DESIGN AND FABRICATION OF AN AUTOMATED EGG INCUBATOR

A thesis report submitted to the department of mechanical engineering for the partial fulfillment of the degree of Bachelor of Science in Mechanical Engineering

A Thesis by

Md Mahfuzul Haqe
BME1903019464

Nahid Hasan
BME 1903019480

Md Shahinur Islam
BME 1903019477

Md Abu Hannan
BME1903019489

Md Razibul Islam
BME 1903019479

.....

Supervisor:

Md. Minhaz Uddin

Lecturer of Mechanical Engineering

DEPARTMENT OF MECHANICAL ENGINEERING SONARGAON UNIVERSITY (SU)

DECLARATION

We, hereby, declare that the work presented in this project is the outcome of the investigation and research work performed by us under the supervision of Md. Minhaz Uddin, Lecturer, Department of Mechanical Engineering, Sonargaon University (SU). We also declare that no part of this project and thesis has been or is being submitted elsewhere for the award of any degree.

- Md Mahfuzul Haqe
  BME1903019464
- Md Shahinur Islam
  BME 1903019477
- Md Razibul Islam
  BME 1903019479
- Nahid Hasan
  BME 1903019480
- Md Abu Hannan
  BME1903019489

CERTIFICATION

This is to certify that this project titled "**DESIGN AND FABRICATION OF AN AUTOMATIC EGG INCUBATOR**" carried out by, Md Mahfuzul Haqe (BME1903019464),Md Shahinur Islam (BME1903019477),Md Razibul Islam (BME1903019479),Nahid Hasan (BME1903019480),Md Abu Hannan (BME1903019489) , meets the regulations governing the award of degree of Bachelors of Science (B.Sc) in Mechanical Engineering, Sonargaon University (SU), and it is approved for its contribution to scientific knowledge and literary presentation.

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Md. Minhaz Uddin
Lecturer of Mechanical Engineering Sonargaon University (SU)

ACKNOWLADGMENT

First of all, we are grateful to Allah, the almighty for giving us the courage and enthusiasm to complete the thesis work. The authors express their gratitude to “Md. Minhaz Uddin” for his constant & meticulous supervision, valuable suggestion and encouragement to carry out this work. For all this, the authors acknowledge their sincere gratitude to him. We are also grateful to all our thesis & project working team of SU for their help in construction of the project work and give their valuable knowledge and time for completing the experiment. Finally, we would like to thank everybody who supported us in any respect for the completion of the thesis.

Authors

Md Razibul islam

Md Shahinur Islam

Md Abu Hannan

Nahid Hasan

Md Mafuzul Haque

ABSTRACK

*One of the major aims of any government in any economy is to ensure food security for its citizens. In that regard, improvements in method of production of agricultural produce is highly encouraged. This project **AUTOMATIC EGG INCUBATOR** focuses on improving the production of poultry birds by setting the required environmental condition for the development of the embryo and possible hatching of the eggs. These conditions include; temperature, humidity, ventilation and turning of the eggs.*

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CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Incubation is a process by which birds sit on egg to keep the egg warm to develop the life within it [1]. Here, it is seen that the most important factor is the constant temperature required for the embryo development for a specific period. In most birds, the heat from the body of the bird provides the constant temperature required, also since most birds lay egg on the surface of the earth, the geothermal heat from the earth crust which can be from decay of leaf also keep the egg warm. Another factor which is of outmost importance is humidity, since the bird usually lay egg in open spaces the humidity is critical to the development of the embryo. If the air is too dry, the egg losses water to the atmosphere and this causes the embryo not to develop fully which in most cases leads to high mortality. As the incubation period increases, an egg will become lighter and the air spaces within the egg becomes larger due to evaporation from the egg so it is important to keep the humidity at a normal level which will make the embryo to develop as required. With all this conditions required for effective development of the embryo it becomes imperative to develop a system to replace the incubation period in birds. From extensive research done it was found that most incubators are analogue this means that the incubator is being monitored every time to check for the temperature and humidity. Early hatching is caused by high incubation temperature while that of late hatching is caused by low incubation temperature. Also blood rings in the egg is caused by inaccurate incubation temperature as a result of analogue temperature control. And lastly dead embryo at the early stages are caused by improper turning and ventilation [2]. With an automated digital models of egg incubator, the egg farmer can get a user friendly, high end incubator with the same price

as above, maybe even lower depending on the capacity and quantity of eggs such incubator can during a particular incubation period.

1.2 Aims and Objectives of Study

The aim of this project is to design and implement an automated electrical based incubator.

The objectives of this project are:

1. To design an automated electrical-based smart incubator.
2. To implement to designed automated electrical-based smart incubator.
3. To evaluate the performance of the implemented electrical-based smart incubator.

1.3 Statement of Problem

Egg hatching has been a major problem in the field of agriculture this is because it is difficult for the hen to hatch all it eggs, also as soon as the breeding process start the laying process stops which is not so desirable to the farmers as the number of eggs to be hatched is effectively reduced. The use of manually operated homemade incubator is not efficient and effective to overcome this problem reason being that it is responsible for hatching most be satisfied, the farmer has to turn the eggs manually at least three to four times a day using his hands, the system must be kept in a place close to room temperature at all time. This factors are very difficult to maintain, this makes the process cumbersome and capable of lowering the morale and interest of the farmer in the business. hence, production is slow and in worst case scenario results to the closure of the business.

1.4 Motivation of Study

In Nigeria, the rate of consumption of poultry and poultry product is very high and it is estimated that each household consume an average of ten eggs per week. With the level of technology in Nigeria this estimate is almost impossible to meet, and this lead to shortage of supply and lead to increase in product price. The use of manuallyor semi-Automatic operated homemade incubator is not efficient and effective to overcome this problem, since most of the incubator used in Nigeria are manually operated which enable the farmer to put the eggs in a room with adequate amount of natural sunlight and air allowed to enter into the room which most times leads to high mortality. Also in few cases semi-Automated incubator bulb and fan that is usually ON at all time and the turning mechanism is achieved by using hand to turn the egg occasionally. It associate problems with this development that lead to problem occasionally. It can achieve the automation of factors responsible for hatching of the egg with high hatching rate which can serve as a means of techno-entrepreneurship self-employment.

1.5 Significance of Study

From extensive research we have carried out towards the achievement of this project, it become more evident that the factors responsible for an effective and efficient incubation should carefully be monitored regularly. Any design of an incubation system should satisfy this condition. The study is necessary so as to provide a system which is focused on meeting the need of our immediate society by producing a cheap and constant source of food (protein in this case). The study also show how we can advance the technological aspect of incubation by developing a model that can hatch any kind of egg within a predefine temperature and humidity

provided that the underlying hardware part is correctly designed. With the only modification being tweaking the software to control the hardware to operate within a specified condition.

1.6 Scope and Limitation of Study

This system is design to operate within a predefined temperature and humidity in an enclosed system, with this reading the system adjust it workings by means of increasing or decreasing fan speed, turn ON and OFF of bulb, starting the water heater to generate water vapour and controlling how much water vapour is needed in the surrounding, means of detecting the water level and turning of the egg tray either clockwise or anticlockwise.

This system is however limited to only hatching of eggs, it does not provide any means of survival of the chick after the egg has hatched. Also, as soon as the incubation period start there is no way to determine whether the egg will have hatched or not(Candling). We can only hope that maintaining the incubation condition will lead to high hatching rate.

1.7 Organization of Study

The organization of this project covers all the activities carried out during the research work. Chapter one covers a brief introduction to the process of incubation and major factors necessary for incubation. Chapter two describes the evolution of incubation, from prehistoric era to modern era. It also gives an insight into past work that has been done on the project. Chapter three covers the methodology of the project and the various component unit used in the project. Chapter four shows the result and chapter five gives necessary recommendation and conclusion.

CHAPTER TWO
LITERATURE REVIEW

2.1 Historical Background

Starting with the earliest form of incubator ever built, from historical record it can be seen that the Egyptians are credited for carrying out extensive research on how to hatch egg artificially. That is, fertilizing the egg and keeping the egg in spaces that will make the egg to hatch. The Egyptian model of incubation consist of keeping hundreds of eggs in a small room which are built from clay, this small rooms are constructed severally and they are referred to as ovens which are placed strategically on each side of a central passageway [14],[15]. In every one of this rooms, the heat source required to keep the egg at the right incubating condition was provided by burning charcoal and animal manure. Airways was also provided in the form of chimney, which serve two purpose. The first being a means of cross ventilation by providing a way for excess carbon dioxide to escape and secondly to bring in oxygen which are vital for the development of embryo within the egg shell. By doing this they have taken care of two important consideration required for incubation “temperature” and “Ventilation”. With humidity being controlled by occasionally placing wet leaves on the egg and replacing them anytime they dried up.

In this ancient form of incubation system, it is interesting to note that the factors affecting incubation which are temperature, humidity and ventilation were actually monitored and controlled without using any sensory devices such as thermometer [18]. It was achieved by allowing the egg farmers live inside the hatchery for the entire incubation period. By doing this, overtime the farmers learn to determine the temperature and humidity of the surrounding

which will make them apply the necessary condition which will make the egg survive during this incubation period.

From extensive research carried out by Aristotle he also describes a method similar to that of the Egyptians with only major difference being that the heat required to keep the egg warm was generated by putting the egg in decomposing manure rather than burning charcoal or animal dung as in the Egyptians model. Egg incubation was also practiced in China and this type of incubating eggs will later spread throughout South East Asia. Like the Egyptian type of incubator, a heavily insulated mud brick building was used, and the inside consist of series of mudbrick ovens which were being heated by charcoal fire. Like the Egyptians they also measure the temperature of the eggs using their eyelid. As soon as the embryo start developing they start to increase the amount of heat supplied to them.

2.1.1 The Development of Modern Incubators

By early 16th century, because of the successes recorded by the Egyptians and Chinese in successfully hatching egg artificially, the Europeans also developed a keen interesting in this method which was due to the commercial viability of this method, they thereby request the Egyptian egg farmer to develop a similar model for them. The outcome of which was a massive mortality and low hatch rate recorded in the same incubator built. It was later seen that the environmental condition of developing an incubator in Europe was more adverse as compared to the of Egypt which has adequate sunlight throughout the year. As a result of the failure of the Egyptians to develop a suitable model for the Europeans now lead to the development a more sophisticated model of incubator which can provide the required temperature, humidity and ventilation necessary for an effective incubator system.

From 20th Century onwards, a rapid increase in the establishment of poultry farming was noticed. This was due to incorporating electronic devices in the incubator which are used to give a more accurate monitoring and control of the incubator system. As a result of this unprecedented rise in incubator system this leads to commercial productivity of egg which serve as a means of employment and wealth.

2.2 Recently Related Works

In an experiment carried out by [1] to determine the choice of incubator to use for incubating eggs, he designed the two major types of incubator which are Forced-air incubators that had a built in fan to circulate the air and a Still-air incubator with no fans, so that air is allowed to stratify. He laid emphasis on "fertility" and "hatchability" as the judging criteria to determine the best fit for your particular egg you want to hatch. In his research, based on the incubation parameter (temperature, humidity, turning and ventilation) he concluded that the Forced-air type is more satisfactory.

[4] also carried out research to ascertain the most appropriate temperature for hatching, he placed equal number of eggs in four different incubators with the temperatures set at 36.1, 37.2, 38.3 and 39.4°C from 18th day of incubation until hatch. Hatching time, hatchability rate and the incidence of embryo malposition were recorded as percentage of fertile eggs. The highest mean embryonic heat production or eggshell surface temperature occurred in the hatching cabinets operated at 39.9°C and lowest at 36.1°C. Eggs incubated at 37.2 and 38.3°C had a significantly higher hatchability than the other treatment groups.

[5] also carried out a research *to* determine the effect of frequency of egg turning on hatchability. Eggs that were turned thrice daily produced greatest hatchability of 72.90%. Embryonic mortality occurred in all the treatments, but the mortality of embryo was highest

(70.85%) for eggs turned twice daily, while late embryonic mortality was highest (66.65%) for eggs that were not turned at all, but hatching occurred in the three zones of the egg.

In this research work, a cost-effective embedded model of a bird egg incubator was developed that contains a smart sensor for monitoring temperature and humidity. It was incorporated with mechanical egg tilting mechanism for tilting the eggs at an angle of 45^0 alternatively on hourly basis. The advantage of this incubator system is that it is cheap and consumes less energy (200 W).

[6] did a research project on performance evaluation of the egg incubator and hatchery system with a view to develop a better incubator system that has the capability of hatching large number of chicks at a time and also attaining high hatchability. The incubator system that was developed was tested and the temperature and humidity reading was recorded on interval of one hour. The reading was plotted graphically and from it they deduced that the incubator will perform its required function of hatching the eggs effectively, this is because the humidity and temperature range were within the required range of 37-38^{o}C and 32-35%.

[7] carried out a research project on the effect of incubator type on the hatchability and chick survival using two incubator types which are electric cabinet and kerosene incubator. Both incubators were maintained at a temperature of 40^{o}C and 25% relative humidity with an incubation period of 50 days. it was found that mortality recorded in hatching with electric cabinet was 30% while that for kerosene incubator was 10%. This suggest that there was low hatchability in electric incubator to kerosene incubator. He concluded that the success of any incubator depends on good hatchery management, With the use of artificial incubation reveals that kerosene incubator was better than electric incubator which could be due to differences in

the turning rate since the kerosene incubator was turned six times a day while the electric cabinet has been programmed to turn 4 times a day.

[8] carried out a research project on cost effective incubators for birds hatching in Nigeria. In the research four models of incubators were developed, which are still air oil lamp incubator, semi-electric forced air incubator, semi-automatic, electrical incubator and embedded computer based incubator. From the research result from the different models testing show that with an embedded computer-based model of incubator present at temperature of 37oC and humidity of 60-75% and proper egg turning rate and increased hatchability is achieved. Also the embedded based incubator has proven far better in terms of hatchability, less human monitoring and hassles involved in manual egg turning. Although the initial cost is very high, it has negligible maintenance cost and better return on investment.

2.3 Theoretical Background

There are four factors that are of major importance in artificial incubation: temperature, humidity, ventilation and turning. Of these factors, temperature is the most critical. Extensive research has shown that the best condition which is most effective and efficient in egg hatching is when optimum incubator temperature is 37°C when relative humidity is 60 percent. Oxygen concentration is kept above 20 percent, the concentration of carbon dioxide should be less 0.5 percent, and air movement across the egg should be 12 cubic feet per minute.

2.3.1 Incubation Parameters

1. Amount of Time required

There are three major factors that determine the total incubation time:

I. Temperature: the lower the incubation temperature, the longer the incubation time and result in larger chicks. A temperature too high leads to early hatching and smaller chicks.

II. Age of egg: After 5 days of storage, each additional day increases the incubation time by one hour.

III. Weight of egg: Above 50 grams, each 2.5 gram increases the incubation time by half an hour.

There are two different thermal phases during incubation are:

I. The first phase (up to 8 days of incubation), when the embryo requires high temperature in order to develop, is called the endothermic phase. During this first phase, low heating, too slow temperature rises or interruption of the "warm chain" can result death of embryo.

II. The second phase (after 8 days of incubation) is when the embryo losses heat to the surrounding; hence, this is the exothermic phase. Besides, some breeds with high growth potential release more heat than others and it should be taken into account during incubation.

Usually, the incubation temperature is set for each hatchery. Depending on the time desired for hatching, the incubation time could be set according to the age and size of the eggs.

2. Incubator Relative Humidity

Humidity is defined as the amount of water vapour in air. Humidity is very important in the overall success of the incubation. The amount of water vapour present in the enclosed surrounding of the incubator system should not be so high, as this can lead to piping. Piping is a period that an animal begins to break from its shell, as the amount of water vapour present increases, piping increases. The consequence of this is that the amount of water that is being absorb is very low and this result in weaker and larger chicks. So also, if the amount of water vapour is low, this result in dehydration as from the laws of thermodynamics their tends to be a balance of vapour in the surrounding and this can only be achieved when the egg begins to

loss water to the surrounding [16]. The consequence of this is that the embryo sticks to the egg shell as they tend to find a means of survival thereby leading to death of the underdeveloped embryo. And in best case scenario, the ones that survived are very small.

3.Provision of Adequate Airways in the incubator system

Ventilation is the process of replacing stale air with fresh air. Ventilation is very important as it provide a means by which oxygen in brought into the system and carbon dioxide is removed from the system. Ventilation is achieved by making holes at the top of the incubator to allow air from the outside surrounding to enter into the system. the main aim of allowing cross ventilation is to provide a means by which the embryo can survive the incubation period. At the early stage of the incubation period, the egg is seen as an acidic environment as more and more oxygen flows into the environment and carbon dioxide is removed from the system the PH of the egg increase.

4.Placement of Egg in the tray and Tray movement

The turning of the egg is crucial to the development of the embryo within the egg, this is because as the embryo developed they tend to stick to the egg shell and this can be prevented by periodic rotation of the egg tray. Another important reason why tray movement is crucial is due to the fact that the water vapour and heat generated within the incubator system should be equally distributed to the egg [17]. The tray movement is achieved by placing a wiper motor which has a large torque and low speed on the tray and this mechanism is placed strategically in the incubator system with a preprogrammed microcontroller which is responsible for clockwise and Anticlockwise rotation. Each egg is placed in a cell which is designed not to allow for complete rotation as this will prevent a particular side of the egg getting adequate heat than the other.

5.When Power Outage Occurs

The incubator system is design to maintain the operating condition which are required for an efficient and effective incubation. This is achieved by constructing an insulation unit made up of a double layer plywood with hollow space between each layer. The first is filled with sawdust while the second is a vacuum. The purpose of this model is to enable continuous development of embryo within the egg and to keep the environment as warm as possible in case of power outage. This model can keep the system at normal condition for a maximum of 18 hours.

2.4 Component Used in The Design

2.4.1 Relay

Relays are switches that can be operated mechanically or electrically, Relays consist of an electromagnet and series of contacts. The switching mechanism is carried out with the aid of a permanent magnet. There are also other operating principles for its working, but they are grouped according to their application. The main operation of a relay comes in places where only one low signal can be used to control a circuit. It is also used in places where only one signal cam be used to control a lot of circuit. Circuits that operate at high voltages or at high currents cannot be controlled directly by an Arduino. Instead, you use a low-voltage control signal from the Arduino to control a relay, which is capable of handling and switching high-voltage or high-power circuits. A relay typically has five pins:

1. Coil input pin1: This is usually connected to the positive terminal of your primary source.
2. Coil input pin2: This is usually connected to the negative terminal of your primary source.

3. Normally Open pin(NO): This pin is usually not connected to the common pin, it is used when the relay is activated.
4. Normally closed pin(NC): This pin is usually connected to common pin and is disconnected when relay is activated.
5. Common: generally, this pin is usually connected to the ground of the source we use to drive our circuit.

2.4.2 Ferrite Magnet Motor

An electric motor is a device that uses the magnetic field of a permanent magnet to convert electrical energy into mechanical energy. The main aim of permanent magnet is to produce magnetic flux in the working space of a device. A ferrite motor is one that has magnets made of ferrous material making them mechanically strong, low cost, temperature stable. The ferrite magnet used in this project has the following characteristic:

I. Linkage type
II. 12V/24V
III. 60 RPM on high speed and 40RPM on low speed
IV. single speed/two speed with thermal cut out

How to determine weight the wiper motor can carry?

To ascertain the weight, the motor can carry, the major determining quantity is the Stall Torque, which is the maximum torque the motor is able to exert. To convert stall torque to weight we take the motor rating which is the stall torque in kilogram-centimeter and divide with the radius of the wheel in centimeter. This result will be the kilogram representing the maximum weight the motor can hold against gravity.

2.4.3 Egg Tray

The egg tray was designed by using a plywood which is made to consist of 9 cells, which each cell having a dimension of 8cm by 8cm by 7cm of length, breadth and height respectively. The inner cell was lagged with a foam in such a way that when the tray moves the egg role and it is being protected by the foam for breaking. The thickness of the foam is the same as that of the tray which is 0.5cm and the bottom of the tray was perforated with small holes to allow for proper passing of air into the egg cell.

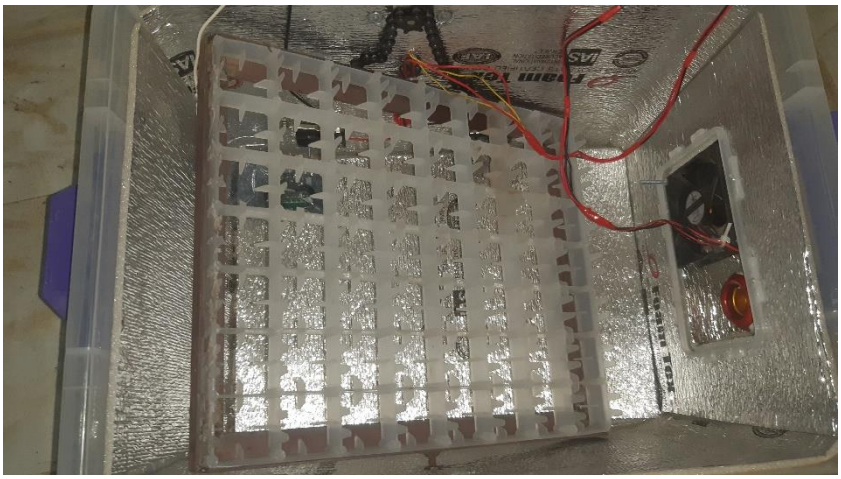

Plate 2.3 Egg Tray

2.4.4 Water Heater

The water heater which is made of steel which is glass-lined on the inside to help prevent corrosion which is used as the heating element which provide the humidity required for the incubating condition. The typical electric heater unit is wired to a 220-volt circuit.

2.4.5 Liquid Crystal Display(LCD)

Liquid crystal display is an electronic display module that is used to output information. The LCD is used in this project is a 16x2 display which means that it can display 16 characters per line divide into 2 row. The LCD has two register namely command and data. LCD is a technology that require less power because their operation is based on the principle of blocking light instead of emitting it. They consist of array of tiny segment called pixels which arrangement can be manipulated to output information.

2.4.6 Arduino Mega 2560

The Arduino Mega is a more complex microcontroller as compared to the Arduino Uno. This is because it allows for computation and design of more complex system such as the incubator built. The Mega consists of more digital pins which helps to improve the capability of the board.

Table 2.1 Overview of technical specification of Arduino Mega

Features	Value
Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V Digital
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16MHz

2.4.7 Ultrasonic Sensor

Ultrasonic sensor is a type of sensor that measure distance from itself to an object by using ultrasonic wave. The sensor emits ultrasonic wave and this wave hit object in it part then bounce back and the sensor receives this reflected wave from the target. Ultrasonic sensor measures the distance to an object by measuring the time between emission and reception. The distance can be calculated by using the formula:

Table 2.2 HC-SR04 Sensor Features

Features	Value
Operating voltage	+5V
Theoretical Measuring Distance	2cm to 450cm
Practical Measuring Distance	2cm to 80cm
Accuracy	3mm
Measuring angle covered	<15°
Operating Current	<15mA
Operating Frequency	40Hz

2.4.8 Temperature and Humidity sensor (DHT 11)

Digital humidity and temperature sensor which is generally known as DHT is a sensor which uses thermistor and capacitive humidity sensor to measure the surrounding air. The

temperature is measure by using a negative temperature coefficient thermistor, since it is an NTC component its resistance is inversely proportional to the temperature. That is, as resistance increases, temperature decreases and vice versa [10]. The humidity is measured by using a moisture dependent resistor whose conductance and resistance changes with changing humidity.

Table 2.3 Overview of DHT11 sensor

Features	Value
Accuracy	±2%
Humidity Range	0 ~ 100% RH
Mounting Type	Through Hole
Operating Temperature	-40°C ~ 80°C
Output	8bits
Output Type	Digital
Response Time	2s
Sensor Type	Humidity, Temperature
Voltage – Supply	3.3 V ~ 6 V

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 Introduction

This chapter contains the design of the circuit as well as the component used along with calculations of required value of various components used during the project. This chapter aims to carefully lay out the design specification and requirement which influence the choices made and show why those choices were made.

3.2 Methodology

The first thing that was done is to acquire all the materials discussed in chapter 2 needed to carry out this project. Those not available in the local market were ordered and the delivery was made. The design of the automated electrical egg incubator is achieved by using divide and conquer. That is, breaking the system into discrete component, building each component to specification and at the end of the day joining the discrete component to form a system.

At the starting point, a predefined humidity and temperature settings is incorporated In the system based on the egg types available. Base on this initial condition the sensory unit of the system is activated, the sensory unit consist of digital temperature and humidity sensor, relay and ultrasonic sensor. Firstly, digital temperature and humidity sensor measure the temperature and humidity of the surrounding, the measured value is compared against a threshold value. If the threshold value is not exceeded time is incremented, then the device takes another reading. if threshold value is exceeded, them the microcontroller sends signal to peripheral device which turn ON and OFF some device such as heater, electric fan (both AC and DC), bulb and relay. Secondly, a relay mechanism which consist of two relays responsible for rotation of the

egg tray either clockwise or anticlockwise. This mechanism is designed to tilt the egg by 15^{o} from the balance position. Lastly, the heater is activated for a short while to boil the water with the main aim of generating water vapor which is then carried upward or across the entire system.

3.3 Design of Project:

The various unit used in the construction of this project is listed below:

1. Power supply unit

2. Relay unit (Automated rotation)

3. Lightening and ventilation unit

4. Sensory unit (both DHT and ultrasonic)

5. Insulation unit

6. Display unit

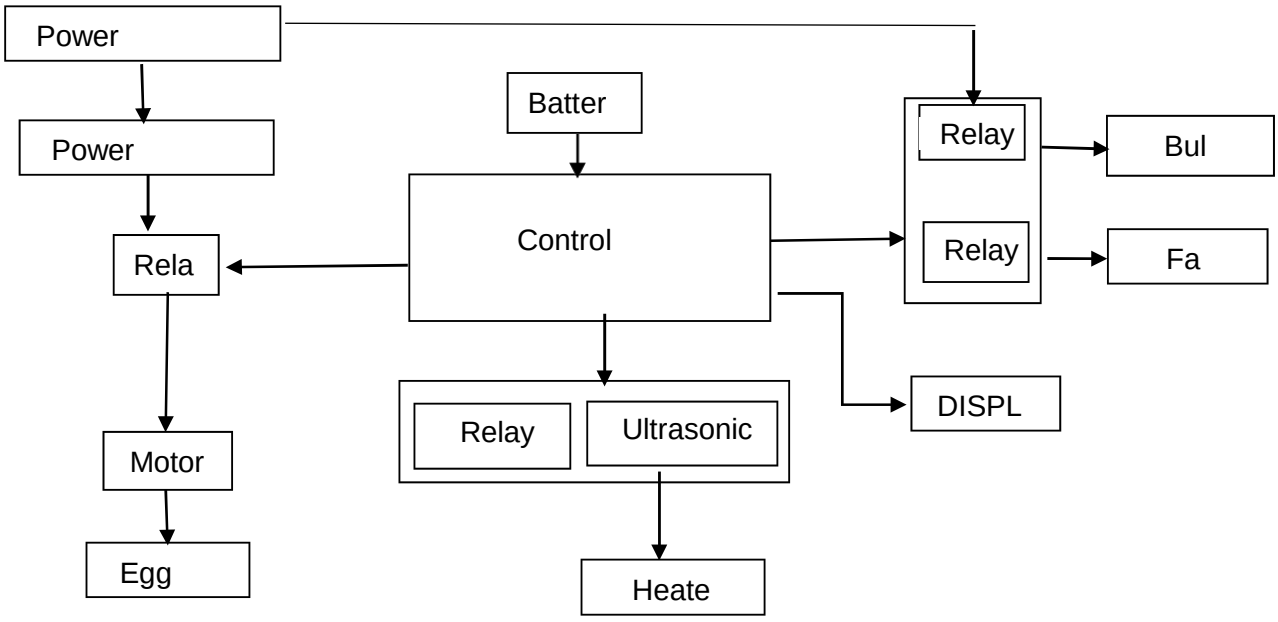

Figure 3.1 Block Diagram of the System

3.3.1 Power Supply Unit

A rectifier is a combination of various electrical component that are connected in a way to convert an alternating current into direct current. This circuit consist of transformer that step down the 220V on the primary side of transformer from the mains supply to 12V on the secondary side, the output is then feed into a rectifier which convert the 12V AC into 12V DC. This is then passed into a capacitor configuration to improve the ripple factor by effectively reducing the ratio of the r.m.s value of A.C component to the D.C component in the rectifier which is then passed into a voltage regulator (7812) and the output is used to drive the motor.

The following calculations were done based on the power supply from the mains.

Supplied Voltage (Vs) = 220V, Frequency (F) = 50Hz, Voltage rating of transformer =220/12V, Transformer Current rating (I) = 1500mA.

Transformer Secondary voltage (V_{Ts}) is given by the equation;

$$V_{Ts} = V_{out}\sqrt{2} \quad (3.1)$$

$$V_{Ts} = 12\sqrt{2}$$

$$V_{Ts} = 16.97V$$

$R = Calculated\ Resistance\ given\ by\ Ohms\ law\ equation\ given\ below$

$$V = IR \quad (3.2)$$

$$Resistance = {}^{V_{Ts}}/_{I} \quad (3.3)$$

$$\frac{16.97}{1.5} = 11.31\Omega$$

The maximum and minimum output of the regulator was measured as follows:

$V_{max} = 5.1V_s$

$V_{min} = 4.7V$

V_r = *Regulated output voltage range*

The ripple Voltage is given by the equation:

$$V_{ac(rms)} = V_r \times 2\sqrt{3} \quad (3.4)$$

$V_{ac(rms)} = 0.4 \times 2\sqrt{3} = 1.3856V$

The ripple factor is given by the following equations:

$$Y_r = \frac{V_{ac(rms)}}{V_{dc}} \quad (3.5)$$

Where Y_r is the ripple factor

$$Y_r = \frac{1.385}{12}$$

$Y_r = 0.1155$

$$C = \frac{1}{4\sqrt{3}RfY_r} \quad (3.6)$$

Where C is the capacitance

$$C = \frac{1}{4\sqrt{3}\times 50\times 11.31\times 0.1155}$$

$C = 452.917\mu F$

$C \approx 453\mu F$

3.3.2 Relay Unit (Automated Rotation Mechanism)

Relays are simple switches which are operated both electrically and mechanically, Relays consist of an electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. The type of relay used for this application is an electromechanical relay module, the rotation mechanism is achieved by connecting the rectified voltage output (12V) to a pair of relay with this connection serving the purpose of reversing polarity which will make the motor to rotate both clockwise and anticlockwise.

3.3.3 Lightening and Ventilation Unit

The lightening and ventilation unit consist of components such as electric bulb, lamp holder, wire cable and electric fan (both AC and DC). The lightening unit contains 2 electric bulb(60watts) which is being held firm by a lamp holder to the wall of the incubator. The bulb are placed adjacent to each other, the bulb is connected to a relay before contact to the power with the aim of cutting the power to the relay at a specified interval. The bulb serves the main purpose of controlling the temperature of the system. Since there are 2 bulbs we can achieve 2^N operation which can be, using the two at the same time, or making one active and making the other inactive and vice versa depending on the area of the system we want to heat up and lastly, making the two inactive [21].

The ventilation unit consist of AC/DC fan and holes which are drilled by hand drill to provide for inlet of oxygen which is necessary for hatching and outlet of carbon di oxide which in high rate lead to high mortality. The high speed (48V) AC fan is placed at the bottom of the incubator system to carry water vapour upward throughout the entire system. Another

important component which we have to look at is the water container which serve the purpose of generating water vapour which is an important parameter for a successful incubation period. The water inside the container is heat up for a specified interval, here it should be noted very importantly that the water is not allowed to boil, the heater only serve the purpose of providing enough heat energy required for evapouration of water.

3.3.4 Sensory Unit (DHT and Ultrasonic Sensor)

The sensor unit is the heart of the system, since the rate of success of the incubator depends on incubating parameters which must be monitored at regular interval. The sensory unit consist of a digital temperature and humidity sensor, in this case a DHT11 sensor and an ultrasonic sensor.

3.3.4.1 How DHT sensor detect temperature and humidity

The digital temperature and humidity sensor serve two purposes, firstly to measure the temperature of the surrounding. It does this with the help of a thermistor which has a negative temperature coefficient of resistance. That is, as the temperature of the surrounding increases, the resistance of the thermistor decreases and based on this value the relay which control other devices is activated. Secondly, DHT11 serve the purpose of measuring the humidity of the environment, in this case the effective amount of water vapour circulating in the system. It achieved this by using a capacitive dependent resistor whose conductance and resistance increase or decreases according to the amount of moisture content present on the substrate.

The second sensory unit is the ultrasonic sensor which is a device that emit ultrasonic wave and on hitting a obstancle the emitted wave is bounced back and necessary measurement is taking.

3.3.4.2 How Ultrasonic sensor detect the water level

This device makes accurate measurement of distance travel by calculating the time it takes for the wave to travel to and fro.

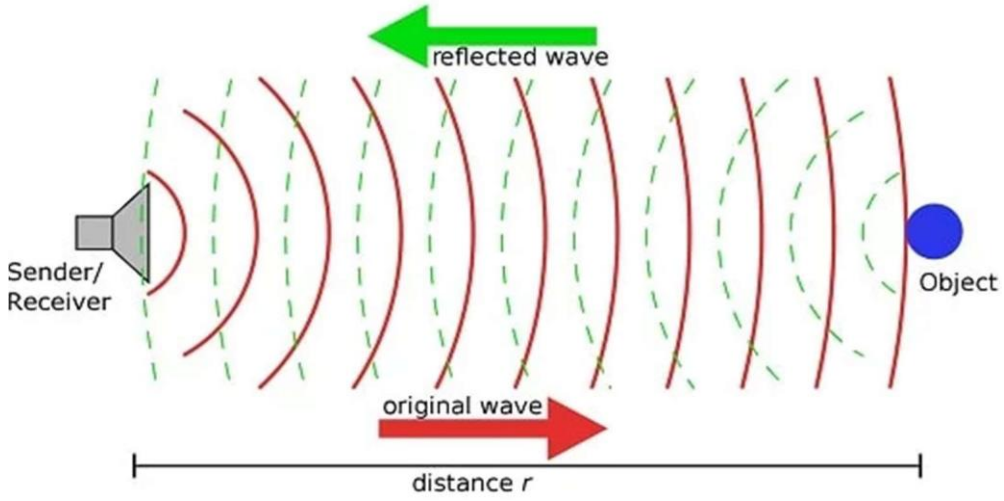

Figure 3.1 How Ultrasonic sensor detect the water level

The Ultrasonic sensor sends out a high frequency sonic wave then compute how long it takes for the echo of the sound to reflect back. The distance can be computed using the equation:

Distance (L) =1/2 x T x C

Where L is the distance, T is the time between emission and reception and C is the ultrasonic speed. ½ is the time to go and return to it source [20].

To measure the water level, the ultrasonic sensor sends out a wave and detect the height of the water. For instance, we test with a full water level and set this height as our initial condition. Any great deviation from this condition gives rise to the microcontroller sending an output via the display that the water level is low.

3.3.5 Insulation unit

The insulation unit is made up of double layer of chassis, the chassis is made of plywood with an hollow space between each layer. The function of the insulation layer is to keep the inner system at a desired temperature. The inner layer which houses the incubator is well sealed and any opening due to construction defect is properly sealed with gum. The first layer is made of plywood with the space in between containing air, since air is a bad conductor of heat because it molecule are not in continuous contact, heat is not rapidly loss to the surrounding and this effectively helps to maintain the temperature at a constant level. The second layer is made up of plywood with the space between them filled with sawdust which is also a bad conductor of heat because wood particle has air molecules in between them. Since wood is a poor conductor but air is a poorer conductor the aggregate of this gives a mixture that is more effective in insulating the body of our controlled system.

3.3.6 Display Unit

This is the graphical user interface of the system; it allows the user to monitor what is happening inside the system without having to open the system. The system unit is programmed to output the temperature, humidity and the period of incubation, it also provides a platform for user to interact with the settings being made to the system.

3.4 Circuit Description

The following processes were carried out in other to achieve the overall development of the project:

I. A sensing device is also incorporated using the Arduino Mega board which was preloaded with controlling program to sense the temperature and humidity of surrounding.

II. A sensing device is also incorporated using the Arduino Mega board to detect the water level in a container.

III. An actuator device was also designed to provide for tilting of egg tray both in clockwise and anticlockwise direction.

IV. Thereafter, the output from the controlling section is then display on the LCD to display the internal activities of the system to the user.

The microcontroller contains programs that are driven into the ports (input and output pin). The program operates the port according to the information it receives form the sensor (DHT and Ultrasonic) as shown in the block diagram. it then uses this information to perform some action (actuation). In this case, activate relay to turn ON and OFF of bulb, fan, heater and tilting mechanism to turn relay.

3.5 System Connection

The relay circuit consists of four relays each rated 5VDC, 250VAC and 10A, which was soldered on a Vero board. The relays are triggered using a 2N222 npn transistor actuated by a control signal from Arduino microcontroller. Two relays are used for rotation of the motor both clockwise and anticlockwise, this is achieved by connecting the motor input to the common of the relay. The main purpose of relay in this mechanism is to reverse polarity. The third relay is used for switching two incandescent lamp and DC fan, while the last relay is used for switching the AC fan. The diode rectifier circuit takes it source from the mains supply (240V AC) and step it down to 12V DC which is used to drive the motor. The sensor takes analog reading by measuring temperature, humidity and distance, then convert this into a digital equivalent which is feed into a microcontroller to perform some action.

The circuit diagram shown below illustrate the connections involved in the actualization of the circuitry.

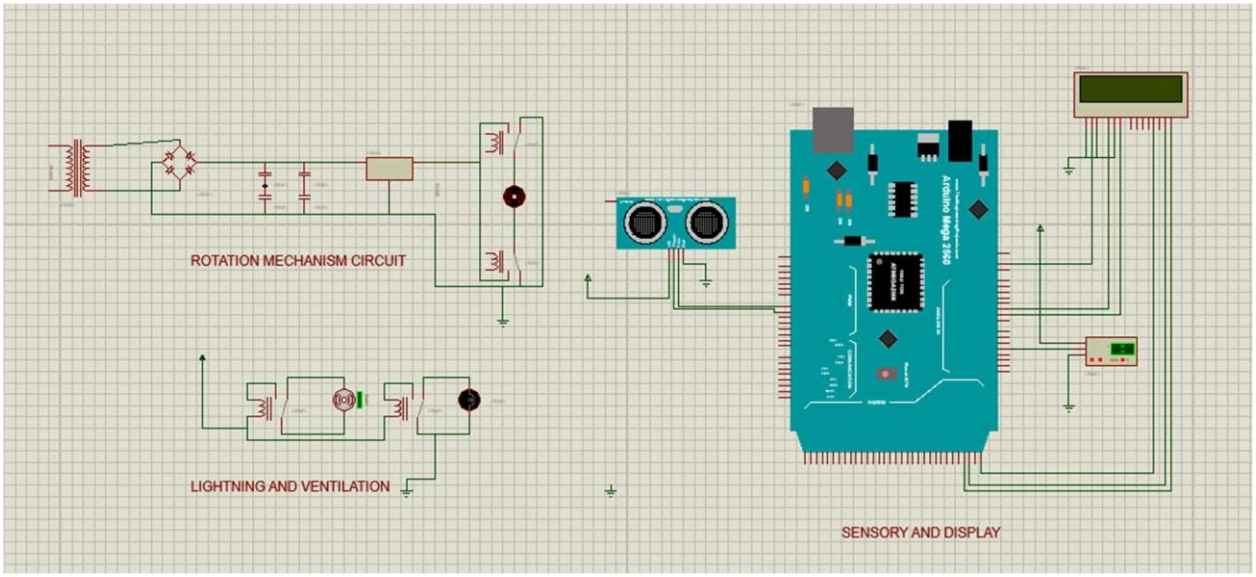

Plate 3.3 Design and Construction of Automatic egg incubator

The flow chart for the complete operation of the system is given below:

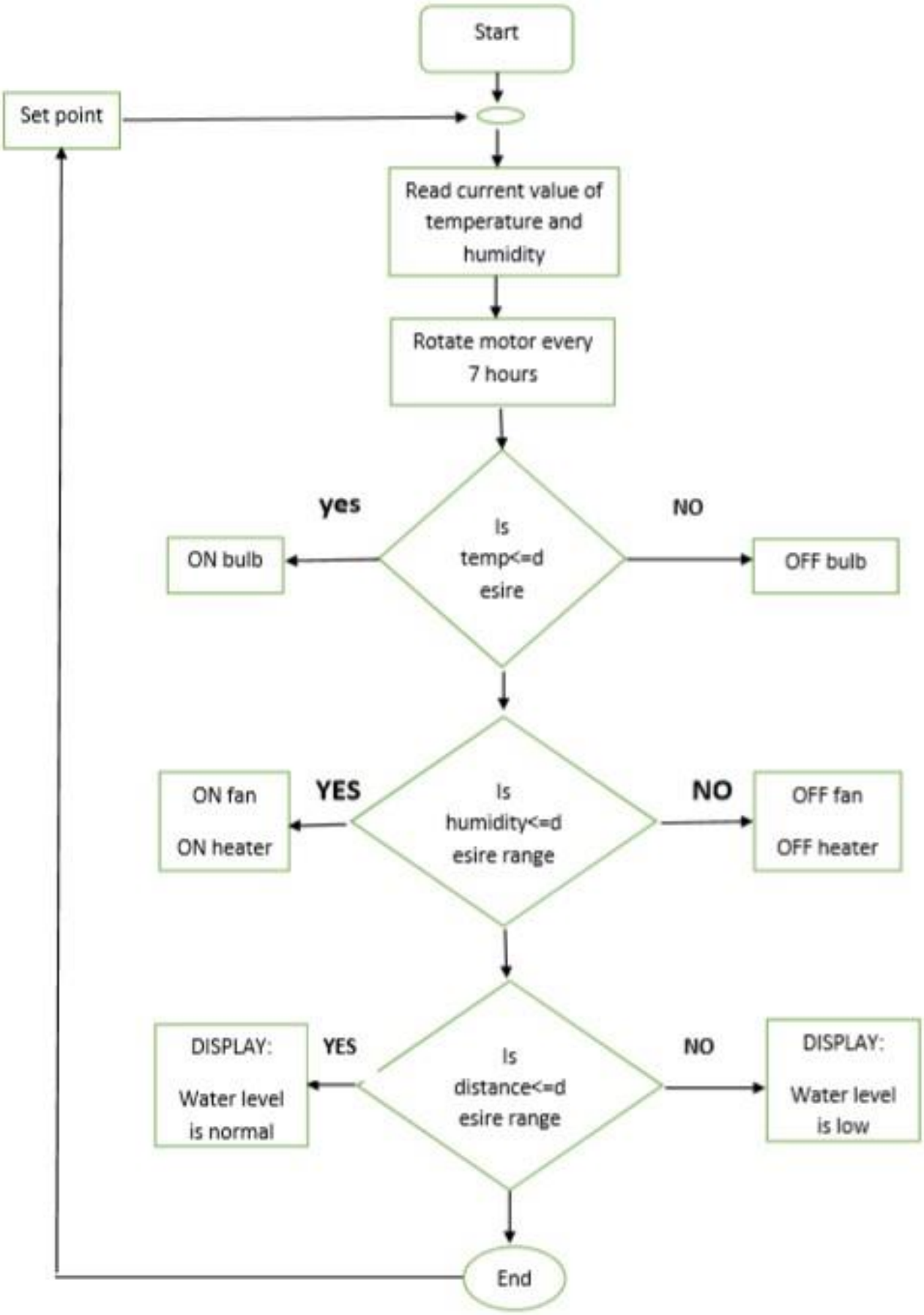

Plate 3.5 The complete incubator system

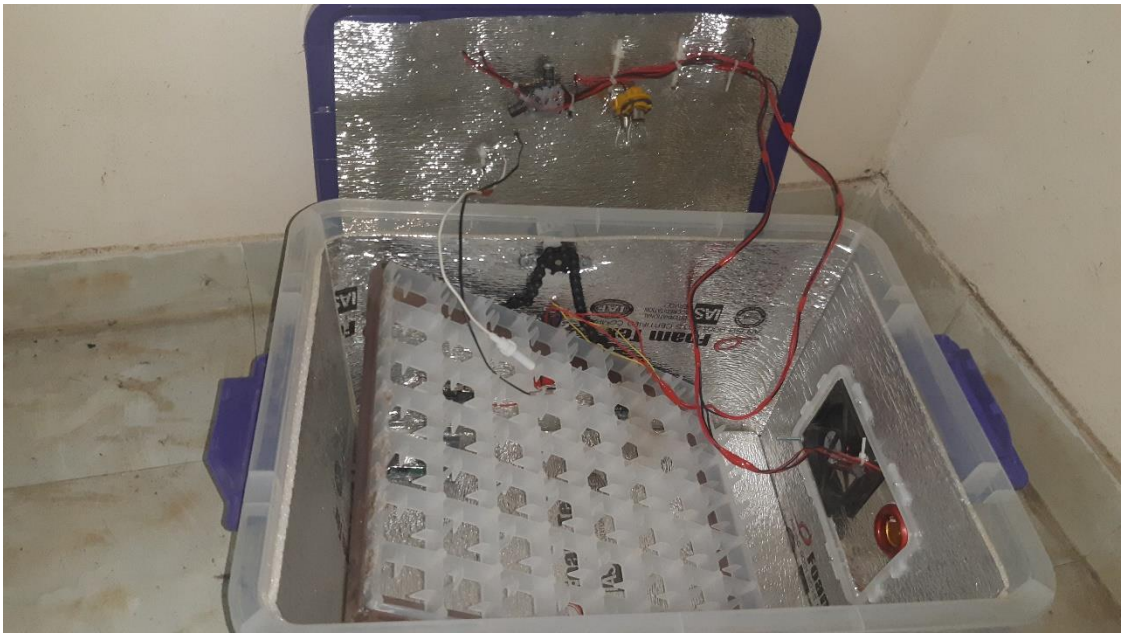

Plate 3.6 Showing circuitry of incubator system

CHAPTER FOUR
TESTING, RESULT AND DISCUSSION OF RESULT

4.1 Testing

Testing is defined as the activities carried out to determine the reliability of the system. it involves logical analysis of system component, ways of interconnectivity of this individual unit to achieve our objectives.

The tests that were carried out are laid out as follow:

4.1.1 Rotating mechanism test

This unit is used to control the direction of movement of egg tray, the functionality of the egg tray is dependent on this unit which makes it vital for reliability test to be carried out on this unit. The test is carried out as follows;

I. The output of our 12V rectifier is used as input voltage to relay configuration.
II. The normally close contact of the two relay is connected to positive rail while connecting the normally open to the negative rail.
III. One end of the motor goes to one relay while the other end goes to the second relay.
IV. On activating the microcontroller and delaying for a particular interval, the motor moves clockwise then stop for some minute the reverse its rotation.

4.1.2 Sensory unit test

This unit is the heart of the incubator system, since it tells us about the internal activities of the system and the factors which are critical to our incubation is dependent on this unit. Therefore, it is important to reliability test on this unit.

The test is carried out as follows;

I. Connect the positive and negative of the DHT sensor to 5V supply and ground, while connecting the OUT pin to digital pin of the microcontroller.
II. Activate microcontroller to get reading from surrounding and take this initial reading and record.
III. Light up a matches and place near the sensor to observe for increase in temperature, then dip a foam in water and place near the sensor to observe for any deviation in humidity reading.
IV. Place ultrasonic sensor above a bowl fill of water then take this distance reading and initialize as start condition, then put half-filled and take reading, then put most almost empty or empty and record.
V. Set condition for water below half way to alert user that water is almost empty by displaying on “LOW WATER LEVEL” on LCD.

4.1.3 Lightning and Ventilation test

This unit is responsible for controlling the temperature and humidity of the system, it does this by varying the time the bulb and fan are being kept ON**.** The test that was carried out on this unit is as follows;

I. Loop the two incandescent bulb to a relay and the two fan to the other relay.

II. If the temperature is below required temperature, the bulbs are activated and left for some time until the temperature rises to the required temperature.

III. When temperature rises to the required temperature and above a tolerance, usually plus or minus 2 of the required temperature.

IV. The same procedure was done for humidity.

4.1.4 Complete incubator system test

After all this various unit have been tested individually, the complete test was carried out to ascertain the interoperability and performance of the system.

4.2 Result

From extensive research, data obtained in the process of testing the incubator by using two different set point which are during the day and during the night were tabulated as shown in the tables It is important to note that the incubator system has been programmed to maintain a temperature range of 36-37^{o} C and humidity of 70-80%.

Table 4.2a: Result for day operation

Time(hour)	Temperature(°C)	Humidity (%)
9:00	32	60
10:00	37	62
11:00	38	65
12:00	40	70
13:00	37	68
14:00	38	74
15:00	36	64

Table 4.2b: Result for night operation

Time(hour)	Temperature(oC)	Humidity (%)
18:00	28	70
19:00	33	80
20:00	37	75
21:00	37	70
22:00	37	74
23:00	38	78
24:00	36	76

4.3 Discussion of result

The result gotten from the project was sound and shows the viability of the design project and its application for commercial use. Due to the changes in the time and weather condition, it was discovered that temperature and humidity in the incubator varies. This indicate that the lower the weather outside the incubator, the higher the humidity inside the incubator. Also the higher the temperature outside the temperature, the lower the temperature inside the incubator. But due to our action of using an embedded system design, the internal temperature is maintained at a mean temperature of 36.85^{o}C and 66%.

CHAPTER FIVE

5.1 Conclusion

The aim of this project is to design an electrical based smart incubator that can hatch chicken and any other type of egg once the conditions are known. From the test carried out, it was demonstrated that the incubator work satisfactorily and according to specifications.

The project has successfully improved in the control of the environmental factors and thus will have higher efficiency when tested on the field.

5.2 Suggestions for further work

The project was successful to some extent and this can be improved upon using a dimmer module instead of the relay. The relay has only two states ON and OFF and thus the relay can only ON or OFF the bulb and heater. This increases the time needed to regulate the system to the required state. The dimmer can be used with the Arduino to calibrate the power supplied to the AC elements (heater and Bulb). This will reduce or increase the intensity of the bulb and the heating power of the heater based on the temperature or humidity.

This project is able to hatch 9 eggs at a time. We suggest the implementation of this project on larger scale.

Based on our research done so far, we can suggest that with extensive advancement of this method it can also be applicable to incubating premature babies.

5.2 Recommendations

One of the major problems of implementing this in Nigeria is the fact that the electrical power supply is not steady. The incubator requires a steady power supply so we strongly recommend integrating the system with an alternate power supply like the solar system and/or a battery back-up that can sustain the incubator for some hours.

We strongly recommend a DHT22 instead of DHT11 used in the project. The DHT22 is more accurate for temperature and humidity reading.

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