e-ISSN: 2289-6589

THE DEVELOPMENT OF AUTOMATIC FORCED AIR EGG INCUBATOR

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Submission date: 15 Jan 2019 Accepted date: 30 April 2019 Published date:10 May 2019

Abstract

The poultry sector is one of the biggest components of the livestock industry in Malaysia. In recent years, there has been a rise in poultry livestock demand which cannot be fulfilled solely by the domestic supply chain leading them to depend on import in overcoming this problem. In order to maintain the livestock, the egg incubator was introduced in the poultry industry. The aim is the large scale production of poultry livestock through egg incubation process. Since the temperature and humidity can affect the egg's embryo development, this project is equipped with sensors to control the accuracy of temperature and humidity during the egg incubation process. The two main sensors used in this project are temperature sensor and humidity sensor. The temperature sensor controls the lighting on and off of the bulk lamp which acts as the heating element producing heat while the humidity sensor controls the mist spray providing the optimum humidity during the incubation process. Then, the latest readings of temperature and humidity detected by the sensors will be displayed on the LCD display. The eggs will be rotated every 3 hours using the automatic egg turner system driven by the motor and also, a forced air fan is used for ventilation system to circulate the air in the incubator to prevent the egg's embryos mortality.The whole system in the incubator is controlled by a microcontroller called Arduino Uno which is programmed to produce an efficient operation system between the inputs and the outputs.

Keywords: Temperature Sensor, Humidity Sensor, Egg Incubator, Egg turner

1.0 INTRODUCTION

The poultry sector is one of the biggest components in the livestock industry in Malaysia. The demands for poultry meat and eggs are increasing every year due to population growth causing breeders the difficulty in maintaining the poultry supply such as chicken, goose, and quail to the consumers.The rise in seafood price is another reason for consumers switching to poultry meat which is cheaper. In the poultry industry, the production of the poultry meat should be in a large scale in order to meet the consumer demand. This is however, impossible to be implemented via natural incubation.

The natural incubation process also faces safety and care risks during the incubation period. This especially includes eggs being exposed to diseases and predators due to lack of supervision. Beside that, there is also a problem in producing an abundant amount of poultry products at a fast pace due to the capability of natural incubation which can only hold a little production at a time. Natural incubation can only provide a small amount of eggs due to the limited space to fit the eggs under a hen which can cause some eggs to be left out and become spoiled. Therefore, natural incubation is not the best for poultry industry. To overcome these problems, this project aims to design and build an automatic forced air egg incubator equipped with automated temperature and humidity control system and also automatic egg turner system to effectively incubate eggs.

2.0 LITERATURE REVIEW

Studies have shown that the three crucial factors influencing the success rate of hatching eggs using incubator are temperature, humidity, and eggs turning. Adequate temperature and humidity during the incubation period play important roles in the development of egg's embryo. Chicken eggs require a minimum temperature of around 37°C to 39°C. The humidity on the first 18 days is around 40% to 50% while the last 3 days require a humidity level of around 60% to 75% for hatching. After the setting of eggs in the incubator, the important part is turning or rotating the eggs at least 3 times in 24 hours in the beginning 18 days and it should be stopped in the last 3 days before hatching. Another factor to consider is the ventilation system of the incubator. This is to allow enough oxygen to enter the incubator for optimal embryo development.

Incubators can be categorized into two types which are forced air incubator and still air incubator. The forced air incubator comes with a ventilation system which uses fan to circulate the air surrounding the incubator making it easy to maintain the humidity and to keep a constant temperature for all parts especially the top and bottom parts of the incubator (Mortola & Gaonac'h, 2016). Still air incubator does not have any fan to cicrculate the air surrounding it. The humidity and heat are allowed to stratify (form layer) due to the different temperature at the bottom and upper parts of the incubator. To overcome this problem, holes are drilled at the upper part to allow air to flow in and out to stabilize the temperature and the humidity. Since this incubator type is not capable of controlling the optimal incubation temperature and humidity, researchers have developed forced air incubator with various design topology for ventilation system using fan controlled by a microcontroller (Ramli et al., 2015; Maano et al., 2018).

Researchers have also reported that the setting of the temperature of an incubator differs between air forced incubator and still air incubator as the air forced temperature is set lower compared to the still air incubator (Adib, 2008). In case of chicken eggs, the temperature is set at 37ºC in air forced incubator and 38ºC in still air incubator which means that there is 1ºC temperature difference between these two incubators. (Mortola & Gaonac'h, 2016) have shown that when the incubation temperature is below 3ºC under normal temperature, the embyro development will be delayed to almost three days causing mortality. In order to prevent the embryo from sticking onto its shell and to ensure the embryo is fully developed , the egg must be rotated or rolled to change its position at least 45º from the original position. This has to be done by using hand manually or automatically operated by motor for every 8 hours (Benjamin & Oye, 2012).

In automatic mechanism, Ramli et al. (2015) proposed an egg turning mechanism using a conveyor rotation system controlled by micontroller to replicate the natural incubation process with 94.17% hatching rates achieved. Another researcher designed a mechanism to change the position of quail eggs by 45º via automatic rotation when the tray is moving forward and in reverse at every four hours using a synchronous motor (Sanjaya et al, 2018). Additionally, another important aspect is the material for the incubator body frame to keep heat longer in the incubator hence reducing power consumption. This is due to the heating element uses heater coil or bulk lamp which consume a lot of power to produce heat. To avoid heat loss which causes the heating element to always being turned on thus increasing power consumption the developer resorted to using plywood (Suriwong et al., 2017) and polystyrene (Redzwan et al., 2017) for the body frame of the egg incubator as they are good insulators.

3.0 METHODOLOGY

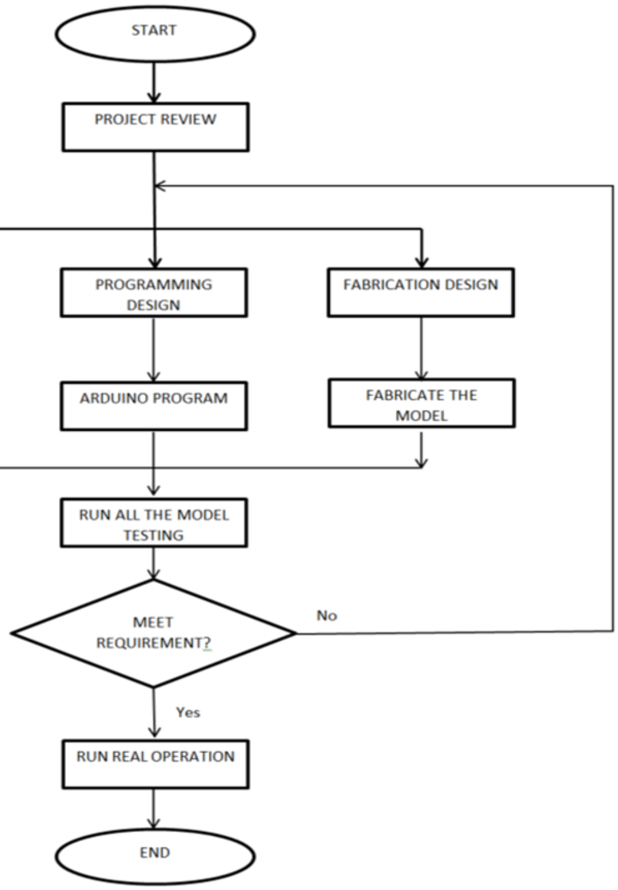

Figure 1. Project Development Flowchart

Figure 1 illustrates the flowchart of the overall project development which is divided into three main parts namely hardware design, programming design, and fabrication design. At the hardware design stage, all electrical and electronic components were identified for the design of the schematic diagram using the Proteus software. The programming design ran the simulation to determine whether or not the circuit works and runs as programmed. Since the circuit worked properly, the circuit was constructed on the breadboard for testing and to verify their functionality. Then, the functional circuit was fabricated into a Printed Circuit Board in the fabrication design. At this stage, all circuits were be integrated with the hardware components. Should there be a problem, troubleshoot will be carried out. Once all three stages function completely, the prototype of the egg incubator was developed and built.

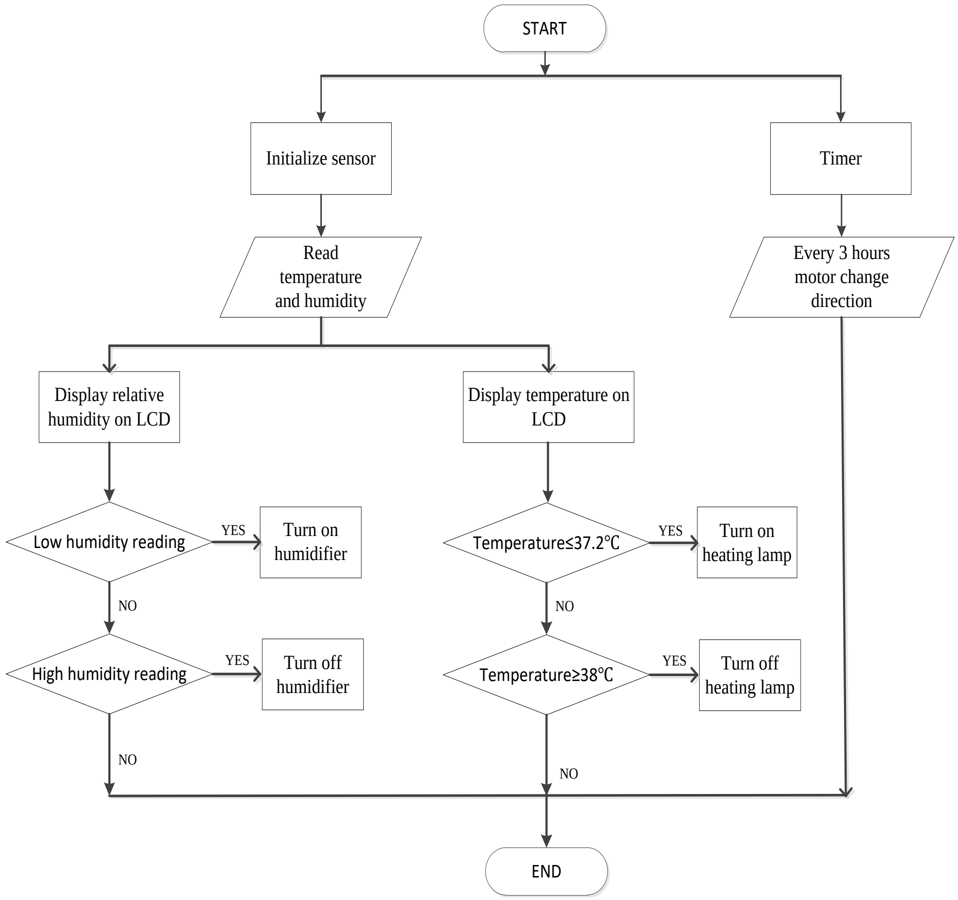

Figure 2. The Flowchart of Forced Air Egg Incubator Operation

Figure 2 displays the flowchart of the forced air egg incubator operation. To start the program, the temperature and humidity sensors were initialized to detect the latest temperature and humidity readings on the LCD display. If the temperature is below 37.2℃, the heating lamp will be turned on to heat the eggs until the temperature reaches the maximum temperature of 38℃. The lamp will be turned off if the temperature exceeds 38℃.

The humidifier will be turned on when the detected humidity is below 65% and will be turned off when the humidity increases to 75%. Then, the blower fan will be turned on to spread the vapour circulating it evenly in the incubator. At the same time, the motor will be powered on to rotate the eggs at every 3 hours according to the programming. The process will continuously run until the eggs hatch. The entire hatching process depends on the type of poultry where chicken eggs usually require 21 days to hatch.

3.1 HARDWARE DESIGN

Figure 3 illustrates the complete circuit of the automatic egg incubator. This project consists of 7 connected circuits with each circuit serving its own function. The Arduino microcontroller which acts as the control circuit organizing the inputs and outputs according to the process flow of this project is powered by a 5V DC adapter. In order to reduce the Arduino pin use, a 16x2 LCD with 16 input pins, used to display the temperature, humidity, and incubation duration, is connected to an I^2C serial via parallel converter to reduce the pins to four input pins which are SDA, SCL, +ve and −ve. DHT11 sensor acting as the main component in this project measuring the latest temperature and humidity in the egg incubator is connected to the Arduino. Any problems occuring in this critical part such as inaccurate reading may result in the failure of the entire project.

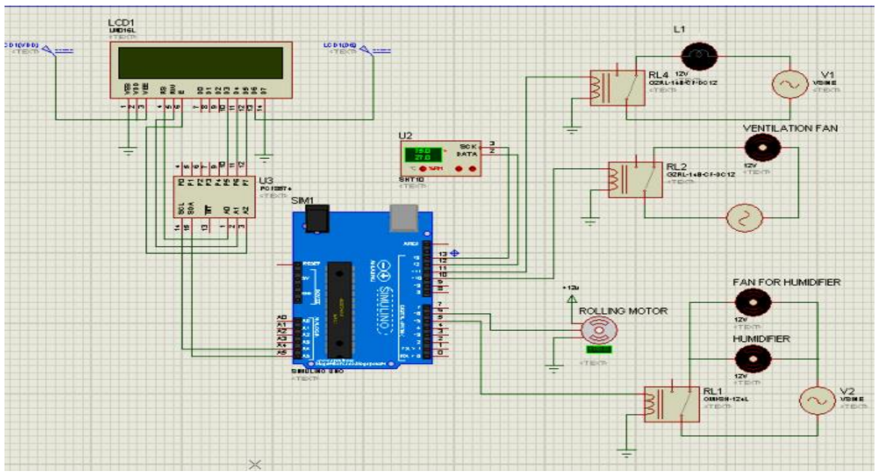

Figure 3. The Overall Schematic Diagram of Forced Air Egg Incubator

Figure 4 (a) illustrates the PCB layout of the heating lamp which acts as a power circuit as it uses 240V AC for power supply. This heating lamp is connected through a 5V DC relay which acts as the control circuit and will turn on when the relay is energized. The power circuit is separated from the control circuit via the relay to prevent the circuits with low power consumption from damage or being burnt due to the excessive power from the 240V AC power. Figure 4 (b) illustrates the PCB layout of the humidifier to control the humidity in the incubator which comes with a power supply of 24V AC parallelly connected to the blower fan through a 5V DC relay. This fan blows out the vapour produced by the humidifier.

Then, a 180° servo motor connected rolls the eggs at every three hours back and forth preventing the embryo from sticking to its inner shell. The stepping down of a single phase 240V AC/24V AC transformer produces 24V AC power supply for the humidifier, fans, and servo motor.

(a) **(b)**

Figure 4. The PCB layout (a) Heating lamp (b) Humidifier

3.2 MECHANICAL DESIGN

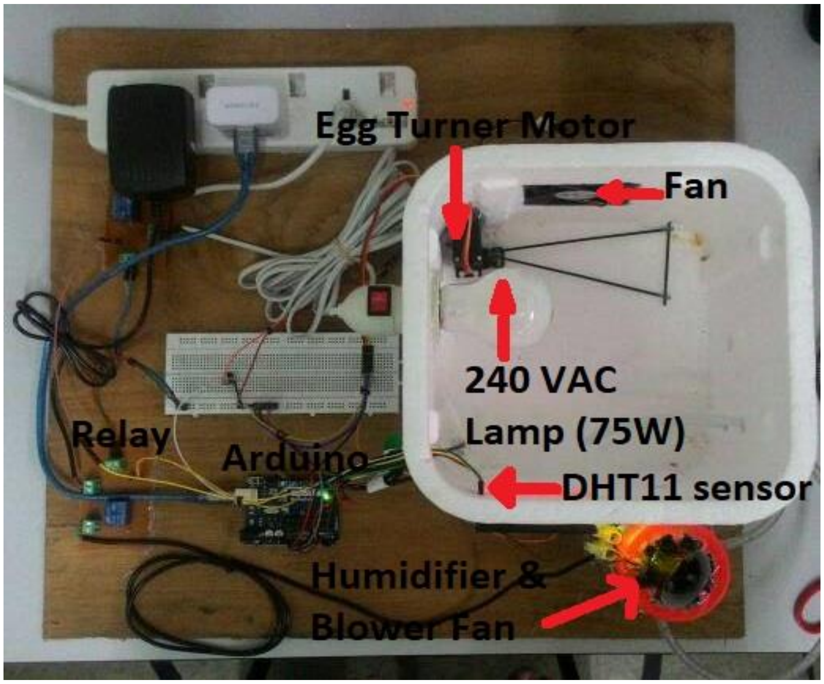

Figure 5. The First Prototype of The Project

Figure 5 displays the first prototype of the project demonstrated in small application to test the functionality of all the hadwares and circuits. Styrofoam box is used as the casing of this project. 240V AC bulk lamp with 75 Watt power is used as the heating element. The first prototype has proven to be flawed as the vapour from the humidifier flooded the base of the box and damaged the motor and the eggs, unlike plywood, Styrofoam does not absorb water. Therefore, to overcome this problem, the casing material was upgraded to plywood which is more durable and efficient for eggs hatching as shown in Figure 6.

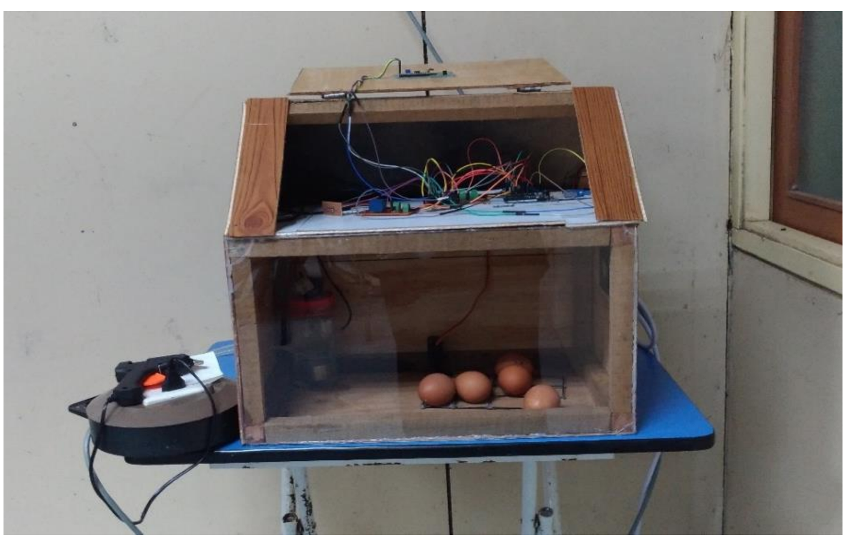

Figure 6. The Final Prototype of The Project

4.0 RESULTS AND DISCUSSIONS

Table 1. The Summary of The Operation of The Heating Lamp and Humidifier

Temperature		Relative Humidity	
Value	**Heating Lamp**	**Value**	**Humidifier**
≤37.2℃	Turn on	≤65% HR	Turn on
≥38℃	Turn off	≥75% HR	Turn off

Table 1 shows the summary of the operation of the heating lamp and humidifier. In order to get an accurate reading, the DHT11 sensor is placed close to the top of the eggs to measure the temperature and the humidity of the air in the egg incubator. The heating lamp is turned on as the relay connected to the Arduino is energized when the reading temperature is below 37℃ .As the temperature increase to 38℃, the relay is de-energized and the heating lamp is automatically turned off. The heating lamp will be automatically turned on again when the temperature drops to 37.2℃ as the temperature range is 0.7℃.

The same concept is applied to humidity. When the relative humidity is below 65%, the relay is energized, turning on the humidifier to increase the relative humidity of the air in the egg incubator. As the relative humidity increases to 75%, it will automatically turn off. Meanwhile, the humidifier blower fan will automatically run as the humidifier is turned on to spread the vapour in the egg incubator. However, the egg turning motor will run separately at every 3 hours rotating the eggs while forced air fan will run at every 2 hours to circulate fresh oxygen in the egg incubator. The summary of the operation of these hardware is shown in Table 2.

Table 2. The Summary of The Operation of The Hardware

Hardware	Operation
Egg turning motor	Runs every 3 hours
Forced air fan	Runs every 2 hours
Humidifier blower fan	Runs when humidifier turn on

5.0 CONCLUSION

In conclusion, this forced air egg incubator is designed to overcome the obstacles present in the poultry industry, providing the best solution to help in increasing the poultry production. The new method to provide the optimum humidity during the egg incubation period using the humidifier may help in increasing the success rate of egg hatching. This proposed design of forced air egg incubator could successfully meet the optimum requirements in the hatching process as it can automatically control the level of temperature and humidity, ventilation, and egg turning.

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