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FABRICATION OF AN INNOVATIVE EGG HATCHERY SYSTEM USING INDUCTIVE HEATING AND RENEWABLE ENERGY

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Abstract

A significant expansion in recent years has been seen in several agricultural subsectors, including poultry farming, which is an essential component of this expansion. Despite this, the business sector has observed a growing concern about incubation. The goal of the current project is to build a prototype of an intelligent and automated incubator that uses an inductive heating system powered by renewable energy. A microcontroller is used inside the incubator to monitor and maintain the appropriate temperature and humidity levels in the space within the device. In order to perform calibration, data logging, and analysis, a GSM module was built. After extensive testing, it was concluded that the new system provides efficiency and dependability to the poultry farming industry.

Keywords: *Incubator, Inductive heating, Renewable energy, Temperature, Humidity, GSM,*

INTRODUCTION

Poultry production in Nigeria has increased dramatically in recent years, and the country is now the leading producer of poultry in Africa (Jatau et al., 2016). A significant expansion in recent years has been seen in several agricultural subsectors, including poultry farming, an essential component of this expansion. The livestock industry is an essential component of Nigeria's socioeconomic development (Amos, 2006; Bamiro et al., 2012; Ekunwe et al., 2010; Hassan et al., 2016; Ibikunle Ogunyemi & Folorunso Orowole, 2020; Joshua Olorunwa, 2018; Kperegbeyi et al., 2009; Maikasuwa (Kiba et al., 2020). It makes a sizeable contribution to the agricultural gross domestic product (FAO, 2006). Keeping chickens, turkeys, or other domesticated birds to harvest their meat or eggs as a source of food is an example of poultry farming. The production of chickens for their meat and eggs requires many birds. Because of the country's growing population, there has been a sharp uptick in the appetite for poultry products such as eggs and meat (Heise et al., 2015).
Incubation of poultry eggs is a necessary step in the process of producing chickens and other poultry, particularly in the first 24 hours of a chick's life (Okonkwo & Chukwuezie, 2012). The hatchery is the first step in the production of poultry. The primary goal of a farmer who operates a hatchery is to acquire a large number of chicks that are suitable for sale. The potential for hatchability is of significant importance for all incubators and requires the appropriate amount of attention (Cavero et al., 2014; Ulmer-Franco et al., 2010; Willemsen et al., 2008). However, the hatchability of an egg can be affected by several factors, including the length of time it was stored, the egg's fertility, the temperature, the relative humidity, the ventilation, the egg's position, turning, and candling. Inadequate hatchery machines are a critical factor limiting the expansion of poultry farming and making poultry products more expensive and scarce (Agidi et al., 2014). It's possible that the lack of commercial incubators in Nigeria and the difficulties associated with the country's conventional poultry incubators are to blame for the limited availability of poultry meats and the exorbitant prices of day-old chicks in the country. These difficulties include maintenance problems, diesel cost, temperature, and power. In order to function appropriately, hatchery incubators need a significant amount of energy (Cui et al., 2019; Olorunmaiye & Awolola, 2017), a resource that is in short supply in Nigeria. In addition, traditional hatchery incubators have been linked to the pollution of agricultural land (Gan & Hu, 2016; Guo et al., 2019). The smart, automated hatchery method is meant for improved efficiency and increased production in the farming industry. Besides ensuring that economic waste is reduced, the smart automated hatchery also provides cleaner energy to the United Nations Sustainable Development Goals (SDGs). This research project aims to construct a smart, automated egg hatchery system with an inductive heating and heat circulation system, a microcomputing unit, and an Android application for communication and user interface powered by renewable energy.

Materials and Method

The current project's primary purpose is to construct a portable incubating system that proves the possibility of an industry-standard efficient hatchery incubator with a smart temperature assessment system powered by renewable energy. The design of the system comprised the housing, mechanical, electronic, and software designs.

The housing

The housing was constructed with stainless steel plates for durability. However, the interior was coated with plywood. The internal dimensions are 507.2 mm × 507.2 mm at the base and 604.8 mm in height. The incubator contained two egg trays adequately separated to avoid contact during rotation. Each egg tray is designed to accommodate eight eggs. A metal was fitted at the center of the floor to enable heat to radiate into the chamber. A transparent glass was fitted at the main door for inspection purposes, while the back contains a window-like opening for temperature regulation.

The egg turner mechanism

The egg tray was constructed with an iron rod with bearings attached to holes in the body frame and fixed to the turner for easy rotation. Perhaps, the egg tray is equipped with a dc motor with an automatic turning mechanism designed to rotate at an interval of 5 hours using a controller unit. The turning controller is a timer and motor speed limiting circuit programmed to power on the dc motor for an estimated period of 40 minutes and set it off for the next 5 hours. The turning intervals are set to allow the tray to rotate a maximum of 4 times per day. The CD4060 is among the popular CMOS chip with a 14-bit binary counter and an oscillator included. The oscillator is made up of inverters attached to various pins. The rotation frequency is controlled by resistor R4. The C2 and R8 are primarily responsible for the period the relay is energized. Thus, it is calculated to be energized for about six minutes. In this project, the relay is directly attached to the motor speed controller, which powers the D.C. Motor with the required voltage. However, a potentiometer is used to avoid knocking the eggs for voltage and gear control.

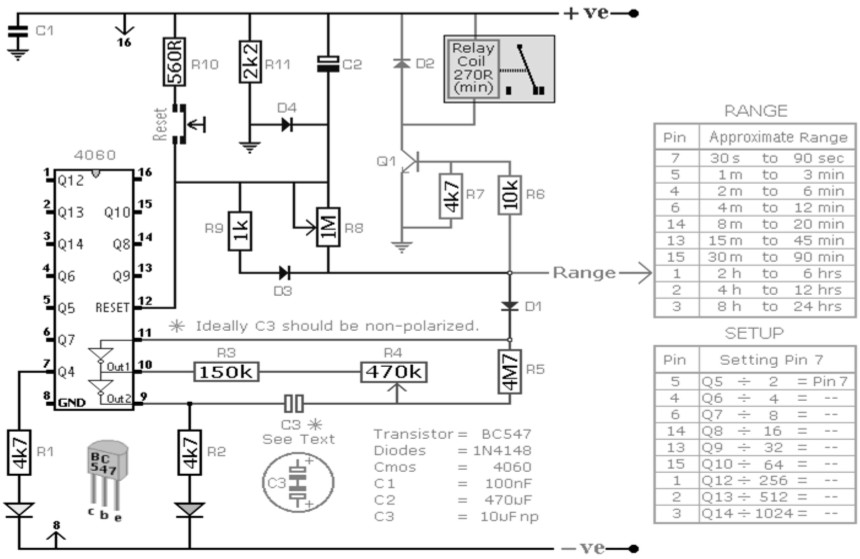

Figure 1: Timer circuit for the egg roller.

Inductive Heating System

An electromagnetic induction air heater element was adapted to connect to an alternating electrical current source. An aluminum molded cylindrical with a loose roll of the magnetizable wire mesh screen is spaced apart in the adjacent position to enable an axial flow of air through the system. The opposite ends of the heating coil were connected to the electrical current source, and a forced-air heating duct was hooked from the cylindrical box housing the heating coil to convey forced heat to the incubator. Air passed through the magnetizable cores is heated by applying alternating electrical current to an induction heating coil surrounding each magnetizable core, the coils being connected in an electrical network.

GSM Module

The GSM module for data reporting and calibration was set up with SIM900. SIM900 GSM/GPRS shield is a GSM modem with a complete Quad-band GSM/GPRS module. It delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and reduced power consumption (SIMCom, 2013). The SIM900 has been widely integrated into electronic devices for real-time feedback (Pramanik et al., 2016; Satria et al., 2019; Tombeng, 2017). This project's temperature and humidity monitoring system was set up following Munir et al. (2015) description. It comprised an end device and a coordinator consisting of an XBee Pro RF module and a SIM900 GSM module. The end device sent the temperature and humidity reports to the coordinator and forwarded them to the web server through GPRS communication using the SIM900 GSM module, thus, making the temperature and humidity data accessible in real-time via an Android application designed for the project. Also, a liquid crystal display is connected to the temperature regulator and positioned at the incubator's main door for onsite temperature monitoring and data logging. The system's power is sourced via a 300w/24v PV solar panel and 200ah/12v battery

System Integration and Testing

The circuits were individually tested for efficiency. Although, some critical adjustments were made. The circuit boards were embedded at the top of the housing unit and were, thus, connected to the various parts of the incubator. The temperature-GSM relation was confirmed via the Android mobile app. As expected, the egg tray turner and the fan were also tested for reliability and timing exactness, and all proved reliable. Temperature calibration, data logging, and reporting were adjusted via the Android app and confirmed over the LCD. The system's reliability was further demonstrated following a deliberate abrupt power cut and the system's response to an unstable power supply. In all, the system was confirmed reliable for use.

Table 1: shows the measurements and testing performed on the incubator.

Parameters	Measured Value	Design Value
Temperature		
Maximum	39o C	40o C
Minimum	39o C	35o C
Relative Humidity		
Maximum	46	50
Minimum	38	40
Standby power consumption	11W	8W
Total Power Consumption	53W	48W
Input Voltage	202-218V	220-240V
Output Voltages	12V, 9V and 5V	220-240V

Conclusion

The current project aims to establish a smart egg incubator's functionality using an inductive heating system powered by renewable energy. The microcontroller remains the central operating mechanism of the system, thus, minimizing the need for hardware. The smart incubator system's completion and operational performance provide the potential for a more extensive and industrial smart incubating system. Similar projects have been constructed (Bolaji, 2008; Kifilideen L. Osanyinpeju et al., 2016; Kyeremeh & Peprah, 2017; Radhakrishnan et al., 2014; Sunday et al., 2020). However, the current project utilized the inductive heating method. The compactness, sensitivity, and reliability of the device's operation, including the Android user interface's simplicity, proved the device to be a dependable incubating system for poultry production.

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