, at approximately 65%. In contrast, the artificial method achieves a significantly higher hatching accuracy of 90%, attributed to better environmental control and automation [13].

Application scale

Conventional methods are usually limited to small-scale operations due to their manual nature and the labor-intensive process. In comparison, artificial incubation systems are scalable and more suitable for large-scale poultry farming, allowing for centralized monitoring and management [14].

Efficiency

Overall efficiency, which includes factors such as hatchability rate, energy usage, and operational effectiveness, is markedly higher in artificial incubators, reaching 90.35% compared to 65.67% in the conventional approach. This increase in efficiency directly contributes to higher productivity and cost-effectiveness in commercial poultry farming [15-17].

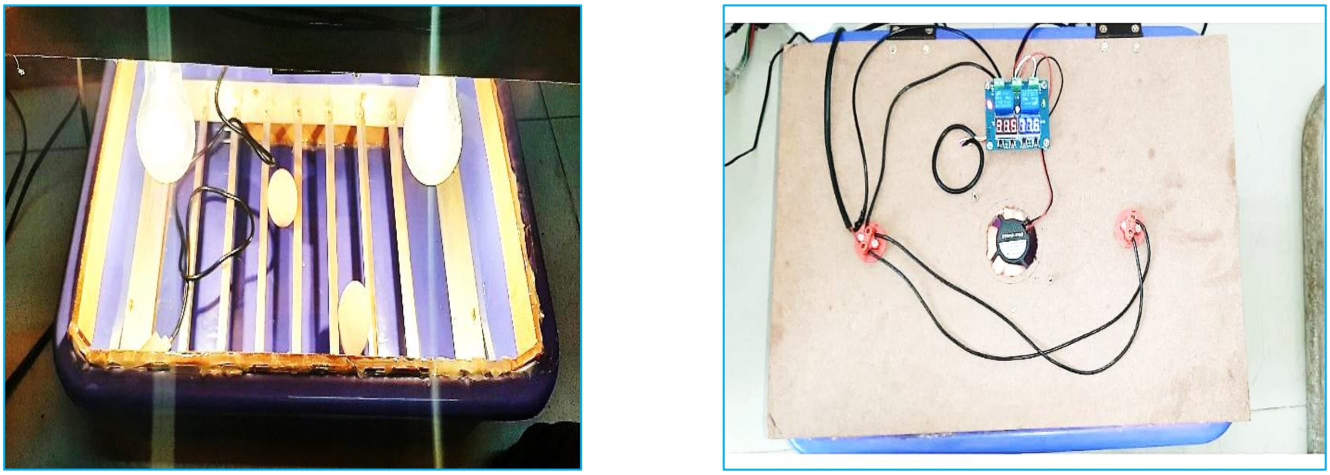

Fig 1 Schematic view of portable egg incubator

CONCLUSION

The design and fabrication of a semi-automatic incubator for poultry egg hatching has proven to be an effective solution for enhancing hatching performance. The integration of precise temperature and humidity control mechanisms, coupled with a reliable egg turning system, has resulted in an impressive hatch rate and the overall health of the chicks. The user-friendly interface allows for easy monitoring and adjustments, making the incubator accessible to both novice and experienced users. Furthermore, the energy-efficient design contributes to sustainability in poultry farming. Overall, this semi-automatic incubator not only meets the essential requirements for successful egg incubation but also represents a significant advancement in poultry breeding practices, promoting higher productivity and better animal welfare. Future enhancements could focus on incorporating advanced monitoring technologies, further improving efficiency and user experience.

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