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SMART EGG INCUBATOR BASED ON MICROCONTROLLER: A REVIEW

Idrees Sarhan Hussein Kocher[1], Guhdar Youcif Izadeen[2]
[1]Energy Engineering, Technical College of Engineering, Duhok Polytechnic University, Duhok, Kurdistan Region, Iraq
[2]Akre Informatic College, Duhok Polytechnic University, Duhok, Kurdistan Region, Iraq

ABSTRACT

Artificial egg incubators are devices that are used to incubate and hatch eggs by maintaining the necessary conditions for fetal development within the egg. Any egg that is being incubated requires a great deal of attention and temperature control. This is accomplished by the use of a temperature control device that runs on electricity. Incubator temperatures are often kept between (98 and 100) degrees Fahrenheit. Even yet, only 78 to 85% of eggs will hatch. To increase the hatchability of the incubator unit, many recommendations are made. Moisture content is another essential consideration that should be stated in the range of 60% to 80%. While hatching the eggs in an incubator unit, there are a number of important aspects to consider. However, the most crucial component is to keep the temperature range within acceptable limits. In this respect, there are many research papers accessible. In general, this article reviewed latest 21 works in literature and provided a complete analysis of a number of ways to control temperature, humidity, and eggs rotation based on microcontrollers to provide a solution to the poultry industry in developing nations. A comparative analysis for recent incubator design approaches in literature is presented by this study including the works of five recent researchers such as, brief discussion of their objectives, problems they try to fix, methodology, preliminary results, and the decision made on each work. Finally, based on reviewing analysis, there is a gap that has not been covered, that is, the remote control and monitoring of the incubator using Internet of Things (IoTs) technology. This function is essential for the incubator to be accessible to boost the product and reduce the malfunction causing product and time losses.

KEY WORDS: Smart Egg Incubator, Internet of Things (IoTs, Temperature Control, Humidity Control, automatically rotating eggs, Microcontrollers, Remote control and monitoring.

1. Introduction

The artificial egg incubator may be used to hatch a variety of eggs. An innovative egg incubator can provide a consistent environment for eggs to hatch based on microcontroller and IoT [1, 2]. It will keep eggs warm on all sides by rotating them continually at a set period, allowing the embryos to develop within and hatch without the need for the mother's presence or human or farmer involvement. It will include all of the required hatching conditions, such as temperature, humidity, air movement, and regular egg rotation. A chicken egg can hatch naturally or artificially. In the natural method, a hen is maintained sitting on a restricted number of eggs, usually from 10 to 12, for 21 days. This lengthy duration is required for the hen to hatch eggs and subsequently incubate chicks. All of this leads to a decrease in productivity [3]. The world's rising population and consumption, on the other hand, cannot depend on this form of incubation [4]. The artificial kind of hatching is used to avoid the drawbacks of the natural type of hatching. In this approach, the hen's broody may be simulated in order to increase the number of eggs laid and provide the necessary circumstances for hatching. Fans circulate the air within the incubation Chamber in forced-air incubators but not in still-air incubators. As a result, forced-air incubators perform better than still-air incubators in terms of maintaining temperature, humidity, and oxygen levels. As a result, forced-air incubators are used in all current artificial incubators [5]. Temperature, humidity, ventilation, and flipping the eggs over time are the four most crucial elements in an artificial incubator for the embryo within the fertilized egg to grow into a chick [6, 7]. Therefore, when designing an artificial incubator, these important variables must be taken into account [8, 9, 10].

1.1. Temperature and Humidity Control

In order to avoid unwanted moisture loss in the eggs, the humidity is maintained. Experts are believing that humidity level should not dip below 25% or beyond 60% between the time the eggs are laid and three days before hatching. The humidity level should be raised to 70-80 per cent throughout the past three days. It is fairly easy to maintain a sufficient humidity range inside the incubator. The amount of water required in the incubator to maintain the proper humidity range will depend on the humidity. Check the water level on a regular basis to prevent them from drying up. Many experts believe that excessive humidity during the first three days of incubation and insufficient humidity during the final three days is a typical causes of low hatch rates. Also, the eggs need to be kept at 99.5 degrees at all times; just one degree higher or lower for a few hours can terminate the embryo [11].

1.2. Eggs Rotation Control

Eggs must be flipped at least 2-3 times every day during the incubation phase. Numerous specialists agree that turning them 4-5 times a day is optimal. Turning eggs during the last three days before hatching is not recommended. The embryos are repositioning themselves for hatching and do not need turning. During hatching. So, an automated egg rotation is necessary for incubation [11]. Also, must keep the incubator door closed during incubation process to maintain the optimum temperature and humidity

1.3 Literature Survey on Related Works

In order to hatch, eggs take 21 days to develop into their infant. The complete creation of a chicken embryo could transform a fertilized chicken egg into a healthy chick. Humidity, ventilation and turning are the three most common aspects of multiple incubators hatching techniques. This is because these three aspects are required for egg hatching in order to guarantee that the creation of the chicken embryo is completed. In addition, to achieve greater performance and to ensure the output, the incubator must be constantly supervised to prevent failures and minimize damages, which are also costly and unpleasant for the owner of the hatcher or the farmer. This critical argument has been overlooked in several of the hatcheries which have been checked in this paper.

Reference [12] proposed a control system to control the temperature and humidity, they used the proteus software and the Arduino IDE. Two Arduino boards, one of which is an Arduino nano, are used in this incubator system. The temperature and humidity parameters within the incubator chamber were read by the Arduino nano and shown on a 16x2 LCD screen. The bell sounds to alarm that the allowable values have been surpassed, and the controller processes if the value is larger or less than the maximum or minimum. Arduino nano is in charge of the motor that rotates the eggs to keep the embryo from adhering to the eggshell. The block diagram of the artificial egg incubator for which they are responsible is depicted as shown in figure 1.

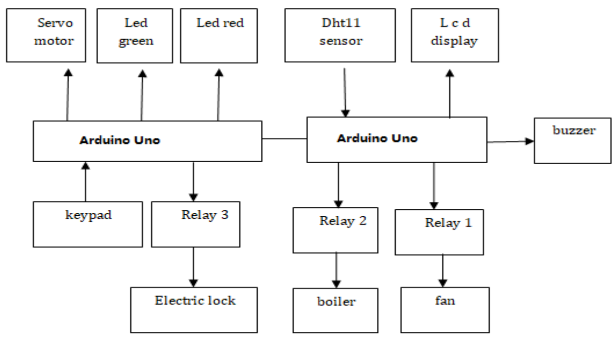

Figure 1: Artificial egg incubator block diagram [12]

Reference [13] suggested a control system to utilize an Arduino Uno to handle the whole system, which included controlling and operating the motor as well as sensors to detect essential environmental conditions and produce an output signal for incubate operation. A DHT22 sensor acts as an input, detecting temperature and humidity in the incubator and sending the data to the Arduino, which displays the incubator's status on the LCD screen, as shown in figure 2.

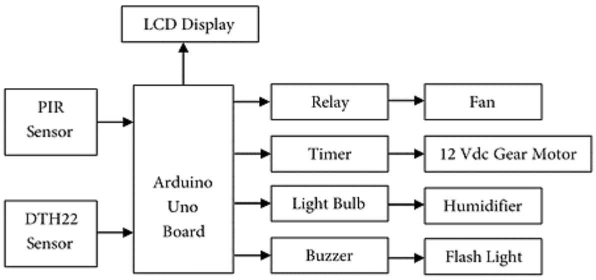

Figure 2: Natasha-CEHIM block diagram [13]

Reference [14] presented the concept and construction of an incubator for chicken eggs. The goal was to develop and create an Intelligent Egg Incubator that can produce chicken eggs autonomously. Figure 3 shows how the author employed a temperature control device in the design to manage the temperature of the incubator. A temperature monitor, heating and cooling components, and a joystick make up this system. If the temperature of the incubator exceeds a specific level, the cooling device will begin to lower the temperature, while the heating system will begin to raise the temperature if the temperature falls below a separate threshold value. The author also utilized a motion detector to detect the egg's motions. The user observes the egg's circumstances if there is movement inside the incubator, and the intelligent egg incubator will therefore incubate different types of eggs. The incubator will be filled with a temperature and humidity sensor that will automatically measure the incubator's state and turn to the appropriate egg position, but there is no distance monitoring.

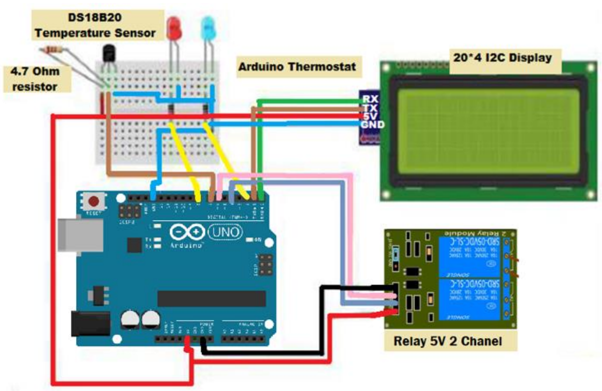

Figure 3: Temperature-Controlled Bulb Schematic Diagram [14]

Similarly, reference [15] developed an automated egg hatching room using the ATMega328p microcontroller-based DHT-11 sensor. The device is configured so that the plant room's temperature and humidity can be automatically modified. The operation of this system in a hands-free setting is complex, requiring a number of interconnected and remote devices with the ability to read, process, and monitor information, data, and output at the same time. The DHT11 to get the meaning of temperature and humidity is the main device in this automatic egg incubator. The sensor data will be interpreted by the microcontroller and shown on the LCD. The fan will turn on and the light will turn off when the temperature reaches too high, while the light will turn on again and the fan will turn off if the temperature is lower than the fixed point. The Universal Design System involves evaluating the DHT-11 components in the test method by integrating all equipment into an interconnected system to ensure that the circuit design is working as anticipated. If the test results from the beginning of hatching until the eggs hatch during the process, it turns out that the conditions of the equipment are still usual. There is no significant disruption, so the egg incubator is ready for application as anticipated in the automatic hatching. Therefore, the design of an automatic egg incubator that relies on a microcontroller can be ATMega328p using a DHT-11 sensor as a re-development, but this paper did not cover distance monitoring.

Reference [16] clarified the study and results of the use of an incubator device light bulb as a thermal source. The internal dimensions of the incubator are 26 inches long (W) x 38 inches high (L) x 26 inches wide (W) x 26 inches tall (L) x 2 inches wide (H). For this experiment, an external mentioning temperature sensor was used as a feedback signal that calculated the internal temperature of the incubator. To execute the experiment, the number of light bulbs and the shape of the light bulbs have to be determined. There are three kinds of light bulbs which are Light Emitting Diode (LED bulb), Incandescent Light Bulb (IL bulb) and Compact Fluorescent Bulb (CFL bulb) (CFL Bulb). To obtain the best output from a lighting fixture, you could prefer a fixture that is the same shape as a 2-bulb, or a 3-bulb fixture. On the grounds of it, only three types of control were tested, i.e., Mode 1, Mode 2 and Mode 3, accordingly. ON-OFF bulb control is mode 1. On-off ventilation fan control and ON-OFF bulb control are also part of mode 2. Finally, Mode 3 is limited to ON-OFF ventilation fans and ON-OFF bulb control. A control approach known as Mode 2 involves turning off the light bulb while the system is cooling off and controlling ventilation fans. Both modes 1 and 2, however, have distinct t2 times, which results in various t times. Interval time (t) is defined as t2-t1 in seconds. System reactions in Mode 1 took longer than those in Mode 2 to cool down. In the setup, the lamp with the three light bulbs run, mode of service, in which the third bulb is working, the scale time taken by overshoot, then return to the setpoint, the scale time taken to go to the set point. The author of [16] claim that tests may conclude that it is better to build the unit with IL type bulb to design an incubator using a light bulb as its thermal source so it can conduct two operations simultaneously. They did not track the people's reactions but rather checked them as a test of the concept. The primary block diagram of the controller is depicted in figure 4.

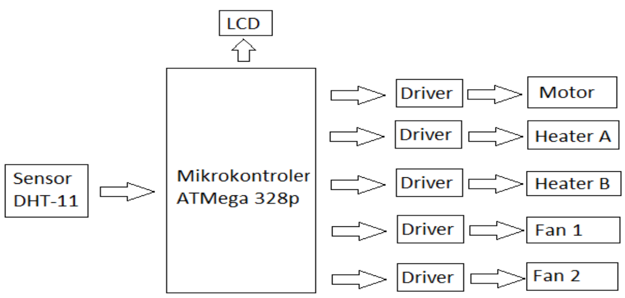

Figure :4 Main Block diagram of controller [15]

Reference [17] assembled hen egg incubator was used a composite aluminum plate to allow the embryo to replicate. To preserve the necessary temperature, light sources (40W, two bulbs) were used. In order to supply oxygen and to eliminate waste carbon dioxide, two fans (5VDC) are also used. These were regulated by the PIC16F877A microcontroller-built circuit and other electronic devices. Using Basic Pro Languages, the program was written and compiled by Micro Studio Plus Software. Win PIC 800 was copied from the hex file. To detect the surrounding temperature, the LM35DZ IC temperature sensor is used. The TS1620L LCD module is used to view the current temperature from the outside of the hen egg incubator model. The chickens can be incubated by means of the Hen Egg Incubator. A compact incubator capable of housing eight eggs using the cheapest local materials was the model they developed. Using the cheapest local resources, they built a modest incubator with room for just eight eggs. Chicks hatch four days later than expected due to poor embryos. due to low incubation temperature and humidity in storage because the window of the incubator is after opened or closed. Thus, the two chicks were dead when they were still within their shells and their eggs.

Reference [18] used bulb as heat source and this incubator system based on an Arduino microcontroller that controls the air circulation fans, heaters and the tray turning mechanism via relays. On a 16x2 LCD panel, the prevailing conditions in the incubator are visualized. The aim of the design is to help create a low-cost hatching incubator for quail eggs that is energy efficient.

Reference [19] addressed that many automated egg incubators were built as heating media using bulb lamps. However, this automated egg incubator utilizes analogue sensors in the incubator room to monitor temperature and humidity manually; eggs are screened by tilting their locations and positioning them upside down on a slate and shifting their location back and forth sometimes. This situation requires a lot of time and human capital to incubate and would cause the incubation temperature to change at times. Electronic Technology Inter-Integrated Circuit (I2C) Temperature and Humidity Sensors DHT11 is a single-chip temperature and relative humidity sensor with multi-sensor modules, the sensitivity of which has been digitally calibrated to provide a strong output signal, fast response time and outdoor interference tolerance. Waking up and falling asleep in real-time on DS1307 clock can be set with the DS1307 as a timer in the regular 12-hour or 24-hour mode (can add a year and leap for the year 2100) with leap year compensation such that it is simple for you to easily set the time in egg replay automatically. These I2C egg-based hackers can assist strengthen the local economy and, inadvertently, raise the strategic importance of cattle civilization conservation.

Reference [20] propose a solar house incubator modelling device to be used for hatching eggs using solar energy as a step towards optimizing renewable energy supplies instead of conventional energy. Indoor tests were performed using two methods to maintain the temperature of the incubator at the optimal stage. Using a solar collector and radiator, the first one operates with a solar cell. The second one is that the heater works by a solar cell only. The DC engine is used to shift the mat and automatically adjust the location of the eggs. like previous works, this device is operated by means of electronic circuits and mechanical thermocouples to provide the needed egg temperature. A programmable integrated circuit will regulate the whole element. The cumulative solar collector capacity falls by 26.8 per cent and 37.5 per cent when using the conventional system in the first and second cycles, respectively, relative to the total power. So, it is handy, affordable and quick to sustain a new template. Due to the untimely inability of electricity to increase the system's performance, solar energy can be used as a heat source. Still, there is a remote monitoring gap.

Reference [21] developed a solar-powered poultry egg incubator. Incubating chambers, monitoring mechanisms, and solar power systems were the key components of the incubator. It measured and calculated the overall heat available in the chamber. The size of the solar-powered device components depended on the amount of energy required and the period of operation. The heat loss across the walls was "59.77 W, 10.9741 W and 0.0003222 W", respectively, by conduction, air convection and drainage hole. In accordance with the findings of Ogunwande et al. [24], this study found a significant positive linear association between the egg incubator's interior and ambient temperatures. The findings of the preliminary test show that the solar-powered poultry egg incubator operated efficiently for good hatchability at the recommended temperature, with an incubator temperature ranging from “36 to 39 °C”, while the ambient temperature ranged from "23.9 to 33.7 °C". This indicates the temperature control unit's reliability and performance and the availability of solar energy. The efficiency of the generated solar-powered poultry egg incubator is "44 % " which is too low efficiency. and there is a weak point which is remote monitoring. figure 5 depicts the solar energy incubator block diagram.

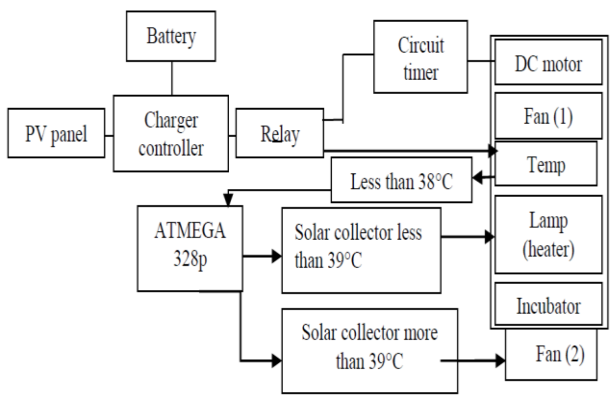

Figure 5: Incubator solar energy block Irrelevant [21]

Also, reference 22 presented an egg incubator system for chicken eggs incubation. The DHT22 and PIR

Table 1: AN OVERVIEW OF FIVE PROPOSED SYSTEMS FOR INCUBATOR

Ref.	Problem	Objectives	Methodology	Main Findings	Discussion
[17]	how to hatch chicken eggs automatically	design and construct an "Intelligent Egg Incubator"	Applied	The incubation chamber come with a temperature and humidity sensor that will the combination of the chamber to the care egg to keep the egg from being harmed.	The researcher achieved the goal, however, there is a problem if there is no electricity, does not know how is the status of the hatching
[18]	how to make egg shelves glide smoothly while carrying the heaviest possible load in an egg incubator	It is possible to refine the electronic cage automated hatch device used in the production of the quail egg industry, in order to encourage the development of healthy eggs.	Applied	By looking at the effects of the electronics and dynamics study, the total electric power used every six hours is 0.78 kWh.	In this research reduced the electrical energy consumption however, there isn't monitoring and this is a big problem.
[19]	How to provide the best temperature for system.	As a recommend, a good Light bulb may be used as a thermal source in an incubator.	Applied	This can be observed from the experiment that when developing an incubator using a light bulb as its heating source, The author explained that is better to use bulb type IL.	The researcher found the best bulb type as a source of heating however, there is no monitoring like previous research.
[20]	How to rotate a large number of eggs using the DC motor and real-time clock DS1307 and SHT11 sensor	rotate a large number of eggs automatically	Applied	In this study only 1 (one) SHT11 sensor used egg incubator with the size of the incubator room p × l × t = 110cm × 50cm × 120cm and a maximum capacity of 720 grains	the system handled large number of eggs efficiently but without regarding to monitoring and incubator status
[21]	How to use renewable energy	use solar energy as source of energy instead of traditional power	Applied	the total power with solar collector decreases by 37.5% compared to the total power when using the traditional method and the solar collector temperature was more than 39 °C nearly for 11 hours every day.	The new system is easy to use, inexpensive and easy to maintain, on the other hand, there is no monitoring of the incubation status

sensors on the chicken egg hatching incubator machine are able to automatically control and monitor the temperature and humidity in the incubator to generate the best conditions for incubating chicken eggs. The Arduino Uno control system served as the system's brain, operating the motor and sensors to detect the required environmental conditions and producing an output signal for the functioning of the incubator. In order for the Arduino to display the incubator's status on the LCD screen display. The purpose of an egg incubator is to allow the mother hen to lay additional eggs while the eggs are being incubated, increasing egg production while using less labor, speeding up hatching, and improving operational efficiency. This experiment has been successfully developed and has at least 17 of 20 chicken eggs capable of hatching. There is a vulnerability point when it comes to being tracked.

In order to generate a smooth movement of egg shelves under the greatest weight that can be supported, reference 23 designed a mechanical system using two types of motors: stepper (one motor) and servo (three motors). The thermostat was employed in the electronic system as the speed controller and the maximum hatch temperature limit, and the dht22 moisture sensor, which was integrated with a microcontroller, was utilized to maintain humidity in the incubator. Furthermore, two air heaters with 220 V/65 W specs served as the incubator's heat supply. According to the results of the examination of the electronic and mechanical systems, 0.78 kWh of electrical energy is used on average every six hours. The driver drives more efficiently with a servo motor when carrying a maximum load of 315 eggs, according to the results of the driving test using a stepper and a servo (9 kg). While there is weak point which is remote monitoring of the proposed system.

2. Comparative Analysis for Recent Incubator Design Approaches in Literature

As shown in Table 1, this review presents the work of five recent researchers including the brief discussion of their objectives, problems they try to fix, methodology, preliminary results, and finally, the decision made on each work.

3. Conclusion

Based on reviewing analysis of latest 11 research works, remote monitoring has been used in a simple and inefficient manner, this function is essential for the incubator to be accessible to boost the product and reduce the malfunction causing product and time losses. Monitoring the eggs incubator is vital to enhance the hatching rate and the efficiency of the incubator, and temperature and humidity control play a significant role in the hatching process. so, it is highly recommended to use different technique of IoT for remote monitoring of egg incubator such as web service, SMS services, call services and ESP cam 32.

Temperature and humidity should be kept within acceptable limits. In addition, the rotation should be done 3-4 times each day in the first few days to ensure optimal hatching efficiency.

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