

# Modification of the Design of Poultry Incubator

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## ABSTRACT

*Egg incubation is a technology that provides opportunity for farmers to produce chicks from egg without the consent of the mother hen; it is also one of the ways of transforming eggs to chicks. Eggs have been incubated by artificial means for thousands of years. Both the Chinese and the Egyptians are credited with originating artificial incubation procedures. Modern commercial incubators are heated by electricity, have automatic egg-turning devices, and are equipped with automatic controls to maintain the proper levels of heat, humidity, and air exchange. To make sure all part of egg was heated by lamp, DC motor is very useful to rotate mat at the bottom side and automatically change the position of egg. The entire element will be controlled using programmable integrated circuit. The programmable integrated circuit is a type of microcontroller that can process a data from sensor and will execute the control element to change the condition in the incubator. The paper present the modification of the design of poultry incubator that will be user friendly, protable, affordable and easy to maintain. Evaluation and test was carried out, thus having result for days of the testing, an average value of temperature was gotten to be 37°C, average percent humidity value of 56.15% and an average angle turn of 46.58°. It was recommended that solar energy should be used as heat source because of the untimely failure of electricity to enhance the efficiency of the system and a two way power source should be used.*

**Keywords:** Modification; Poultry; Design, incubator; Ventilation

## 1. INTRODUCTION

Egg incubation is a technology that provides opportunity for farmers to produce chicks from egg without the consent of the mother hen, is also one of the ways of transforming eggs to chicks. The most important difference between natural and artificial incubation is the fact that the natural parent provides warmth by contact rather than surrounding the egg with warm air.

Nothing can be more interesting than the study of the chicken egg and its development from the unincubated stage to the emergence of the chick from the shell. The developing chick in an egg is called an embryo, and a careful study of the different stages of embryonic development will uncover many interesting facts. Incubation of eggs will show you the effects of heat, air, and moisture on hatchability. You will find out how an egg is formed, what its different parts and their functions, and how a chick embryo develops. Eggs have been incubated by artificial means for thousands of years. Both the Chinese and the Egyptians are credited with originating artificial incubation procedures. The Chinese developed a method in which they burned charcoal to supply the heat while the Egyptians constructed large brick incubators that they heated with fires right in the rooms where the eggs were incubated. Over the years incubators have been refined and developed so they are almost completely automatic. Modern commercial incubators are heated by electricity, have automatic egg-turning devices, and are equipped with automatic controls to maintain the proper levels of heat, humidity, and air exchange. Both still-air and forced-draft incubators are used in hatcheries. However, all the new incubators are forced-draft; that is, they have fans to circulate the air. They are capable of maintaining more even temperature, humidity, and oxygen levels than still-air incubators [1].

Since the 1930s and 1940s, the poultry industry has become one of the most efficient producers of protein for human consumption. It expanded rapidly during World War II because of the shortage of beef and pork, which require a much longer time to develop; only seven weeks are required to produce a broiler and five months to produce a laying hen. More recently, in response to public concern over dietary fat, poultry has again become a popular substitute for beef and pork [1].

The world's population is growing at an alarming rate and so is the demand for protein especially in the rural areas, poultry is a good source of protein and it is affordable. A broody hen (a hen that wants to set and hatch eggs and raise the chicks) can hatch just about 10-12 eggs at once in 21 days, which reduces its productivity as it takes time to incubate and hatch the chicks. In contrast, some large birds, such as condors and albatross, may lay only a single egg every two years. For the world growing population, relying on this natural type of incubation is not enough, hence the need for artificial incubation. This way, a female bird just concentrates on laying eggs while the incubation is done for her artificially.

Incubators of several types and capacities with adapters for eggs from different species are available. Basically, an incubator is a box that holds and rotates eggs while maintaining appropriate temperature, humidity and oxygen levels. An automatic rotator rotates eggs at least twice a day. Humidifiers are of several types, some are actuated by wet bulb systems while others are designed to maintain humidity by a simple water reservoir surface area system. Either of these systems can be used effectively. Temperature can be controlled by the older wafer system or by newer microprocessor systems. Whatever the system chosen, an incubator with a backup controller set at less than 102°F (38.9°C) can save the hatch if the primary temperature controller ever malfunctions. Remembering that temperature, humidity, ventilation and turning are the important factor during incubation, so these factors are to be monitored [1].

Eggs of exotic birds and common chickens require a standard measure of care in storage and incubation to ensure a successful hatch. Environmental conditions, handling, sanitation and record keeping can impact the success of incubating and hatching eggs. Most eggs are laid by mid-morning. Eggs should be collected several times a day to reduce the amount of time eggs remain in the nest. This practice decreases the number of cracked and soiled eggs and also prevents premature incubation. Embryos begin to prematurely develop at temperatures above 72°F (22.2°C). The size, shape, color, and texture of a bird egg are specific to each species. Eggs provide an ideal environment for the developing embryo, and the shells of eggs are made from calcium carbonate. They contain thousands of pores through which water can evaporate and air can seep in, enabling the developing embryo to breathe. Developing embryos are extremely sensitive to the temperature of its immediate environment, it was observed that some eggs will hatch if they continuously maintained at a temperature between 35°C and 40°C, [2] further suggested that the optimum temperature is between 37°C and 38°C in forced draft incubator and about 1°C higher in still air incubator, they observed the relationship between the relative humidity and temperature in forced draft incubator and inferred that as the humidity increased the temperature required decreased.

#### **Statement of Problem**

- i. Improper control of humidity in the incubator system.
- ii. Failure of electricity to enhance the efficiency of the system.
- iii. The existing incubator was not properly lagged, thus leading to loss of energy.

#### **Aims and Objectives**

The aim is to re-design and modify the performance of an existing incubator.

The objectives of this project are:

- i. To design and construct an incubator using a well lagged material, ensuring affordability compared to the imported type of incubator for every household
- ii. To use a bi-directional dc motor, so as to produce regular turning of egg tray
- iii. To provide a design that will use modern method of spraying water, using a controllable device (automated), in order to maintain the humidity and temperature needed in the system.
- iv. To design and construct an incubator using two alternative power source (electricity).

## **2. LITERATURE REVIEW**

Incubation is the process by which birds hatch their eggs, and to the development of the embryo within the egg. The most vital factor of incubation is the constant temperature required for its development over a specific period. Especially in domestic fowl, the act of sitting on eggs to incubate them is called brooding, and most egg laying breeds of chicken have had this behavior selectively bred out of them to increase production.

In most species, body heat from the brooding parent provides the constant temperature. The humidity is also critical, and if the air is too dry the egg will lose too much water to the atmosphere, which can make hatching difficult or impossible. As incubation proceeds, an egg will normally become lighter, and the air space within the egg will normally become larger, owing to evaporation from the egg [3].

#### **Type of Incubator**

- i. Still-air incubator
- ii. Forced air incubator.

#### **Forced Air Incubator**

This type of incubator has fans that circulate the air in the incubator and around the eggs; the effect of force air is to ensure air incubating temperature which varies from 37.36°C to 37.56°C and an humidity which varies from 28.3°C to 31.1°C (wet bulb).

#### **Incubator Still-Air**

A still air incubator consists of a box or container with appropriate dimension (30.50cm × 30.5cm × 40.5cm). there is a 0.95cm inlet at each end between the level of the eggs and the water pan, two outlets 0.95cm in size are provided by

pushing tape over half of the hole to restrict the rate of air flow. Heat source is provided by the use of two 40w light bulb, and connected to the thermostat in series for the controlled of the temperature.

Humidity is supplied from a part half the size on the floor area placed at the bottom of the incubator, when the eggs are hatched the type placed over half of the hole is removed to increase the flow or air it common.

A simple egg tray made from 0.64cm hardware cloth or wedded wire, and is placed on a platform above the cake pan containing the water.

Ventilation is provided through small holes on the side of the ice chest. A total of about 16 holes appropriately 0.64cm in diameter was provided. The holes are made on two opposite side of the chest such that on one side four holes in series are drilled at about 5.1cm from the top of the chest and another series of four holes are spaced 10.16cm apart. A window made of glass is placed at the top of the chest is provided for observation without removing or opening the chest causing on temperature or humidity.

The incubator is provided with a thermostat placed on the egg tray so that the bulb is about 2.57cm above the egg tray. This is to ensure that the temperature around the egg is taken [4].

### **Factors to be considered in Incubation Process**

#### **Length of Incubation**

Chicken eggs require 21 days to hatch, but the incubation period for the eggs of other species of poultry varies. The approximate periods of incubation required for various species of poultry and game birds are:

**TABLE 1**

<b>S/N</b>	<b>BIRDS</b>	<b>DAYS</b>
1	Chicken	21
2	Turkey	28
3	Duck	28
4	Muscovy Duck	33-35
5	Goose	29-31
6	Guinea	26-28
7	Pigeon	16-18
8	Ring-neck Pheasant	23-24
9	Mongolian Pheasant	24-25
10	Bobwhite Quail	23
11	Japanese Quail	17-19
12	Chukar Partridge	22-23
13	Peafowl	28

#### **Temperature**

The fertile egg will resume development when it is placed in an incubator, and the recommended temperature for the incubation varies that is from 99-103°F with no harmful effects. If the temperature stays at either extreme for several days, the hatch may be reduced.

Overheating is much more critical than under-heating, it will speed up rate of development causing abnormal embryos development in the early stages, and lower the percentage of hatchability [5].

#### **Humidity**

Humidity is of great importance for the development of chicken that is from their embryonic stage. During incubation (embryonic development) moisture is lost from the egg through the tiny holes on the shell, this increases the size of the air cell, which after 19 days of incubation occupies about one-third of the egg [5].

Although a variation of 5 to 10% is acceptable, the relative humidity of air within an incubator for the first 18days should be about 60% during the last 3days (matching period) should be nearer 70%. When the humidity is lower than the recommended it causes excess evaporation of water, while high humidity prevents the evaporation of sufficient amount of water from the egg. In both cases, hatchability is reduced [6].

#### **Turning of eggs**

When eggs are put in an incubator, lay them on their sides and turn them at least three times a day. Turning prevents the embryo from sticking to the shell membranes, as it will if it is left in one position too long. Good results can be obtained by turning the eggs the first thing in the morning, again at noon, and the last thing at night.

It is best to turn the eggs more than three times a day, they should be turned an odd number of times so that the egg will not be in the same position every night because that is the longest stretch of time between turns. When you turn the eggs, move them to a different part of the tray to offset variations in temperature in the different parts of the incubator. Continue to turn the eggs day 2 through day 17, but do not turn them after day 17 [7].

### **Ventilation**

As the embryo develops it uses oxygen and gives off carbon dioxide. Thus, sufficient ventilation within the incubator is required to ensure an adequate supply of oxygen and the proper removal of carbon dioxide. The best hatching results are obtained within 21% oxygen in the air the normal oxygen level in the atmosphere. The embryo will tolerate a carbon dioxide level of 5%. Since the normal oxygen and carbon dioxide concentration present in the air seem to represent an optimum gaseous environment for incubating egg, no special provision to control these gases is necessary other than to maintain adequate circulation of fresh-air at the proper temperature and humidity [6].

### **Fertile Egg Quality**

From the smallest canary eggs to the largest ostrich eggs, high quality fertile eggs should always be considered rare and fragile. To successfully hatch eggs, begin with fresh, clean, fertile eggs. Eggs can be produced “on site” or purchased from many sources. Commercial hatcheries will ensure good fertility, but often will not ship small quantities of eggs [8].

### **Storing Fertile Eggs**

Fertile eggs are alive. Each egg contains a living cell mass that develops into an embryo, and finally into a chick. Each incidence of improper handling reduces the probability of a successful hatch. Fertile eggs usually are gathered over a period of time before an adequate number of eggs can accumulate for incubation, or until the incubator is available for a new set of eggs. These normal situations require that, before incubation, eggs must be stored properly to ensure hatchability [5].

### **Cleaning and culling**

Cracked, poorly shaped, soiled and unusually large or small eggs should not be incubated. These eggs rarely hatch and they increase the probability of introducing infection into the incubator. Eggs should not be washed. Washing or wiping with a damp cloth removes a protective layer that coats the egg. Soiled eggs should be cleaned by gently buffing the soiled area with fine sandpaper. Washing eggs transfers disease infection agents from the surface to the inside of the eggs. If an egg is washed, it should be washed briefly in 110°F water that contains a commercial egg sanitizer. Washing an egg in water that is cooler than the egg itself causes egg contents to contract. Contraction of egg contents draws water into the egg through pores in the shell. This water carries infecting microorganisms into the egg. If fertile eggs are produced “on site” at the business location, the breeding stock must be maintained and supported for maximum health and fertility. Basic egg production is severely affected by day length and lighting control [2].

### **Fumigation**

Fumigation is an operation aimed at destroying organism that may kill the embryo or infect the hatched eggs (chicks) by exposing the organism to poisonous gas. Fumigation should be carried out before the use of incubator for hatching eggs.

### **Storage time**

Ideally, eggs should be set in the incubator as soon after gathering as possible to maintain egg quality. If eggs are to be stored before incubation, the best hatchability occurs when eggs are stored for less than 7 days from the time they were laid. However, some species are more sensitive to storage than other species. Hatchability decreases rapidly in eggs held in storage for more than 10 days. Storing eggs longer than 2 weeks also can extend the normal incubation time as much as 1 day [6].

### **Embryonic Development**

Embryonic development is a continuous process that can roughly be divided into three different phases. They are differentiation, growth and the maturation. Typically, differentiation of organs occurs in the first days of incubation. The growth and the maturation of the organs occur in the later phases of development. Each of these phases requires specific incubator conditions. As the embryo grows, its metabolic rate increases and this is accompanied by increased heat production. Consequently, the natural pattern of the embryo and eggshell temperature shows an increase towards the end of incubation. In the incubator we must differentiate between the temperature set point at which the incubator operates and the temperature of the air at the level of the eggs, which determines the temperature of the egg and embryo.

At the start of incubation the embryo produces little heat and eggs must be warmed. This means that the air temperature must be higher than the egg temperature. As the embryo grows, metabolic heat production increases, the air surrounding the eggs must be cooled such that heat is removed from the eggs by so doing overheating can be prevented [9]—[10].

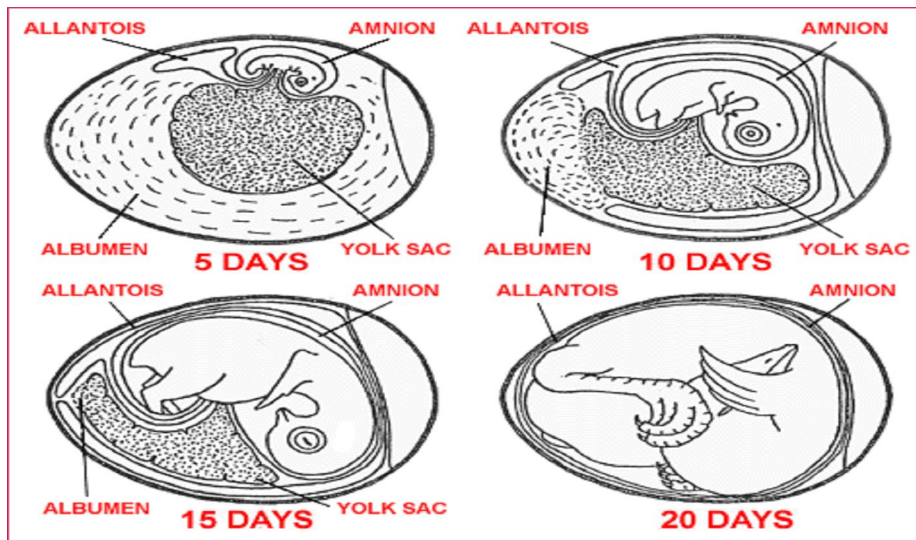
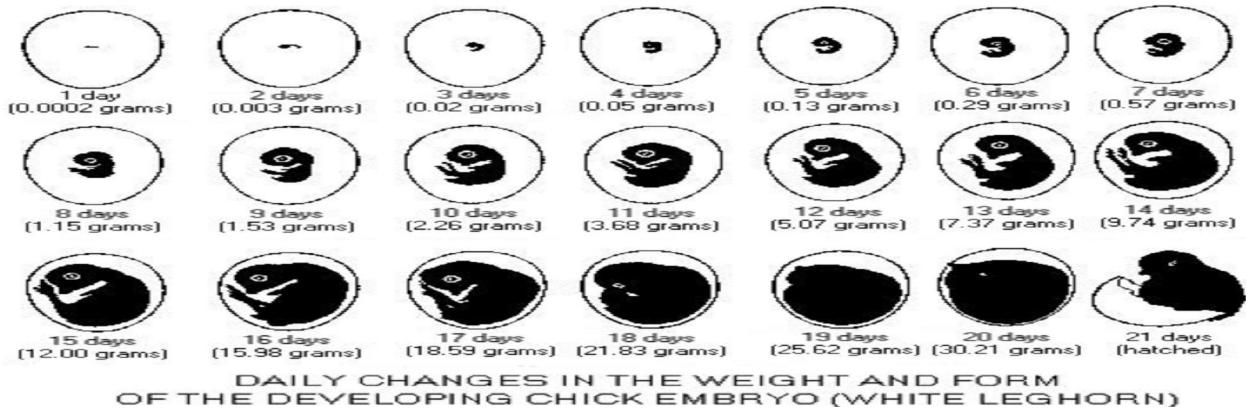


Figure 1: Much closer view

**Design Specification and Analysis**

This chapter presents the design details for the incubator to be constructed, i.e.

**The Incubation Components**

Frame/Chamber: Wood and Glass

Heating System: Bulb and Plastic Can

Ventilation: Fan

Control System: Micro-Controller and Digital Thermometer

Turning System: 2 way Dc Motor, Pulley, Carpet, and

- i. Determination of appropriate materials and dimension incubator box.
- ii. Parameter of the temperature control loops/ programming

When it comes to the design of an incubator, heat required and transferred are critical factors and are of major importance. Temperature and relative humidity in the incubator are dependent on the heat supplied and level of ventilation. Adequate heat supply and ventilation enhance air circulation and heat transfer [11]—[12].

**Determination of Humidity**

The humidity required for the incubation of poultry egg is require to be the mass of water vapor per unit volume over unit volume of air. It keeps the egg from losing too much or too little moisture during the incubation process. However, humidity depends on mass flow of air, temperature and speed of the fan, there to determine the humidity we have [11].

$$H = \frac{m_v}{V} \tag{3.1}$$

$$p_v V = m_v R_v T \tag{3.2}$$

$$H = \frac{p_v}{R_v T} \tag{3.3}$$

Where; H = Humidity  
 $m_v$  = Molar mass of water  
 $q_v$  = Energy density or heat density  
 $R_v$  = Gas constant  
 T = temperature  
 V = volume

**Determination of Heat Generation**

Heat generated Q, is determine as  $MC\Delta T$ . Therefore heat required to raise the temperature of the incubator will be the heat required to raise the temperature of the air, eggs, glass, egg tray, water and wooden wall. Hence, we determine these heats below;

For heat generated in the incubator;  
 $Q_I = M_I C_I \Delta T$  3.4

Therefore, heat required to raise the temperature are listed below;

Air  
 $Q_A = m_A C_A \Delta T$  3.5

Eggs  
 $Q_e = m_e C_e \Delta T$  3.6

Water  
 $Q_w = m_w C_w \Delta T$  3.7

Plywood  
 $Q_p = m_p C_p \Delta T$  3.8

Where; Q = heat  
 C = specific heat capacity  
 $\Delta T$  = change in temperature  
 m = molar mass

Therefore, total heat required to raise the temperature of the incubator will be the summation of all the heat of the parameters listed above, given as;

$Q_I = Q_A + Q_e + Q_T + Q_w + Q_p + Q_g$  3.9

**Heat Loss**

Due to the loss of heat during the lagging of wooden wall whereby a 100% work is not certain, heat will be loss by conduction. Therefore to determine the heat loss will be by the following expression;

Considering the plane layer of thickness dx with one face maintained at a temperature T and the other end (T +  $\Delta T$ ). The rate of heat flow is given by;

$Q = -KA \left( \frac{dT}{dx} \right)$  3.10

Since the flow is a steady flow, i.e. it does not vary with time.

So,

$Q dx = -KA dT$

Integrating, we have

$Q = -KA \left( \frac{T - T_{\infty}}{x} \right)$  3.11

Therefore, the heat loss during the incubation will be as follows;

Top and Bottom Wall  
 $Q_{PT} = -K_p A_p \left( \frac{T - T_{\infty}}{x} \right) \times 2$  3.12

Side Walls  
 $Q_{PS} = -K_p A_{PS} \left( \frac{T - T_{\infty}}{x} \right) \times 2$  3.13

Back Wooden Wall  
 $Q_{PB} = -K_p A_{PB} \left( \frac{T - T_{\infty}}{x} \right)$  3.14

Front Wooden Wall

$$Q_{PF} = -K_p A_{PF} \left( \frac{T_i - T_e}{x} \right) \quad 3.15$$

Glass Window

$$Q_{gw} = -K_g A_g \left( \frac{T_i - T_e}{x} \right) \quad 3.16$$

Where; Q = heat

PF = plywood front

PS = plywood side

PB = plywood back

PT = plywood top and bottom

gW = glass window

QL = heat loss

Total heat that will be loss is given as

$$Q_L = Q_{PT} + Q_{PS} + Q_{PB} + Q_{PF} + Q_{gw} \quad 3.17$$

This implies that, actual heat required for the system is given as;

$$Q = Q_L + Q_i \quad 3.18$$

### Design of Ventilation Holes

Ventilation is basically the volume of mass flow in and out of the incubator, so the volume flow ratio is given as;

Volume flow rate = Cross sectional area x Velocity

Where Volume =  $\frac{\pi d^2}{4}$

$$\text{Therefore the Fan speed} = \frac{\pi d^2}{4} \quad 3.19$$

### Selection of DC Electric Motor

Torque generated by electric motor

$$T_m = \frac{\text{POWER}}{\text{ANGULAR VELOCITY}} \quad 3.20$$

I.e.  $T_m = \frac{60 \times \text{POWER}}{2\pi N}$

Where N = Speed in rpm

### Design of Pulley

When designing pulley drive, the following are highly considered;

- i. Pulley diameters
- ii. The velocity ratio
- iii. Distance between driver and driven
- iv. Number of revolution of the drive
- v. The power needed and tension of the tight and slack side

$$P = WT \quad 3.21$$

$$W = 2\pi N$$

$$P = 2\pi NT \quad 3.22$$

N = rev per min.

T = Torque

A. design of driven and driving pulley diameter

i. Driving pulley diameter is selected based on power of the electric motor;

$$W_i = \frac{2\pi n_i d_i^2}{60} \quad 3.23$$

$W_i$  = Angular velocity of the driving pulley

$n_i$  = number of revolution of the driving pulley in rpm.

ii. Driven pulley diameter, we consider the angular velocity of the driving pulley as well as the diameter of the driving pulley, thus

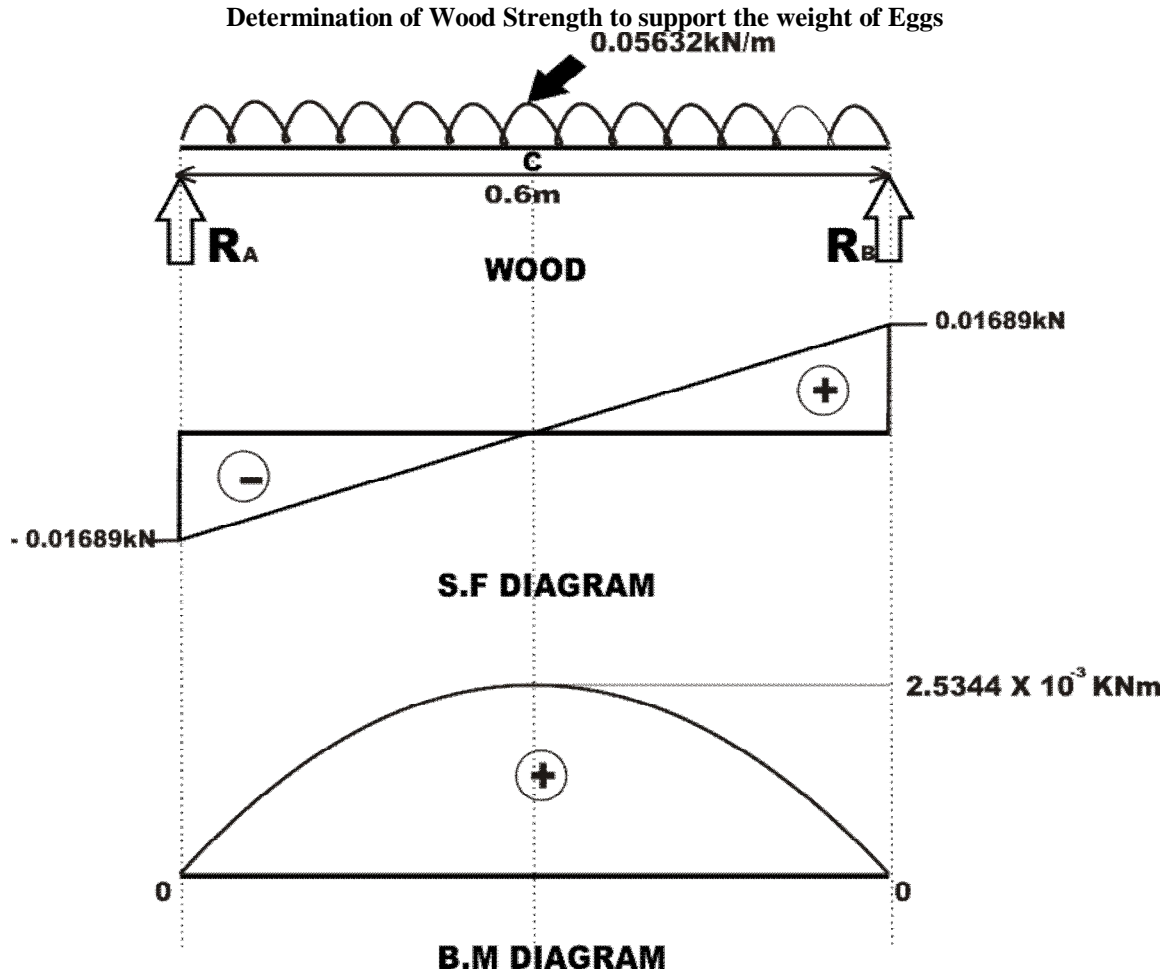
$$W_1 d_1 = W_2 d_2 \quad 3.25$$

Where;

$$W_2 = W_s$$

$$d_2 = W_1 d_1 / W_2 \quad 3.26$$

$d_2$  = diameter of the driven pulley  
 $d_1$  = diameter of the driving pulley  
 $W_2$  = Angular velocity of the driven pulley  
 $W_1$  = Angular velocity of the driving pulley



Taking into consideration of the loading due to the weight of the eggs;

Since they are uniformly distributed on the wood, therefore;

Length of plywood = 0.6m

Mass of plywood  $m_p = 2.40714\text{kg}$

Mass of an egg = 0.0689kg = weight of the egg

So the mass or weight of 50 eggs will be

$$W_e = 0.0689 \times 50 = 3.445\text{kg}$$

$$W_e = 3.445\text{kg}$$

Since the weight of the eggs is 3.445, then the UDL will be the weight of the egg divided by the total span of the wood which is 0.6m

$$UDL = \frac{W_e}{L} = \frac{3.445}{0.6} \times 9.81 = 0.05632\text{kN/m}$$

$$\text{For a UDL: } R_A = R_B = \frac{wl}{2}$$

$$= \frac{0.05632 \times 0.6}{2} = 0.01689\text{KN/m}$$

So the shear forces at point A and B will be

$$S_A = -\frac{wl}{2} = -0.01689\text{KN}$$

$$S_B = \frac{wl}{2} = 0.01689\text{KN}$$

So the bending moment at mid-point will be  $M_C$

$$M_C = \frac{wl}{8} \times l = \frac{0.05632 \times 0.6}{8} \times 0.6 = 2.5344 \times 10^{-3}\text{KNm}$$



$$M_c = 2.5344 \text{ Nm}$$

Where at end of the wood,

B.M at B i.e will be  $M_B = 0$

B.M at A i.e will be  $M_A = 0$

So since the shear strength of the wood (oak) is 12.2mpa,

$$12.2 \text{ Mpa} = 12.2 \times 10^6 \text{ N/m}$$

From the calculation, Maximum bending moment of the eggs (50) is 2.5344Nm which is less compared to the shear strength adopted (12.2x10<sup>6</sup> Nm).

Therefore, the wood (Oak) used can withstand the load of the eggs.

**Heat Loss**

The heat loss in the incubator is derived through heat loss from the wooden walls, and the windows can be achieved by using the conduction equation

$$Q = -kA \frac{(T - T_s)}{X}$$

The heat loss through the top and bottom wall will be given as;

$$\text{Area}_{TB} (A_{TB}) = L \times b = 60 \times 43 = 2580 = 0.258 \text{ m}^2$$

$$A = 0.258 \text{ m}^2$$

$$x = 0.015$$

Therefore;

$$Q_{TB} = \left[ -\frac{0.08 \times 0.258 (12.2)}{0.015} \right] \times 2 = -143.104 \times 2$$

$$= -286.208$$

$$Q_{TB} = -0.286208 \text{ w}$$

The heat loss through side wooden wall is given by;

$$Q_s = -K_p A_s \frac{(T - T_s)}{X}$$

Where;

$$A = 43 \times 43 = 0.1849 \text{ m}^2$$

$$X = 0.015$$

$$Q_s = -\frac{0.08 \times 0.1849 (12.2)}{0.015} \times 2 = 102.557867 \times 2 = 205.115734$$

$$Q_s = -0.205 \text{ w}$$

The heat loss through the back wooden wall is given as;

$$Q_B = -K_w A_B \frac{(T - T_s)}{X}$$

Where;  $A = 60 \times 43 = 0.258 \text{ m}^2$

$$X = 0.015$$

$$Q_B = -\frac{0.08 \times 0.258 (12.2)}{0.015} = -143.104 \text{ J}$$

$$Q_B = -0.143 \text{ w}$$

Heat loss through the glass window

$$Q_g = -K_g A_g \frac{(T - T_s)}{X}$$

Where;  $A = 43 \times 22.5 = 0.09675 \text{ m}^2$

$$X = 1$$

$$K_g = 0.5,$$

$$\text{Therefore; } Q_g = -\frac{0.5 \times 0.09675 \times 12.2}{0.01} = -61.92 \text{ J}$$

$$Q_g = -0.06 \text{ W}$$

The heat loss through front wall is;

$$Q_F = -K_w A_F \frac{(T - T_s)}{X}$$

Where;  $A = 2902.2 = 0.29025 \text{ m}^2$

$$X = 1.5 = 0.015 \text{ m}$$

$$Q_F = -\frac{0.08 \times 0.29025 \times 12.2}{0.015} = -160.992 \text{ J}$$

$$Q_F = -0.160992 \text{ w}$$

$Q_L$  = total heat loss

$$Q_L = Q_{TB} + Q_s + Q_B + Q_F + Q_g$$

$$Q_L = (-0.286208 - 0.205 - 0.143 - 0.160992 - 0.06) \text{ w}$$

$$Q_L = 0.8552 \text{ W}$$

Having a total heat generated by the bulb to be 120W, therefore the remaining heat in the incubator will be;

$$120 - (0.8552 + 67.2296) = 51.9182 \text{ W}$$

**Design of Ventilation Holes**

Assume number of holes = 16 holes

Assume diameter of holes = 0.64cm

Volume flow rate of through one hole is given as;

Volume flow rate = cross section area × velocity from equation 3.21

$$\text{Volume of Hole } (V_H) = \frac{\pi d^2}{4} = \frac{\pi \times 0.64^2}{4} = \frac{3.142 \times 0.64^2}{4}$$

$$V_H = 0.322\text{m}^2, 0.0322 \text{ m}^3$$

From A.kTheraja 2003.

Motor feed = speed of fan = 0.25rev/sec

Volume flow rate = speed of fan x volume

$$\text{Volume flow rate} = 0.25 \times 0.0322$$

$$\text{Volume flow rate} = 0.00805 \text{ m}^3/\text{s}$$

**Selection of DC Electric Motor**

Torque generated by the electric motor is given as;

$$T_m = \frac{\text{Power}}{\text{Angular velocity}}$$

Where;

$$\omega = \frac{2\pi N}{60}$$

$$3.6 = \frac{2 \times 3.142 \times N}{60}$$

$$N = \frac{60 \times 1000}{2 \times 3.142} = 34.4 \text{ r.p.m}$$

$$T_m = 27.76 \text{ Nm}^2$$

**Result and Discussion**

It was observed that the total heat generated inside the incubator is 120watt; while the total heat used in raising the temperature of the incubator is (Q<sub>i</sub> = 67.2296 w) but the total heat losses through the plywood and glass window are (Q<sub>L</sub> = 0.8552w).

A test was carried out on the authors’ construction to determine the working possibility of the construction, and the following data was gotten for two (2) days;

**Table 2:** result of day 1 evaluation

DAY1			
Time (hr.)	Temperature (°C)	Humidity (%)	Turning (° at every 4hrs) Clockwise(+) and Anti-clockwise(-)
1	37	45	
2	37	45	
3	38	45	
4	37	45	47
5	38	55	
6	36	55	
7	38	55	
8	37	55	- 48
9	37	55	
10	36	55	
11	38	60	
12	37	60	46
13	37	55	
14	36	55	
15	37	55	
16	36	55	- 45
17	37	60	
18	38	55	
19	36	55	

20	38	60	46
21	37	60	
22	36	60	
23	37	55	
24	37	55	- 47

**Table 3:** result of day 2 evaluation

DAY2			
Time (hr.)	Temperature (°C)	Humidity (%)	Turning (° at every 4hrs) Clockwise(+) and Anti-clockwise(-)
1	36	60	
2	36	60	
3	37	60	
4	36	60	48
5	37	60	
6	37	60	
7	36	60	
8	37	60	- 46
9	38	55	
10	36	60	
11	36	55	
12	37	55	48
13	37	55	
14	38	55	
15	37	55	
16	38	55	- 46
17	37	60	
18	38	55	
19	37	60	
20	38	55	45
21	37	55	
22	37	60	
23	38	55	
24	37	60	- 47

Finding the mean value for the days;

For temperature;

$$37^{\circ}\text{C} - 24 \text{ times} = 888$$

$$38^{\circ}\text{C} - 12 \text{ times} = 456$$

$$36^{\circ}\text{C} - 12 \text{ times} = 432$$

$$888 + 456 + 432 = \frac{1776}{48} = 37^{\circ}\text{C}$$

For humidity

$$45\% - 4 \text{ times} = 180$$

$$55\% - 25 \text{ times} = 1375$$

$$60\% - 19 \text{ times} = 1140$$

$$180 + 1375 + 1140 = \frac{2695}{48} = 56.15\%$$

For turning

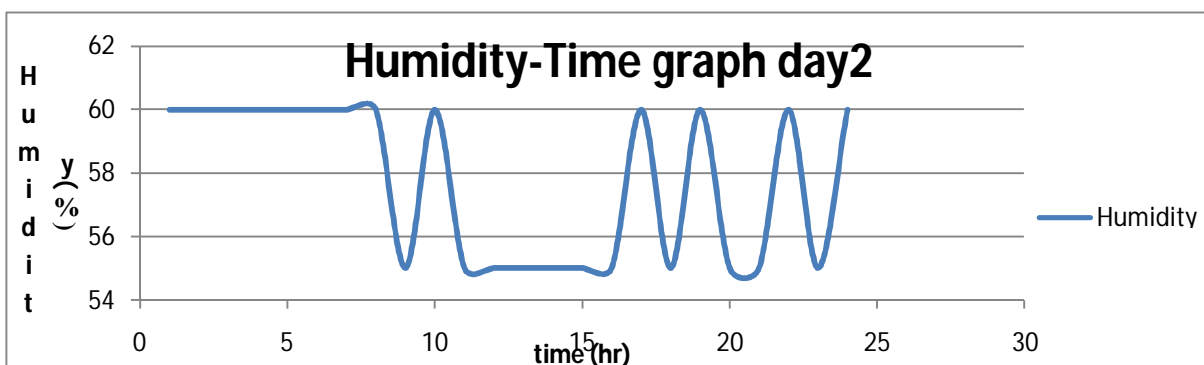
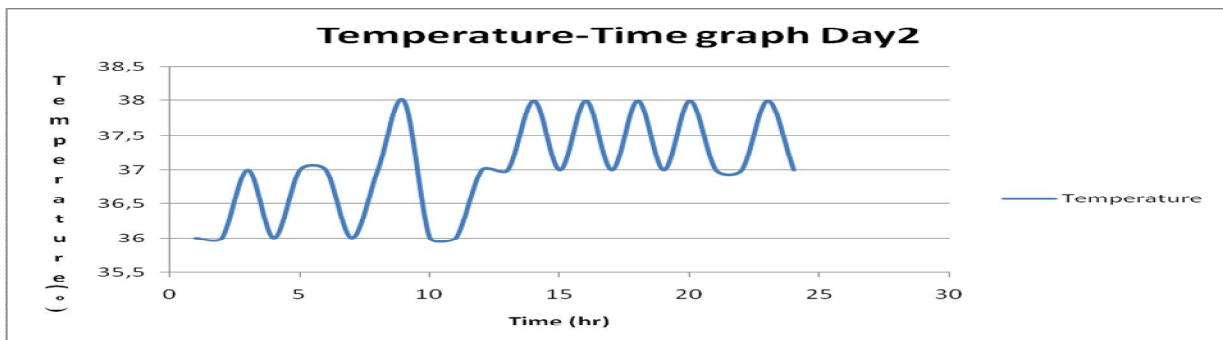
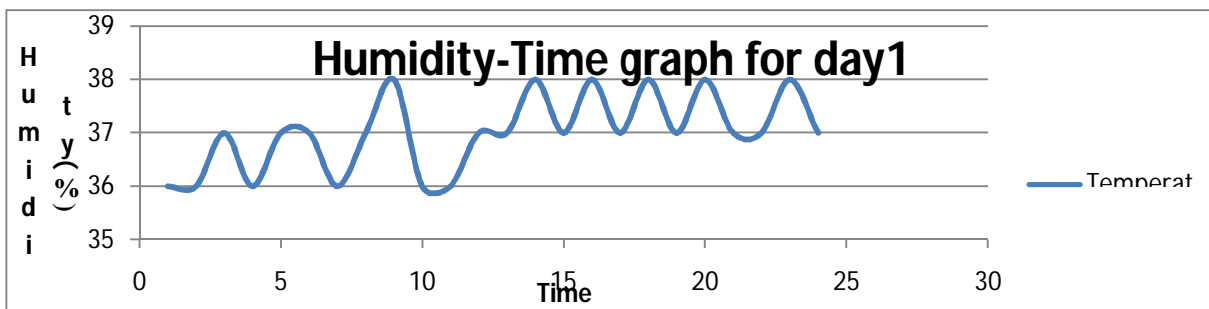
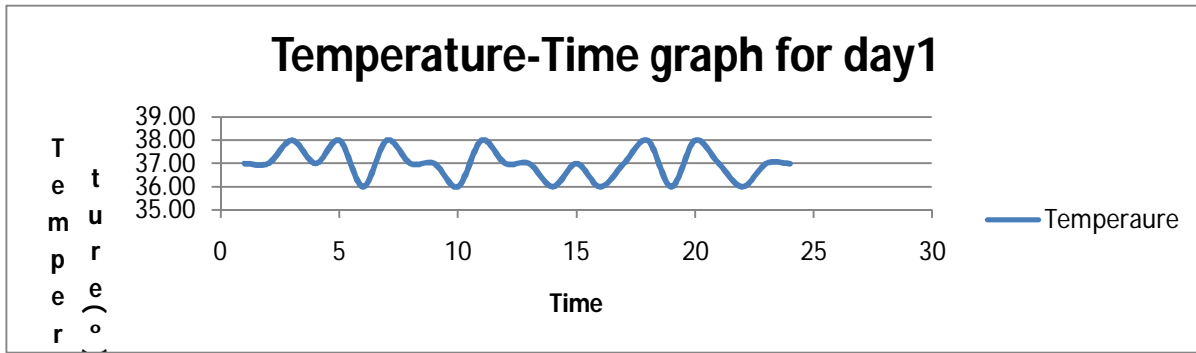
$$45^{\circ} - 2 \text{ times} = 90$$

$$46^{\circ} - 4 \text{ times} = 184$$

$$47^{\circ} - 3 \text{ times} = 141$$

$$48^{\circ} - 3 \text{ times} = 144$$

$$90^{\circ} + 184 + 141 + 144 = \frac{559}{12} = 46.58^{\circ}$$



Due to the change in time and ambience temperature, it was discovered that humidity and the temperature in the incubator chamber varies, so the lower the ambience temperature the higher the humidity and temperature in the incubator chamber, but due to the action of the programmable integrated circuit the internal temperature of the incubator is maintained between 36 – 38 degree Celsius.

### 3. CONCLUSION

In this paper the equipment designed is portable, affordable and easy to maintain. Evaluation and test was carried out, thus having result for days of the testing, an average value of temperature was gotten to be 37°C, average percent humidity value of 56.15% and an average angle turn of 46.58°. Since the environmental condition for the hatching of different poultry eggs are within a similar range [1], the equipment could be used to hatch the eggs of poultry such as

ducks, turkeys, goose, guinea fowl and ostrich, thus, increasing the country's food production. It was recommended for household use, subsistent poultry farmers to increase the production of poultry products. The authors recommended that the solar energy should be used as heat source because of the untimely failure of electricity to enhance the efficiency of the system.

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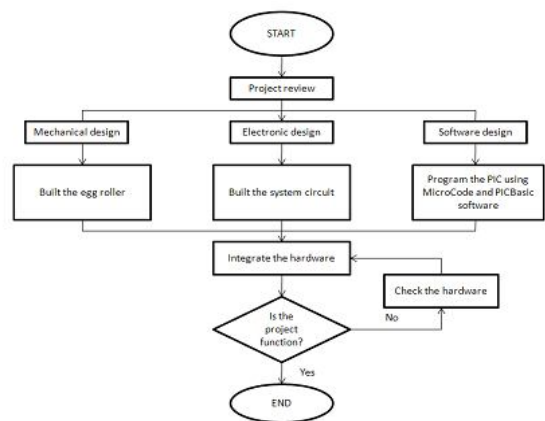
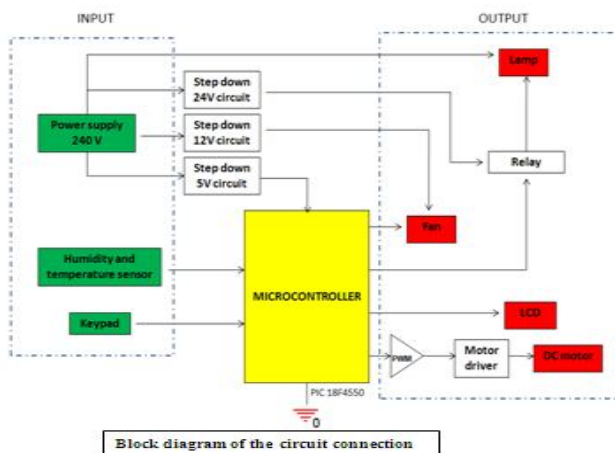


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**APPENDIX**



Flowchart of the project development