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APPLICATION OF THERMOELECTRIC EFFECT IN THE DESIGN AND CONSTRUCTION OF AUTOMATIC TEMPERATURE REGULATING EGG-INCUBATOR WITH DIGITAL READ-OUT

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ABSTRACT

Automatic temperature regulating egg – incubator is a device which conditions an enclosure to a pre-determined temperature comparable to that of natural egg incubating temperature of 39°C. In this study an automatic temperature regulating egg – incubator had been designed and fabricated using the principles of thermoelectricity. Active and passive electronic components with special features are employed to control the incubating temperature automatically. This is aimed at solving the problem of temperature fluctuation usually experience by poultry farmers which leads to production loss. As a result incubating, egg expected to hatch within stipulated period of time fail to do so thereby subjecting the farmer to extra expenditure and powered by a 220-volt AC source is designed involving a modular approach comprising of power supply control unit, temperature controller/sensor and heating sections. When tested the portability, sensibility, reliability and simplicity of operation of the device proved the instrument as a dependable tool to farmers in the poultry production. Its workability is about 70% efficient. Automatic temperature regulator, egg-incubator thermoelectricity digital reading

INTRODUCTION

Electrical incubator is a device used for scientific incubation process in which temperature, humidity and other environmental variables can be maintained at desired temperature levels. For an egg-incubator, it enhances the propensity of hatching egg in mass. A great number (Adichie et al., 1985) of eggs can be hatched at a time while the layers (mother hens) can be free to lay more eggs thereby resulting into high poultry production and low reduction in expenditure. The relevance constitutes an aspect of encouraging or promoting food production and security which is very significant in our present dispensation of global economic melt-down.

The complexities involved in the fabrication of incubators manufactured in the developed countries are too advanced in terms of materials/technical expertise and are very expensive (Alabi and Isah, 2002) to come by for less developed countries to cope with. Concerted effort has been made to use the principles of physics/electronics to design and construct an egg incubator that is very simple to operate and use.

MATERIALS AND METHOD

The materials for the work comprise of K-types diameter fan, siemens contactor (22E) with 2NC and 2NO, mains fuse, control cables wires and connectors, Digital temperature controller, wooden casing to house the electrical assemblage, a humidifying (Oluyemi and Roberts, 2000) tray and egg tray. The function of these components shall be specified in due course.

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Modular approach was adopted in designing the device as shown in Figure 1. This involves splitting the whole system into sections – power supply, control network, temperature controller with sensor and heating section. The output of one section constitutes the input of the next section and thus the connected aggregate of all the sections make up the entire system.

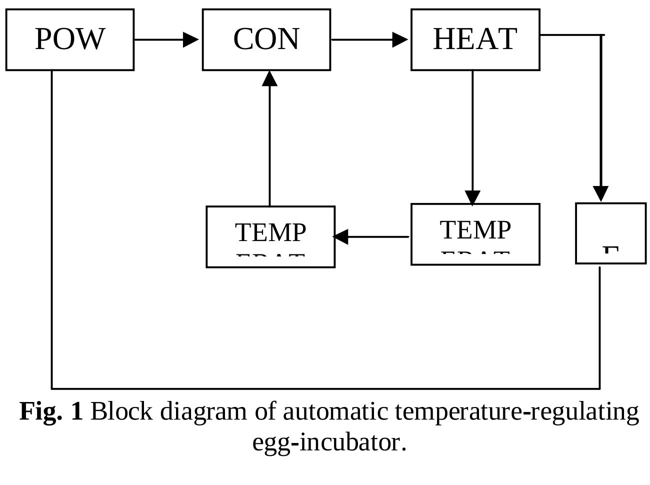

Fig. 1 Block diagram of automatic temperature-regulating egg-incubator.

The output signal of the temperature sensor is input of the temperature controller. Output of the temperature controller is connected to the control unit which controls the system to work automatically in terms of ON and OFF of the heaters. The side and top heaters were connected in parallel to the A.C power supply through the control unit. All components were carefully mounted on a plane board with each component placed at proper position of the board. However, some components like the fan were mounted off board. Neat soldering was applied to connect the electrical/electronic components and the whole assemblage was encased in a ply-wood cubic dimensioned box of 61½ can size. Electrical wiring was done with flexible wires and connectors (Hall, 1989; Popoola and Ogunlade, 2005).

Principles of operation

A renowned physicist Seebeck discovered that when any conductor is subjected to a thermal gradient, it generates voltage (Nelkon and Parker, 1995; Resnick and Halliday, 1992). This is called Seebeck or thermoelectric effect. To measure this electromotive force (emf) involves connecting another conductor to the “hot” end. This other usually made of another material will experience a temperature gradient and develop a voltage of its own which will oppose he original one but the magnitude of the effect depends on the particular material used. The whole set up now becomes a thermocouple (Nelkon and Parker, 1995) with two junctions at different temperatures, one fixed and the other varying. This thermocouple is of K-type which serves as the temperature sensor whose range is -200 to 1350^{0}C with sensitivity of about 41μV/^{0}C

The relationships between temperature and output voltage of a thermocouple is non-linear which is given by the polynomial

$$\Delta T = \sum_{n=0}^{w} a_n V^n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Mode of operation

Power is supplied to the circuit as shown in figure 2. Fertilized eggs are properly situated in the incubator which is already switched on as powered by the supply at a pre-determined incubating temperature of 39^{0}C. This temperature is maintained by the compatibility operation of the temperature sensor, temperature controller and the contactor as the major components (Sani et al., 2000; Oluyemi and Roberts, 2000).

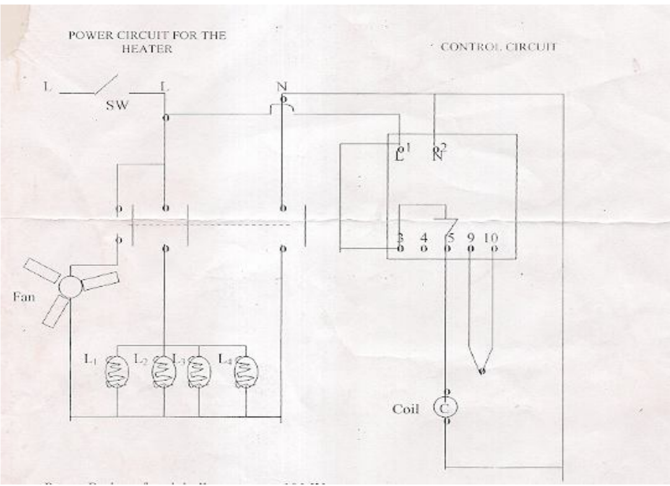

Fig. 2 Circuit diagram of the device

When the switch closes, current flows into the system thereby energizing the contactor that powers the bulbs which serves as heating elements to the system, the fan ensures equal distribution of warm air in the entire system. When the temperature in the system gets to 39^{0}C the digital temperature controller sends an electrical signal to the contactor which de-energized thereby switching off the heaters temporarily. Also, when the temperature reduces beyond 39^{0}C, the contactor will be energized once again thus; switches on the system. Automatically, with time, this process continues with the required time of hatching as long as there is power supply (Aihonsu and Sunmola, 1999).

Testing, workability and discussion

The workability of the device was tested. Observation shows that the equipment works based on the general performance if the various units of the entire assemblage in which the temperature sensor stands out as a major element when the incubator was powered for the first time, the temperature time variation within the first (23.0 ± 0.3) minutes (or 1380 ± 20 seconds) was observed as shown in Table 1 and Figure 3.

Table 1 Temperature variation with time

Time (min)	Temp ^{0}C	Time (min)	Temp ^{0}C
0	29	13	37
1	30	14	37
2	31	15	38
3	33	16	38
4	33	17	38
5	34	18	39
6	34	19	39
7	35	20	39
8	35	21	40
9	36	22	40
10	36	23	40
11	36	24	
12	37	25	

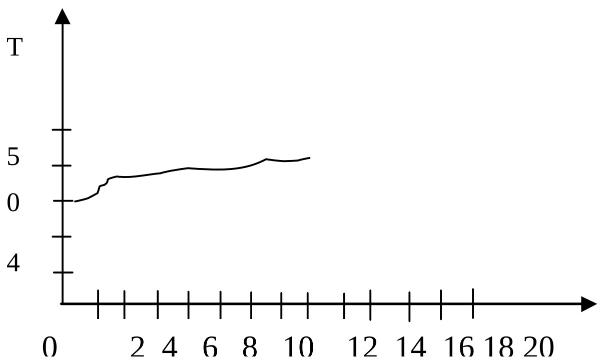

Fig. 3 Graph of temperature time characteristics.

After the test the desired incubating temperature was achieved. From the output characteristics in fig. 3, the slight rigorous path on the curve is suggestive of the effect of external factors such as tiny holes on the woody casing, etc. These factors are negligible and were not beyond tolerance. Again, longer period of time (ie about 20 minutes after the system was switched on) the incubator’s performance assumes the behavior or characteristics of a simple harmonic oscillator (Main, 1993) with a frequency of 2.5 X 10^{-2} Hz (see Table 2 and Fig 4). The incubating temperature of the device is approximately maintained within appreciable tolerance value of ± 1^0C. It fluctuates between 38^0C and 40^0C.

Table 2 Temperature / time variation of incubator

Time (s)	Temp ^{0}C	Time (s)	Temp ^{0}C
0	39	160	39
10	40	170	40
20	39	180	39
30	38	190	38
40	39	200	39
50	40	210	40
60	39	220	39
70	38	230	38
80	39	240	39
90	40	250	40
100	39	260	39
110	38	270	38
120	39	280	39
130	40	290	40
140	39	300	39
150	38	310	38

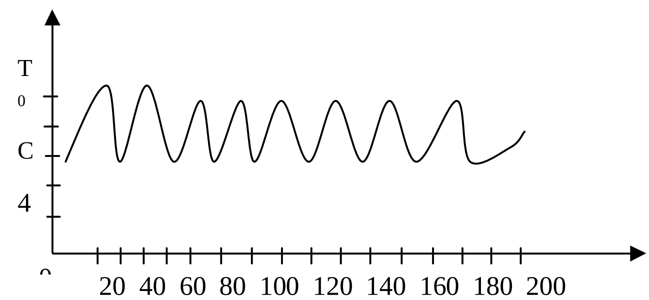

Fig. 4 Graph of temperature - time variation

Another observation made over the same period won that the time response of thee thermocouple was between 17-20 seconds. This implies that while the sensor maintained a constant incubating temperature of 39^0c, it takes sensor approximately 17 to 20 seconds to respond to a shift in temperature above or below 39^0C.

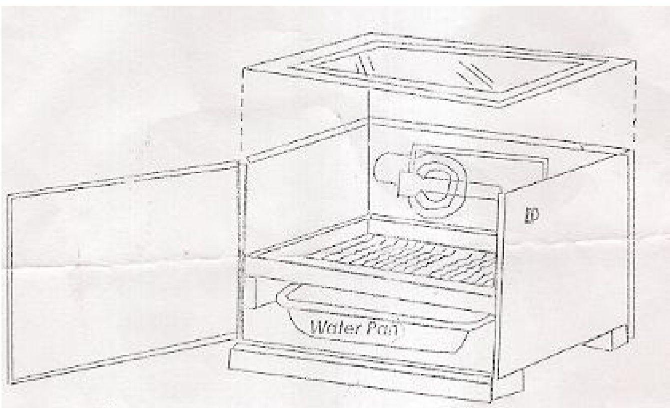

Fig.5 Internal arrangement of the automatic temperature regulating egg incubator

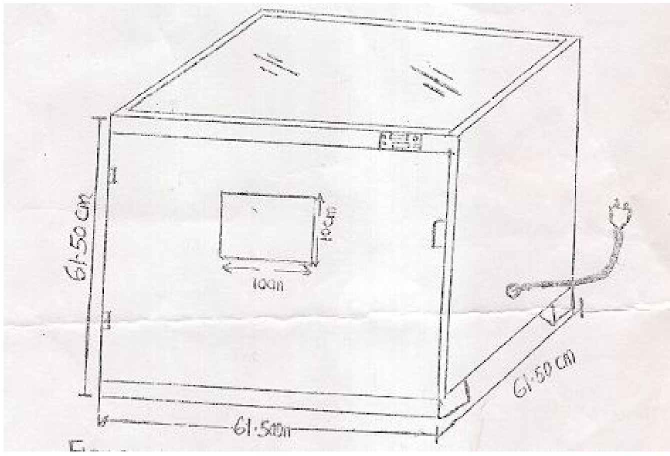

Fig. 6 Casing of the automatic temperature regulating egg-incubator

CONCLUSION

The design, construction and testing of an automatic temperature regulating egg incubator has been successfully done. It has a digitally visual read-out. The automatic temperature regulating incubator is a scientific device which conditions an enclosure to a pre-determined temperature comparable to that of natural (hen) incubating temperature of 39^0C. The equipment performs at a very high degree of accuracy maintaining incubator temperature average of 39^0C throughout the test period when tested in the department of Animal Science and Production. The portability, sensitivity, reliability and simplicity of operation of the device proved the instrument a dependable tool to farmers in poultry production. Its workability is about 70% efficient. This is a part of an on-going project to utilize solar energy to power the system in view of the rampant and frequent power fluctuation our country.

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