

# Egg Incubator Control System: A Review

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**Abstract**— Chicken or duck farming is one of the businesses that has good prospects. Conventional hatching of chicken or duck eggs has its own risks with a hatching success percentage of <81%. The hen or duck also needs time for further breeding because they have to incubate the eggs first. Egg incubators on the market usually use on-off controls to regulate incandescent lights which can cause the temperature to fluctuate. Air humidity settings are also manually set by the user. Several researchers have conducted studies related to temperature and humidity settings. This article reviews articles from the Scopus database related to control systems in egg incubator with research questions: controlled parameters, sensors used, control theory, methods, and research results that have been carried out. The method used is Systematic Literature Review (SLR). The result of this article can provide an overview of the research development related to egg incubator control systems. It can be concluded that temperature and humidity are the parameters controlled by the majority of researchers. The egg incubator system uses one of the sensors such as DHT11, DHT22, LM35, PT100, and DS18B20. PID control is the most effective control theory to control temperature and humidity and has the best hatching success results compared to on/off control. Majority of the article use experimental method. Overall, the researchers have successfully regulated the temperature and/or humidity to the ideal parameters of 37 to 38 degrees Celsius and 50 to 75 percent relative humidity (RH).

**Keywords**—egg incubator, control systems, review

## I. INTRODUCTION

One of the promising businesses is chicken or duck farming. With an 81% hatching success rate, conventional hatching of chicken or duck eggs has its own risks [1]. Furthermore, conventional egg hatching methods take 21-22 days for chicken eggs and 25-28 days for duck eggs [2]. This makes the hen or duck sit on the eggs, which puts off the next breeding season. Because of this, less eggs are laid, so tools or machines are needed to hatch them.

Temperature and humidity are the two most influential factors on egg hatching success [3]. In most egg incubators

on the market, the incandescent lamp that acts as a heater is controlled by an on/off switch, which can cause the temperature to change. The user can also change the humidity settings on the machine by hand. For example, the right temperature for eggs that need to hatch is between 36 and 38<sup>o</sup> C [4], [5]. If the temperature is below 36 degrees Celsius, the incandescent lamp will turn on and stay on until the temperature slowly goes up. If the temperature is higher than 38°C, the lights will turn off. This happens on its own and all the time. Users can use the sensor to check the air humidity instead of the humidity. 55%RH is the expected humidity for eggs to hatch [6]. The user needs take manual action to achieve the appropriate level of humidity.

So far, only one review article has been written about egg incubators themes. King'Orl [7] examined the elements that influence egg fertility and hatching rate, including nutritional factors, parent factors, egg quality, incubation factors, and environmental factors. A review article about the technical parts of the control system for the egg incubator has not yet been written.

On the basis of this background, the author wishes to write a review paper discussing technical aspects of egg incubator control systems with the following research questions (RQs):

- RQ1: What parameters are controlled in the egg incubation system?
- RQ2: What sensors are used?
- RQ3: What control theory is used?
- RQ4: What methods are used?
- RQ5: What are the results of the research that has been done?

The method used is systematic literature review (SLR) with the articles used are articles in the Scopus database. There are several articles that used SLR method. Santo et al [8] used SLR to analyze cloud based control system that used 64 out of 581 articles (11,01%) in the database (not mentioned what database is used). The SLR method could

gathered information about a review in areas such as the demographics, topics of the research, evaluation method, and application domain. Askarzadeh et al [9] used SLR to analyze drone utility in railway condition monitoring with the keyword used in searching Scopus document is ("drone" OR UAV OR "unmanned aerial vehicle" OR "remote sensing") AND (track OR rail OR railroad OR railway) AND (monitoring OR inspection). Askarzadeh et al [9] used 47 out of 7900 articles (0,59%) to gather review of open technical, safety, and regulatory challenges about drone utility in railway condition monitoring. Taboada et al [10] used SLR to analyze AI role in project management with the keyword used in searching Scopus and Web of Sciences document is "project management" AND "artificial intelligence". The author did not mention the number of articles that used in the paper but the results obtained is artificial intelligence, especially machine learning, can be useful in the management of construction and IT projects.

Based on that, this article used SLR to gather information about RQs mentioned earlier. The results of this review are expected to provide an overview to researchers related to the development of existing research related to egg incubator control systems to be able to find originality and novelty of their next research.

## II. METHODS

This article is a literature review with the method described in detail as follows:

### A. Article Selection

Using the Scopus database, relevant articles were selected. Scopus was picked since it is one of the largest and most reputable indexers of scientific articles in the world [11]. The search keywords used were based on ("egg incubator" OR "egg hatch\*" AND "control system"). The search was conducted on March 20, 2023 with the following details (table 1):

TABLE I. ARTICLE SELECTION PROCESS ON SCOPUS DATABASE

No	Process	Number of Article
1	Entering keywords ("egg incubator" OR "egg hatch*" AND "control system") in the Scopus search field based on title, abstract and keywords.	20 articles
2	Exclude conference review article	18 articles
3	Filter articles not related to engineering	11 articles
4	1 Article is closed access	10 articles
<b>Final number of articles used</b>		<b>10 articles</b>

Based on table 1, the total Scopus document based on the keyword are only 20 documents. After we applied the exclusion criteria, we only use 10 articles (50%) of the total 20 article.

### B. Article Review Process

After the article selection process is complete, then the author downloads the 10 articles and reviews the articles by answering the 5 predetermined RQs, providing discussion, and providing conclusions.

## III. RESULTS AND DISCUSSION

### A. Article Metadata

The metadata of the 10 articles used is shown in Table 2:

TABLE II. METADATA OF THE ARTICLES USED

No	Author (s)	Year	Paper Title	Conference / Journal Source
1	Gutierrez et al [6]	2019	Development of Hen Eggs Smart Incubator for Hatching System Based on Internet of Things	2019 IEEE 39th Central America and Panama Convention, CONCAPAN 2019
2	Setiawan et al [1]	2022	Hybrid Solar Heat Accumulator Control for Egg Hatcher Applying Power Hysteresis Method	Proceedings - IEIT 2022: 2022 International Conference on Electrical and Information Technology
3	Omar et al [12]	2016	Smart eggs incubator system	International Journal of Simulation: Systems, Science and Technology
4	Hossain et al [13]	2021	Duck Eggs Hatching Procedure with A Low Cost User Convenient Integrated Device for Developing Countries	2021 IEEE 9th Region 10 Humanitarian Technology Conference (R10-HTC)
5	Shafiudin and Kholis [14]	2018	Monitoring System and Temperature Controlling on PID Based Poultry Hatching Incubator	IOP Conference Series: Materials Science and Engineering
6	Dutta and Anjum [15]	2021	Optimization of Temperature and Relative Humidity in an Automatic Egg Incubator Using Mamdani Fuzzy Inference System	2021 2nd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST)
7	Yendri et al [16]	2021	Temperature and Humidity Control System of Duck Egg Incubator Based on Proportional Integral Derivative	Proceedings - 2nd International Conference on Computer Science and Engineering: The Effects of the Digital World After Pandemic (EDWAP), IC2SE 2021
8	Rakhmawati et al [17]	2019	Thermal optimization on incubator using fuzzy inference system based IoT	Proceeding - 2019 International Conference of Artificial Intelligence and Information Technology, ICAIIT 2019
9	Evstatiev and Evstatieva [18]	2022	Conceptual Model of a System for Controlling the Process of Egg-Hatching in Incubators	2022 IEEE 28th International Symposium for Design and Technology in Electronic Packaging, SIITME 2022 - Conference Proceedings
10	Aldair et al	2018	Design and	2018 4th

[19]		Implementation of Intelligent Control System for Egg Incubator Based on IoT Technology	International Conference on Electrical, Electronics and System Engineering, ICEESE 2018
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According to the data in table 2, 9 articles (90%) were obtained from international conference proceedings, and 1 article (10%) was obtained from international journals. This demonstrates that the topic of egg incubator control system is

still underrepresented in international journals. This means that other researchers will have a better chance of publishing their articles on this topic in international journals.

### B. Article Review Summary

Furthermore, the summary results of the article reviews that have been carried out are as in table 3:

TABLE III. ARTICLE REVIEW RESULTS

No	References	RQ1	RQ2	RQ3	RQ4	RQ5
1	Gutierrez et al [6]	Temperature and humidity	DHT11 sensor	PID for temperature control based on IoT	Experimental method	Egg hatching success rate is 87.55%
2	Setiawan et al [1]	Temperature and humidity	Temperature sensor (PT100 and DS18B20), light sensor (BH1750), and proximity sensor	Hysteresis method algorithm	Experimental method	Combination of heat control in the incubator with the help of sunlight, lights and blowers. The percentage of electricity savings is 41.6%. There is no egg hatching test yet.
3	Omar et al [12]	Temperature and humidity	LM35, PIR sensor	On / off control	Three stages of design making are mechanical, electrical and software design.	When the temperature is below 35 C, the lights will turn on and the fan will turn off, then when the temperature is above 37 <sup>o</sup> C, the lights will turn off and the fan will turn on until the temperature reaches the range of 35-37 <sup>o</sup> C. The average humidity is 32.16% RH.
4	Hossain et al [13]	Temperature and humidity	DHT22 sensor	On / off control	System conceptualization, literature review, specification and analysis of system requirements, setup and validation	When the system is activated the temperature and humidity sensors work together to maintain a temperature limit of 35.6°C to 37.8°C and humidity of 60% to 80%. When the conditions are 35.6°C and/or, >37.8°C and 60% and/or, >80% then the lights will be activated. The sensor will continue to work reading the changes in temperature and humidity that occur. When it returns to the intended condition, the lamp is turned off. The percentage of hatching success is 85%.
5	Shafiudin and Kholis [14]	Temperature and humidity	DHT11 sensor	PID control for temperature	making hardware design, making electrical circuits, arranging sensors, lights, LCDs, fans, and system testing.	Hatching eggs can be processed for 19 days using a 15 watt lamp with good temperature stability with a PID controller, but when using a lamp of 25 watts and causing the temperature to rise and fall, causing a longer egg hatching process of 21 days.
6	Dutta and Anjum [15]	Temperature and humidity	DHT22	Mamdani Fuzzy Inference System to control temperature and humidity level	Experimental method	The results of the egg incubation system that the temperature generated in the first 17 days stabilized at 38 <sup>o</sup> C and humidity 53.60%, then on days 18-21 the temperature stabilized at 38.2 <sup>o</sup> C and humidity 64.10%. The Mamdani fuzzy inference system used in this modeling is suitable for controlling parameters in multiple input multiple output (MIMO) systems.
7	Yendri et al [16]	Temperature and humidity	DHT22	PID Controller untuk menstabilkan ambient temperatur	Phase 1: problem identification Phase 2: problem analysis, temperature reading, PID Controller Phase 3: process after analysis Phase 4: system design, hardware and software Phase 5: testing and implementation of system	When the temperature is below 37.8 <sup>o</sup> C, the relay activates and turns on 2 lights until the temperature reaches 39 <sup>o</sup> C, when the humidity in the box reaches less than 55%RH, the pump will turn on and spray water for 1 second until the humidity is as desired. The success rate of hatching is 92%.
8	Rakhmawati et al [17]	Temperature and humidity	LM35 sensor	Fuzzy inference system based on IoT	STM32F4 microcontroller to process the data read by the sensor through ADC, then the data is processed using fuzzy method, and IoT integrated with smart phones.	The time from the initial position of 28.85 <sup>o</sup> C to reach the set point of 38 <sup>o</sup> C takes 52 seconds, but to achieve stability at the steady state set point takes 115 seconds. And the largest overshoot reached 38.6 <sup>o</sup> C at the 60 seconds.
9	Evstatiev and Evstatieva [18]	Temperature and relative humidity ranges, eggs position	Not mentioned clearly	Not mentioned clearly	The author proposed Conceptual Model of a System for Controlling the Process of Egg-Hatching	The author summarizes the conceptual model related to the egg hatching device.
10	Aldair et al [19]	Temperature and humidity	DHT11	Fuzzy temperature control based on IoT	Experimental method	Smart controller is designed by using fuzzy controller to ensure that the suitable conditions are available inside the incubator for healthy growth of the embryo. By using the IoT technology, the egg incubator can be controlled and monitored by using simple web page from

### C. Answering RQs

The success of egg hatching is influenced by several factors including air quality, temperature, humidity, egg quality, parent age, disinfection and egg positioning process [2], [5], [6], [20]. A brief description of these factors are:

- **Air quality:** Adequate oxygen levels must be maintained inside the incubator during the incubation process. To do so, fans are usually used to move air in and out or open and close the ventilation holes.
- **Temperature:** The temperature in the incubator should be maintained at 37-38 degrees Celsius. Temperature is one of the main factors for hatching success.
- **Humidity:** The rate of water evaporation depends on the humidity present in the hatchery unit. In the first 17 days, the relative humidity level should be maintained at 55% and the last four days the relative humidity level should be around 70% to 75% [2].
- **Egg quality:** This factor cannot be controlled during the hatching process. The quality of the eggs depends on the age of chicken/duck.
- **Disinfection:** Before the hatching process begins, the egg hatching equipment must be disinfected to make it free from mold or bacteria that can interfere with the process.
- **Rotating the egg position:** Turning the eggs at set time intervals per day from day 1 to day 14 (for quail eggs) or day 17 (for chicken eggs) of incubation will keep the embryo in the center of the egg, and this will prevent the embryo from sticking to the eggshell. To achieve this, incubator programming considers turning the eggs at 1-hour intervals during the day. The optimal turning angle is 45°C [21].

Based on the article review results, RQ1 about “what parameters are controlled in the egg incubation system?” has answered. The majority of articles state that the parameters controlled are temperature and humidity [1], [6], [12]–[19]. 90% of researchers employ incandescent bulbs and fans as actuators for achieving the appropriate temperature. Unlike other researchers, Setiawan et al [1] employed sunshine and fans to maintain the proper temperature within the egg incubator.

In conjunction with RQ2, the egg incubator system uses DHT11, DHT22, LM35, PT100, and DS18B20 temperature sensor. To detect the hatchlings' movement, proximity sensors are utilized [1].

In relation to RQ3, Omar et al [12] and Hossain et al [13] used on/off control of lights and fans to control temperature and humidity with a hatching success rate of 85%. While Yendri et al [16] and Gutierrez et al [6] used PID control to control temperature. As a result, the success of egg hatching has a presentation of 92% and 87.55%, respectively. From these results, it can be seen that PID control has a higher hatching success rate than on/off control. Researchers who use a variety of fuzzy control techniques show that the egg hatching control system can function properly but have not tested egg hatching [15], [17], [19]. Researchers also apply

IoT to this egg hatching tool so that the system can be controlled/monitored remotely [6], [17], [19].

In relation to RQ4, the majority of researchers used experimental methods starting with the system planning, design and testing stages. Only one researcher used article review to propose a conceptual model of a system for controlling the process of egg-hatching [18].

In relation to RQ5, overall, the researchers have successfully controlled the temperature and/or humidity in accordance with the desired conditions in the range of 37-38 degrees Celsius and 50%-75%RH. The highest hatching success results are those that apply PID control to the system.

## IV. CONCLUSION

This article examines Scopus-indexed articles on control systems in egg incubators. The search keywords used were based on ("egg incubator" OR "egg hatch\*" AND "control system"). The search was conducted on March 20, 2023 and obtained 10 articles. The topic of egg incubator control system is still underrepresented in international journals. This means that other researchers will have a better chance of publishing their articles on this topic in international journals. After the review process is done, it can be concluded that temperature and humidity are the parameters controlled by the majority of researchers, compared to other parameters mentioned above. The egg incubator system uses one of the sensors such as DHT11, DHT22, LM35, PT100, and DS18B20. PID control is the most effective control theory to control temperature and humidity and has the best hatching success results compared to on/off control. Majority of the article use experimental method. Overall, the researchers have successfully regulated the temperature and/or humidity to the ideal parameters of 37 to 38 degrees Celsius and 50 to 75 percent relative humidity (RH).

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