Preliminary studies on A.C/D.C heat source cum kerosene lantern for egg incubation

B.A. Adewunmi

Department of Agricultural Engineering, Federal University of Technology, Akure, Nigeria

Abstract

The study was initiated to determine the possibility of using a.c/d.c heat source to power table incubators for domestic and small scale production of chicks. A low cost electrical incubator with a capacity for 60 eggs was designed and used for the study. The incubator was provided with a kerosene lantern to supplement the a.c/d.c heat source during prolonged power failure, with the combustion products from the lantern prevented from having contact with eggs. The incubator was equally provided with a fan to assist air circulation. Three tests were conducted. The temperature and relative humidity in the incubator during the tests were found to be adequate and within the recommended limits. The actual percentage hatchability in the incubator was relatively low with a maximum record of 18.75%. It was found that the embryos in the fertilized but unhatched eggs actually developed but died in shell within the 18th and 21st day of incubation. It was also found that almost all the embryos that died were fully developed when the shells were broken after the incubation period. Preventing such occurrences would improve the hatchability result of the incubator. This could be achieved by improving the ventilation in the incubator and improving on the present design.

Keywords: Electrical incubator, egg, chicks, lantern, hatchability, temperature, relative humidity

Introduction

Incubation involves the management of fertilized eggs to ensure satisfactory development of embryo to normal chicks (Oluyemi and Robert, 1979). It could be achieved naturally or artificially. Artificial incubation is possible in birds because the fertilized ovum does not have a physical connection with the mother and the embryo development occurs outside the body of the mother, unlike in mammals (Anthony, 1990). In order to meet up with the increasing demand for animal protein, artificial incubation is preferred to natural incubation.

Artificial incubators simulate the environmental conditions (temperature and relative humidity) provided by mother birds during natural

incubation (Obioha, 1992; Singh, 1990; Nico and Johan, 1990). Adequate air supply and the turning of eggs must equally be ensured in incubators. The control of temperature is probably the most critical single factor required for successful hatching (Leslie, 1979). Overheating speeds up the rate of chicks development and causes abnormal embryo in the early hatches, and consequently lowers the percentage hatchability (Landauer, 1967). The best hatching results are obtained at 21% oxygen in air, a temperature range of 37.2 – 39.4°C, relative humidity range of 56 – 90% and a carbon dioxide level of 0.5% is tolerable, depending on the type of poultry egg and the stage of incubation (Funke, 1934; Barrot, 1937, Aremu and Shaiwaye, 1993; Ralp, 1987; Payne, 1990; Oluyemi and Robert, 1979). The use of

incubators is particularly recommended for the hatching of the eggs of birds with high commercial values such as geese and ostrich (Obioha, 1992; World Poultry, 1988). There are various type of incubators which are classified either on the basis of system capacity, source of energy or mode of air movement (Adewunmi and Oduniyi, 1999). Incubators could be classified as small or large type based on system capacity. While small incubators could handle up to 500 eggs, the large incubators on the other hand could accommodate several thousands of eggs per operation (Judith, 1977).

Incubators have been classified as electrical, biogas, solid fuel, fossil/oil or solar types based on the source of energy (French, 1984; Akuru *et al.*, 1986; Anthony, 1990). incubators are also classified as free or forced convections type based on the mode of air circulation. air movement in forced convection incubators is achieved by the use of powered fan while air movement in free convection type is by normal convection (Adewunmi, 1998; Olorunisola and Ewemoje, 1998; Adewunmi and Oduniyi, 1999).

The various types of incubators have their merits and limitations. Table incubators are generally cheap but their efficiencies are relatively low. They also have low capacity (Nico and Johan, 1990; Adewunmi, 1998). Large incubators have high initial cost and cannot be afforded by peasant poultry farmers. They require uninterrupted electricity supply for efficient operation. The use of forced convection, adequate air and heat circulation, and automatic turning mechanism couple with mass production and high efficiency makes large incubators acceptable in the large-scale poultry industry (Obioha, 1992; Singh, 1990). Incubators having solid fuel, fossil, oil or biogas as their sources of heat generate soots and other combustion products which could lower the percentage hatchability of eggs (Adewunmi and Falayi, 1999). If the combustion products are prevented from diffusing into the incubation chamber, efficient hatching occurs (Adewunmi and Oduniyi, 1999).

Electrical incubators are generally the best types but are limited by interrupted power supply in the developing nations where electricity supply is not stable (Adwumi and Oduniyi, 1999). The supply can be made steady and readily available by incorporating a direct current (d.c) source using rechargeable wet cell to augment the alternate current (a.c) supply (Macwave, 1984). The aim of the study is to improve the design of an existing kerosene lantern incubator and incorporate an a.c/d.c heat source as the primary source of power supply. The existing kerosene lantern incubator had the problem of soot generation with its consequent effects on the incubator performance (Adewumi and Falayi, 1999). The improvement of the kerosene lantern heat source design prevents the soot from having contact with the eggs in the incubator chamber.

Materials and Methods

An existing kerosene fueled incubator was used for the study (Adewumi, 1998; Adewumi and Falayi, 1999). The design of the existing incubator was however modified during the course of the study. An a.c/d.c heat source and a temperature control circuit were incorporated into the incubator.

Modifications on the existing incubator

The modifications made on the existing table incubator involve a redesign which was carried out in the following stages:

1. Increasing the capacity of the incubator from 30 eggs to 60 eggs.
2. Designing and incorporating an a.c/d.c heat source with a temperature control circuit. The electrical source is made the primary source of powering the incubator while the kerosene lantern is made a supplementary or back-up source of heat in case of prolonged a.c failure, particularly when the d.c cell is weak.
3. Increasing the ventilation port to improve ventilation in the

A.C/D.C. heat source cum kerosene lantern

- incubator as a result of the increase in the capacity of the incubator.
4. Lining the inner wall of the incubator with aluminum foil in order to ensure adequate conduction of heat in the incubator.
 5. providing with a metal stand for ergonomic reasons and firmness.
 6. Designing and coupling a cylindrical meta case to the floor of the incubator to accommodate the kerosene lantern. The heat generated by the lantern is

transferred into the incubator by conduction and convection. An exhaust pipe is attached to the lid of the cylindrical metal to convey the combustion product away from the incubator.

7. Incorporating a fan unit below the heating elements to ensure uniform distribution of air and heat in the incubator.
8. Incorporating a dimmers switch in the electrical circuit to stabilize temperature in the incubator.

The electrical heat source and temperature control circuit

The electrical power supply was designed such that electricity is trapped from the a.c mains and it incorporates as 12V d.c cell at a full load of 1A. The power supply unit steps down the voltage from the mains (240V), rectifies it, smoothen out the ripples and regulates it to

provide a steady d.c voltage. The power unit includes a d.c bulb, d.c cell, integrated circuit, voltage regulator, filter rectifier, dimmer switch and transformer. The temperature control circuit is made up of resistors (741 op – Amp transistors), thermistors, relay and Light Emitting Diodes (LEDAS). The thermistor was calibrated and the resistance of the thermistor corresponding to a temperature range of 33-43°C is shown on Table 1

Table 1: *The temperature in the incubator corresponding to the thermistor resistance during the calibration of the thermistor*

Resistance, K	Temperature, °C
24.2	33.0
23.8	34.0
22.9	35.0
22.2	36.0
21.2	37.0
20.6	38.0
20.5	39.0
20.3	40.0
20.1	41.0
19.6	42.0
19.3	43.0

The temperature control circuit employs a thermal transducer as a sensor which translates a change in temperature or voltage to optical signals. The voltage fed on the comparators in the temperature control circuit is compared with a reference voltage. The output of the comparator is used to operate a series of LEDs

which serves as indicators for the various ranges of temperature. The comparator is used to drive a relay through a Darlington pair configuration. One of the LED lights up at a time, which indicates the temperature at the three different stages namely;

1. Green LED indicates temperature below 37°C
2. Yellow LED indicates temperature between 37 – 39.5°C
3. Red LED indicates temperature above 39.5°C

The yellow LED required for the operation of the incubator.

Equipment testing

Before the incubator was loaded with eggs for testing, the electrical power source was test run for 40 hours and the relative humidity and the temperature in the incubator was monitored. Wet and dry bulb temperatures in the incubator were measured using thermometers. The relative humidity as determined using a psychometric chart. Three tests were conducted to evaluate the performance of the incubator.

In the first test (Test 1), only the electrical power system was used while the kerosene lantern was removed. The second test (Test 2) was carried out with the kerosene lantern used as a supplementary source of heat during prolonged power failure from the mains. An electric fan was also installed at the lower part of the incubator for the second test. The third test (Test 3), involve using a dimmer switch in the electric circuit to stabilize temperature.

Fertilized eggs of broiler and layer stocks of hen were used for the tests. The eggs were candle on

the 7th and 18th days. The first candle on the 7th day identified the fertilized eggs while the second candling on the 18th day identified the stage of development of embryos temperature and relative humidity were monitored in the incubator during the tests. The percentage fertility (F), expected percentage hatchability (H_{EXP}) and the actual percentage hatchability (H_{AC}) were determined using the following relationships;

$$F = \frac{N_F}{N_L} \times 100 \dots \dots \dots (1)$$

$$H_{EXP} = \frac{N_{FD}}{N_F} \times 100 \dots \dots \dots (2)$$

$$H_{AC} = \frac{N_C}{N_F} \times 100 \dots \dots \dots (3)$$

Where

N_F = Number of fertilized eggs

N_{FD} = Number of fully developed embryo

N_C = Number of hatched chicks

N_L = Number of eggs loaded into the incubator

Results and Discussion

Table 2 shows the dry bulb temperature and relative humidity in the electrical incubator before the incubator was loaded with eggs. The result indicated that under a steady supply of electricity, the electrical unit could be operated at an adequate temperature and relative humidity range recommended for egg incubator (Ralph, 1987; Payne 1990; Barrot, 1937).

Table 2: Dry bulb temperature and relative humidity in the incubator for 40 hours before loading - the eggs

Time (hrs)	Dry bulb temperature (°C)			Relative humidity (%)		
	Range	Mean	SD	Range	Mean	SD
0-10	30.0-39.5	37.5	2.79	50.0-85.0	55.60	10.75
11-20	31.0-38.4	36.35	2.24	51.0-64.0	56.70	3.61
21-30	38.0-39.0	38.15	0.32	50.0-55.0	52.90	1.14
31-40	38.0-38.5	38.10	0.20	53.0-57.0	54.00	1.61

Table 3 shows the daily record of temperature and relative humidity while Table 4 shows the

percentage fertility and hatchability in the incubator for the three tests carried out.

A.C/D.C. heat source cum kerosene lantern

Table 3: Mean daily Dry bulb temperature and relative humidity in the incubator for Tests 1-3

Day	Dry bulb temperature (°C)			Relative humidity (%)		
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
1.	38.25	38.00	37.50	57.50	63.00	58.00
2.	38.00	37.25	37.75	66.00	60.00	59.00
3.	37.50	38.00	39.00	62.00	62.00	55.00
4.	38.50	38.00	37.50	60.25	60.00	58.00
5.	38.50	37.75	38.25	54.00	59.00	58.00
6.	36.75	38.75	37.75	64.00	60.00	57.00
7.	39.00	37.50	37.50	53.00	60.05	57.50
8.	39.00	37.50	38.00	53.00	64.00	57.00
9.	37.25	38.00	38.50	57.00	60.00	58.50
10.	38.00	38.25	38.75	52.00	57.00	54.00
11.	37.50	38.00	37.50	54.00	60.50	54.00
12.	37.00	38.50	37.50	55.00	60.00	58.00
13.	37.50	38.00	37.75	58.00	61.50	59.00
14.	37.00	38.25	37.75	55.00	60.00	57.00
15.	37.00	37.50	38.50	55.00	66.00	56.00
16.	37.00	38.50	38.50	55.00	62.00	57.00
17.	38.00	38.25	38.25	54.00	69.50	58.00
18.	37.00	38.00	38.00	55.00	71.00	58.00
19.	37.00	38.00	37.50	55.00	69.50	60.00
20.	37.00	38.25	38.00	55.00	63.50	62.00
21.	37.00	39.00	38.00	55.00	62.43	57.93
Mean	37.61	38.06	37.99	56.42	62.43	57.93
SD	0.85	0.50	0.49	4.02	4.27	1.99

Table 4: Percentage fertility and hatchability for Tests 1- 3

Measurements	Test 1	Test 2	Test 3
No of eggs loaded	20	28	21
No of infertile eggs	5	0	5
No of fertile eggs	15	28	16
% Fertility	75%	100%	76.19%
No of partially developed embryo	14	8	4
No of fully developed embryo	1	20	12
Expected % hatchability	6.66%	71.43%	75.00%
No of chicks hatched	1	5	3
Actual % hatchability	6.66%	17.85%	18.75%

It was observed during Test 1 that prolonged a.c power failure weakened the d.c cell and resulted in very low voltage and power output. This informed the use of the kerosene lantern as a supplementary heat source during period of prolonged power failure. Daily temperature fluctuation was observed during the second test. This was caused by the variations in the atmospheric temperature resulting in frequent rate of energizing the relay in the control circuit. A dimmer switch was therefore incorporated into the electrical circuit during Test 3 to regulate the irregular relay energisation and ensure a minimize temperature fluctuation in the incubator.

Plate 1a: Dead chicks in the shell during performance test

Plate 1b: Emergence of the hatched chicken in the incubator

Table 3 shows that the incubator operated within the recommended temperature and relative humidity range. But, the actual hatchability records are very low. However, the incubator performed better when the kerosene lantern was introduced as supplementary heat source (Table 4). The introduction of the fan to assist air and heat distribution equally improved the performance of the incubator for Tests 2 and 3 as shown in Table 4.. the actual percentage hatchability was highest during Test 3. The use of the dimmer switch to stabilize the temperature could also be responsible.

The expected percentage hatchability from the observations during the second candling was high for Test 2 and 3 with values of 71.43 and 75.00% respectively. It was however very low (6.66%) for Test 1 because of the prolonged electrical failure. Generally, the second candling observations on the 18th day showed that the chicks in the fertilized eggs developed until the 18th day but majority of the embryo never hatched at the end of the experiments.

The expected eggs were thereafter broken and it was ascertain that almost all the features of the embryos (such as feathers, eyes, beak, and so on) were fully developed before the embryos died in their shells. Plate 1 shows the content of some of the broken unhatched eggs.

LEGEND

1. LIGHTING PLATE	7. VENTILATION PORT
2. WET AND DRY BULB THERMOMETER	8. EGG SETTER
3. WATER CONTAINER	9. LAMP
4. BEAK	10. THERMOCOUPLER
5. KEROSENE LANTERN HEAT SOURCE	11. DOOR
6. ELECTRIC BULB	

FIG 7: ISOMETRIC VIEW OF THE A.C FOR: CUBIC KEROSENE LANTERN INCUBATOR USED FOR THE STUDY

From the records of the second candling observations and the sharp difference between the expected and the actual percentage hatchability it could be inferred that the embryos died in shell between the 18th and 21st day of incubation. The introduction of the fan sharply increased the hatchability result for Test 2. therefore, it is envisaged that air supply might not be adequate in the incubator. Hence, the embryos might have suffocated in the shell as a result of inadequate supply of air. It may be essential to carry out further study to ascertain why the embryos died in shell between the 18th and 21st day of incubator and investigate the quantity of air supply and the air circulation in the incubator.

The a.c/d.c cum kerosene lantern incubator reported should steer research interest because of its cheap cost and potentials. The cost of production of the incubator was about six thousand and five hundred naira (₦6,500.00) as at February, 2000. breakthrough in this research area would make mechanized hatching of poultry eggs affordable to peasant poultry farmers and at domestic level even in areas with erratic and prolong failure of electricity supply. The electrical circuit of the incubator reported in this study allows the d.c wet cell to be charged when power is supply from the mains.

Acknowledgements

The author acknowledges O.Odejobi, O.O. Ndola and B.E. Oladipo of the Agricultural Engineering Department, Federal University of Technology, Akure, Nigeria for the technical assistance they rendered during the period of the study.

References

- Adewunmi, B.A. 1998. Development of a free convection kerosene fueled incubator. Transaction of the Nigeria Society of Engineers. 33(2) 30 – 40.
- Adewunmi, B.A. and Falayi, F.R. 1999. Performance evaluation and modification of a kerosene fueled table incubator. *Nig. J. Anim. Prod.* 26:111-114
- Adewunmi, B.A. and Oduniyi, A.I. 1999. Design, fabrication and testing of a charcoal fueled incubator. *J. of Appl. Sci.* 2 (1) 159 – 175.
- Akuru, I.O., Nurudeen, A and Bamiro, O.A. 1986. Introductory technology for schools and college. Evans Brothers Publisher Limited, Nigeria. First Edition. Pp 32 - 35.
- Anthony, J.S. 1990. Poultry science. Macmillian Publishers, London, first Edition. Pp 148 – 157.
- Aremu, A and Shiawoye, E.L. 1993. An investigation into the hatching performance of Western and Funky incubators at Gwaba, Niger State. *Nig. J. Anim. Prod.* 20:125 – 127.
- Barrot, H.G. 1937. Effect of temperature, humidity and other factors on energy metabolism of chick embryos. Technical bulletin of Missouri Agricultural Experiment station. No. 553. Pp 3-6

- French, K.M.** 1984. Poultry raising. Manual of Peace Corporation, Washington D.C. Pp. 48 – 53.
- Funke, E.M.** 1934. Factors influencing hatchability in domestic fowls. Missouri Agricultural Experiment station. Technical Bulletin No. 244. pp 5-7.
- Judith, P.** 1977. Poultry production. A magazine of West Africa Farming. Alian Charles Publishing Ltd. Pp 13 – 15.
- Landauer, W.** 1967. The hatchability of chicken eggs as influenced by environment and heredity. *Poultry Science*. 46:57-65.
- Leslie, E.C., Maiden, C.N. and Austin, R.** 1979. Poultry production. Bailure Tindal, London. Second Education. Pp 92.
- Macware, J.** 1984. Introduction to electronics and instrumentation. Longman Publishers, England. Pp 50 – 57.
- Nico, V.W. and Johan, M.** 1990. Hatching eggs by hen or by incubator. Published by Agromisa, Wageningen. Second Edition. Pp 4 – 25.
- Obioha, F.C.** 1992. A guide to poultry production in the tropics. ACENA Publisher, Nigeria. First Edition. Pp 170 – 174.
- Olorunnisola, A.O. and Ewemoje, J.A.** 1998. The development and evaluation of a flat-type wooden incubator. *Applied Tropical Agriculture*. 3(2) 114-119.
- Oluyemi, J.A. and Robert, F.A.** 1979. Poultry production in wet climate. Macmillian Publishing Co, New York. Second Edition. Pp 308.
- Payne, W.A.** 1990. An introduction to animal husbandry in the tropics. Longman Group Limited, London. Third Edition. Pp 596 – 647.
- Ralph, R.S.** 1987. Manual of poultry production in the tropics. C.A.B. International Publisher, United Kingdom. English Edition. Pp 308.
- Singh, R.A.** 1990. Poultry production. Kenya Publishing Co, New Delhi. Third Edition. Pp 89 – 100.
- World Poultry.** 1998. Effective artificial incubation of ostrich eggs. Magazine of poultry production, processing and marketing. 14(7):20-21.

(Received 21 August 2000; Accepted 03 March 2001)