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A Smart Hybrid Eggs Incubator for Small Scale Application

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Abstract– *In this study, a smart hybrid incubator was constructed and tested. To increase production of day-old poultry chicks, the incubator has solar power system to compliment power shortage in the event of failure from the national grid. The capacity of the incubator is 720 eggs. During the performance evaluation of the system, a temperature of 38.5 ^{0}C and humidity 64% were maintained. Turning of the eggs' tray was achieved by a microcontroller that control the electric motor at an angle of 45 ^{0} after a period of six hours. Fresh eggs of Broiler, Noilier chickens, guinea fowl and turkey were tested twice from 6th May to 3rd June, 2020 and 7th June to 3rd July,2020. Fertility of the eggs were determined by candling method after ten days of laying the eggs after which fertile eggs were returned to the incubator. The system hatching rate of the incubator was between 88.6% to 96.1%. The automatic turning of the eggs was effective throughout the period. However, turning should stop some few days prior to hatching; that is three or four days maximum, because the embryos are moving into hatching position and need no turning. Therefore, three days to hatch the eggs were transferred to the hatching basket or hatcher. Utilizing the solar power indeed has provided a solution to the major constraint of power failure or inadequacy for commercial poultry farming.*

Keywords: *Incubator; Hybridization; Microcontroller; Hatching, Renewable energy; Chicks.*

I. Introduction

An incubator is an electro-mechanical device that used to provide temperature and humidity for fertilization of eggs (Ozioma *et al.*,2016). Egg fertilization is an important factor in the hatching of poultry eggs. It is possible to hatch eggs without the consent of the mother hen. The fertilization of egg embryo remains a priority of any farmer since his profits depend on hatchability rate of the eggs, this embryo when mature well give birth to a chick. It is therefore necessary to manage the fertilized eggs with care which latter develop into a normal chicken. The eggs required warmness either naturally or artificially as the case may be. The natural method required the bird to provide the warmness or the required temperature by sitting on the eggs in an open space (Idoko *etal.*,2019). Poultry is a kind of domestic birds that can be kept at home by human so that their eggs are collected. It is second most widely eaten meat. Poultry farming include egg hatching and brooding. Incubation is a process whereby poultry eggs under goes to hatch their eggs, embryo is developed within the egg (Ramli *et al*., 2015). Incubation is also being described as technology by which eggs are incubated and hatched with the help of man-made technology called incubator. The incubator controls the temperature and humidity in preparation for hatching process and also provides fertile egg with the moist warm air and artificial stirrer as the embryo emerges into a poultry within a period of 21 to 41 days (Osanyipeju *etal.*,2018).

Hatching of eggs comes in two different ways naturally (here mother chicken provides the warm by direct contact with egg for the required period) while the artificial egg incubator technology that provides opportunity for farmers to produce chicks from eggs without the consent of the mother hen. Artificial incubation it is one of the fastest 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 (Salawu, 2020). Artificial incubation procedures of eggs hatching were originated in both chines and Egyptian, chines developed a method of burning charcoal to supply the required heat, the Egyptian incubator was developed by constructing a large brick incubator which was heated with fire right in the room where the eggs are kept for hatching (Ajani, 2020).

Modern poultry industry incubation requires mechanical systems to replace the broody hen for egg incubation which was commercialized into large scale only within the period of 60 - 70 years (Adeoye,2015). The three important parameters for incubation of eggs are the relative humidity (warmed air surrounding the egg), temperature and egg turning in terms of angles of inclination of egg tray as its wing in either side of the axes within the incubator. The ambient temperature has a strong relation with the incubator it forms the basis for calibrating the incubator chamber temperature against the ambient temperature and this relationship can be used for predicting the incubator temperature at any given time for unknown ambient temperature (Osanyinpeju *et al.*,2018). In addition, ventilation is yet another important factor during the incubation process. While the embryo is developing, oxygen enters the egg through the shell and carbon dioxide escapes in the same manner (Mohd, 2008). The air vent openings are gradually opened to satisfy increased embryonic oxygen demand as well as to take care of humidity during the hatching period. Unobstructed ventilation holes, both above and below the eggs are essential for proper air exchange (Mohd, 2008).

Solar energy has gain significant interest as means of providing the electricity to the incubator for incubation of eggs, this will have answer to the insufficient power constraints faced by poultry industries in remote areas. Continuous supply of electricity in Nigeria is a mirage due to the frequent power failure which also lead to the used of other sources like generators, kerosene and gas, therefore building and utilizing a solar powered egg incubator will improve the result of poultry

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chicken farming and the overall living of the farmers and communities in general (Kelebaone *etal.*,2019).

TABLE 1: Condition for various eggs incubation

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

Measured at degrees F, in a force air incubator. For still-air incubators, add 2-3-degree F. Measured at degree F using wet-bulb thermometer. Use chart to convert to relative humidity.
Source: Missippi state university Extension services.

II. Materials and Methodology

2.1 Materials Used

The construction of the smart solar powered incubator was made from the following

Materials; Plywood, Humidity fan, Humidity and temperature sensor, Ventilation fan, Solar panels (PV) Inverter, Plastic egg crates, Angle bar, Microcontroller, Chain, Sprocket, Water container. The various parts were fabricated separately and later assembled.

2.2 Mechanical Components

The mechanical components of the incubator consist of; incubator box, fan, the egg turning tray, chain and sprocket and the savor motor.

2.2.1 The incubator box

Plywood type of good quality and insulation properties was used to construct the box-like shape to form the main casing of the incubator as shown in the Figure 1 below. The plywood was chosen due to ease in construction flexibility and durability. In order to construct an incubator of 720 capacity the dimension 1240mm by 900mm was chosen.

2.2.2 Egg turning trays

The egg turning tray is fabricated from angle bar with dimension of 0.59m × 0.79m to accommodate the egg plastic crates. There are four egg trays each containing 180 eggs, they were positioned inside the incubator at an angle of 45^0 and turns after every 6hours either side of its pivot to enable uniformity in temperature and humidity level.

2.2.3 Chain and sprocket

The chain and sprocket provided connection between the savor motor and the egg turning trays.

2.3 Electrical and Electronic Components

The electrical component of the incubator includes the electric bulb 100W which serve as the source of the heat to warm the inner unit to temperature of 38.5^0C. The solar panels were placed on the roof, battery, charge controller and AC to DC inverter were positioned by the right-hand side of the incubator as shown in Figure1.Other components are intelligent microcontroller that record and display the temperature, humidity and the turning time of the egg's tray.

2.3.1 Electric motor (Savor Motor)

The savor motor is used to drive the egg turning tray and tilt it to angle of angle 45^0 either Side after a period of 6hours via the microcontroller setting.

2.3.2. Humidity fan

The humidity fan is used to facilitate the temperature and humidity in the incubator in order to keep them within the requirement of the preset values.

2.3.3. Ventilation fan

The ventilation fan provides cooling to an overheated egg incubator and make sure exchange of oxygen-carbon dioxide is maximized. Ventilation fans were installed from the rear as well as the upper end of the incubator to ensure proper humidity and temperature distribution (Dalangin and Ancheta,2018)

2.3.4. Temperature and humidity sensor.

The temperature and humidity sensing device were connected to measure the temperature and humidity of the incubator.

2.3.5. Intelligent microcontroller

The intelligent microcontroller is an electrical hardware, which is programmed to control all the important parameters involved in the incubation process and display the result on the LCD screen

2.3.6 LCD screen

The LCD screen is an electronic hardware connected to the temperature and humidity sensing device in order to display the temperature and humidity and other related information of the incubator.

2.3.7 The bulb

Two (2)100watts bulbs were used to provide the required amount of heat to raise the temperature to 38.5^0C.

2.3.8 Relay

The relay is an automatic switch, when the temperature is above the requirement the relay automatically switch OFF and ON when the temperature falls below pre- determined value.

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III. Results and Discussion

3.1 Result

The results were obtained based on the following tests

3.1.1 Testing of the unloaded Incubator

After the construction of the incubator, it was protected indoor to avoid the sudden change weather conditions. The temperature and humidity of the incubator was set and maintained between 34.5^{0}C -38.5^{0}C and humidity between 55 to 70% respectively. Table 2 shows the record of the temperature and humidity of the incubator for a period of 5days.

Figure 1: The incubator system after construction

TABLE 2: Record of Temperature and Humidity for five days.

S. No.	Date	Temperature (^{0}C)	Humidity (%)
1.	1st May,2020	38.5	59
2.	2nd May,2020	37.5	55
3.	3rd May,2020	37.6	56
4.	4th May,2020	37.8	58
5.	5th May,2020	38.5	64

3.1.2 Testing of the loaded incubator.

After the incubator was tested unloaded with eggs for five days. Variety of eggs was loaded in the machine in order to test its performance as shown in the Figure 2. The hatchability and embryo mortality rates of the eggs were determined by using the following relations and the result is as shown in Table 3 below.

$$\text{Hatchability Rate} = \frac{number\ eggs\ htched}{number\ of\ fertile\ eggs} \times 100 \quad \dots (1)$$

$$Embryos\ mortality\ rate = \frac{Number\ of\ dead\ embryos}{Number\ of\ eggs\ incubated} \times 100 \quad \dots (2)$$

(Dalangin and Ancheta,2018)

Figure 2: Incubator loaded with eggs

Figure 3: Hatching process in the hatcher.

Figure 4: Successful Hatched chicks

Figure 5: Sample of unsuccessful hatched chicks

Figure 6: Successful hatched Guinea fowls

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Figure 7: Sample of various hatched birds.

3.2 Discussion of Results

The incubator was located indoor in order to protect it from weather changes, temperature and humidity were maintained as shown in Table above which was recorded for five days. Fresh healthy eggs of Broiler chicken (300), Noilier chicken (170) Duck (40), Guinea Fowl (220) were loaded to the incubator. Candling process was done on the 10^{th} day to determine the fertility of the eggs. Finally, on the 21^{st} day hatching process of the chicken took place and on the 28^{th} days hatching process of the guinea fowl and duck took place. During the process of the incubation closer observation was made, assistance was given to chick during the hatching for those that failed to break the shell after 8hours (Osanyinpeju *et al.*,2018).

TABLE 3: Record of incubation from (6^{th} May to 3^{rd} June,2020)

Types of Eggs	Days of incubation	Number of eggs	Fertile Eggs	Infertile eggs	Hatched eggs	Hatchability (%)	Embryo Mortality rate (%)
Chicken (broiler)	21	300	280	20	263	93.9	6.1
Chicken (Noilier)	21	170	152	18	146	96.0	4.0
Duck	28	40	35	5	29	82.9	17.1
Guinea fowl (broilers)	28	220	197	22	190	94.4	56.6

TABLE 4: Record of incubation from (7^{th} June to 3^{rd} July,2020)

Types of eggs	Days of incubation	Number of eggs	Fertile eggs	Infertile Eggs	Hatched eggs	Hatchability Rate (%)	Embryo mortality rate (%)
Guinea fowl	28	300	276	24	254	92.1	7.9
Turkey	28	20	16	4	15	93.7	6.3
Pigeon	17	25	23	2	20	86.9	13.1
Chicken (Boiler)	21	240	220	20	197	89.5	10.5
Chicken (broiler)	21	100	88	12	78	88.6	11.4

The process was repeated for a period between May to July of year 2020.Equation (1) was used to determine the hatchability of the system.

IV. CONCLUSION

Performance test was conducted on the smart solar power poultry egg incubator with a hatching capacity of 720 eggs. The solar power provides a stable power supply to the machine throughout the incubation period. Hatchability rate of the system was between 88.6% to 96.1%. The automatic turning of the eggs was effective throughout the period but three days to hatching, eggs were transferred to the hatcher or hatching basket based on their incubation and hatching periods. Interior temperature was also observed to be 38.5^0C. Utilizing the solar power for incubation of eggs provided a solution to a major constraint of power failure for commercial poultry farming.

4.1 Recommendations

After construction and testing of the incubator, the following recommendations were made;

(i) There is need to design the incubator of this capacity putting into consideration the ease and accessibility of the materials and equipment used.
(ii) Lagging of the incubator is required in order to reduce heat lose which usually affect the temperature and humidity of the incubator.
(iii) Information obtained from this work should be made readily available to direct users by relevant authority concerned.
(iv) Sponsorship should be provided by relevant agencies to researchers in order to improve the machine and stop importation of incubators.
(v) There is need to include SMS module in order to monitor the conditions of the eggs and send feedback from far locations.

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