Design and Implementation of a Remotely Monitored Smart Egg Incubator

Ohemu Monday Fredrick[*1], Umar Tanimu Umar[2], Ajimah Nnabueze Edmund[3], Zubair Zuleihat Ohunene[4]
monfavour@gmail.com[*1], utanimu850@gmail.com[2], ajimahnnabuezeedmund@gmail.com[3], zubairelizabeth@gmail.com[4]

Abstract
The Automated smart egg incubator is microcontroller based device that can aid in large proportion production of chicks for poultry establishment. It entails an automatic transfer switch that transfers the load to any available source by making the grid the priority to make sure that there will be steady power supply. To achieve temperature regulation, a DHT22 sensor is integrated into automatically temperature and humidity monitoring system of the incubation system that ensures the temperature and humidity are within the required value. An egg tray was attached to a DC motor to form the egg spinning mechanism to spin the egg at angle 45**°** at interval of an hour. Due to temperature and humidity variation, the eggs may hatch at about 21 days. A sound sensor picks the sound from a day old chicks to send message to the farmer, alerting the condition of the farm. To monitor the temperature and moist level in the farm, an LCD displays the status of the incubator temperature and humidity. For remote monitoring, a GSM module to send temperature and humidity update on request to the farmer, this makes the system flexible as it reduces stress of visiting the location of the incubator. The result obtained shows that the system could regulate the temperature within the range of 37°C to 39°C which was adequate for the egg to hatch. The system can be used for different types of egg as it gives room for adjustment of the temperature and also adjustment of the spinning time through its setting bottoms.

1.1 Background of the study

With regard to the agricultural sector, Nigeria's economy has experienced a gradual decline since the discovery of crude oil. Petroleum advertisement is a significant factor in the un-productivity of young people who move to rural areas in search of white-collar employment [1]. To build entrepreneurship opportunities and start-up projects, there is a need to revisit the agricultural sector. This prompted the design and development of an automatic smart egg incubator with automated power source that seeks to provide a cost-effective way to generate stable revenue in the current economic environment.

Egg incubation is the mechanism by which eggs are kept warm under certain temperatures and humidity in order to mature and hatch the embryo within after a certain number of days [2]. A constant temperature and humidity must be sustained over a period of days, and that is most critical requirement for incubation. The animal performs this process either by lying on it called brooding or burying it under the ground using geothermal heat or by heat produced by rotting vegetation, earth and other material, created to form a giant compost heap [2].

The humidity around the egg is also critical; the egg may lose too much water to the atmosphere if the air is too dry, which can make it difficult or impossible to hatch. The egg will typically become lighter as incubation continues, and the air space inside the egg will generally become larger due to evaporation from the egg. Adequate humidity is needed to ensure the proper hatching of the eggs [2].

This natural incubation process, with the growth of the agricultural sector and its

commercialization, cannot keep pace with the vast increase in the world's population, which has led to an increase in food demand. Devices and systems that can assist agricultural production are of vital importance in order to increase food production to feed the growing population. The Egg Incubator is one of these machines. An Egg Incubator is a system that provides the egg under incubation with constant temperature and humidity during hatching, invariably taking up the work of an animal for a particular period of days.
Humidity is the measure of water vapour present in the air. The various physical, chemical, and biological processes are influenced by the level of humidity in the air. The measurement of humidity specifies the amount of moisture in the gas that may be a combination of water vapour, nitrogen, argon, or pure gas, etc. Depending on their measurement units, humidity sensors are of two kinds. They are a sensor of relative humidity and a sensor of absolute humidity.
Temperature is a quantity that reflects hot and cold in physical terms. It is the manifestation of thermal energy, which is the cause of the occurrence of heat in all matter, a flow of energy when a body is in contact with another that is colder or hotter. DHT22 is a digital temperature and humidity sensor and use in this proposed project to measure temperature and humidity of the incubator. Temperature and humidity are the major parameters to be monitor in the incubation process.
Existing works were designed using ATMEGA 328P for the control of the entire system, while DHT22 was used for the monitoring of temperature and humidity of the system, a GSM module to send information about the incubation situation to the famer, and incandescent lamp to generate heat for the incubation process. The overall system have inability to provide an alternative power source for incubation in the event of power failure and also inability to detect if the egg hatches before or after the slated 21 days.

In this work, implementation of a smart egg incubator with automated power source is a model that integrate a complete system of automation into a typical incubator.
It will consist of a temperature and humidity control system (DHT22), an automated egg spinner system that is a DC motor with a gear system to increase the torque connected to the egg tray. An automatic transfer switch that can transfer the load from the grid to the solar system and vies verse. The design also includes a DC heater (180w) that provides heat for the incubator and a cooling fan that provides air into the incubator. The GSM module (SIM900 mini) is a system designed to transmit and receive user information anywhere and at any time through a messaging interface. ATMEGA 328P microcontroller is used to program the entire system's operations and sequences.
The incubation room consists of two chambers, which are incubation chamber and the brooding chamber.
The incubation chamber is the chamber where the chickens are hatch under constant temperature and humidity, and after successful hatching the birds are been drop to brooding chamber.
The brooding chamber is where the chickens are kept comfortable and warm after hatching the eggs and can be vaccinated.

1.2 Statement of the problem

If power supply to the incubator is not constant, incubation process will be aborted and the farmer will suffer huge lost. Sometimes the egg may be hatched before or after the desired day, the far may also forget the actual hatching day and be far away, there is need for the farmer to be informed when the egg hatched. This project seeks to solve this challenge by demonstrating an automated shift switch that can move the load to a backup power source available power source with priority to the grid source. Because the capacity of the incubator to attain maximum hatchability depends on the ability of the egg incubator to maintain a constant heat at temperatures of 37°C to 40° C and humidity of (RH) 30-60% for effective incubation. Sometimes the incubation may take place before or after the desire date i.e. 21 days. To resolve this challenge a sound detector circuit is designed to pick the sound from the bird to convert it to an electrical signal, and send it to the microcontroller to process, the microcontroller now send a code as a text to the user notifying him of the incubation state.

1.3 Aim and objectives

The aim of this work is to implement an automated smart egg incubator which is achievable using the following objectives:

I. To design an automatic transfer switch circuit that can shift the load to any power source available.
II. To implement temperature and humidity regulator with GSM module using a microcontroller
III. To design the cabinet for the incubator with egg spinner mechanism and DC fan circuit

1.4 Project motivation

As the Nigerian economy is diverting towards the agricultural sector, there is a need for individual to align with the Federal government decision to improve agricultural productivity. This motivated me to design and construct an automatic smart egg incubator with automated power supply. This will reduce the cost of purchasing egg incubators by small-scale poultry farmers.

1.5 Project scope

Design and construction of an egg incubator with automatic temperature and relative humidity monitoring system using a programmable interface controller (Arduino Uno)[3] with a microcontroller (ATmega328), a G S M messaging system (SIM900) for transmitting information and receiving user instructions, a temperature and humidity sensor (DHT22), In the event of a power outage, an automatic shift switch (ATS) to transfer the load to the available power source and a sound transducer that selects the sound from the birds transforms it into an electrical signal and sends it to the microcontroller for further processing.

1.6 The significant of the project

Following the completion of the project:

- Some electronic components will be introduced to me through this project.
- It will allow farmers to produce in large quantities.
- It will address the cost of small-scale farmers buying industrial egg incubators.

2.3 Review of similar work

Many people have worked on this topic, and we shall review their work in this section

Abu Musa Bin Muhd Adid [4], created a smart egg incubator device of different types of eggs. Using the PIC18F4550 microcontroller and incandescent lamp in which the limitations include the absence of wireless transmission of information to the user and the inability to provide alternative means of power supply.

Agboola et al. [5]**,** studied the efficacy of three incubator models: still air forced air, touch incubator, and made used of forced air type to developed cost-effective models for birds-egg incubator with the microcontroller model (ATmega328p) and a thermostat to measure temperature. The constraint concerns the absence of an alternative power supply and a wireless infrastructure for user information transmission (Agboola et al., 2013).

Nithin T Abraham et al. [6]**,** Designed and implemented a Solar PV Poultry Incubator which can switch between grid and solar, whichthey made of a relay, temperature and heater. It constrain of this project involve lack of relaying information to the famer and inability to know if the egg hatches before or after 21 days.

K. Radhakrishnan et al. [7], Designed and implemented a fully automated egg incubator, which they made use of ATEMEGA16, LM 35, incandescent lamp, liquid crystal display and a DC fan, but no means of relaying state of the incubator to the user, they did not put in consideration humidity and no alternative power source to the system.

Okpagu N. [8]**,** designed a Temperature regulated smart egg incubator device using a microcontroller (AT89C52) for different types of eggs in which the limitations include the absence of wireless information to the user and the inability to provide alternative means of power supply.

Kyemereh et al. [1]**,** built a large-scale incubator for a commercial Arduino-based microcontroller capable of carrying a total of 14,000 quail eggs with incandescent bulb of 100W and DHT22 to monitor the temperature and humidity but it's limitation involve lack of alternative source, inability to relay the incubation condition to the farmer.

Yakasai Basher H [9], Ahmadu Bello University, Zaria. Design and construction of an automated egg incubator with GSM interface which he made use of microcontroller (ATEMEGA328P), GSM module, DHT22 to monitor temperature and humidity, LCD to display the condition of incubation, and incandescent bulb as source of heat but its limitation involve in ability to provide an alternative source of power to the system and also inability to detect if the egg hatches before 21 days or after 21 days.

Several similar reports have shown a lack of respect for renewable sources of power, inability to detect if the egg hatches before 21 days or after 21days, and automated temperature and humidity control. This proposed project work is therefore intended to resolve these issues.

The goal of this project is to design and construct an egg incubator system. That can incubate chicken egg and is known as the Automatic Smart Egg Incubator system (ASEIS). The ASEIS will have temperature and humidity sensor that can measure the condition of the incubator and will automatically change to the appropriate condition for the egg. The health of egg is very important for the development of embryo within the egg. Improper control means that the temperature or humidity is too high or too low. In this project, the DC heater is use to give the suitable temperature to the egg. By using the water and controlling fan, it is can make sure the humidity and ventilation in good condition, a sensor that automatically tracks both temperature and humidity (DHT22) will be used in this project, as it is important to control both temperature and humidity.

Research gap

The previous work made use series of microcontroller such PIC18F4550, AT89C52, ATMEGA 16, ATMEGA328P for the circuit coordination and monitoring system, made use of LM35 and incandescent lamp as source of heat to the system, made use of thermometer, DHT22, and DHT22 as temperature and humidity monitoring system of the incubator system, made use of GSM module to relay the information to the user, and made use of 16x2 LCD display to show the incubation condition. But the constrain of these previous project works was that they were not be able to provide alternative power source to the system and inability to notify the user if the egg hatches before or after the slated date.

In this new work which is Design and Construction of an Automatic Smart Egg Incubator with Automated Power Switch System shall address these two constrain [10].

In the incubation process, power loss is a major issue, so this problem can be solved by constructing an automatic transfer switch that transfers the load between the grid and the solar system to provide the system with a constant power supply. Using a sound transducer that converts sound energy from the birds into electrical energy and sends it to the microcontroller for further processing would resolve the problem of detecting when those eggs hatch before 21 days and after 21 days. The status condition in the ASIES will appear on the LCD screen display. DC motor is very useful in which a spinner will be attached to it to rotate iron mesh at the bottom side and automatically change the position of the egg for proper incubation. A microcontroller (ATMEGA 328P) would be used to monitor the entire system. The ATMEGA 328P is a type of microcontroller capable of processing data from DHT22, DC motor, GSM module, automatic transfer switch, and executing the control portion to adjust the ASEIS state.

3.4 Methodology

For this project, C programming language is used to write the program for the incubation system. The preparation symbol of the power system which is the "START" begins the programming process. The microcontroller unit is to detect if the power from grid is available or not. If not it transfers the load to solar energy and grid been made the priority as shown the figure 3.10below.

The preparation symbol of the incubation process which is the "START" begins the programming process. The system is then initialized, connecting the various units of the circuit. After this, the status of the incubator system is display on the LCD, the DC heater and DC fan are activated simultaneously. Then a decision is made; if the DHT22is active to measure both temperature and humidity of the incubator, if they are within the range (37.5°Cand 38.5° C) it go ahead and activate the spinning mechanism for incubation process and the status are display on the LCD, for the period of 21 days the eggs are expected to have hatch if not a sound detector circuit is incorporated to detect sound from the birds that hatches before or after 21 days. After the incubation the birds are drop to brooding chamber and this is where they are vaccinated and also a text is send to the user likewise displaying the status on the LCD as shown in figure 3.11 below.

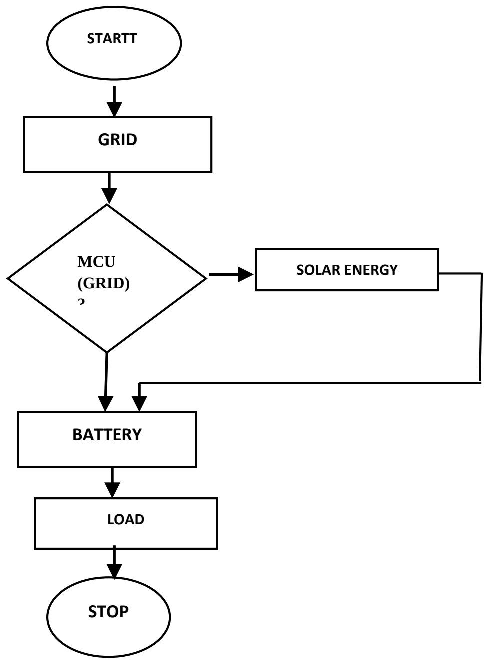


Figure 1: Flow Chart for the Power System

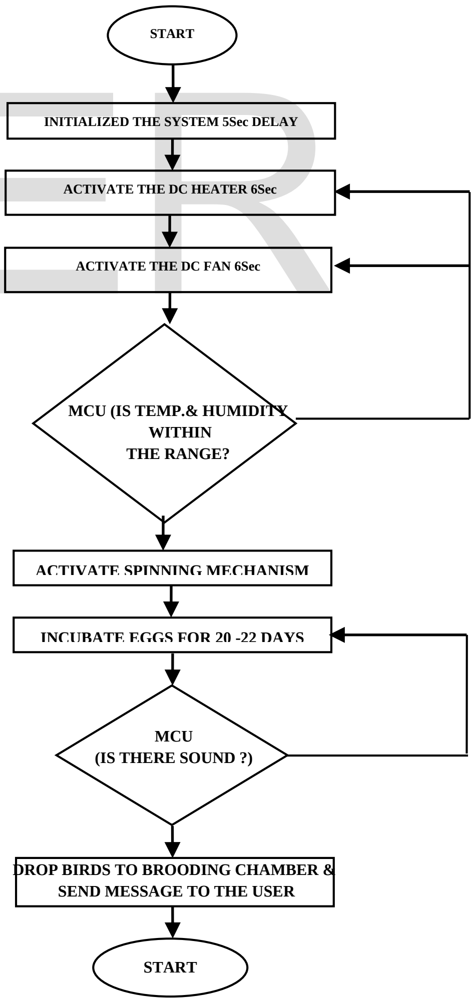


Figure 2: Flow Chart for Incubation Process

3.4.1 Design of the incubator cabinet

The incubator cabinet is made up of MBF wood of 1 inch-thick and it is planted with aluminium foil in other conserved the heat energy within the incubator chamber. The incubator cabinet have dimensions of length35Cm, width 35Cm, and height of 80Cm and these are the outer dimensions of the cabinet.

$$volume = lenght * width * height\ (cm^3) \quad 3.3$$

$$volume = 35 * 35 * 80 = 98000\ (cm^3)$$

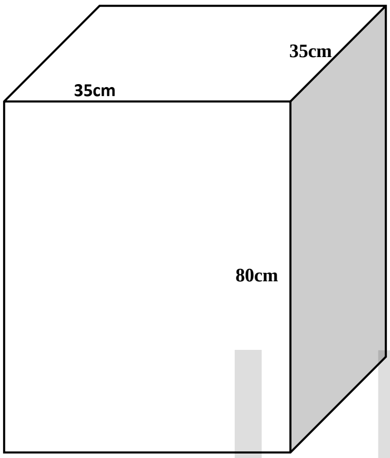


Figure 3 : Schematic Dimension of the Incubator

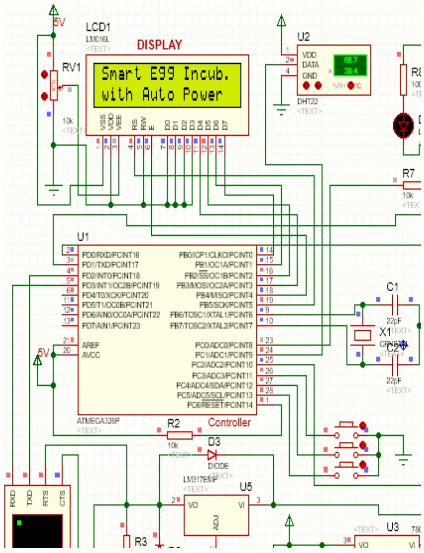


Figure 4: Proteus simulator displaying on LCD the auto power

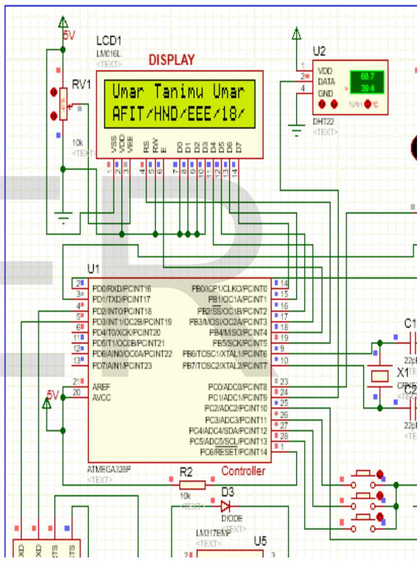


Figure 5: Proteus simulator displaying on LCD the claim of ownership

RESULT AND DISCUSSION

4.1 Introduction

This chapter presents the description of test performed on the various sections of the overall system and their corresponding results as well as the result of the overall system performance, in order to verify the functionality of the system.

4.2Testing

The complete circuit diagram of the incubator system was simulated on proteus software before implementation on bread-board and vero-board. Figures 4, 5 and 6 show the simulated results of the circuit.

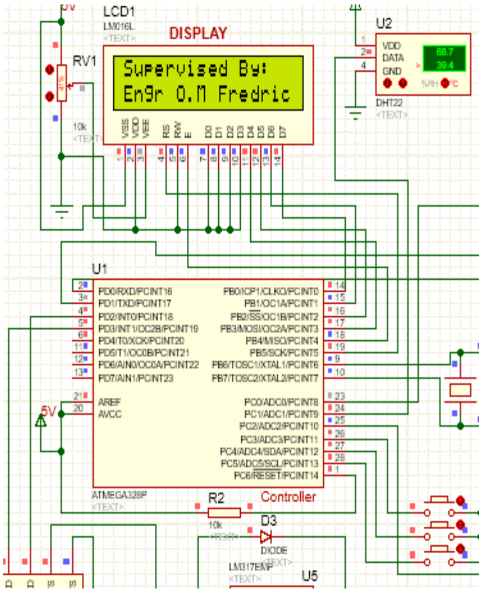


Figure 6: Proteus simulator displaying on LCD one of the supervisors

The components used for the implementation of this project were test for better performance, and were later transferred to the Vero-Board and soldered. The heat applied during soldering was just moderate to avoid damage of the Vero and the components since most of the components have low heat resistance.

After the soldering, the system was put under test to ascertain its functionality. The circuit was supply with appropriate voltages from either the grid or solar system through the automatic transfer switch circuit and the battery, it was found to function according to the circuit designed specifications. The LCD was found displaying the initial information about the incubator according the designed and methodology. The spinning mechanism was found to move according to the design and timing from the program codes.

The DC heater and DC fan was found to trigger ON when the temperature was 37^{o}Ccorresponding to it humidity and trigger OFF when the temperature was above 40^{o} C, the DHT22 was found monitoring both temperature and humidity of the incubator chamber, the GSM module was able to send the require information according to the programmed codes and finally microcontroller (ATMEGA 328p) was found coordinating the operation of the incubation system.

4.3 Result

After testing the incubator system the following were obtained as shown in Charts in Figures 7, 8 and 9 below for everyone hour

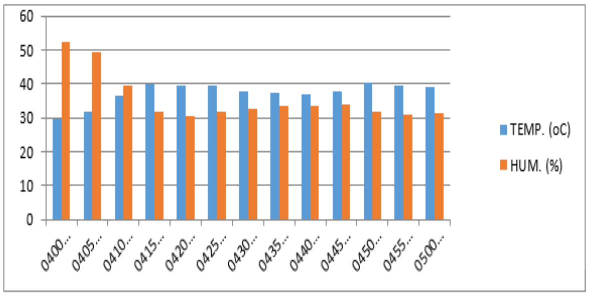


Figure 7: Relationship between the temperature and humidity for the first one hour

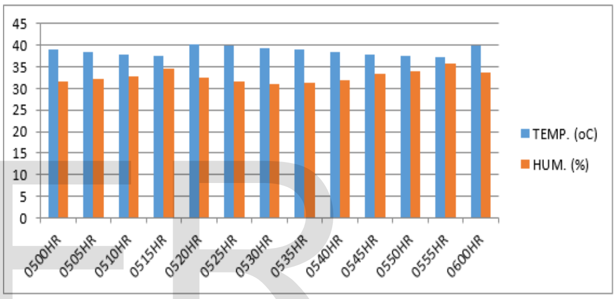


Figure 8: Relationship between temperature and humidity for the second one hour

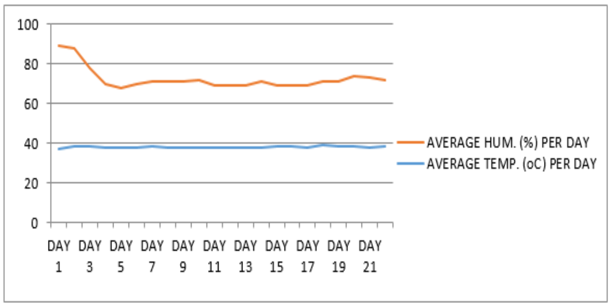
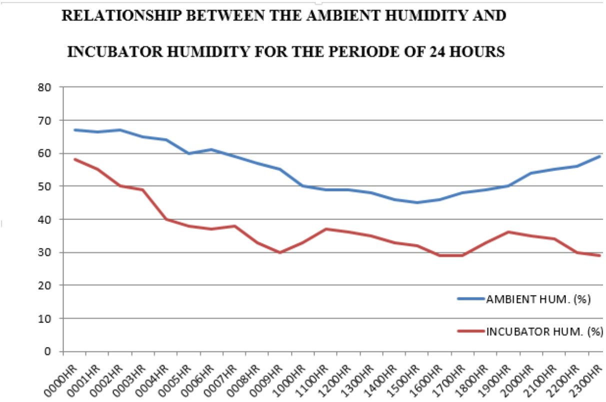


Figure 9: Relationship between temperature and humidity for 21 days



4.3.3 G S M Module

The following screenshots show the text received from G S M module. Figure 10A: shows the temperature request and Figure 10B: shows when the grid failed.

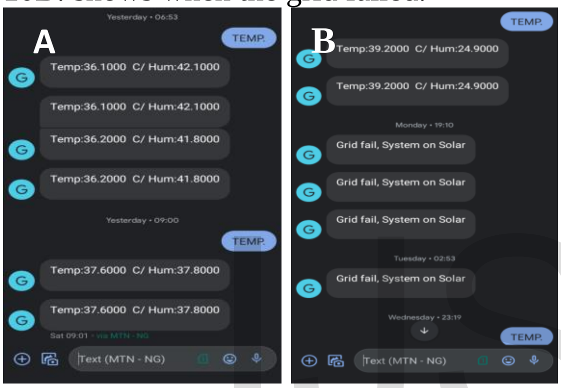


Figure 10: A: Temperature Request B: Grid failed

4.4 Packaging

Packaging this is putting together the various part of the incubator system in a cabinet after the implementation of the circuit diagram on a Vero-Board. Figure 11 below shows the top view of the system; Figure 12 below shows the incubation chamber, and finally Figure 13 shows complete packaging.

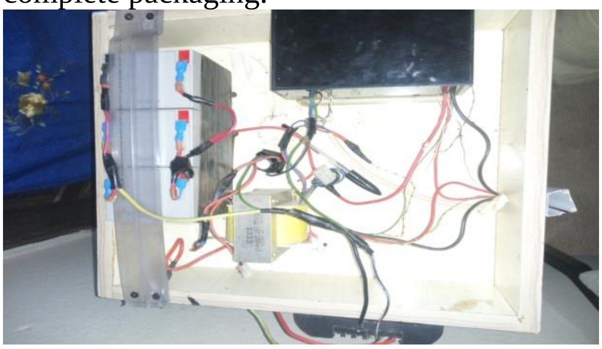


Figure 11: Top view of incubator system

Figure 12: Incubation chamber

Figure 13: Complete Packing of the Incubator

4.4 Discussion

- It was observed from the above chart that the temperature is inversely proportional to the humidity.
- It was also observed that the DC heater triggers ON at temperature of 37^0c with its corresponding humidity and triggers OFF at 40.1^0cwith its corresponding humidity.

CONCLUSION, LIMITATIONANDRECOMMENDATION

5.1 Conclusion

This project was designed with the aim of being able to maintain the temperature and humidity required for the common species of the poultry in Nigeria. This will reduce human interaction, increase the accuracy of maintaining the desired values of temperature and humidity, and increases the overall incubation rate. With this the following objectives were achieved in the curse of testing the project.

- The automatic transfer switch that shift load between the grid and solar system.
- The egg spinning mechanism that spins the egg at interval of one hour for one second.
- The temperature and humidity monitoring system.
- The ability for GSM module relay information to the user.

But the ability to detect in the egg hatches before or after the slated was not ascertained because the system has not been putting into for 21 days.

5.2 Limitation

During the course of this project, some limitations were encounter. These include the poor signal service hindering the use of the GSM module, ability to detect in the egg hatches before or after the slated was not ascertained because the system has not been putting into for 21 days, and the battery capacity was low.

5.3 Recommendation

The recommendation for anyone willing in back on this project is to improve on the following: on the means of relaying the information the incubator to the farmer, the incubator system should be put under test for 21 days, and increase the battery capacity.

6.0 REFERENCES

[1] P. Kyemereh, "Design and Construction of an Arduino Microcontroller-based EGG Incubator," *Int. J. Comput. Appl.*, vol. 1, no. 8, 2017.

[2] A. J. . O. and A. M. A. Bamikefa I. A, Ogunwuyi O. J, "Design and construction of a smart egg incubator system with GSM base remote access," *Indian J. Sci. Technol.*, vol. 8, no. 6, 2017.

[3] S. Anderson, "chapter3:arduinoschematic," in *Aduino Uno Simple*, 2016, pp. 169–176.

[4] B. M. A. Abu-Musa, "Smart Egg Incubator Device of Different Types of Eggs," 2008.

[5] B. . Agboola, A, Olaniyi, O.M, Aliyu, S.O, Ayanwale, "Livestock productivity in Nigeria: development of cost-effective mosels for bridge egg incubator," *Int. J. Eng. Technol. Adv. Eng.*, vol. 3, no. 3, 2013.

[6] K. Nithin, T Abraham, Shaema, Lizbeth, Mathew, C.A Pradeep, "Design and Implementation of Solar PV Poultry Incubator," *Int. J. Eng. Adv. Technol.*, vol. 3, no. 3, 2014.

[7] K. R. Radhakrishnan, "Design and implementation of a fully automated egg incubator," *Int. J. Adv. Res. Electron. Instrum. Eng.*, vol. 3, no. 2, 2014.

[8] N. Okpagu, "Development and Temperature control of smart egg incubator system for various type of eggs," *Eur. J. Eng. Technol.*, vol. 4, no. 2, 2016.

[9] B. H. (ABU Z. Yakasai, "Design and construction of an automated egg incubator with GSM interface," *Int. J. Res. Dev. Technol.*, vol. 2, no. 1, 2019.

[10] C. Woodford, "How do relay works?," *http//www.explainthatstuff.com/howrelayswork.html*, 2018. .