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CONSTRUCTION OF HEN EGG INCUBATOR CONTROLLED CIRCUIT USING PIC16F877A

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Abstract

The hen egg incubator model is constructed using composite aluminum plate to enable reproduction process with the developing embryo. Light sources (40W, two bulbs) are used to maintain the require temperature. Two fans (5VDC) are also used to provide oxygen and to remove waste carbon dioxide. These are controlled by the circuit constructed using PIC16F877A microcontroller and other electronic devices. The program is written by using Basic Pro Language and it is compiled by Micro Studio Plus Software. The hexafile is downloaded by Win PIC 800. The temperature sensor, LM35DZ IC is used to detect the surrounding temperature. LCD module, TS1620L is used to display the present temperature in the hen egg incubator model from outside it. The chickens can be incubated from hen eggs by using Hen Egg Incubator Controlled Circuit.

Introduction

The hen egg incubator model which can be hatched eight eggs is constructed with aluminium and composite aluminium plate. This model is constructed with five components. They are the temperature controlled circuit, two light sources of bulbs (40W), two fans, egg tray and water container.

The controlled circuit is constructed with PIC16F877A microcontroller and other electronic components. Microcontrollers are intelligent electronic devices used to control and monitor devices in the real world. Microcontrollers are programmed devices. Pic Basic Pro Languages are used to program PIC microcontrollers. The two bulbs (40W) are used as light sources to get the available temperature. The two fans control the available temperature in the incubator. The egg tray is used for rolling eggs to obtain the same temperature on the eggs. The egg must be frequently turned and carefully positioned so that the embryo passes through fresh nutrients in the white of the egg, while forming in the correct position hatching. In the

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incubation period, the egg loses water by passing through pore in the shell. The humidity of the air in the incubator must be controlled by the water container. Four holes on one side, four holes on other side and eight holes on above side of the incubator are drilled to provide ventilation automatically. The egg breathes so there must be a supply of fresh air to provide oxygen and to remove waste carbon dioxide. Eggs are susceptible to infection so the incubator must provide a clean, disinfected environment.

Theoretical Background

Microcontroller Systems

A microcontroller is a single chip computer. Micro suggests that the device is small, and controller suggests that the device can be used in control applications. Another term used for microcontrollers is embedded controller, since most of the microcontrollers are built into (or embedded in) the devices they control. The simplest microcontroller architecture consists of a microprocessor, memory, and I/O. The microprocessor consists of a central processing unit (CPU) and the control unit (CU). The CPU is the brain of the microcontroller and this is where all of the arithmetic and logic operations are performed. The CU controls the internal operations of the microprocessor and sends out control signals to other parts of the microcontroller to carry out the required instructions. Memory is an important part of a microcontroller system. Depending upon the type used memories can classified into two groups: program memory and data memory. Program memory stores the program written by the programmer and this memory is usually non-volatile, i.e. data is not lost after the removal of power. Data memory is where the temporary data used in a program are stored and this memory is usually volatile, i.e. data is lost after the removal of power.

There are basically five types of memories. They are RAM, ROM, EPROM, EEPROM and Flash EEPROM. RAM means Random Access Memory. It is a general-purpose memory which usually stores the user data used in a program. RAM is volatile, i.e. data is lost after the removal of power. ROM is Read Only Memory. This type of memory usually holds program or fixed user data. EPROM is Erasable Programmable Read Only Memory. This is similar to ROM, but the EPROM can be programmed using a suitable programming device. EEPROM is Electrically Erasable Programmable Read Only Memory, which is a non-volatile memory. These memories can be erased and also be programmed under program control. EEPROMs are used to save configuration information, maximum and minimum values, identification data, etc. Flash EEPROM is non-volatile and is usually very fast. The data is erased and then re-programmed using a programming device.

The Hardware Features of Microcontroller

Supply Voltage

Most microcontrollers operate with the standard logic voltage of +5V. Some microcontrollers can operate at as low as +2.7 V and some will tolerate +6 V without any problems. A voltage regulator circuit is usually used to obtain the required power supply voltage when the device is to be operated from a mains adaptor or batteries.

The Clock

The microcontroller requires a clock (or an oscillator) to operate. The clock is usually provided by connecting external timing devices to the microcontroller. Most microcontrollers will generate clock signals when a crystal and two small capacitors are connected. Some will operate with resonators or external resistor–capacitor pair. Some microcontrollers have built-in timing circuits and they do not require any external timing components. The microcontroller is actually operated at a clock rate which is a quarter of the actual oscillator frequency.

Timer

Timers are important parts of any microcontroller. A timer is basically a counter which is driven either from an external clock pulse or from the internal oscillator of the microcontroller. It is typical to have at least one timer in every microcontroller. Some microcontrollers may have two, three, or even more timers where some of the timers can be cascaded for longer counts.

Watchdog

Most microcontrollers have at least one watchdog facility. The watchdog is basically a timer which is refreshed by the user program and a reset occurs if the program fails to refresh the watchdog.

Reset Input

A reset input is used to reset a microcontroller. An external reset action is usually achieved by connecting a push-button switch to the reset input such that the microcontroller can be reset when the switch is pressed.

Interrupts

Interrupts are very important concepts in microcontrollers. An interrupt causes the microcontroller to respond to external and internal (e.g. a timer) events very quickly.

Brown-out Detector

Brown-out detector reset a microcontroller if the supply voltage falls below a nominal value.

Analogue-to-digital Converter

An analogue-to-digital converter (A/D) is used to convert an analogue signal such as voltage to a digital form so that it can be read by a microcontroller. Some microcontrollers have built-in A/D converters.

EEPROM Data Memory

EEPROM type data memory is also very common in many microcontrollers. The advantage of an EEPROM memory is that the programmer can store non-volatile data in such a memory, and can also change this data whenever required.

Analogue Comparator

Analogue comparators are used where it is required to compare two analogue voltages. Although these circuits are implemented in most high-end PIC microcontrollers they are not common in other microcontrollers.

PIC16F877A Microcontroller

In the constructed system, PIC16F877A microcontroller is used as one digit score board which is manufactured by the Microchip Technology Inc. It is a 40-pin device with 8 Kbytes of flash program memory. The PIC16F877A has five I/O ports, PortA, PortB, PortC, PortD and PortE. Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin .The pin diagram of the PIC16F877A microcontroller are shown in figure1.

Introduction to Bipolar Junction Transistor

Two basic types of transistor are the bipolar junction transistor (BJT) and the field-effect transistor (FET). The BJT is used in two broad areas such as linear amplifier and as an electronic switch.

In the bipolar junction transistor (BJT), three doped semiconductor regions are formed as two back to back connected p-n junctions consists of two n regions separated by a p region, and the other consists of two p regions separated by an n region.

The p-n junction joining the base region and the emitter region is called the base emitter junction. The junction joining the base region and the collector region is called the base collector junction. These leads are labeled E, B, and C for emitter, base, and collector, respectively.

The base region is lightly doped and very thin compared to the heavily doped emitter and the moderately doped collector regions. Figure 2 shows the schematic symbols for the n-p-n and p-n-p bipolar transistors. The term bipolar refers to the use of both holes and electrons as carriers in the transistor structure.

Embryo Development (based on hen egg)

The yolk is dropped from the ovary into the unfundibilum where it is fertilised by the male sperm if present. The embryo commences development while the yolk travels down the egg canal. Here it receives coatings of white. The egg progresses to the shell gland where it receives membranes and forms the shell itself. This process takes approximately 20 hours, in which time the embryo grows to about 4mm in diameter. The egg is laid.

After the egg is laid it cools and growth slows or stops. Many birds (but not all) accumulate a ‘clutch’ of eggs before commencing incubation. During this ‘storage’ time temperature is preferably between 0 and 20°C but some species tolerate more extreme temperatures. However, embryonic death is a risk if extremes are maintained. In the first day of incubation a line called the primitive streak appears. This allows the formation of a third layer of cells. From these new cells the organs of the body will form. The cells are made up in three layers called ectoderm, mesoderm and endoderm. Ectoderm forms the skin, feathers, beak, nervous system, claws eyes and mouth. Mesoderm forms the skeleton, muscle, blood and reproductive organs. Endoderm forms the respiratory organs, secretary system and digestive system. By the end of the first day’s incubation, the head, eyes, nervous system and blood island have started to form. The heart is formed on the second day and is functioning by 44 hours.

On the fourth day the heart changes from its simple form and becomes a fully formed beating heart. During this time extra membranes are formed to produce the amniotic sack. The embryo will now float in the amniotic fluid for the rest of incubation. The amniotic fluid and turning of the egg ensure the embryo orientsitself correctly for hatching. By the fourth day, legs and wing buds begin to form and the heart is still positioned outside the body.

By six days the legs and wings are almost complete, and by eight days feathers are appearing. On the 9th day the embryo starts to look like a chick. The heart is now within the body with blood circulation to the outside via the umbilicus. By ten days the bones are now being formed.

Thirteen days into incubation and the down is apparent and is coloured. By sixteen days the beak, leg scales and claws are almost complete. The albumen is used up with just the yolk remaining. The amniotic fluid decreases and the yolk then acts as a food source. By the nineteenth day the yolk is incorporated into the body. The ability of the embryo or now ‘chick’, to get oxygen through the shell and into the blood system is now limited. The carbon dioxide levels in the blood therefore rise dramatically, which causes twitches in the chick’s neck muscle. The beak then forces its way into the air cell at the large end of the egg. The beak now opens for the first time and the lungs inflate. This causes the blood system to circulate within the lungs. This is time of great stress for the chick, where any deficiencies become apparent. The stress is so much that it will kill chicks that are not strong enough, usually those who have a lack of group B vitamins. The chick continues to try to breath in earnest, which causes more twitching and hopefully a breakout through the shell. This process forces the beak out and chips a small hole in the shell. The legs push the chick slightly to the side so next time there is a twitch the next piece of shell will fall off. This continues all the way round the shell until the end of the shell falls off. The chick has an egg tooth, which helps with this hatching process. The tooth falls off soon after hatching. After the end falls off the chick kicks itself out of the shell. The old blood vessels and membranes in the cell. Embryo development of hen egg from first day to 21days is shown in Figure 3.

Temperature

Accurate incubation temperature is by far the most important requirement for successful hatching of chicks. Even marginal temperature differences can affect hatch rates, although these differences seem to have less effect on eggs in contact incubators. The growth processes in the development of the embryo are very temperature sensitive and small deviation can cause development to progress out of sequence resulting in losses or deformities. The design basis for Brinsea incubators is a maximum ±0.25C across the egg tray and ±0.25C over a period of time.

It is the egg centre or embryo temperature that is most critical. To ensure this is correct it is of highest importance that the incubator is set up correctly, particularly for still air machines. Still air incubators have temperature variations from top to bottom, therefore the sensor of the temperature controller and the thermometer bulb need to be positioned as close as possible to the top of the eggs. Here the temperature needs to be slightly higher than the mean temperature used in forced draft incubators and accounts for the important difference found in the instructions. It is therefore vital to follow the manufacturer's recommendations for the incubator used.

Humidity

Constant accuracy of humidity is less critical than that of temperature. Ideally, the egg needs to lose 13 – 15% of its weight between the time of laying and pipping, (more for some altricial species). Fairly wide tolerances in humidity are bearable although not ideal, as long as the chick ends up having lost the correct amount of weight by the time of hatching. Correction can be made in later stages for errors earlier.

Experience has shown Contact Incubation to be less critical of exact humidity control, perhaps due to the egg being in a more natural air-flow environment. Never the less, digital humidity control is available for all Brinsea Contact and Forced Air incubators.

The weight loss rate will vary according the type of egg, the amount of ventilation, the handling of the egg, the breeder diet and the time in the season in which it was hatched. There are two guides that help indicate correct humidity.

Firstly, the air cell. The air cell increases as the incubation proceeds. In order to see this at first sight, the eggs need to be candled.

The other indicator is weight loss. If you weigh eggs before setting and weigh them as incubation progresses, the weight loss can be plotted on a graph (example below) to determine if the average weight loss has been correct.

Humidity can be adjusted during the incubation period according to the graph reading at that particular time in the incubation process. As a general rule, if actual weights are lower than ideal, then humidity needs to be increased. If actual weights are higher than ideal, then humidity needs to be decreased.

All incubators should have the facility to adjust humidity levels. There are two controllable factors that influence humidity levels. These are the amount of water surface area, and the amount of fresh air that the incubator draws in. The greater the water surface area, and the less fresh air being drawn in, the higher the humidity levels inside the incubator will be. One method to increase water surface area is to use evaporating pads or blotting paper. Finally, the environment in which the incubator is set up in can have an effect on accurate humidity control. If the ambient humidity in the air outside the incubator is very dry, then incubation humidity levels will be lower than if the air is very humid (wet). Also, cold air cannot retain much water vapour, so when cold winter air is warmed the RH level will be very low. This happens in heated houses in winter, and also inside incubators. The result of this in general is that humidity levels tend to be lower in the winter than in summer and so humidity levels should be adjusted with this in mind.

Some breeders go to great lengths to control the incubation room environment and overcome seasonal variations in ambient humidity. In extreme cases, sections of the egg's shell are removed to allow extra water loss, or covered with tape to reduce water loss. This should be regarded as strictly for the experts though and a high risk method. The humidity levels required when a chick is hatching need to be higher than previously in the incubation period. For the last day or so, high humidity levels are required to prevent the membranes of the egg drying too fast as the chick hatches and becoming tough and difficult to tear. The humidity level when hatching should therefore be at least 60%RH.

Turning and Rolling

As the egg is turned the embryo is swept into fresh nutrients, allowing the embryo to develop. This is critical for the first week when the embryo has no circulation system. After the first week, eggs still need to be turned but not as often. The turning regime is often different between species and altricial birds tend to need more frequent turning than precocial birds. Whereas fowl are turned through 80 degrees every hour or so, parrots are often turned through 180 degrees many times an hour in the early stage.

Rollers work by being rotated by a moving floor. Eggs sit on rollers that in turn sit on the moving floor. Ribs on the rollers help reduce the tendency for an egg to 'walk' along the roller length.

Candling

Candling lamps are lights with a concentrated beam that may be shone through the shell of the egg to illuminate the egg contents. This allows the size of the airspace to be determined which offers a guide to the weight loss rate. If the air space is larger than expected too much water is being lost and the humidity in the incubator should be increased to reduce the rate of water loss. If the air space is smaller than expected then the opposite applies. Diagram for extent of airspace development throughout incubation (in days) is shown in Figure 4.

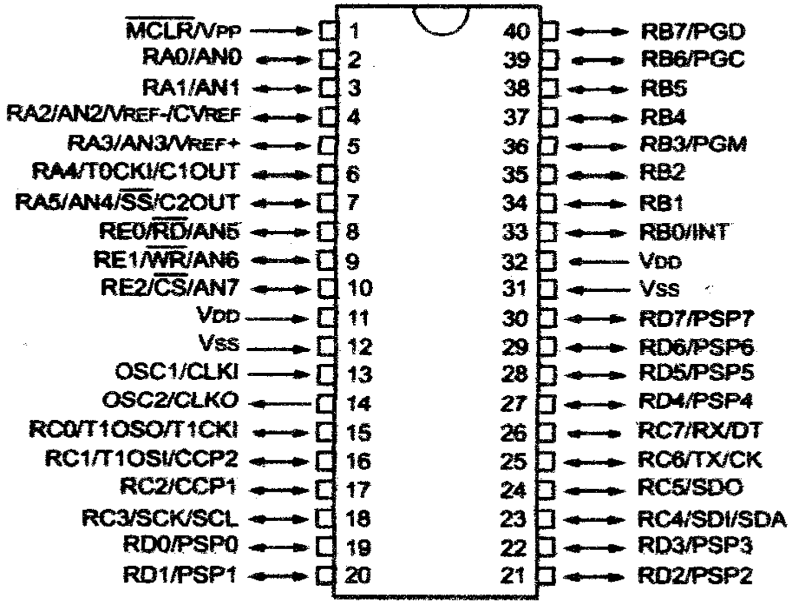

Figure 1: Pin diagram of PIC16F877A microcontroller

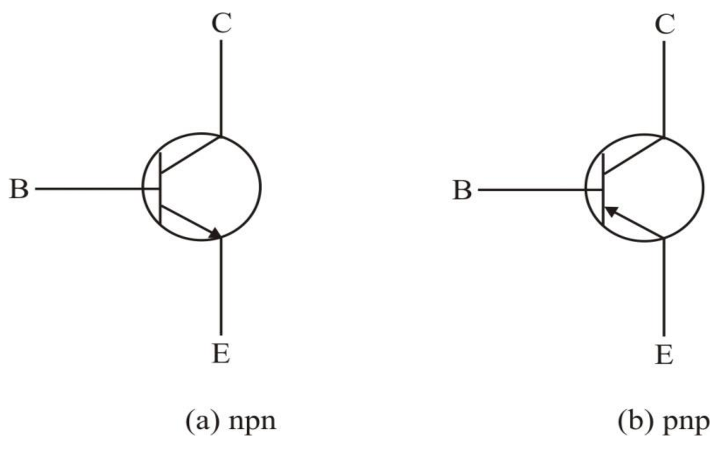

Figure 2: Standard bipolar junction transisor (BJT) symbols

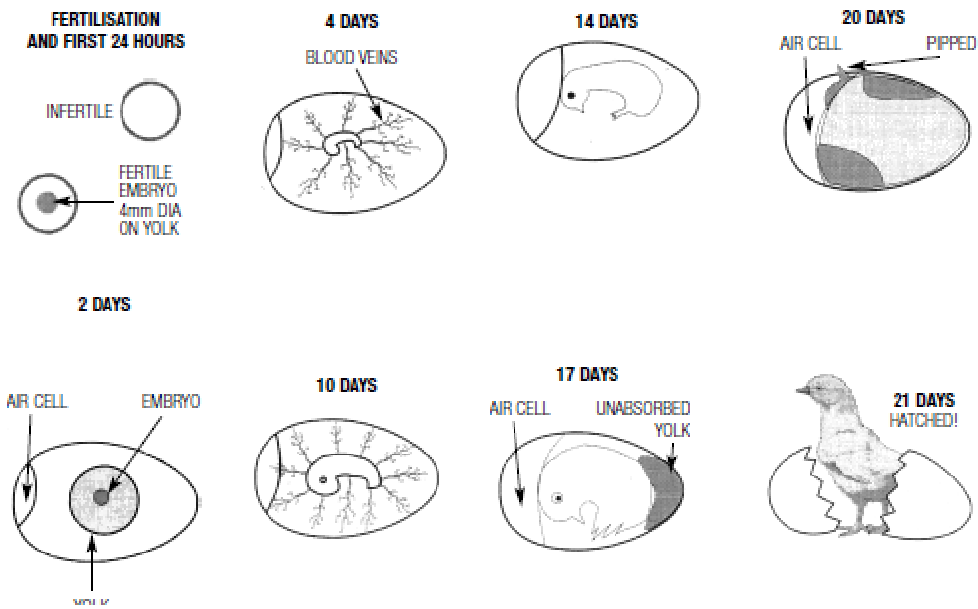

Figure 3: Embryo development of hen egg from first day to 21days

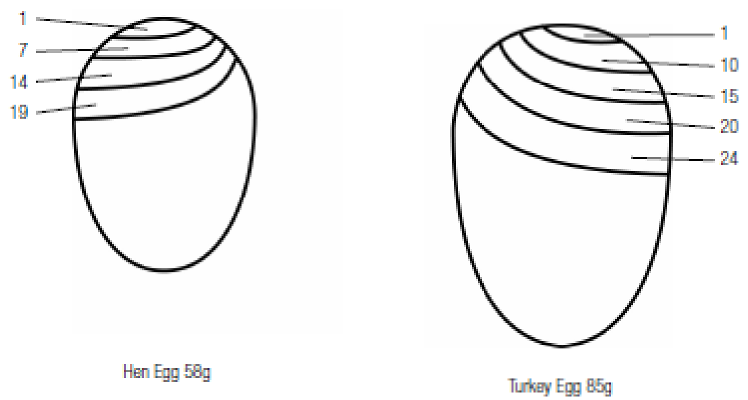

Figure 4: Diagram for extent of airspace development throughout incubation(in days)

Construction and Operation of the Whole system

Constructed hen egg incubator

The incubator can take up to 8 eggs. It is 30cm length, 30cm breadth and 45cm long . It can be made composite aluminium plate. The aluminium plate of the front side of the incubator is used as the window to open by pulling upward and to close by pushing downward. The lamp 1 controlled by dimmer is set up on the back side of the incubator. The lamp 2 controlled by the setting temperature is set up on the top side of the incubator. The two fans are also set up in topside of the incubator. The eight holes are drilled on the right side and left side. The four holes in the center of each fan are also drilled on the top of the incubator. The water container $\left(25cm \times 15cm \times 2cm\right)$ costructed by using zinc plate is taken place on the bottom side of the incubator. The dimension of constructed is shown in Figure 5.

Power Supply Circuit

A positive 5V regulated power supply has been constructed. A 7805 IC, a step-down transformer, two 1N4007 p-n junction diodes and a capacitor are used. The voltage regulator give positive 5V. IC7805 is a three terminal voltage regulator . Pin 3 of IC gives the output. An input voltage is given to pin 1 and Pin 2 must be grounded. The input voltage must be DC voltage higher than the desired output voltage. To obtain two 5V DC inputs, a full-wave rectifier converts AC to DC and a 9V step-down transformer is also used. The circuit diagram of the constructed +5V regulated power supply is shown in Figure 6.

Controlled circuit of constructed hen egg incubator

The controlled circuit of hen egg incubator is constructed by using PIC 16F877A, LM35, LCD display, two relays, two fans, two bulbs, AC220V, dimmer, two transistors (BD139 and C945), capacitors and resistors. The pin 1 of pic is used as master clear that is joined to the 4.7kΩresistor applied by the +5VDC.The pin 2 of pic is connected to the pin1 of LM35 and the pin2 of LM35 is applied by+5VDC and pin3 is grounded. The pin 3 of pic is connected to the variable resistor (10k) applied by +5VDC. The pin11 of pic is applied by +5VDC and the pin 12 of pic is grounded. The pin 13 of pic is as the RC network (4.7k and 22pF) that is generated to the clock pulse. The pin

15, 16 of pic is connected to the base of BD139 and C945 transistor with 1k resistor respectively. The pin 21, 22, 27, 28, 29, 30 of pic is connected to the pin 4, 6, 11, 12, 13, 14 of LCD module respectively. The pin1 of LCD is connected to the pin3 of LCD with 4.7k resistor and is grounded. The pin2 of LCD is applied by +5VDC and the pin 5 of LCD is grounded. The collector of C945 transistor and BD139 transistor is connected to relay 1 and relay 2 respectively. The relay 1 is connected to the bulb 1 applied by AC220V but the bulb 2 is connected to AC220V with dimmer. The relay 2 is connected to fan1 and used as a switch for fan2 applied by +5VDC.The constructed controlled circuit of hen incubator is shown in Figure 7.

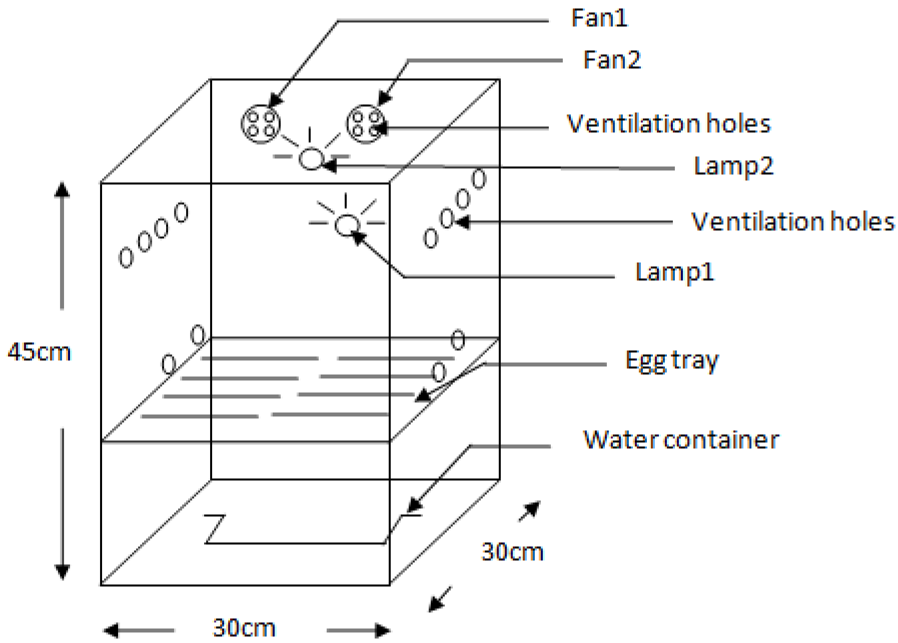

Figure 5: Dimension of constructed hen incubator model

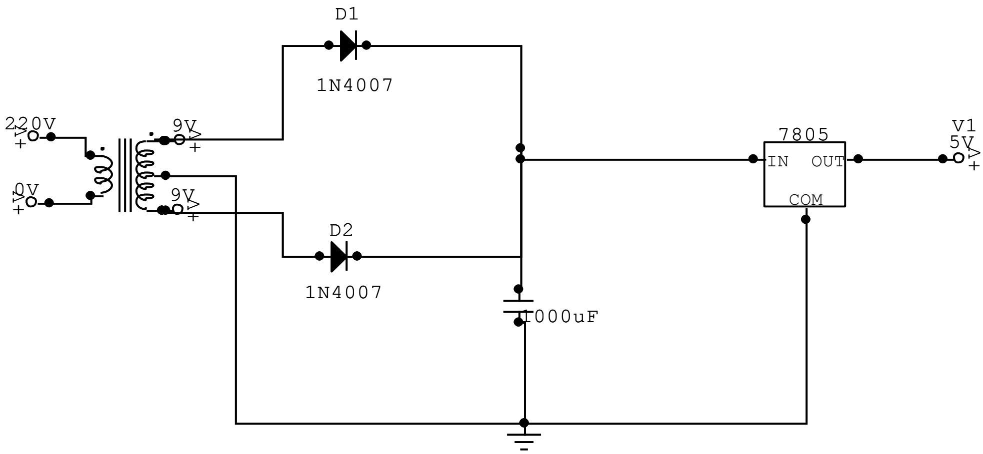

Figure 6: Constructed circuit diagram of +5V regulated power supplies

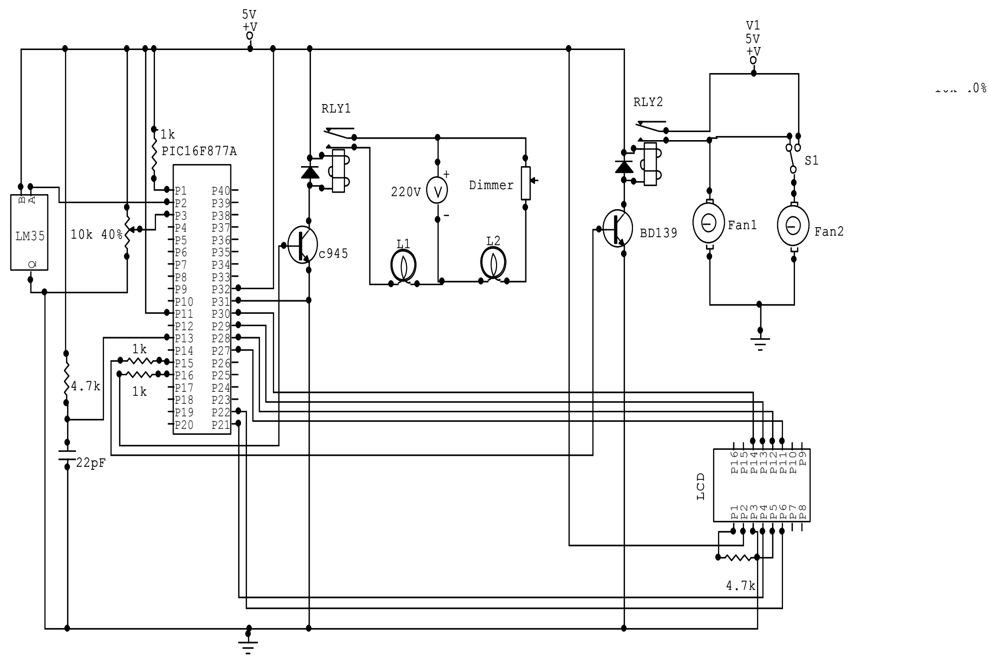

Figure 7: The constructed controlled circuit of hen egg incubator model

Results and Discussion

Results

The controlled circuit by using PIC16F877A microcontroller for hen egg incubator has been constructed as shown in Figure 8. The hen egg incubator model as shown in Figure 9 has also been constructed to investigate the growth of the embryo. The incubator is set up correctly, particularly for still air machines to have temperature variation from top to bottom. The right side of incubator as shown in Figure 10 exists the ventilation holes and the rope tied the rod for rolling eggs. The light sources, fans and temperature sensor as shown in Figure 11 are set up in the incubator model. Before hatching the position of the eggs on the trays, water container and thermometer for measuring the surrounding temperature are shown in Figure12.

To investigate the growth of embryo for the first time we choose the five eggs which each have weight of 36 gram. They are placed into the egg tray as shown in figure 12. The total time taken for the eggs is 21days from 1.11.15 to 22.11.15. The incubator without controlled circuit and the light source controlled by the dimmer are provided on the eggs, therefore the temperature stored by the eggs is from minimum temperature 32^0C to maximum temperature 40^0C. The surrounding temperature is nearly from 19^0C to 28^0C during the incubation period. After 7days, we observed dead embryo due to the lack of electricity. This situation is shown in Figure 14.

For the second time we choose the eight eggs which each has weight of 45 gram. The total time taken for the eggs is 26days from 14.12.15 to 9.1.16. The incubator with controlled circuit, fans, light source controlled by the dimmer are provided on the eggs, therefore the temperature stored by the eggs is from minimum temperature 35^0C to maximum temperature 40^0C. The surrounding temperature is nearly from 9^0C to 25^0C during incubation period.

After 21days, when the one of the eggs is cracked, we observed that the alives in the shell. The front and back view of chick are shown in Figure 14 and 15. So the seven eggs were still-born in the incubator. After 24days, the three egg were successfully cracked and hatched out. The next day, the one egg is also cracked and hatched out. The photograph of the chicks breaking out of the four eggs after 25days is shown in Figure 16.

After 26days, the two eggs do not hatch out and do not alive in the shell. The two dead chicks without hatching out of the eggs as shown in Figure 17. Since the last one egg does not crack, when it is cracked by hand, we observed that the chick alives in the shell. The living chick without cracking of the egg after 26days is shown in Figure 18.

Discussion

Our constructed model is a small incubator capable of holding eight eggs by using the cheapest local materials. It is weak embryos so that chicks hatch late for 4-days. Because the window of incubator is after opened or closed, it is low incubation temperature and humidity in storage. So the two chicks stuck in shell and dead without breaking out of the eggs.

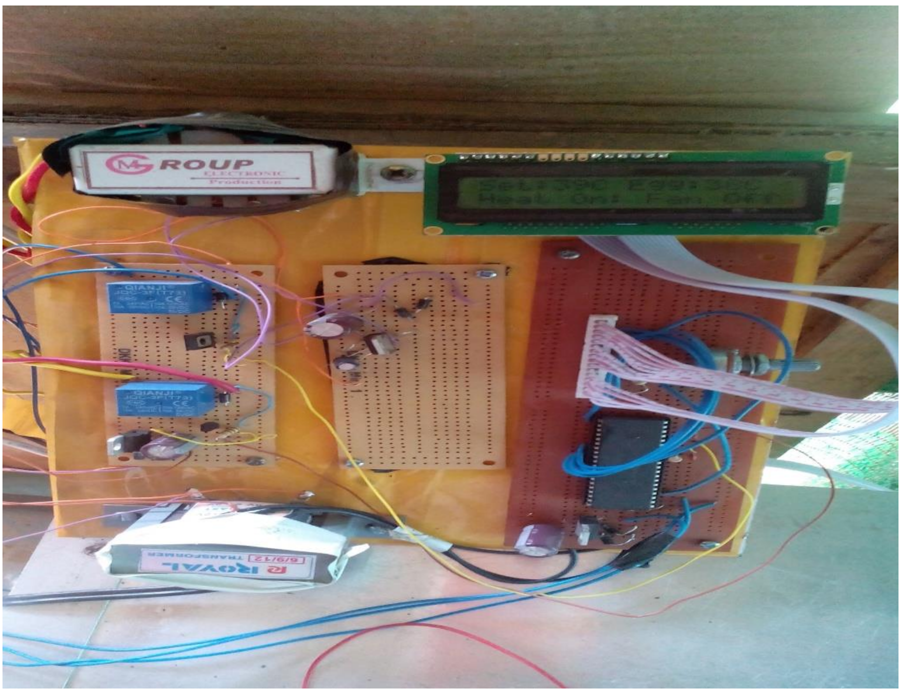

Figure 8: Photograph of the controlled circuit for hen egg incubator.

Figure 9: Photograph of hen egg incubator model.

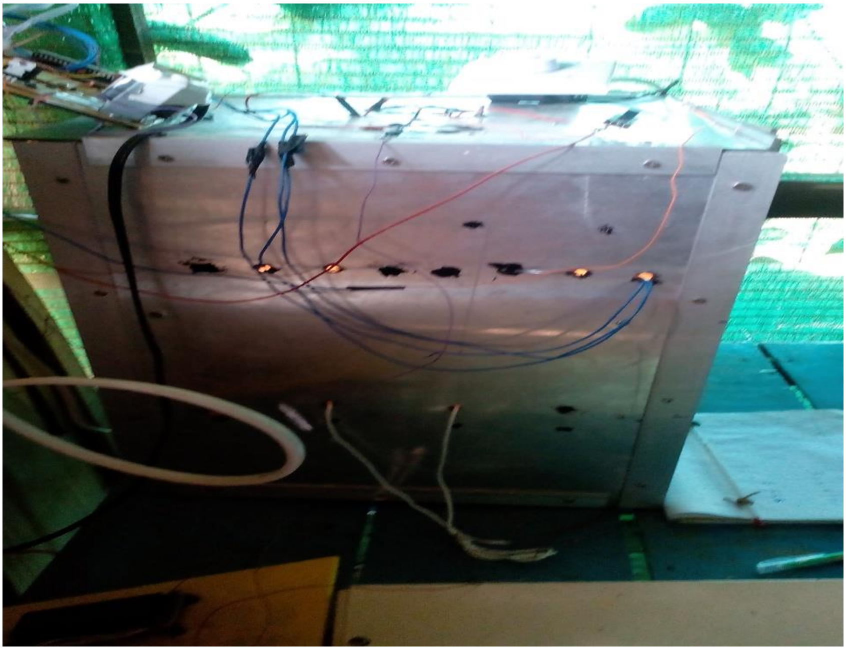

Figure 10: Photograph of the right side of incubator model**.**

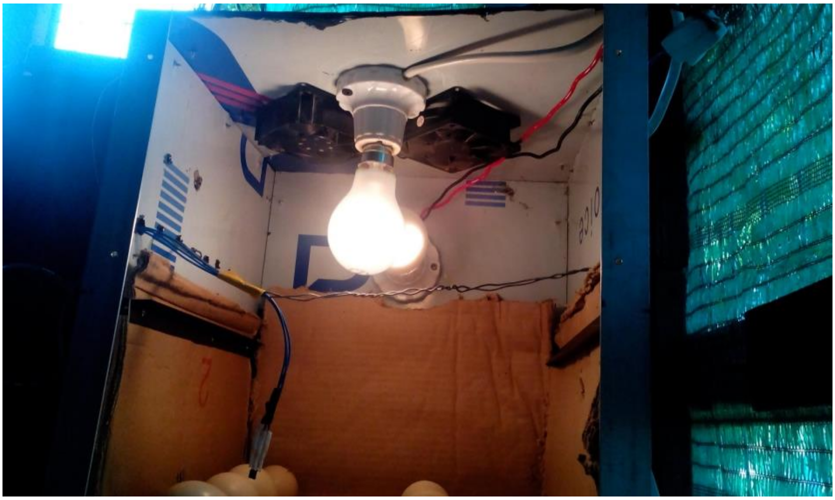

Figure 11: Photograph of setting bulbs and fans in the incubator model.

Figure 12: Photograph of the eggs on the tray before hatching.

Figure 13: Photograph of the condition to develop the embryo.

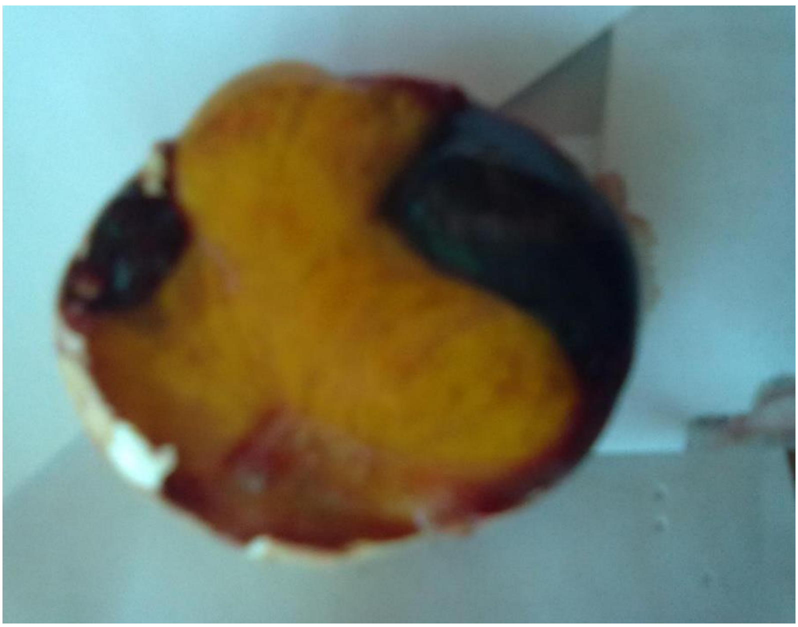

Figure 14: Photograph of the front view of chick after 21days.

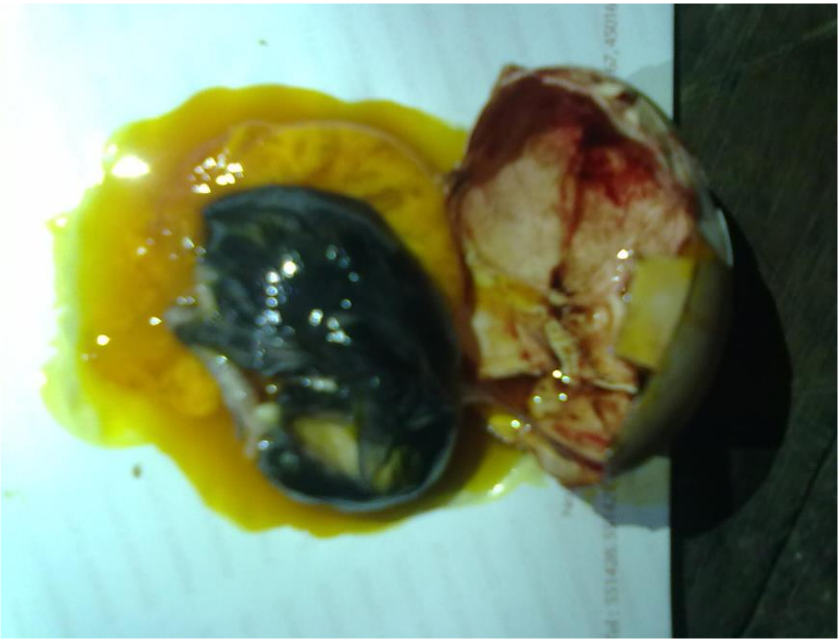

Figure 15: Photograph of the back view of chick after 21days .

Figure16: Photograph of the chicks hatching out of the four eggs after 25days.

Figure17: Photograph of the two dead chicks without hatching after 26days.

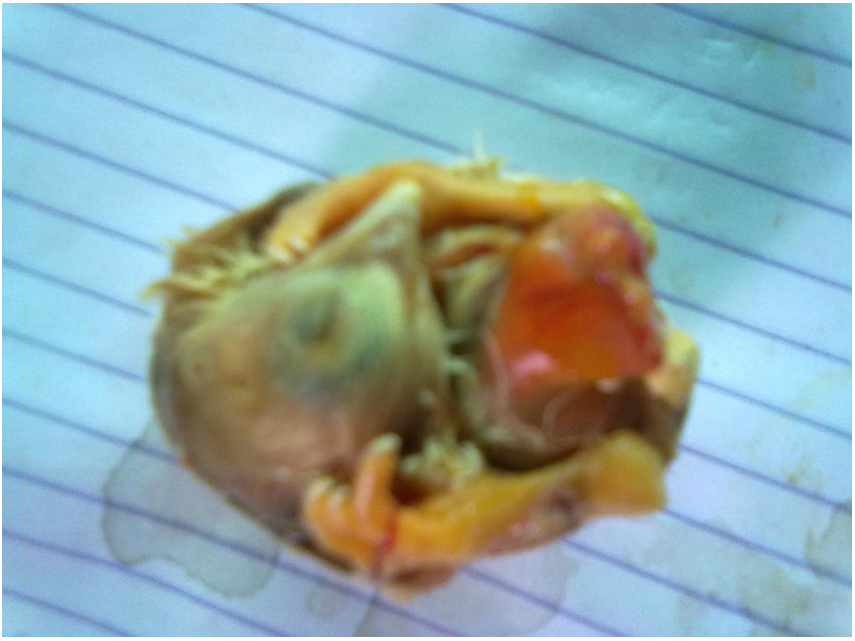

Figure 18: Photograph of the living chick without cracking after 26days

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