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Optimisation of electronics and mechanics system of automatic egg incubator machine

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Abstract: In this research report result of optimisation of the electronic and mechanical system of an automatic egg incubator machine. The design of mechanical systems using two types of motors are stepper (one motor) and servo (3 motors) with the aim to produce a smooth movement of egg shelves in the maximum load that can be accommodated. In the electronic system used the thermostat as the controller of speed rate or maximum hatch temperature limit, while to maintain the humidity in the incubator moisture sensor used dht22 which integrated with a microcontroller. Also, the heat source on the incubator used two air heaters with 220 V / 65 W specifications. From the results of electronic and mechanics analysis per average the electrical power spent every 6 hours is 0.78 kWh. From the results of the driving test using a stepper and servo, the driver moves more optimally using a servo motor at a maximum load of 315 eggs (9 kg).

Keywords: hatching machine;electronic system;mechanical system;servo;a stepper motor.

1. Introduction

Egg hatching machine is one of the most widely used equipment in the field of poultry farms [1]. This machine is used to increase the quantity of egg hatching. Although many egg hatching machines are either manual, semiautomatic or automatic, the success rate or percentage of hatchability is low. One of the most influential causes is the uneven distribution of temperatures [2]. In this era of globalisation time and energy are so meaningful that use is so cared for to be as effective and efficient as possible. With the rapid development of technology, for the work of electronic equipment is increasing and encourage people to seek innovations in the provision of facilities and means to achieve these goals. One of them is the optimisation of electronic cage automatic hatch system to help the development of quail egg farmers [3]. This hatchery has one egg shelf that will hold 315 quail eggs. The advantages of this hatching machine are to accelerate the process of egg hatchery, effective and efficient in the process of quail egg dropper and efficient in the use of electric power [4][5].

Tia et al (2016) in the research that has been done successfully designing prototype of automatic atmega328 microcontroller based on DHT11 sensor that is by laying some eggs to be conditioned in the testing machine with the temperature in the incubator and checking for the first two hours with checking interval of 10 minutes with automatic playback technique with the help of servo



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motor [6] [7] [8]. In this paper, the results of mechanical system optimisation with a comparison of the drive system with a servo motor and stepper and also in electronic systems have been analysed for the needs of the device to produce energy-efficient hatching machines..

2. Materials and Methods

In this study the tools and materials used are wood as the primary material, stepper motor load 10 kg, two servo motor each with load 10 kg, two 65 watt air heater, thermostat, Arduino Uno, dht22, LCD with i2c wiring, aluminium foil, wire.

The design of the hatching machine includes two stages of designing mechanical systems and electrical systems. In mechanical systems, the primary material used as housing is wood, wood is selected for its heat-resistant properties both within the incubator and from the environment. Next is on the drive system, selected two kinds of motors are servo and stepper because the rotation coordinates can be determined [9].

In the electronic system used two 65W heater at 220V voltage. Use of two air heaters to obtain a faster hatching temperature of 39-40 °C. Furthermore, in controlling the temperature so as not to exceed the maximum temperature of hatching used a thermostat device. In a humidity setting a dht22 moisture sensor is deprogrammed using an Arduino uno microcontroller. Fig. 1 shows how is the system works.

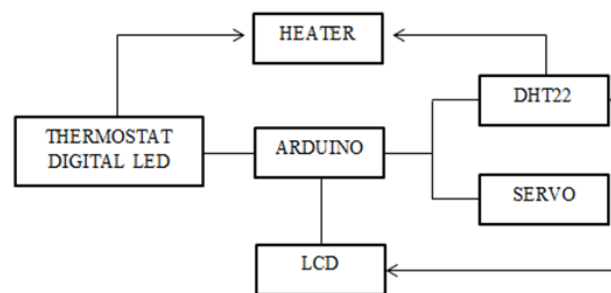


Figure 1. How the system works

3. Result and Discussion

3.1 Mechanical System

The Fig. 2 is the design of the hatching machine as well as Fig. 3 is the test of the heating laying in order to obtain a uniform heat distribution within the incubator.

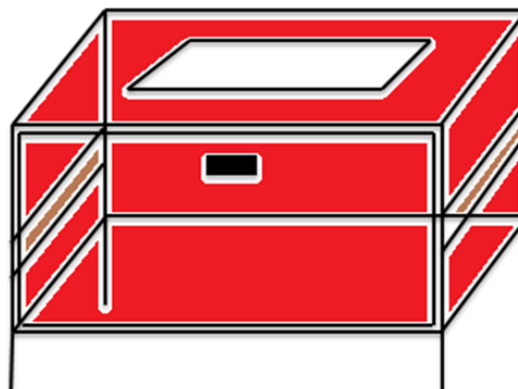


Figure 2. Design of the hatching machine

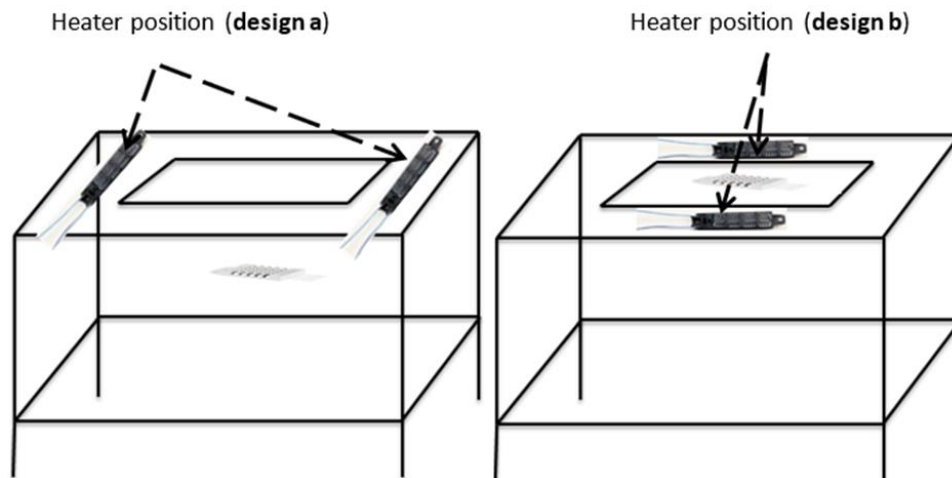


Fig. 3. Laying heater with the distance of both sources is 35 cm (a) and 25 cm (b)

Testing of heating laying was done on several variations namely the distance between the heater and the distance between the air heaters with the shelf. In Fig. 3a the distance between the heaters is 35 cm, and the heating distance to the egg is 28 cm. At such distances, the heat distribution was evenly distributed at virtually every point of temperature testing with an analogue (mercury) thermometer with a difference of not more than 0.8°C . While in Fig. 3b the temperature at the centre of the incubator always exceeds 40°C when some test points have not reached 39°C (optimum temperature hatching).

Servo servicing was done by varying the number of servo used and the servo laying position. The result is that using two servos placed at the centre point of each side of the shelf is more effective in moving the rack than using two servos placed on one side of the shelf.

3.2 Electronic System

In the design of electronic systems, things to consider is the power consumption of each component used in particular is in the form of heating. Initially before this research was conducted used four incandescent lamps with $220\text{V} / 100\text{W}$ specifications that can spend power of 9.6 kW every 6 hours. While this study reported using two $220\text{V} / 65\text{W}$ air heater can spend 0.78 kW every 6 hours of usage. However, one of the drawbacks of using the air heater is the time required to achieve 39°C hatching temperature is relatively long in 60 minutes compared to using an incandescent lamp that is only 35 minutes.

In controlling and monitoring the temperature and humidity in the incubator initially using DHT22 sensor but obtained inaccurate in the measurement so its using thermostat for monitoring and to control the temperature while DHT22 still used to control the humidity. Completed electronics design is shown in Fig.4. The description of Figure 4 is as follows:

- A. IC driver to controlling dc motor
- B. Servos
- C. Stepper Motor with 10 kg.cm of torque
- D. Humidity sensor (DHT22)
- E. Relay to controlling the air heater
- F. Air heater
- G. LCD to displaying the information of temperature, Relative humidity (RH)
- H. AC power (220 V)
- I. DC power (9 V) to supplying 3 of servos

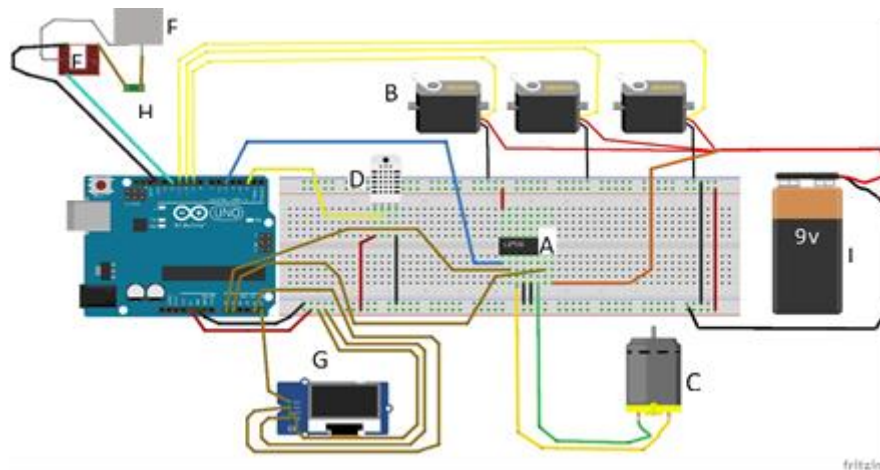


Figure 4. Electrical system design

Table 1 is the result of a servo simulation test using 6 hours and produced the first two movements right to 6 hours and the second to the left with 6 hours.

Table 1: Testing of motor movement

The first 6 Hour Test		Second 6 hour Test		Third 6 hour Test		Fourth 6 hour Test	
S	SM	S	SM	S	SM	S	SM
to right	to right	to left	to left	to right	to right	to left	to left

*SM = Stepper Motor, S = Servo

Table 2: DHT22 Simulation Test

Temperature above 39 °C	Temperature below 37 °C
Air heater was off	Air heater was on

Table 3: Testing of voltage variations on Motor

5 volt		6 volt		9 volt	
S	SM	S	SM	S	SM

The load that can be pulled was 8 kg	The load that can be pulled was 6.4 kg	The load that can be pulled was 9 kg	Can not move	Can not move (excess current)	Can not move
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In the Table 2, a temperature sensor is tested. in this test the DHT22 temperature sensor detects changes in temperature in the incubator and the results are used as information to control the air heater. the test results show that the air heater will be automatically turned off when the temperature exceeds 39 °C and the heater is on again when the temperature is below 36 °C.

In the table above, we conducted an experiment with variations in electrical voltage by 5 volts, 6 volts, and 12 volts on the servo motor and stepper motor. Maximum load that can be driven by a servo or stepper motor at a voltage of 5 volts was 8 kg, then the 6 volt servo voltage can drive a 9 kg load while the stepper motor does not move at all, then when the voltage was increased to 12 volts both servo and stepper motors it does not move at all this is presumably because the current on the two motors is too large to exceed the maximum load current capable of holding.

4. Conclusion

From the results of the electronics and mechanics analysis performed the average electric power spent every 6 hours is 0.78 kWh. From the results of the driving test using a stepper and servo motors generated more optimal movement by using servo motor at the maximum load of 315 eggs (9 kg).

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