

DEVELOPMENT AND PERFORMANCE EVALUATION OF A KEROSENE FUELED INCUBATOR

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Abstract

The price of day old chicks has recently skyrocketed in the Nigerian poultry market. This is mainly due to the scarcity of materials for producing day old chicks, a problem resulting from the prohibitive cost of imported incubators.

Design and construction of a locally made incubator if proved functional will save a lot of foreign exchange. The availability of a locally built incubator will be an advantage to farmers. In as much as the machine will be simple in construction, its operation will not be difficult for the average farmer.

This paper reported design and operation of an incubator which uses kerosene as a source of heat. The control of temperature and relative humidity is done manually. Temperature is controlled by varying the size of the air inlet/gate at the sides of the incubator. Humidity is however varied by varying the sizes of water tray placed at the base of the incubator. The turning of the eggs for the first eighteen days was carried out semi-automatically

The observed temperature during the test period ranges between 37°C and 40.5°C and the relative humidity between 50% and 60% for the first eighteen days after which it was increased to 77% for the last three days. At the end of the incubation period, five strong chicks emerged out of their shells, four fully developed chicks unable to hatch following pipping and two dead 'germ' showing percent hatchability of the machine to be 47%.

INTRODUCTION

Chick production is a specialised branch in the poultry industry. Chicks are highly perishable commodity and their marketing is highly competitive. Thus the profit margin is low. Natural and artificial incubation are two methods that can be used for producing chicks. The former uses natural instincts of the broody hen to incubate and takes care of the chicks. She actually hatches the eggs herself. The latter method is achieved by the use of special machines known as incubators. To embark on this industry, a lot of capital is required to buy land and equipment, the incubator being the most costly item. This in effect results in high production cost, hence there is a need for a low cost, locally developed incubator whose operation is simple and easy to manage.

Having a locally fabricated incubator will be an advantage to the nation and the poultry farmers. It will save a lot of foreign exchange as there will be a fall in the importation of incubators. The average farmer will also be able to operate and maintain the machine since the local users' interests will be considered in the design.

LITERATURE REVIEW

Eggs can be incubated either naturally or artificially. Natural method is that carried out by a broody hen sitting on the eggs to incubate them until they are hatched while artificial method is by the use of incubators. Natural method is the one normally practiced by local poultry producers. The incubation nest is placed in a quiet corner where the hen will not be disturbed and can be allowed to exercise for short period of time sometimes twice a day (Akinsanmi, 1975). Detailed studies on the incubating temperature have been carried out on the domestic hen. Her body temperature during incubation varies between 39°C and 40.7°C with the eggs maintained at only one and a half to three degrees lower (*The American People Encyclopedia*, 1962).

In modern poultry farming, incubation is carried out artificially in box-like structures known as incubators. The incubator is an enclosure device that simulates the environment necessary for the development of living creatures (*The American People Encyclopedia*, 1962).

The temperature in the incubator must be sufficient to keep the embryo within the egg alive. The air in the incubator must not be too dry, as there will be loss of moisture from the egg. There should be constant supply of oxygen in circulation. The carbon dioxide produced by the respiring embryo should not be allowed to accumulate in the incubating chamber hence the need for the ventilation.

Environmental condition inside the incubator:

To operate the incubators successfully, it is helpful to have some knowledge of the development of the chick embryo to develop satisfactorily.

Temperature

The temperature inside the incubator must be sufficient to keep the embryo within the egg alive. Embryonic development is initiated when the eggs are exposed to a temperature of 26.6°C to 29.4°C but development is most satisfactory when the temperature ranges from 37.2°C to 39.4°C (Oluyemi and Roberts, 1979).

If the temperature is relatively low, it leads to delay in hatching, if high it leads to hatching too soon and malformed chicks may arise (Nico and Johan, 1985).

Relative Humidity:

The exact relative humidity depends on the type of incubator and the age of the eggs in the incubator. A 50-60% relative humidity is however generally considered as standard. Humidity that is too low at the end of incubation impedes the emergence of chicks from their shells while too high humidity may lead to chicks emerging with wet down feathers (Oluyemi and Roberts, 1979).

Ventilation

The developing embryo respire thereby needing an adequate ventilation. An average sized eggs (of about 50g) consumes nine (9) pints of oxygen and emits five (5) pints of carbon dioxide through the incubation period (Lane - Peter, 1960). To meet the respiratory

needs, there should be 21% oxygen inside the incubator as in normal air.

Turning:

It is necessary to turn the eggs regularly. If the eggs are not turned, the hatching results will be very poor. The eggs should be turned not less than three times a day and for an odd number of times if turning is confined to day time. If turned for an even number of times, the eggs will continue to rest on one particular side every night which will tend to defeat the purpose of turning which is to prevent the embryos from getting stuck to the shell.

Materials and Method

Description of the Machine

The incubator designed and constructed is of the table type with the frame work made of wood. The heat section is linked with the incubating chamber by a 60mm diameter pipe. This conveys heated air into the incubating chamber.

The heating accessories consist of a stove, a cylindrical connector made of sheet metal and a pipe. A 60mm diameter hole was drilled into the incubation chamber at the lower portion of the machine through which the inlet pipe enters into the incubator.

The main chamber which is the incubating chamber consists of two layers, one is the setter while the other is the hatcher. The setter is above the heater because the temperature needed during the first eighteen days is higher than that needed during the last three days and since heated air always circulate to the upper chamber and because of the location of ventilation opening, the temperature at the setter is higher than that of the hatcher.

The two egg trays consist of wire mesh at their bases. The wire mesh facilitates the holding of the eggs and movement of heated air around the eggs. The trays are supported by wooden racks at the sides to aid the sliding action of the trays inward and outward during turning. Each tray, holds 30 eggs.

Beneath the second egg tray, is a tray containing water for relative humidity control. At one opposite side of the incubator are two 120mm by 60mm slots for ventilation purpose. The size of each slot is varied to control the temperature of the chamber.

Figures 1 and 2 show the isometric and orthographic views of the machine respectively. At the other opposite sides of the incubator are two 10mm holes with a cord passing

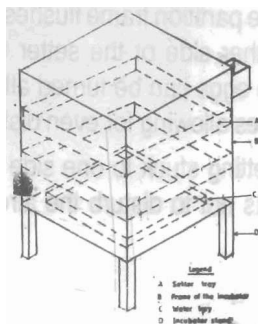


Fig. 1: ISOMETRIC VIEW OF THE INCUBATOR.

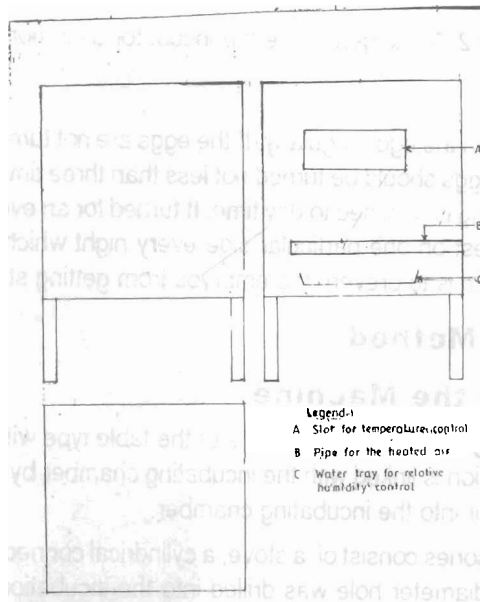


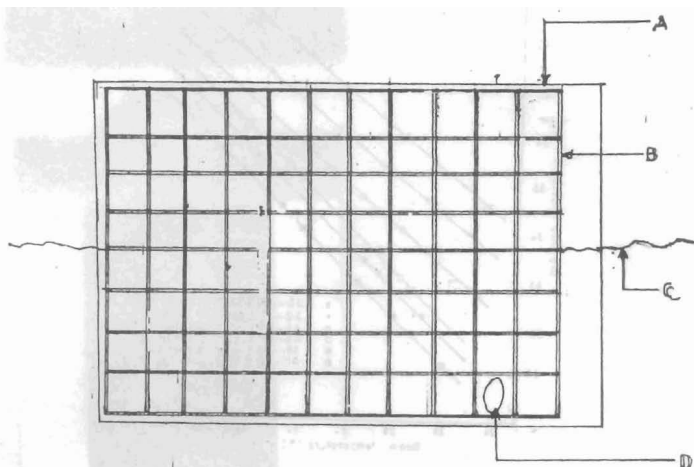
Fig. 2: ORTHOGRAPHIC VIEW OF THE INCUBATOR.

through it for turning the eggs. The two 120 x 60mm slots at the sides of the incubator are to facilitate good ventilation. They can be closed partially or fully depending on the temperature inside the incubator. Figure 3 shows the plan view of the setter tray with turning mechanism.

Turning Mechanism:

The turning mechanism was semi-automated in that the incubator door need not to be opened before all the eggs are turned. All the eggs are turned at the same time and this was made possible by partitioning the setter tray into 30 spaces with each space containing an egg as shown in Figure 3. The material used for partitioning was not fixed to the setter tray frame but was fixed together to make a single solid frame so that if any part of it is moved, other parts are equally moved. A long cord was tied to the centre of both ends of the fixed frame with the ends of the cord passing through the hole drilled at the centre of the setter tray's frame sides of the incubator.

At any point in time, one end of the partition frame flushes with one side of the setter tray leaving a clearance between the other side of the setter tray and the other end of the partition frame. With this setting, the eggs can be turned alternatively from the sides. The eggs were turned through 180 degrees allowing for even distribution of heat throughout the egg, preventing the embryo from getting stuck to one side of the egg shell. Turning was stopped on the eighteenth day so as not to disturb the already formed chicks inside the eggs.



Legend

- A. Frame for the setter
- B. Setter
- C. Rope for turning
- D. Egg to be incubated

Fig. 3: PLAN VIEW OF THE EGG AND TRAY.

Calibration of Temperature

During the no load test (i.e. test carried out when the machine was empty without egg), the temperature of the incubating chamber was observed to be fairly constant during the early hours of the day and rose towards noon until it attains the peak for the day around 4.00p.m. The temperature inside the chamber was directly related to room temperature. The rise in temperature would cause excessive heating of the eggs during incubation. To prevent this, and in view of the non availability of a mechanical thermostat, the temperature of the incubator was calibrated against room temperatures for different slot openings. Figure 4 shows the calibration curves for the six slot openings. The curves were obtained from regression analysis.

Test Procedure

The machine was tested before loading with eggs in order to see the temperature and relative humidity variation. The temperature of the incubator was observed to be fairly constant during the early hours of the day, rose towards noon and was at its peak later in the day. When the temperature began to rise above the limit required, the slots were opened to keep the temperature under control. As this is being done, cool air comes in to cool the heated air in the chamber thereby lowering the temperature. This method was based on the observation of the natural broody hen which leaves her nest for some time thereby cooling the eggs.

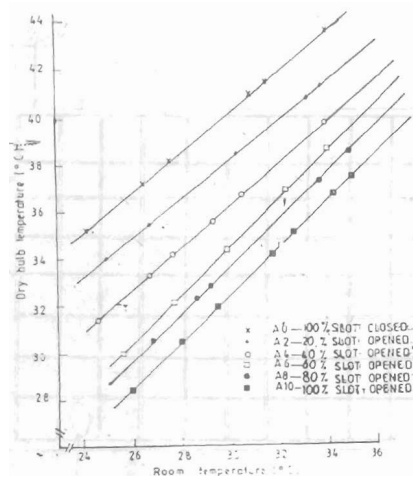


Fig. 4: Calibration curves of dry bulb temperature against room temperatures.

The relative humidity was controlled by the movement of heated air over the water surface in the tray beneath the inlet pipe. The larger the surface area of the tray, the higher the rate of water evaporation hence the higher the relative humidity. During the last three days of incubation - a tray with larger surface was used for holding water. This increased the relative humidity.

Experimental Procedure:

Temperature and relative humidity were successfully controlled at the required range of about 37°C - 40°C and 50% - 60% respectively. The kerosene stove was initially filled with kerosene and all necessary adjustments were made. The tray was filled with water to control relative humidity while the dry and wet bulb thermometers were put in place for temperature measurement. Thirty eggs used for this study were arranged and placed in the setter. The temperature was gradually increased with the eggs inside the incubator so as to prevent temperature shock. The temperature readings were taken four times daily.

RESULTS AND DISCUSSION

Figure 5 to 7 show the variations of dry bulb temperatures, wet bulb temperature and relative humidity inside the incubating chamber over the twenty-two days of test. From the tests carried out, the ranges 37-39.4°C dry bulb temperature, 28-30°C dry bulb temperature and 50% - 60% relative humidity (for the first eighteen days) were observed. These are within the acceptable ranges obtained by other researcher (Oluyemi and Robert, 1979). The maximum deviation of the dry bulb temperature was +2.10°C which is +1.0°C above the needed value. This however occurred only on the fourth day.

The chicks began to pip on the twenty-first day, and by the end of the day, five chicks had already hatched. The remaining eggs were carefully broken. It was observed that the remaining eggs contained:

- (i) four fully developed very weak chicks
- (ii) two eggs containing dead developing embryo
- (iii) nineteen watery eggs with the content showing less visible distinction between albumen and yolk, an evidence showing that they were unfertilized (Alan *et.al.*, 1957)

The percent hatchability, which is a measure of hatching percentage based on the number of the fertile eggs was thus calculated to be 47%.

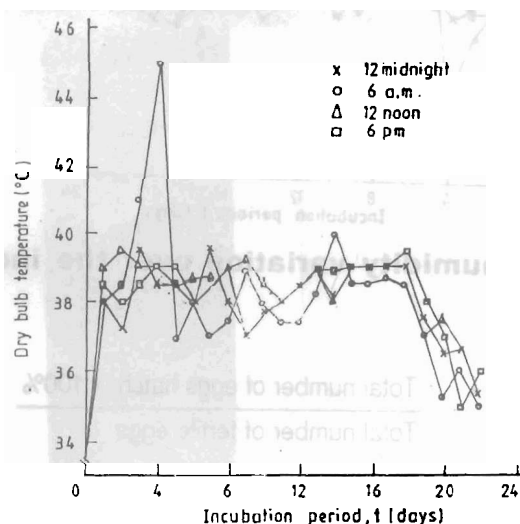


Fig. 5: Variation of dry bulb temperature over the incubation period.

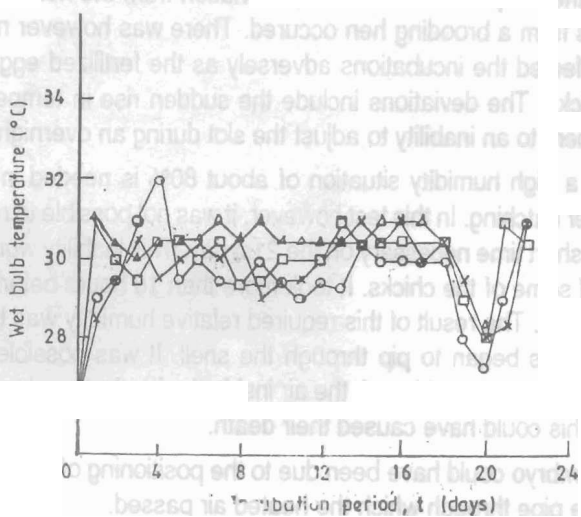


Fig. 6: Wet bulb temperature variation over the incubation period.

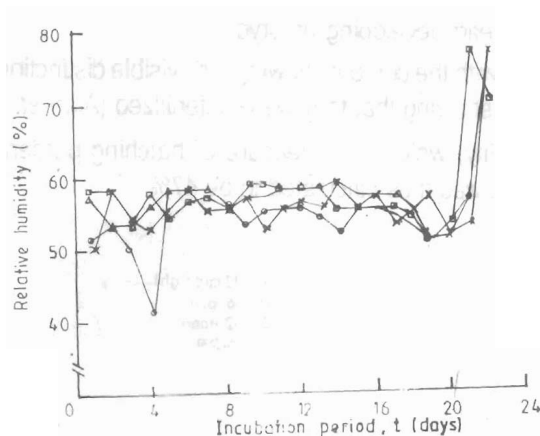


Fig. 7: Relative humidity variation over the incubation period.

$$\begin{aligned}
 \text{The \% hatchability} &= \frac{\text{Total number of eggs hatch} \times 100\%}{\text{Total number of fertile eggs}} \\
 &= \frac{5}{11} \times 100\% \\
 &= 47\%
 \end{aligned}$$

The 19 unfertilized eggs were not detected until the end of the experiment. All the 11 fertilized eggs developed during the process of incubation. This is an indication that the incubator is adequate for the job, temperature and humidity being properly controlled.

Observation of the temperature shows that deviation from the normal temperature as given by recordings from a brooding hen occurred. There was however no indication that these deviations affected the incubations adversely as the fertilized eggs still developed into fully grown chicks. The deviations include the sudden rise in temperature on day 4 which was consequent to an inability to adjust the slot during an overnight period.

Life has it that a high humidity situation of about 80% is needed in the 21st day of incubation for proper hatching. In this test however, it was not possible to reach such a high humidity within the short time necessary on the 21st day. This inability would have affected the development of some of the chicks. It took more than 10 hours before the humidity of 80% could be obtained. The result of this required relative humidity was that 6 hours after it was achieved, chicks began to pip through the shell. It was possible that before the required relative humidity was achieved, the air inside the incubating chamber was too dry for the chicks and this could have caused their death.

The two dead embryo could have been due to the positioning of the eggs lying directly above a hole on the pipe through which the heated air passed.

CONCLUSION

A kerosene-fueled incubator was developed from the available local materials. The capacity of the incubator was about sixty (60) eggs per incubation period. The performance of this incubator was evaluated by incubating 30 eggs. Temperature and humidity control were found to be adequate and the turning of the eggs to prevent sticking of the embryo to the shell proved efficient. Within the limit of the experiment, the hatchability was 47%.

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