MODIFICATION AND PERFORMANCE EVALUATION OF HYBRID EGGS INCUBATOR

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DECLARATION

I hereby declare that this research project titled: **"MODIFICATION AND PERFORMANCE EVALUATION OF HYBRID EGG INCUBATOR"** is my own work and has not been submitted by any other person for any degree or qualification at any higher institution. I will also declare that the information provided therein are mine and those that are not mine are properly acknowledged.

Faniran-Emmanuel — 04/08/25

Name of Student — **Date & Signature**

CERTIFICATION

I, hereby declare that this research project titled MODIFICATION AND PERFORMANCE EVALUATIONOF HYBRID EGG INCUBATOR was carried out by Faniran Emanuel Ayobami with matric number HND/23/ABE/FT/0035 is my own work and has not been submitted by any other person for any degree or diploma in any higher institution. I also declare that the information provide therein are mine and those that are not mine are properly acknowledged

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DEDICATION

This project work is dedicated to God Almighty who granted me strength, knowledge and wisdom to complete my project work successfully. Also to my parents, Mr and Mrs. Faniran, Mrs Akeredolu, and Mr Olasunkanmi Faniran for their support, financially, morally and spiritually for their care, attention and advice, Glory be to God.

ACKNOWLEDGEMENT

All praises belong to Almighty God for all His wondrous work in my life and for giving me wisdom, knowledge and strength to complete this project work successfully.

I sincerely express my profound gratitude to my supervisor Engr Mrs. Onipede for her motherly support, advice, time, and correction toward the completion of this project. Indeed, I and my fellow project colleagues can testify that you are a true mother to us, May God bless you and your home in Jesus name.

I am extremely grateful to my lovely and beloved parents for their support throughout my academic pursuit, may Almighty God bestow you long life and good health to eat the fruit of your labour, (Amen).

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

A hybrid egg incubator was modified and constructed to solve the problem of power outages that militate against poultry egg incubation. The hybrid egg incubator was constructed from medium density fibreboard (MDF) plywood and lagged with fibre glass to prevent heat loss. The hybrid egg incubator was made of two unit; the main cabinet and auxiliary unit.

The main cabinet contains of egg trays, bulbs, DC fans, water tray and turning mechanism. The auxiliary unit contains of solar PV panel, battery, inverter and charge control. The incubation parameters were measured by control board. The temperature and humidity range within the incubator were 36.1 - 37.5 °C and 50.1 % to 60% respectively, the angle of turn was 45°. The result of performance evaluation showed 91% hatchability, 66% fertility and maturity rate 9%.

The hybrid egg incubator is affordable because it was made from locally available materials and it is therefore recommended for poultry farmers both at rural and urban centers.

CHAPTER ONE

1 INTRODUCTION

1.1 Background of the Study

Poultry farming plays a significant role in global food security and rural livelihoods, particularly in developing countries such as Nigeria, where it serves as a major source of income, nutrition, and employment (Food and Agriculture Organization of the United Nations FAO, 2018). A critical component of poultry production is the incubation of eggs, which directly influences the productivity and profitability of poultry enterprises. Traditionally, egg incubation is carried out using natural methods, where broody hens provide the necessary warmth and humidity for embryo development. Although biologically adequate, this method is often inefficient, limited in scale, and unpredictable due to environmental factors and variability in brooding behavior (Okonkwo & Akubuo, 2001).

Poultry farming is a crucial aspect of agriculture in Nigeria, contributing significantly to the economy and providing essential protein sources through eggs and meat. It is estimated that Nigeria's poultry sector is one of the largest in Africa, producing over 500,000 metric tons of eggs and 300,000 metric tons of poultry meat annually (Ojo, 2020). The sector plays a vital role in the livelihoods of smallholder farmers, providing employment and contributing to food security. However, challenges such as inadequate technology, poor management practices, and high mortality rates hinder optimal production (Akinola & Essien, 2021).

Artificial incubators have become a preferred alternative in commercial poultry production due to their ability to maintain stable conditions of temperature, humidity, and ventilation (Onu & Aja, 2015). However, in many rural and peri-urban areas, access to a stable power supply remains a major constraint to the adoption and consistent operation of electric incubators (Ige et al., 2020). This dependency on the electrical grid renders such systems unreliable, leading to frequent disruptions during the critical embryonic development period.

1.2 : Problem Statement

The world's growing population and increasing health awareness have led to a surge in demand for poultry product, which are perceived as a healthier alternative to red meat due to their lower cholesterol and trans fat content. this trend is expected to continue as driving growth in the poultry industry. The process of hatching egg by natural method is limited and the artificial incubators that can hatch more eggs at a time are faced with erratic power supply for an electrical incubator, adverse weather condition for solar incubator, lack of adequate control system of incubation system and besides an inadequate hatcheries contributing to high cost of day old chicks

1.3 Aim and Objectives

The aim of the project is to modify and carryout the performance evaluation of existing egg incubator to improve hatchability, reduce energy consumption, and enhance efficiency and sustainability.

While the specific objectives are to :

i. Identify short coming in the existing incubator

ii. Modify component to improve hatchability

iii. Assess the temperature and humidity control capabilities of incubator under different environmental conditions

iv. Evaluate the machine performance in terms of hatchability

1.4 : Justification

The study will contribute to sustainable poultry farming in Nigeria by addressing power failure and weather related challenges, reducing energy consumption and operating costs, making incubation practices accessible in rural areas and increase the income of poultry farmers.

1.5 : Scope of the Study

The scope of the study focuses on modifying an existing egg incubator in terms of construction material, insulation materials, temperature and humidity control, mechanical turning of the egg, procurement of fertile eggs and carryout of performance evaluation in terms of hatchability

CHAPTER TWO

2 LITERATURE REVIEW

2.1 : Incubation Technology

Incubation technology refers to the methods and devices used to hatch eggs, which is a critical component of poultry production. It ensures a continuous and reliable supply of chicks for the poultry industry. The advancement of incubation technology has allowed farmers to increase the efficiency of egg hatching and reduce losses (Ibrahim, 2021). Incubation methods can be broadly classified into two types: natural incubation and artificial incubation

a. Natural Incubation

Natural incubation is the process whereby a broody hen provides the necessary warmth, humidity, and turning of eggs until hatching occurs. This method is instinct-driven and biologically efficient in small-scale or subsistence farming systems (Ibrahim & Lawal, 2018). Natural incubation does not require any external power or machinery, making it ideal in low-resource environments.

However, it suffers several drawbacks which includes broody hens can only cover a limited number of eggs, usually between 10–15 at a time, the process is time-consuming and cannot be scaled for commercial production and temperature and humidity regulation is inconsistent and highly influenced by environmental conditions (Afolabi & Oni, 2020).

Despite these limitations, natural incubation still plays a role in rural poultry systems where capital investment in artificial incubators is not feasible.

b. Artificial Incubation

Artificial incubation involves using a device (incubator) to replicate the natural conditions required for embryo development. These devices control key parameters such as temperature (typically 37.5°C), humidity (around 55–60%), ventilation, and egg turning (Tunde et al., 2021). Artificial incubation allows for mass production of chicks and improves consistency in hatchability.

To address this challenge, hybrid incubators that combine both solar and electric power have emerged as a practical solution. These systems harness solar energy during daylight hours and switch to electric power from the grid or batteries during nighttime or low solar availability, thereby ensuring uninterrupted incubation cycles (Emmanuel et al., 2021). Solar energy, being abundant and renewable, presents an environmentally friendly and cost-effective alternative, particularly in sub-Saharan Africa where sunlight is plentiful year-round (Akinbile et al., 2017).

Types of Artificial Incubators Includes:

i. Electrical Incubator: Uses electricity to generate heat and control humidity. It is reliable and commonly used where power supply is stable.

ii. Solar Incubator: Uses solar energy for heating, ideal for off-grid or rural areas. Its efficiency depends on sunlight availability.

iii. Hybrid Incubator: Combines two power sources, such as solar and electricity, ensuring continuous operation during power failure.

iv. Gas-Powered Incubator: Uses gas like LPG or natural gas as a heat source, serving as an alternative where electricity is unavailable.

v. Kerosene-Powered Incubator: Heated using kerosene, mainly used in remote areas. It requires manual monitoring to maintain correct temperature.

vi. Battery-Powered Incubator: Operates on rechargeable batteries, often as a backup for other power sources.

2.1.3 Hybrid Incubators: Solar and Electrical Power Integration

Hybrid incubators utilize both solar and electric energy sources to maintain stable incubation conditions. These systems are equipped with photovoltaic (PV) solar panels and battery banks that store solar energy for use during periods of low sunlight or power outages. When solar input is insufficient, the system automatically switches to electric power (Mohammed & Okeke, 2021).

These incubators offer significant advantages:

i. Reduced energy costs: Solar energy minimizes dependence on the grid.

ii. Improved reliability: Dual power ensures consistent operation.

iii. Environmental benefits: Lower carbon emissions compared to fully electric systems.

Hybrid systems have proven effective in improving poultry hatchability in energy-deficient regions and contribute to the broader adoption of green technologies in agriculture (Adebisi et al., 2022).

2.2 Incubation Parameters

Successful artificial incubation depends on the careful control of certain parameters that influence embryo development. These parameters include temperature, humidity, ventilation, and egg turning.

i. Temperature: The optimal temperature for hatching chicken eggs is usually between 37.5°C - 38°C (Meijerhof, 2019). Temperature fluctuations can lead to poor hatchability or embryo mortality.

ii. Humidity: Humidity levels should be maintained between 50-55% during the incubation period and increased to 65-70% during the last three days to prevent excessive moisture loss from the eggs (French, 2020).

iii. Ventilation: Adequate oxygen supply and removal of carbon dioxide are crucial for the embryo's survival. Insufficient ventilation can lead to weak chicks or embryo death (Davis & Zhang, 2021).

iv. Egg Turning: Regular turning of eggs is essential to prevent the embryos from sticking to the eggshell and to ensure proper development. Eggs are typically turned 4-6 times per day during incubation (Tullett, 2019).

v. Egg Fertility: Egg fertility is also an important parameter that enhance hatchability hence there is a need for egg candling to ascertain the fertility of eggs incubated.

2.3 Feature of Hybrid Poultry Eggs Incubator

Feature of Hybrid Poultry Eggs Incubator are;

i. Dual power source: it combines two power source such as electricity and solar power to provide a reliable and consistent incubator environment

ii. Backup power system: Hybrid incubator may include backup power system such as batteries or generator to ensure continuous operation during power outrage or period or low sunlight

iii. Advanced temperature control which can maintain optimal temperature for poultry egg incubator even in extreme weather condition

iv. Humidity control to maintain optimal humidity for poultry egg incubation

v. Automated egg turning and monitor to ensure proper turning to track incubator parameter such as temperature, humidity and egg turning

2.3 Condition for Various Eggs Incubation

The species of the bird, the incubation period, and other parameters for incubation is as shown in table 2.1

TABLE 2.1: Condition for various egg incubation

Species	Incubation Period (Days)	Temp F	Humidity (F)	Do not turn after	Humidity Last 3days	Open vent more
Chicken		100	85-87	18th day	90	18th day
Turkey	21	99	84-86	25th day	90	25th day
Duck	28	99	85-86	25th day	90	25th day
Muscovy duck	28	100	84-85	31st day	90	31st day
Goose	35-37	99	86-88	25th day	90	25th day
Guinea fowl	28-34	100	85-87	25th day	90	24th day
Peafowl	28	99	84-86	25th day	90	25th day
Pheasant	28-30	100	86-88	21st day	92	25th day
Pigeon	23-28	100	85-87	15th day	90	14th day
Bobwhite	17	100	84-87	20th day	90	20th day
Cotumix	23-24	100	85-86	15th day	90	14th day
Chukar	17	100	81-83	20th day	90	20th day
	23-24					

2.4 Review on Artificial Incubation

Artificial incubation has evolved significantly over the years, with advancements in both the design of incubators and the understanding of optimal incubation conditions. Early incubators were rudimentary and required manual control of parameters such as temperature and humidity. However, modern incubators are highly automated, incorporating sensors and control systems that maintain precise incubation conditions, leading to higher hatchability rates (Fasanmi et al., 2021).

Several studies have demonstrated the effectiveness of artificial incubation in improving hatchability and chick quality.

Oluwaseun and Akinwale (2022) found that using automated incubators improved hatchability by 15% compared to traditional natural incubation methods.

Bello et al. (2020) reported that artificial incubation led to more consistent hatching outcomes, reduced the mortality rate of chicks, and enhanced productivity in commercial poultry farms.

Despite the benefits, artificial incubation is not without its challenges. The high initial cost of incubators and the need for a reliable power supply are significant barriers to its adoption by smallholder farmers in Nigeria (Okonkwo & Eke, 2021).

The development of hybrid incubators that combine solar and electrical energy sources offers a promising solution to this problem, particularly in rural areas with limited access to electricity (Amadi et al., 2022). These hybrid systems provide a sustainable and cost-effective method for improving hatchability and ensuring continuous chick production.

Olaoye et al., (2013) developed a 120 egg a capacity electric incubator. The system which was coupled with three 100 w electric bulb produced 75.2% fertility in addition to the hatchability rate of 64.8%.

Soeb et al., (2021) developed a low-cost incubator that is made up of the embedded controller Incorporated to an egg turning trays with hatchery apartment of 116 egg capacity for Bangladesh market. The manual and automatically evaluations of the developed hatchery showed a 79.3% and 87.1% hatchability rate respectively. The eggs were turned both manually and automatically as the case may be at intervals of 6hours.

Osanyinpeju et al.,(2016) walked on the development of solar powered poultry egg incubator. The heat produced by metabolic activities of 150 eggs in the system was 21.9 w. The percentage fertility of 64% in addition to 44% hatchability rate was observed with the system. The low hatchability was attributed to faulty hygrometer used which led to increase in the number of opening made at the last stage.

Ogunwande et al., (2015) developed a biogas powered poultry egg incubator that utilizes biogas as a fuel to provide thermal energy via a heater situated at the base. The system produced temperature range of 36-39.4° c within the incubating compartment. At the end of an evaluation test, a hatchability percent of 59.7% was realized.

Uzodinma et al., (2020) carried out a characterization of hybrid solar powered poultry egg incubator. The hybrid incubator is made up of a double glazed flat plate solar collector coupled with paraffin PCM in addition to a PV subsystem. The evaluation of the system reviewed that the incubating temperature was maintained between 36 and 39° c in addition to the mean hatchability rate of 62.37%.

Muhammad et al,. (2022) Studies a thermoelectric egg incubator coupled to heat storage system. Did Samuel electric component is utilized in the daytime process while a heat storage system made up of a phase change material (PCM) which provides derma energy during off-sunshine (especially nights) periods is complementary heat source. The electric energy that is changed to heat for starting the operation is provided with the arrays of the solar PV. The result of the 300 egg capacity system showed that temperature inside incubator chamber was between 36 iPhone 39° c with 73.3% hatchability.

okonkwo et al (2024) researched on energy sources for poultry egg incubator efficiency and hatachability. the result showed that sources of energy for incubation are categorized into grid supply electricity solar system, fossil fuel, biogas and thermochemical materials, from reviewed articles 50% identified grid supplied electricity as energy source for poultry egg incubation and hatachabiliy range from 80.9%-98.4% however, due to erratic nature of electricity supply and non availability in rural areas especially in developing nations, the study recommends increase research intereston other every source to improve their hatachability.

Olasukanmi et al., (2015) developed a GSM based DC battery powered poultry egg incubator. The system is remotely tracked. The major components of the incubator were the DC motor, humidifier, ventilation fans, in addition to the custom made lower-power DC heater provided for controlling the turning of eggs, humidity, ventilation and temperature, respectively. The hatchery could either be powered using solar PV system, greed power electricity via an inverter or any medium that could charge the DC battery.

Despite growing interest in hybrid incubators, existing models have reported technical issues such as inefficient energy storage, poor insulation, inconsistent temperature regulation, and inadequate hatchability results (Mohammed & Okeke, 2019). However, advancements in energy storage technologies, thermostatic controllers, and solar panel efficiency have opened up new opportunities for developing reliable and affordable hybrid incubation systems (Olayemi & Balogun, 2022).

CHAPTER THREE

3 MATERIALS & METHODS

3.1 Materials

The following materials were used in the construction of hybrid egg incubator ;

i. MDF Plywood (Medium Density Fibre Body)
ii. Marine Board
iii. Bolt and Nut.
iv. Screw
v. Ardonic Cabinet Hinge
vi. Edges Tape
vii. Door Bolt
viii. Nails
ix. Screw Cover
x. Plank for the Egg Tray Seat
xi. Egg
xii. Hammer
xiii. Glass Fibre

3.2 Area of Modification

The result from the test of previous machine showed that the machine was able to hatch 20 egg out of 45 eggs after operating the machine this gives 44% hatchabililty rate. The recommendation suggested that the turning mechanism, the temperature and humidity control should be automated for better performance hence the turning mechanism, temperature and humidity control system will be automated and some technical issues like egg fertility will be addressed

3.3 Description of the Hybrid Eggs Incubator

The hybrid eggs incubator assembly and exploded view are shown in figures 3.1 - 3.2. The hybrid eggs incubator are made up of two components ; the main cabinets and the auxiliary unit.

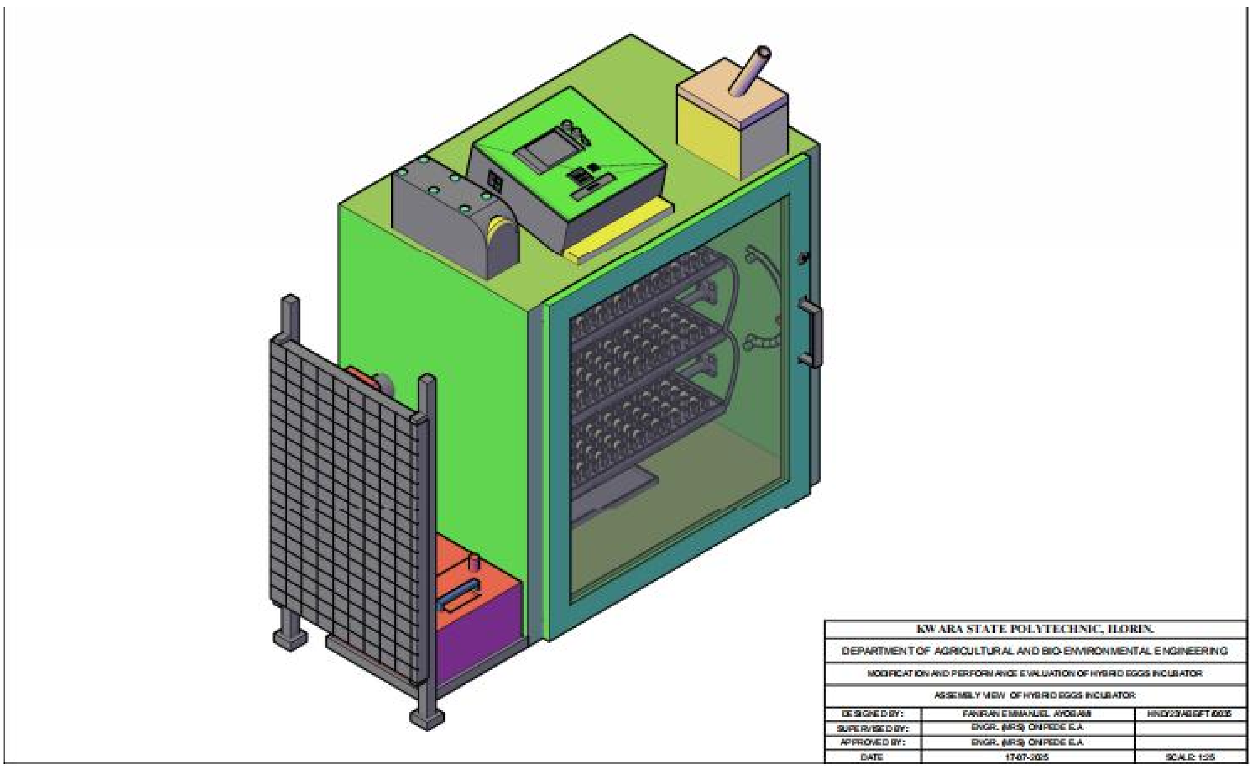
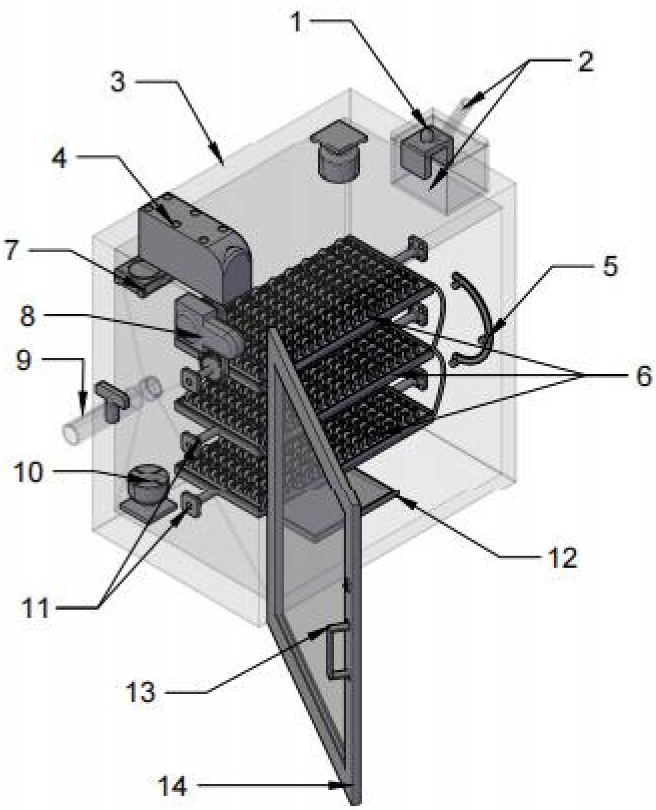


Fig 3.1: Assembly view of hybrid eggs incubator



LEGEND OF AN HYBRID EGGS INCUBATOR			
S/NO	COMPONENTS	MATERIAL	QTY
1	EGG SAMPLE	-	1
2	EGG CANDLER	WOOD	1
3	MAIN FRAME	PLY WOOD	1
4	INVERTER	FINISHED PRODUCT	1
5	ANGLE ADJUSTER	MILD STEEL	1
6	EGG TRAYS	PLASTIC	3
7	FAN	FINISHED PRODUCT	2
8	MOTOR	FINISHED PRODUCT	1
9	VENT	PLASTIC CONTROL VALVE	1
10	BULB	FINISHED PRODUCT	2
11	BEARING	FINISHED PRODUCT	4
12	WATER TRAY	PLASTIC	1
13	DOOR HANDLE	-	1
14	DOOR	PLY WOOD	1

EXPLODED VIEW OF HYBRID EGGS INCUBATOR
ALL DIMENSION IN MM
SCALE 1:25

Fig 3.2: Exploded view of hybrid egg incubator

3.2.1 The Main Cabinet

The main cabinet is the incubating box which consists of the egg trays, fan, bulbs, egg turner, humidity tray, controller and savor motor.

i. The incubating box is made from MDF plywood due to it, insulation properties, ease of construction, flexibility and durability. The dimension of the incubating box is 920 mm x 950 mm x 640mm.

ii. Egg turning trays: The Egg turning trays, is constructed from wood with dimension of 635mm x 335mm x 60 mm to accommodate the egg plastic crates. There are six egg creates, each containing 30 eggs, they were positioned inside incubator and turn 6 hourly.

iii. Humidity tray Is made up of plastic and placed at the bottom of the incubating box to increase and recover humidity in the incubator during experimental period.

iv. The fan is incorporated to facilitate the temperature and humidity in the incubator in order to keep them within the requirement of the present values.

v. The controller was incorporated to sense the temperature, humidity and the turning mechanism of the incubator for effective incubation.

vi. The electric bulb 100 w cells as the source of heat to warm the inner unit to temperature range of 36 - 37.5° c.

vii. The savor motor is used to drive the egg turning tray and tilt it to an angle of 45° either side after a period of 6 hours.

3.2.2 The Auxiliary Unit

The auxiliary unit consists of solar PV panel, solar charge control, battery and inverter. The solar PV panel: Absorb solar energy to charge the battery, the solar charger controls the charging of the battery to prevent overcharging, the inverter converts the direct current from the battery to alternating current to be used by the incubator and at the same time charged the battery when there is electricity.

3.3 Design Consideration

The following factors were considered when designing hybrid eggs incubation

(a) Environmental Control

i. Temperature range of 36.5°C - 37.5°C within the incubator

ii. humidity range of 50% - 60% to prevent water loss and promote healthy development

iii. ventilation within the incubator is necessary for adequate airflow to maintain oxygen levels and remove carbon dioxide.

(b) Egg Handling

i. Regular turning (every 1-4 hours) to prevent embryo adhesion to the shell

ii. Egg orientation to ensure eggs are positioned correctly (large end up) to facilitate proper development.

(c) Energy Deficiency and Sustainability.

i. Incorporating solar energy source to reduce reliance on electrical energy source

ii. Automatic egg turner to reduce labor and ensure consistent turning

iii. Temperature and humidity monitoring to ensure optimal condition

3.4 Design Calculation and Analysis

The design criteria are based on making the equipment more affordable, efficient and durable. the incubator capacity, heating system, turning mechanism, size of battery, power from battery size of solar panel were all designed during the development process.

3.4.1 Determination of Incubation Chamber

The capacity of the incubator is directly proportional to the number of eggs and the number of egg trays. The incubator was design to hatch 180eggs per hatch. The design of incubation chamber was done using equation 3.1 and 3.2.

$$c = \frac{n}{60} \quad (3.1)$$

Where,

C = number of trays

n = number of eggs to be hatched

$c = \frac{180}{60}$

c = 3egg trays

the incubation chamber was designed to contain the egg trays; the incubation chamber was rectangular box like structure.

Volume of incubation chamber

$V = l \times b \times h$

(3.2)

Where:

V = volume of incubator (m^3) (Abubakar et al 2023)

L = length of incubator (m)

B = breadth of incubator (m)

H = height of incubator (m)

3.4.2 Determination of Heat Required for Incubation

Heat required in the incubator was determined from equation 4

$Q = MC\Delta T$ (Benjamin and Oye ,2012)_ _(3.3)

Where;

Q = total heat required

C = specific heat capacity

ΔT = change in temperature

M = molar mass

$$QT = (M_aC_a\Delta T) + (M_eC_e\Delta T) \times N_e + (M_pC_p\Delta T) + (M_wC_w\Delta T) \quad (3.4)$$

(Abubakar et al 2023)

Where;

$M_aC_a\Delta T$ = heat required by air

$M_eC_e\Delta T$ = heat required by eggs

N_e = number of eggs

$M_pC_p\Delta T$ = heat required by plywood

$M_wC_w\Delta T$ = heat required by water.

3.4.3 Heat Loss by Incubator

The heat loss due to conduction can be calculated from the equation 3.5 - 3.9

$$Q = -KA\left(\frac{ST}{Sx}\right) \quad (3.5)$$

The flow of air is steady inside the incubator therefore it does not vary with time.

$$QSx = -KAST \quad (3.6)$$

$$Q = -KA\left(\frac{Tinc - Ts}{X}\right) \quad (3.7)$$

Where;

Q = heat

K = thermal conductivity coefficient of plywood (0.65) in the design

X = is the thickness of the plywood (15mm)

Heat loss during incubation is given as top and bottom of plywood.

$Qptpbpspfpbt = -KA(\frac{Tinc - Ts}{X}) \times 2$ _ (3.8)

(Bala et al, 2020)

Where;

Pt = is the plywood top

Pb = plywood backside

Ps = plywood side

Pf = plywood front

Pbt = plywood bottom.

A = area of incubator chamber

K = thermal conductivity coefficient (0.65 forMDF) plywood (Ajani et al 2020).

The quantity of heat loss is calculated using the following equation

QL = Qptm + Qpss + Qpfb_ (3.9)

The quantity of heat required for the incubation

Q = Ql + Q1_ _(3.10)

Where:

Q = quantity of heat required for incubation

QL = heat loss by the incubator

Q1 = heat required of the incubator.

3.4.5 Determination of Humidity

The humidity keeps the eggs from losing two much moistures in the process of incubation it is calculated from equation 3.11 – 3.13

$$H = \frac{Mv}{v} \quad (3.11)$$

$$\rho = MvRvT \quad (3.12)$$

$$H = \frac{v}{RvT} \quad (3.13)$$

Where:

H = humidity

ρ = energy density/heat density of water

T = temperature

Mv = molar mall of water

Rv = gas content

V = volume of the incubator’s chamber

3.4.6 Total Power Consumption

The total power consumption of the entire incubator system can be calculated from the following equation.

Total power consumption (PT) =P1+Pfh+Pfv+Pc _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ (3.14)

(Abba- ayi et al 2024)

Where;

P1 = power of the incubator chamber

Pfh = power of humidity fan

Pfv = power of ventilation

Pc = power of control board.

3.4.7 Power Requirement and Selection of Battery Solar Panel and Inverter

Total power consumption is added up to 130.435W base on the total power requirement of the incubator. A 200AH lithium phosphate acid battery 12v, a 1KVA inverter and a 300W solar panel will be used to power the entire incubator.

3.4.8 Size of Solar Charger

Size of solar charger was determine using equation 3.15.

SSc = $\frac{wp}{v} \times Pf$

Where;

SSc = size of solar charger (AH)

Wp = wattage of solar panel (W)

V = voltage of the battery (V)

Pf = power factor (1.25)

Size of solar charger =21AH but use 25AH

3.4.9 Battery Running Time

The battery running time was calculated using equation 3.16

$$BR = \frac{Bc}{L}\ Pf \qquad (3.16)$$

Where;

BR = battery running time (H)

Bc = capacity of battery (AH)

L = load of appliance (w)

Pf = power factor (10)

Battery running time is 16 hours but charging should start after 12 hours.

3.5 Material Selection

The following materials are put into consideration for the selection of materials used for hybrid eggs incubator

i. Conservation of heat: MDF plywood was used for construction to conserve heat.

ii. Availability of material: The material used is easily available for repair and replacement.

iii. The cost of material: The cost of materials used is not expensive and will eventually leads to low cost of the incubator.

iv. The durability of the material: The material for construction was the type that will last long and have resistant to insect infestation.

v. The easy of construction: The material used for construction is easy to work upon for mass production.

vi. The weight of material: The material used for construction was light weight for easy transportation.

vii. Lagging material: Fibre glass was used as a lagging material to further conserve and prevent loss.

3.6 Construction and Assembly Procedure of Hybrid eggs incubator

The tool used for the construction include; the hammer, hacksaw, paper tape, nail, bolt and nut. The medium density fibreboard (MDF)plywood of 50mm thickness was cut according to the design specification and joined together by nails and screw to form the incubating box. The three egg trays were in incorporated into the incubating box using bearing at ---- interval between one another to serve as egg crates seat. The savor motor was incorporated to the egg tray to facilitate the turning of the egg trays. The control board that houses temperature, humidity and time of turning was also incorporated.

3.7 The operation of hybrid egg incubator

The hybrid egg incubator is operated using two sources of energy (electrical and solar energy) that complement one another to prevent power interruption and for efficient incubation. When electricity is available, the incubator is powered directly from the main but in case of power outage the incubator is powered by solar power system. The solar power system consists of solar panel, solar charge control, battery and inverter.

The solar PV absorbs solar energy from the sun and charge the battery via the solar charge control, the DC from the battery is converted to AC by inverter for the use of the incubator thereby preventing power interruption that may be caused by power outage. The switching of power from electricity to solar or vice-versa is made possible through automatic incubator control system.

3.8 Bill of Engineering Measurement and Evaluation

Bill of engineering measurement and evaluation is presented in table

Table 3.1 : Bill Of Engineering And Evaluation

S/N	Material	Rate	Quantity	Amount
1	MDF Plywood 15mm	35,000	1	35,000
2	Marine Board 15mm	45,000	1	45,000
3	Egg Tray	20,000	3	60,000
4	Egg Crate	800	6	4,800
5	Turning Mechanism	50	-	50,000
6	Incubator Box Glass	30	1	30,000
7	DC Fan	8,000	2	16,000
8	Bearing	8,000	6	4,800
9	Electric Motor (Savor)	45,000	1	40,000
10	Controller Board	95,000	1	95,000
11	Eggs	7,500	6	45,000
12	Miscellenous	15,000	-	15,000
	TOTAL			440,600

3.9 Performance Evaluation of Hybrid Eggs

3.9.1 Source of Material Source: The fertile eggs for evaluation were purchase from a poultry farm in Oke Ose, Ilorin East Local Government of Kwara State.

3.9.2 Preparation of Sample: The eggs were cleaned using sand paper, the eggs were of good size and shape. The incubator was fumigated for a day to prevent any contamination in readiness for incubation.

3.9.3 Output Parameter: The output parameters to be measured are;

Percentage Hatchability:

i. Percentage hatchability is the number of hatched eggs to the number of fertile eggs loaded into the incubator in percentage.

The equation is stated in 3.17

$$\text{Ph} = \frac{Nh}{Nfe} X100 \text{ .... } 3.17$$

Where;

Ph = Percentage hatchability (%)

Nh= Number of hatched eggs

Nfe= Number of fertile eggs loaded

ii. Percentage Fertility:

Percentage fertility is the number of fertile eggs to the number of eggs loaded into the incubator in percentage.

The equation is stated in table 3.18

$$\text{Pf} = \frac{Nfe}{Nf} X100 \text{ .... } 3.18$$

Where;

Pf = Percentage fertility (%)

Nfe = Number of fertile egg

Nf = Number of eggs loaded into the incubator

iii. Mortality Rate

Mortality rate is the number of death to the number of fertile eggs loaded into the incubator

The equation is stated in 3. 19

$$MR = \frac{Nd}{Nfe} X100$$

Where;

MR = Mortailty rate

Nd = Number of death

Nfe = Number of eggs loaded

3.10 Experimental Procedure

The performance evaluation of hybrid eggs incubator was carried out at Kwara State Polytechnic Institute of Skills Acquisition, Mini Campus, Ilorin. The hybrid eggs incubator was fumigated and run empty for one day to ascertain the satisfactory performance of the incubator.

One hundred fowl eggs were purchased from a poultry farm in Oke Ose, Ilorin East Local Government of Kwara State and loaded into the hybrid egg incubator.

The temperature, humidity and turning of egg tray were monitored. The temperature and humidity were taken three times a day and the mean value for each day was recorded while the turning of egg trays was on 6 hourly.

The candling of eggs was done on the 7th day of loading and the second candling was done on the 14th day of loading. The turning of egg tray was stopped on the 18th day of loading. The unfertilized and bad eggs removed from the incubator was 34 eggs while the remaining 66 eggs were incubated for the period of 21 days. The hatching of eggs started on the 20th day of incubation. The number of hatched eggs were 58 while the remaining 8 were dead in the shell.

CHAPTER FOUR

4 RESULT AND DISCUSSION

4.1 Result

The result of performance evaluation of hybrid egg incubator is as shown in table 4.1 - 4.3

Table 4.1 Candling test on 7th day on incubation

S/N	No of Eggs	Development	Observation	Remark
i	10	not visible	Clear	Infertile
ii	11	not visible	Larger air space	Infertile
iii	40	visible at one end	Liner running across	Fertile
iv	39	visible at the centre	Visible patches of red strain	Fertile

Table 4.2 Candling test on the 14th day of incubation

S/N	No of Eggs	Development	Observation	Remark
i	13	Not visible	Clear	No development
ii	61	Dark appearance	Clear air space	Development in progress
iii	6	The whole egg is dark	No air space	Development ceased
iv	5	Dark Appearance	Beak is visible	Almost fertile
v	7	The whole egg is dark	Visible patch of red stain	Development ceased

Table 4.3 Average records of temperature and humidity for 21days of incubation

S/N	Temperature(°c)	Humidity(%)
1	37.2	50.1
2	37.4	52.1
3	37.3	53.1
4	37.2	52.6
5	37.3	57.7
6	37.4	54.9
7	37.4	58.2
8	37.5	58.3
9	37.4	59.8
10	37.4	56.0
11	37.4	56.3
12	36.1	50.4
13	37.5	56.2
14	37.5	56.2
15	37.5	56.1
16	37.3	52.4
17	37.3	55.9
18	37.5	53.4
19	37.4	57.9
20	37.3	60.0
21	37.4	54.1

The output parameter are;

i. Percentage hatachability = $\left(\frac{number\ of\ eggs\ hatched}{number\ of\ fertile\ egg}\right) \times 100$

$$= \frac{60}{66} \times 100 = 91\%$$

ii. Percentage fertility = $\left(\frac{number\ of\ fertile\ eggs}{number\ of\ eggs\ incubated}\right) \times 100$

$$= \frac{66}{100} \times 100 = 66\%$$

iii. Mortality rate = $\left(\frac{number\ of\ death\ embroy}{number\ of\ eggs\ incubated}\right)$

$= \frac{6}{66} \times 100$ = 9%

4.2 Discussion

The result of incubation from 4.1 showed the temperature range of (36.1° – 37.5°) during the performance evaluation which corroborate the findings of Hard et al (2010), Gbabo et al (2014), Nithin et al (2014), Oniya et al (2010). This showed that the equipment was suitable for incubating fertile eggs. The relative humidity range (50.1 -60%) during performance evaluation was within the range obtained by Oniya et al(2013). The minimum temperature and humidity from the first day to 21st day were 36.1c° and 50% respectively while the maximum temperature was 37.5°c and maximum humidity was 60% for the period of incubation.

CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

A hybrid egg incubator that combines electricity with solar energy to complement one another to prevent power interruption of the machine during incubation was modified and constructed. The temperature and humidity range within the incubator during performance evaluation were 36.1 – 37.5°c and 50.1 – 60% respectively. The percentage hatachability of the incubation is 91%. The incubator is suitable for the hatching of poultry eggs and is therefore recommended for poultry farmers.

5.2 Recommendation

Intensive performance evaluation should be carryout using other species of poultry birds like turkey, duck, guinea fowl. Sponsorship should be provided by relevant agencies in order to improve the machine and stop importation of incubators.

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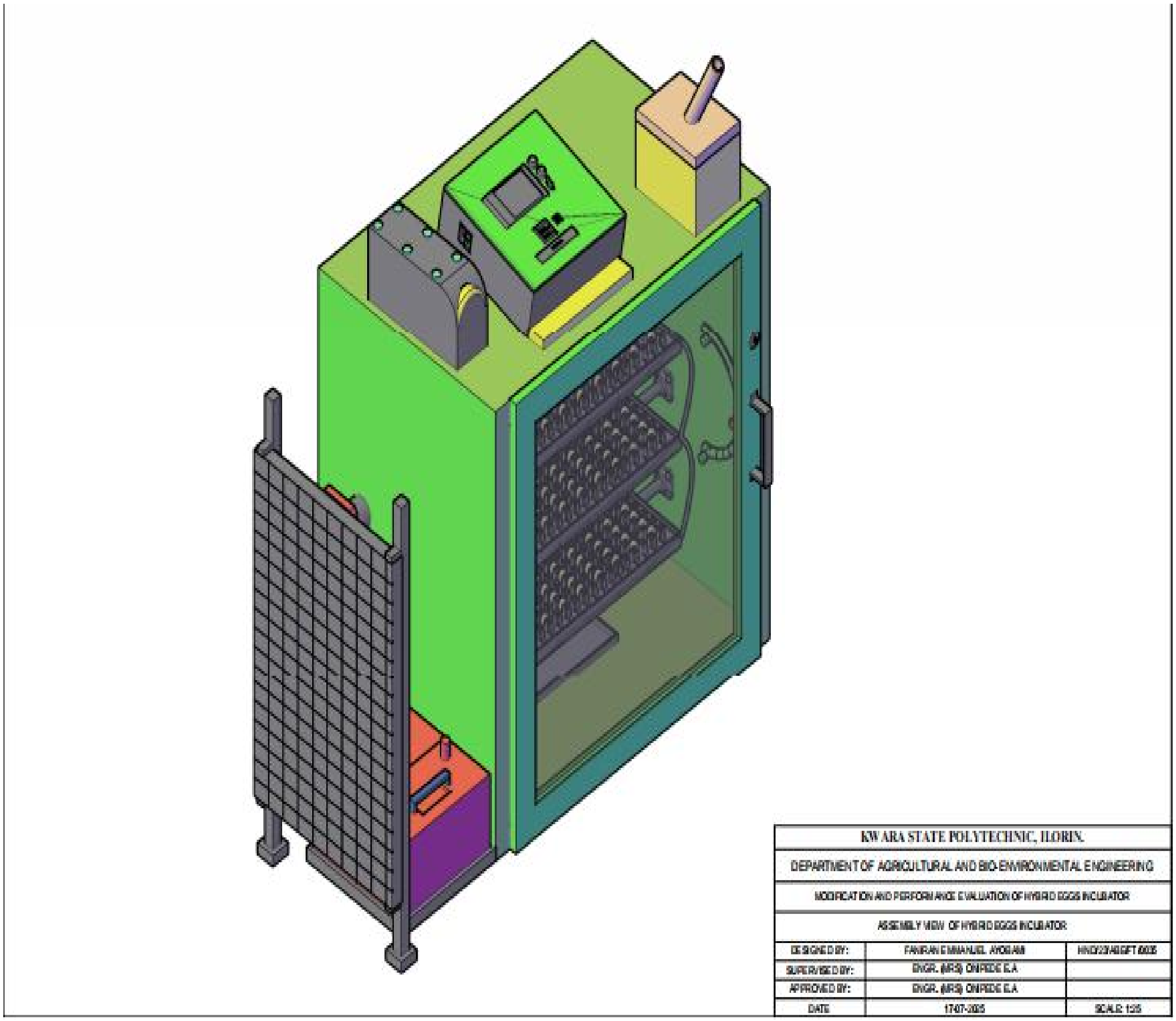
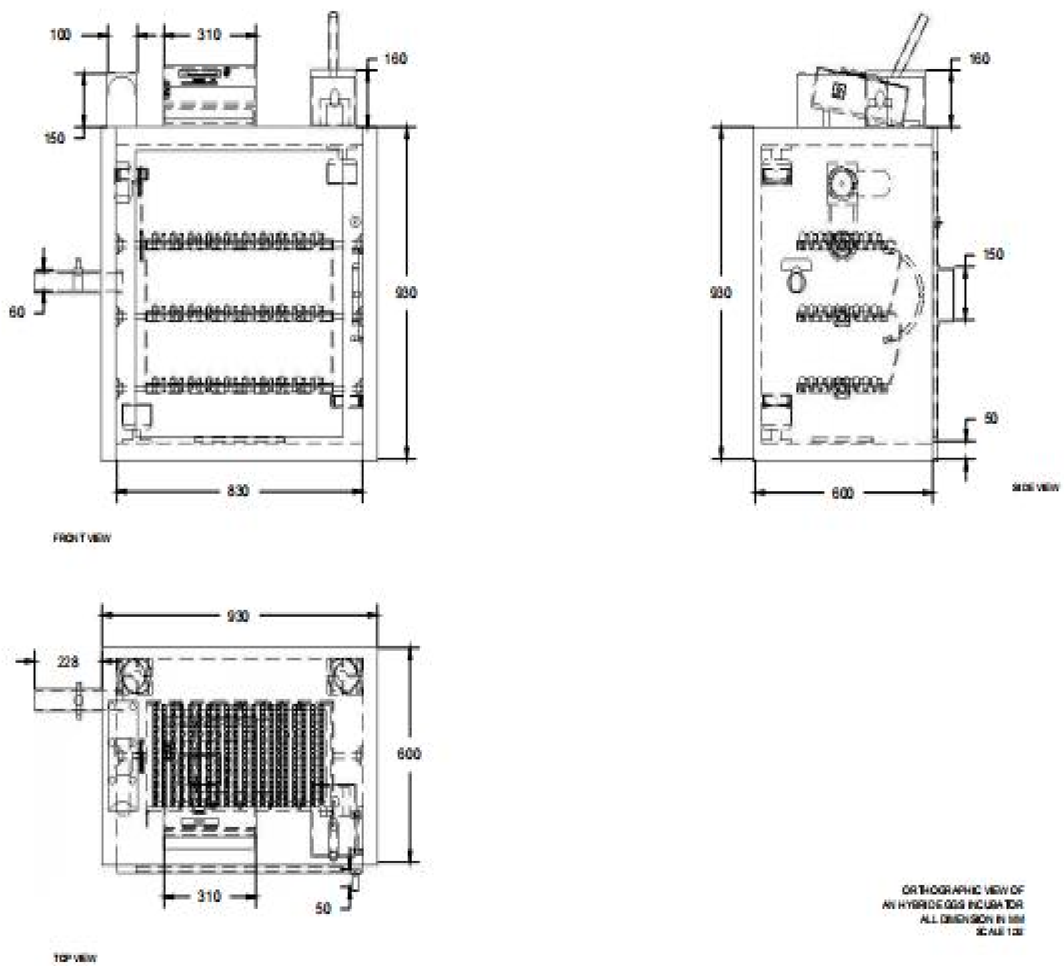
APPENDIX A



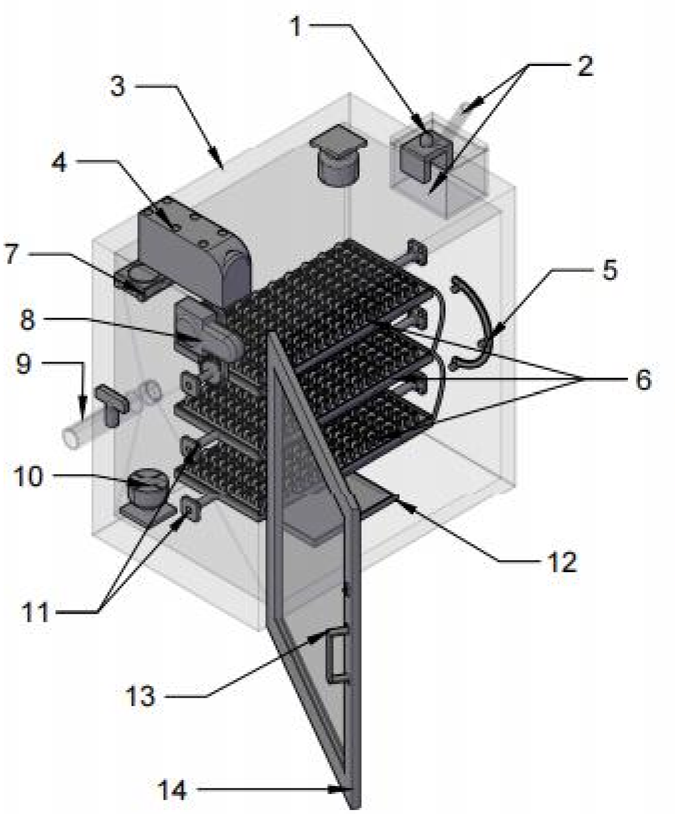
Assembly view of hybrid eggs incubator

APPENDIX B



Orthographic view of an hybrid eggs incubator

APPENDIX C



LEGEND OF AN HYBRID EGGS INCUBATOR			
S/NO	COMPONENTS	MATERIAL	QTY
1	EGG SAMPLE	-	1
2	EGG CANDLER	WOOD	1
3	MAIN FRAME	PLY WOOD	1
4	INVERTER	FINISHED PRODUCT	1
5	ANGLE ADJUSTER	MILD STEEL	1
6	EGG TRAYS	PLASTIC	3
7	FAN	FINISHED PRODUCT	2
8	MOTOR	FINISHED PRODUCT	1
9	VENT	PLASTIC CONTROL VALVE	1
10	BULB	FINISHED PRODUCT	2
11	BEARING	FINISHED PRODUCT	4
12	WATER TRAY	PLASTIC	1
13	DOOR HANDLE	-	1
14	DOOR	PLY WOOD	1

EXPLODED VIEW OF HYBRID EGGS INCUBATOR
ALL DIMENSION IN MM
SCALE 1:25

Exploded view of hybrid eggs incubator