DEVELOPMENT OF A FULLY AUTOMATED SMART INCUBATOR SYSTEM

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DEVELOPMENT OF A FULLY AUTOMATED SMART INCUBATOR SYSTEM

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2022

DECLARATION

I declare that this report entitled “Development of a Fully Automated Smart Incubator System” is the result of my own work except for quotes as cited in the references.

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Signature : ....

Author : MUHAMMAD AZFAR AMINUDDIN BIN MAZHAN

Date : 18 JANUARY 2022

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

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Signature	:	………………………………………
Supervisor Name	:	TS. SITI ROSMANIZA BINTI AB RASHID
Date	:	18 JANUARY 2022

DEDICATION

Special dedicate to my parents, my dedicated supervisor and all my beloved friends in helping me to successfully accomplish this project.

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ABSTRACT

Poultry egg incubators are easily found with variety of hatching features. If heat and humidity in incubator are not optimal, the stability of eggs will deteriorate. As a response, in order to make it work and technology emerge, an enhanced chicken egg incubator is required. The entire system is controlled by using Arduino UNO as the brain of the system which having interface with LCD and DHT11 sensor. The sequence of operation started with DHT11 sensor detect surrounding temperature and humidity while LCD displaying the value. Then, in certain conditions, heat is constantly supplied by such heating elements while ventilation system triggered when temperature and humidity is out of desired value. The egg progress is monitored regularly by inspecting their embryo within their staging phase. This research compares three type of heating elements which is fluorescent light bulb, LED light bulb and heating mat. From the analysis that has been made, the LED bulb can produce the ideal temperature for hatching process which is 37.5°C out of those two heating elements. Besides, the incubator also works well in terms of controlling the humidity where it can maintain the optimum value which is about 55% RH. Tilting mechanism also helps in the hatching process where 65% was hatched under tilted condition even though there is 25% of the eggs without tilted condition successfully hatched.

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ABSTRAK

Inkubator mudah didapati dan didatangkan dengan pelbagai ciri penetasan. Sekiranya haba dan kelembapan dalam inkubator tidak optimum, kestabilan telur akan merosot. Untuk menjadikannya berfungsi dan memacu teknologi, inkubator baharu diperlukan. Keseluruhan sistem dikawal oleh Arduino UNO dengan pengendalian DHT11 sensor dan LCD. Turutan operasi bermula dengan sensor DHT11 mengesan suhu dan kelembapan sekeliling sambil LCD memaparkan nilai. Kemudian, dalam keadaan tertentu, haba dibekalkan oleh elemen pemanas manakala sistem pengudaraan bertindak apabila suhu dan kelembapan berada di luar nilai yang dikehendaki. Keadaan telur dipantau secara berkala dengan memeriksa embrio mengikut fasa tertentu. Penyelidikan ini membandingkan tiga jenis elemen pemanas iaitu mentol lampu pendarfluor, mentol lampu LED dan tikar pemanas. Daripada analisis yang telah dibuat, mentol LED boleh menghasilkan suhu yang ideal untuk proses penetasan iaitu 37.5°C daripada dua elemen pemanas tersebut. Selain itu, inkubator juga berfungsi dengan baik dari segi mengawal kelembapan di mana ia dapat mengekalkan nilai optimum iaitu kira-kira 55% RH. Pemusingan telur juga membantu dalam proses penetasan di mana 65% telah ditetas dengan pusingan walaupun terdapat 25% telur berjaya menetas tanpa sebarang putaran.

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ACKNOWLEDGEMENTS

All praises be to ALLAH S.W.T, Lord of the Universe, the most Merciful, the most Gracious and Beneficent to Prophet Muhammad S.A.W, His Companion and the people who follow His path. First and foremost, a lot of thanks to Almighty Allah for giving me strength and patience in completing this Final Year Project (FYP) for my final year.

I want to take this opportunity to express my gratitude to my respected supervisor, Ts. Siti Rosmaniza Binti Ab Rashid for her encouragement, guidance and time throughout the progress of this project. Without her continued support and interest, I would not be able to complete my project. The satisfaction that accompanies the successful completion of task would be but incomplete without mentioning the people, who made it possible, whose gave me advice and moral support to keep me going on and never give up.

Besides, my appreciation also goes to my family who always give moral support to keep me motivated and never give up. Their blessings for my success are inspire me to give my best in completing this project. Their love and supports are helpful to ease my pressure. In addition, my sincere appreciation to my university and others who have provided assistance at various occasions. Their helps and tips are useful and I put it to good use.

Last but not least, I would like to thank to those who involved direct or indirectly in helping me to accomplish my project especially my friends and lab assistant that helping me to complete this project successfully. I really appreciate their constructive comments and ideas for improving my project, I hope those people who helped me will have a blessed life.

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LIST OF SYMBOLS AND ABBREVIATIONS

RH	:	Relative humidity
LCD	:	Liquid crystal display
DHT	:	Digital humidity temperature
DC	:	Direct current
°C	:	Celsius
°F	:	Fahrenheit
PV	:	Photovoltaic
AC	:	Alternating current
LED	:	Light emitting diode
PWM	:	Pulse width modulation
USB	:	Universal serial bus
ICSP	:	In-circuit serial programming
IDE	:	Integrated development environment
T	:	Temperature
NTC	:	Negative Temperature Coefficient
IC	:	Integrated Circuit
IoT	:	Internet of Things

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CHAPTER 1

INTRODUCTION

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Egg incubator requires several parameters that need to be monitor. Usually, process of incubation for hatching system required 21 days. With this automated smart incubator system, it will reduce egg spoilage and obtain more benefits from it. It can be applied either in factory farming or poultry industries. Overall overview is given in this chapter of the project which consist of objective, problem statement, scope of project and importance of study.

1.1 Project Overview

A smart chicken egg hatching incubator machine is a fully automated system that will hatch chicks from egg efficiently. The purpose of this project is to produce an efficient incubation system for hatching chicken egg. The higher efficiency of this incubator, the higher production of egg will get. This is in order to enhance the production of chicken egg which can breed eggs while the broody hen can lay more eggs. It will reduce time consumption where mother hen does not need to incubate their eggs. It is also to reduce the egg spoilage from the natural egg hatching phenomenon. The conceptual of previous project or any existed system usually are using thermostat and light bulb for the incubator. Temperature will be regulated manually by using switches. There are two switches for turning on/off fan and turning on/off light bulb. That’s mean light bulb and fan will manually turn on/off while thermostat will control surrounding temperature. Also, the mechanism used to tilt eggs is control manually every 6 hours a day until required day. That’s mean every certain time, need to monitor the incubator. From that, many features could be improve such as automated smart incubator system. This project will automatically control surrounding with ideal temperature using temperature controller. The best recommendation for temperature and humidity are 37.5 °C and 55% RH. It applied combination of analysed ventilation system and heating system. It is important to have best air circulation inside the incubator while maintaining it temperature and humidity. Temperature controller will either cooling or heating surrounding until it reaches reference or required condition. In incubation process, it is very vital to make sure the position of the egg does not fixed. Hence, daily turning process eggs is needed. Eggs are turned every 6 hours, 4 times a day. The egg turner process function for 18 days before completely stop at the last 3 days of incubation due to a hatching phase, where rotation is no longer needed. This emerging technology system supplied source of heat, water, and oxygen to ensure it has sufficient incubation needed. It is to ensure that the process of hatching egg going well and give comfortable environment to egg.

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1.2 Problem Statement

From the literature, egg incubator system existed mostly semi-auto operated. Usually, for egg tilting features from most previous project will rely on human manual effort where every 6 hours from day 1 until day 18, the rotation of the mechanism is done manually using manpower. This egg tilting is important to ensure that the surface and embryo receive sufficient heat needed. Few existing incubators did not have automated temperature controller to ensure the balance between the temperature and humidity. Too high or too low temperature and humidity value will affect the egg growth. In addition, several external factors were also affected hatched egg process. Moreover, if the hen is too young, the incubation might also failed due to less experience in incubating eggs. There is a need to do an analysis towards the heating elements as it will affect the incubation process. Resulted from the analysis, it may help in proposing the ideal heating elements to equip with the incubator so that the incubator may work efficiently. Another significance part in the incubator system is the correct ventilation system where it helps to maintain the air circulation.

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1.3 Objectives

There are several objectives for this project which are:

1. To design an egg incubator that creates ideal conditions to incubate, hatch chicken eggs and develop a monitoring system for the hatching eggs.
2. To analyze the utilization of different heating elements in building an efficient incubator.

1.4 Scope of Project

This project use temperature and humidity controller to regulate surrounding environment. If the surrounding becomes too hot, ventilation system was triggered to regulate air circulation by removing hot air from inside to outside. In order to achieve best performance, there are several parameters that need focus on which are temperature, humidity, air circulation, egg tilting and duration of incubation. Those parameters are the factor of effectiveness of the incubation process. DHT sensor functioned as humidity sensing and surrounding temperature, LCD became system notification which display the value of temperature and humidity detected. DHT11 sensor detected the incubator environment and signal was sent to LCD while temperature and moisture was monitored in the incubator. Meanwhile, LCD displayed the output from sensor as a system notification. Arduino Uno used to control all the system for incubate operation. Arduino UNO used to organize entire system which having interface with DHT11 sensor to sense surrounding temperature and humidity, with LCD to display the temperature and relative humidity, with temperature controller using ventilation and heating element. The condition of surrounding regulated by temperature controller system as required. The temperature and humidity required was set as a reference. Both values are the optimum and efficient condition for egg hatching which temperature controller automatically triggered if both value is higher or lower than reference value. Egg tilting rotate in certain direction 4 times a day until day 18^{th} where distributed heat to surrounding and receive by each egg.

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1.5 Important of Study

The sign of hatching failure is depended on effectiveness of heat distribution among surrounding. If the heat is insufficient, temperature controller automatically regulated surrounding temperature by turning on the heater until it achieves reference heat needed. Also, when the surrounding is in high humidity, again the temperature controller triggered ventilation system automatically. It is vital to ensure the humidity and temperature surrounding in ideal and optimum conditions. One of the most significant aspects of this study is to determine best ideal amount of temperature reference which is 37.5°C while determining best optimum humidity reference which is 55% RH (Relative Humidity). Besides, it is also important to analyse the implication of egg growth within major difference in temperature and humidity value. The smart incubator is to assist hatching egg efficiently and minimize egg spoilage. With a subjected controlled hatching temperature and humidity, it provided best condition for incubation process. This project also aimed to provide condition control, egg tilting and indication capability. The duration of incubation is also significant factor which normally takes 21 days to hatch. From day 1 to day 18, incubator need to be supply by constant heat distribution and another two days is the preparation of egg to hatch. Besides, automated smart incubator system ensure embryo to raise in the fertilized egg, without the help of broody hen. The system capable to be implemented either in small scale farmer or industrial purpose application. This research compares three type of heating elements which is fluorescent light bulb, LED light bulb and heating mat. From the analysis that has been made, the LED bulb can produce the ideal temperature for hatching process which is 37.5°C out of those two heating elements. Besides, the incubator also works well in terms of controlling the humidity where it can maintain the optimum value which is about 55% RH. Tilting mechanism also helps in the hatching process where 65% was hatched under tilted condition even though there is 25% of the eggs without tilted condition successfully hatched.

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1.6 Chapter Outline

The Fully Automated Smart Incubator System is developed to solve any problem that always occur in factory farming and improve artificially performs role of broody hen. This project information was explained in each chapter of the thesis as stated here.

Chapter 1: This sector will provide a quick overview of the prototype. Several theories for a recent progress of main circuit are taken to recognise the system. The objectives, problem statement, scopes, the significant of study and the chapter outline for the whole prototype are explained detailed in this chapter.

Chapter 2: This chapter will review about theory or journals that linked to the project. There are many research or studies from previous project which can explained briefly about this project.

Chapter 3: This sector will show on methodology of project. There are some stages to be analyse in developing fully automated smart incubator system. This segment shown project block diagram, procedure that applied and discussion about implemented hardware on this prototype.

Chapter 4: In this sector result gained are present which have been accomplished along the task period. It also reveals finalized outcome of project based on the achieved objectives.

Chapter 5: This segment is explain about hypothesis and discussion for the overall incubation process. It also attached project review, research analysis and future suggestion to upgrade the project.

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CHAPTER 2

BACKGROUND STUDY

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This chapter will highlight the parameters and variables, comparison of previous projects research findings and descriptions of software and hardware being used, which related with design of egg hatching incubator system.

2.1 Parameters and Variables

Table 2.1.1: Factors that affect hatchability[1]

Factors that affect hatchability	
Breeder	**Hatchery**
Breeder nutrition Disease Mating activity Egg damage Correct male and female body weight Egg sanitation Egg storage	Sanitation Egg storage Egg damage Incubation—Management of setters and hatchers Chick handling

Based on Table 2.1.1, there are many factors that affect hatchability which divided into two categories, breeder and hatchery. In this project, factors taken to develop smart incubator are egg damage, egg storage and management of setters, hatchers in incubation process [23]. Egg damage refer to egg failure during incubation process occurred while egg storage depends on egg tilting mechanisms. Environmental temperature and evidence are important aspects for hatchability process. Fertile egg is sensitive where it contains active cells which is embryo. The fragile of eggs is higher and to complete hatch must start with fresh and fertile eggs [2]. Chance of hatchability decrease when eggs not properly handled or absorb too high or too low heat in. Fertile eggs must be handled very careful and stored wisely along incubation process. Storing eggs with ideal temperatures value will ensure the embryo progress development going well.

Table 2.1.2: The incubating and hatching egg and chick classification[1]

Culled eggs	Cracked, misshapen or otherwise not likely to hatch
Infertile eggs	Determined to have no germ. Originally infertile
Early dead	Embryos died during first quarter of incubation. Dead early embryo, show no development, development but no blood, or a blood ring
Middle dead	Embryos died after the early (middle third) period but before transfer
Late dead	Embryos died during the hatch phase of incubation
Malformed	Embryos that have an obvious deformity
Malposition	Embryos not positioned correctly for hatching
Live pips	Chicks that have pipped and are living, but not hatched
Dead pips	Pipped chicks that died but are not malformed or malposition
Rots	Infected or contaminated eggs
Culled chicks	Chicks that hatched but are unsound
Good chicks	Good quality, healthy normal chicks

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Based on Table 2.1.2 along the incubation process, it will produce different kind of egg and chick classification depend on the efficiency of incubator. Basically, incubator is space that store eggs while keeping optimum humidity, temperature and level of oxygen. Incubator needs automatic turners, ventilation, and temperature controllers [7]. Incubators come in forced air which is humidity and temperature is high persistent [22]. It can returns to required parameter variables immediately after being opened. The incubator must be in a space without direct sunlight and the amount of temperature must be controlled from time to time.

Table 2.1.3: The incubation period, temperature and humidity levels [1]

Common name	Incubation conditions			Hatcher conditions		
	Days	Temperature °F	Humidity %RH	Transfer day	Temperature °F	Humidity
canary	13–14	100.5	56–58	11	99	66–74
chicken	21	99.5	58	18	98.5	66–75
cockatiel	18–20	99.5	58–62	15–18	99	66–74
cockatoo	22–30	99.5	58–62	20–27	99	66–74
conure (sun)	28	99.5	58–62	25	99	66–74
conure (various)	21–30	99.5	58–62	18–27	99	66–74
dove	14	99.5	58	12	98.5	66–75
duck	28	99.5	58–62	25	98.5	66–75
muscovy duck	35–37	99.5	58–62	31–33	98.5	66–75
finch	14	99.5	58–62	12	99	66–74
Domestic goose	30	99.5	62	27	98.5	66–75
geese (various)	22–30	99.5	62	20–27	98.5	66–75
grouse	24–25	99.5	54–58	22	99	66–74
guinea	28	99.5	54–58	22	99	66–74
lovebird	22–25	99.5	58–62	20–22	99	66–74

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According to Table 2.1.3 previous project have determined the average value for incubation and hatching conditions. During the incubation period, ideal temperature must be 99.5°F to 100°F (37.5°C to 37.8°C). Each species have particular conditions requirements. Temperature value should be monitor from time to time. Reference value for humidity must be 55%RH until 58%RH (Relative Humidity) as a stable condition. It will affect egg growth when humidity value inside incubator is too high or too low [24].

$$\% \, Fertility = \frac{Number \ of \ fertile \ eggs}{Number \ of \ total \ eggs \ produced} \qquad \text{(Eq. 2.1.1)}$$

$$\% \, Hatchability = \frac{Number \ of \ eggs \ which \ hatch \ out}{Number \ of \ fertile \ eggs} \qquad \text{(Eq. 2.1.2)}$$

Based on Equation 2.1.1 and 2.1.2, it shows the parameter to measure the performance and efficiency of this project. Fertility is determine by the percentage of fertile eggs of all eggs produced [20]. Besides, percentage of hatchability is rate of total eggs manage to be hatch into chicks [21]. The higher the value of fertility and hatchability, the higher efficiency of this smart incubator system. Besides, the duration of incubation is also important to find out the efficiency of incubation process [19]. Usually, the duration of incubation process is between 20.3 to 21.8 days. Different kind of result could be achieve as temperature, humidity and heat distribution affect egg growth [3]. The duration of egg to be hatch could be slower or faster is depends on the analysis being done in this project which involving specific range of temperature and specific heating elements being used.

2.2 Previous Research Findings

Table 2.2: Comparison of previous egg incubator projects

Authors	Research Objective	Research Finding	Research Limitations
S. Mashori, 2020 [6]	To develop system that reduce the manpower and give a better efficiency of incubation process.	Indication capability. Automated egg tilting.	No analysis for heating elements and temperature range. Semi-auto temperature controller.
K. B. Azahar, E. E. Sekudan, and A. M. Azhar, 2020 [5]	To design incubator that hatch eggs automatically without the need of human intervention.	Automated temperature controller. Automated egg tilting Output Indicator.	Lack of analysis for heating elements and temperature range.
Kelebaone Tsamaase, 2020 [1]	To design reliable project which can facilitate the rate of chick production.	Display system. Solar PV system is source of egg tilting features.	No analysis for heating elements and temperature range. Manual setup for temperature variations and relative humidity range. Manual egg rotation.
E. Bala, 2020 [2]	To design an egg incubator using electric, battery and inverter.	Condition control. Automated egg tilting. Inverter powered incubators.	Lack of analysis for heating elements and temperature range. High cost of maintenance.
S. Ganiyat and I. R. Afolake, 2020 [3]	To develop solar powered incubator, portable, user friendly and low cost of maintenance.	Solar powered. Automatic egg turning. Heat & moisture controller. Low-cost maintenance.	No analysis for heating elements and temperature range.
B. A. P. Dhimas Bagus Adi Saputro, Ritzkal, 2020 [8]	To design an egg incubator and web-based monitoring.	Information display on temperature and humidity values.	Manual egg tilting. Manual temperature controller. Lack of analysis for heating elements and temperature range.
Boleli, Morita, Matos, Thimotheo, and Almeida, 2018 [9]	To analyse the hatchability of egg incubator.	Automated temperature controller. Automated egg tilting. Display system.	Lack of analysis for heating elements and temperature range.
M. A. M. Zain and Y. Yusop, 2021 [11]	To control and monitor the incubator in distance by using the internet optimally.	Have control and monitoring system of chicken eggs incubator machine which can be accessed through website.	No analysis for heating elements and temperature range. High cost of maintenance because using webcam.

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Authors	Research Objective	Research Finding	Research Limitations
K. F. Dzogbema, E. Talaki, L. Lare, and A. W. Tchabozire, 2021 [14]	To explore the controlling and typology of traditional poultry farms.	Characteristics of the different classes of traditional poultry farms.	Manual setup for temperature variations and relative humidity range. Manual egg rotation.
Ezzat K. I. Al-Samrai, 2021 [15]	To assess the effects of coverage, storage, and pre-incubation on egg characteristics of broiler breeders.	Effect of coverage, storage, and pre-incubation in Hatchability and Shell characteristics of broiler breeder.	No analysis for bulb variations. No analysis for various temperature range.
M. B. Ramli, H. P. Lim, M. S. Wahab, and M. F. M. Zin, 2019 [16]	To design and develop a force air system of eggs incubator to incubate various types of eggs through a conveyor rotating system.	Automatically change the parameters to the suitable condition to fit the various types of eggs.	No recommendation for best temperature and humidity of incubation process. No analysis about heating elements specifications.
N. Sobejana and E. J. Bacalso,2021 [17]	To create an environment where the egg incubation process occurs in a more orderly and safe manner.	Less hassle. easiest way of controlling and monitoring using desktop application.	Semi-auto operation. Too wide range of humidity and did not conclude best value for hatching process.
E. O. Ehsan Alawad, 2021 [18]	To design and implement an egg incubator system in order to provide adequate conditions for egg hatching.	Controls the motor that turns the eggs to change their position in order to prevent the embryo from sticking to the shell.	Use two Arduino boards for this project which is not practical and not relevant.

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Mostly previous projects from background studies applied semi-auto operation, lack of analysis for best heating elements for incubation process and also no analysis about necessity of egg tilting features. Also, those projects did not include analyzing of heating elements power specifications. Based on Table 2.2, it has been analyzed that many improvements could be add in achieving higher percentage of hatchability and efficiency of incubation process. In this project, all the limitations will be overcome in analysis part.

2.3 Hardware Description

2.3.1 Arduino UNO

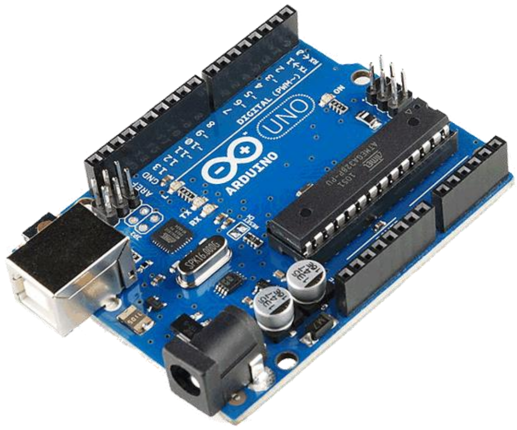

Figure 2.3.1: Arduino UNO Module

Arduino is an electronics platform open source and also ease everything including software and hardware as shown in Figure 2.3.1. Arduino configuration capable to access inputs and produce outputs from its analogue and digital pin [10]. Arduino UNO also a microcontroller system or brain by ATmega328P. It contains 14 digital pins for input and output (of which 6 of them functioned as outputs of PWM), 6 inputs analog, quartz crystal with 16 MHz, connection for USB, power jack, header of ICSP and button for clear or reset. It projects capable to stand-alone or they are able to interact with software while running on a computer. It also can have interface with various kind of module and variety of components. The integration of Arduino with other components also could be apply in many applications to replace IC such as utilize monitoring system, combination of sensors, controlling motor and other else.

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2.3.2 LCD 16x2

Figure 2.3.2: LCD component 16x2

Table 2.3.2: Datasheet of LCD[10]

Pin Number	Pin Name	Description
1	Vss (Ground)	Ground pin connected to system ground
2	Vdd (+5 Volt)	Powers the LCD with +5V (4.7V – 5.3V)
3	VE (Contrast V)	Decides the contrast level of display. Grounded to get maximum contrast.
4	Register Select	Connected to Microcontroller to shift between command/data register
5	Read/Write	Used to read or write data. Normally grounded to write data to LCD
6	Enable	Connected to Microcontroller Pin and toggled between 1 and 0 for data acknowledgement
7	Data Pin 0	Data pins 0 to 7 forms an 8-bit data line. Can be connected to microcontroller to send 8-bit data. Can also operate on 4-bit mode in such case data pin 4,5,6 and 7 will be left free.
8	Data Pin 1	
9	Data Pin 2	
10	Data Pin 3	
11	Data Pin 4	
12	Data Pin 5	
13	Data Pin 6	
14	Data Pin 7	
15	LED Positive	Backlight LED pin positive terminal
16	LED Negative	Backlight LED pin negative terminal

The LCD will be used is as shown in Figure 2.3.2 and will apply several pins as classified in Table 2.3.2. The operating voltage for LCD is from 4.7V to 5.3V and it consume current up to 1mA. The LCD display has alphanumeric module which able to show number, alphabets and contains of two rows while each row can print 16 words. Usually. LCD modules are applied in most integrated projects because its availability, low cost and easy to use.

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2.3.3 DHT 11 Sensor

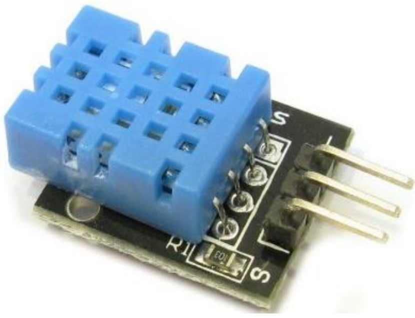

Figure 2.3.3: DHT11 sensor module

Table 2.3.3: Comparison between DHT11 and DHT22 sensor[10]

DHT11		DHT22
0 - 50°C / ± 2°C	*Temperature Range*	-40 - 125 °C / ± 0.5 °C
20 - 80% / ± 5%	*Humidity Range*	0 - 100 % / ± 2-5%
1Hz (one reading every second)	*Sampling Rate*	0.5 Hz (one reading every two seconds)
15.5mm x 12mm x 5.5mm	*Body Size*	15.1mm x 25mm x 7.7mm
3 - 5V	*Operating Voltage*	3 - 5V
2.5mA	*Max Current During Measuring*	2.5mA

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Referring to Figure 2.3.3 and Table 2.3.3 it was determined that DHT 11 is relevant enough for this project. The DHT11 is a super low cost digital humidity and temperature sensor. It measured relative humidity value by resistance of electric among two electrodes. Basically, it operating voltage is between 3 to 5V and maximum current during measuring is 2.5mA. Its body size is 15.5mm x 12mm x 5.5mm and lower than 1 Hz rate of sampling which mean each second got one. DHT11 is convenient to this project because its temperature range and humidity range is in ideal and optimum caps.

2.3.4 AC Fan (Ventilation)

Figure 2.3.4: AC Fan

As the ventilation system AC fan as shown in Figure 2.3.4 will be used to ensure best air circulation inside incubator. The AC fans, are supplied with a potential difference. AC fan act as a ventilation system which blows out unwanted or hot air from inside. This is important for moving hot air to the outside of the incubator, as well to provide ideal surrounding temperature. The fan motor is a vital part that must be running well for the AC unit to do its job. AC fans are used because it is needed regularly and consistently [12]. It also become more efficient for the incubation process. This is ideal for commercial settings, like real incubator, which can keep fans running all day without need any changing of voltage supplied.

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2.3.5 Bulb (Heating Element 1)

Figure 2.3.5: Light bulb

Light bulb is an electric lamp which a filament gives off light when heated to incandescence by an electric current. An incandescent bulb usually contains of a glass enclosure containing a tungsten filament. An electric current pass through the filament, heating it to a temperature that produces light. Incandescent light bulbs usually contain a stem or glass mount attached to the bulb's base which allows the electrical contacts to run through the envelope without gas/air leaks. The bulb as shown in Figure 2.3.5 is needed as one of the heating elements to supply heat to the surrounding.

2.3.6 Heat Mat (Heating Element 2)

Figure 2.3.6: Heating mat

Heat mats usually is to give heat to surface or base gently, thus heat produce can be spread to occupy space. They are useful for rooting cuttings. According to Figure 2.3.6 heat mats are marketed as a propagation mat or seedling heat mats as well, but the function is the same. In this category heat mat will be base of incubator and heat surrounding from downside to upside. It will distribute heat as required by incubation process. It can be applied anywhere indoors such as on a windowsill, box, container, or in greenhouse. Heating mat can hit temperatures from 70°F to 95°F (21°C-35°C) and it also consume low electricity than a 15 watt bulb [13].

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2.4 Software Description

2.4.1 Proteus 8 Professional

The Proteus Design Suite is a specialized suite of software tools largely applied for automating design of electronic. Modern technicians and computer engineers construct circuit and prints electronics for the creation of printed circuit boards primarily use the software. Proteus has a broad range of components in its database such as Figure 2.4.1. For such cases, Proteus has given a method by design Proteus component and add all of its features to it. Proteus is quite lenient in circuit designing and it works on ideal conditions. By constructing circuit in schematic design, faulty error could be determined and output result could be identified by simulation.

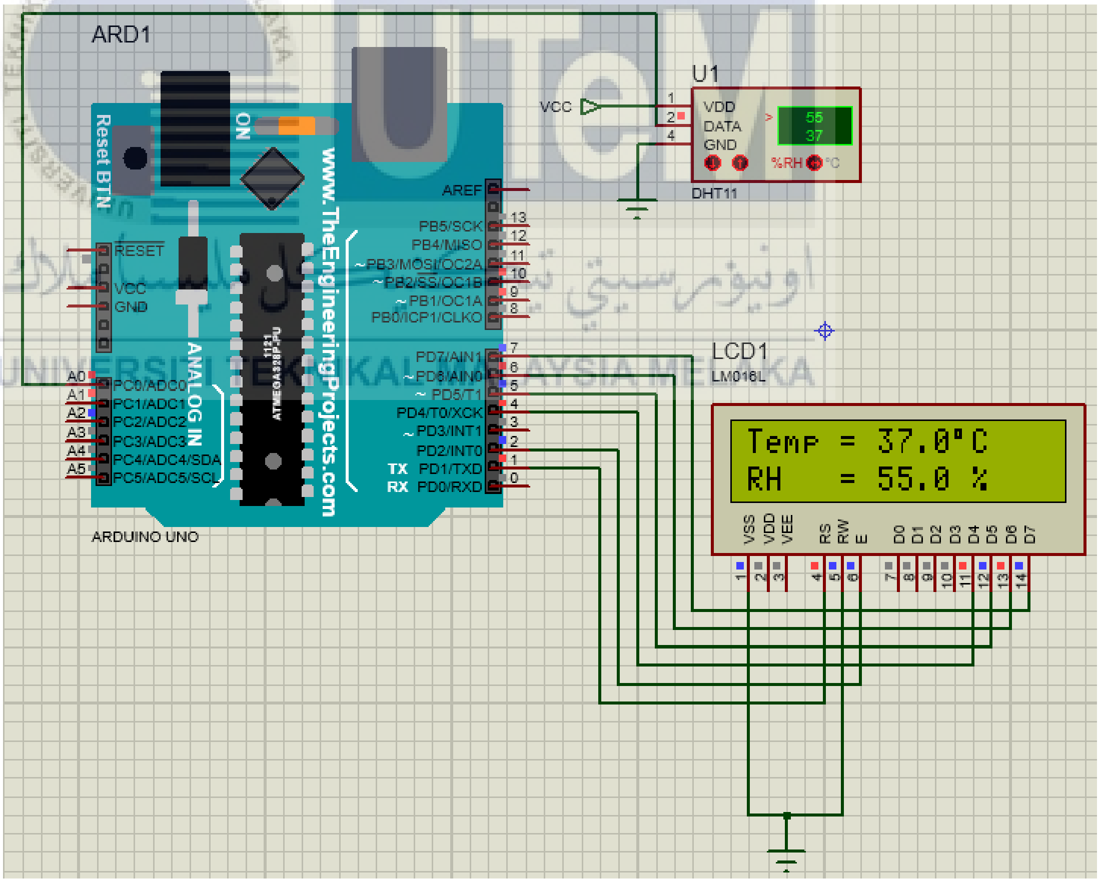

Figure 2.4.1: Software proteus

2.4.2 Arduino Software IDE

The open-source Arduino Software (IDE) are ease for write program and upload it to the board. The Arduino Integrated Development Environment contains text console, message area, text editor for writing code a toolbar with buttons for common operations and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and integrated with them [4]. Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module. It is an official Arduino software, making code compilation quite easy that even a common person with no prior technical knowledge. Arduino code is written in C++ with an addition of special methods and functions. C++ is a human-readable programming language.

Figure 2.4.2: Software arduino IDE

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CHAPTER 3

METHODOLOGY

This chapter show the method used in this project function and the working principles used in order to make this project successful. The flowchart of overall process also included with the block diagram. The operation of each circuit was explain clearly. This chapter also discussed on the flow of the procedure for this system. Moreover, the modern engineering tools and materials used in this prototype is describe detailed such as operations, benefits of components applied to complete the incubator successfully.

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3.1 Block Diagram

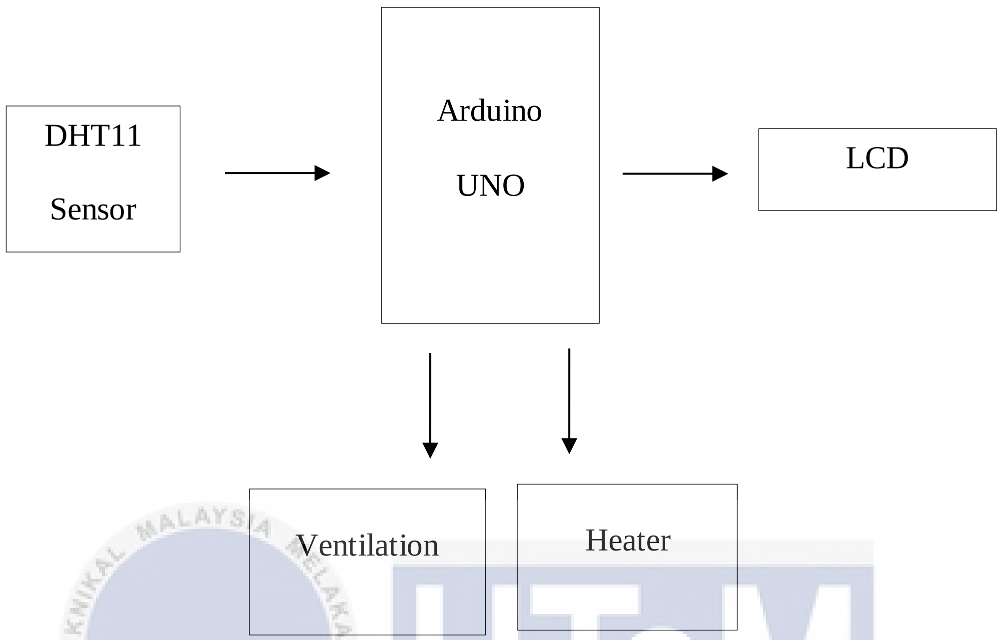

Figure 3.1: Circuit block diagram of this project

The brain of this system is Arduino UNO where it will conduct any system notification and detection to trigger the mechanism and temperature controller system. Overall process operated automatically based on programmed setup in Arduino UNO. Arduino UNO used to control entire system with interface of DHT11 sensor with LCD 16x2, and temperature controller along the incubation process as shown in Figure 3.1.

3.2 Research Flowchart

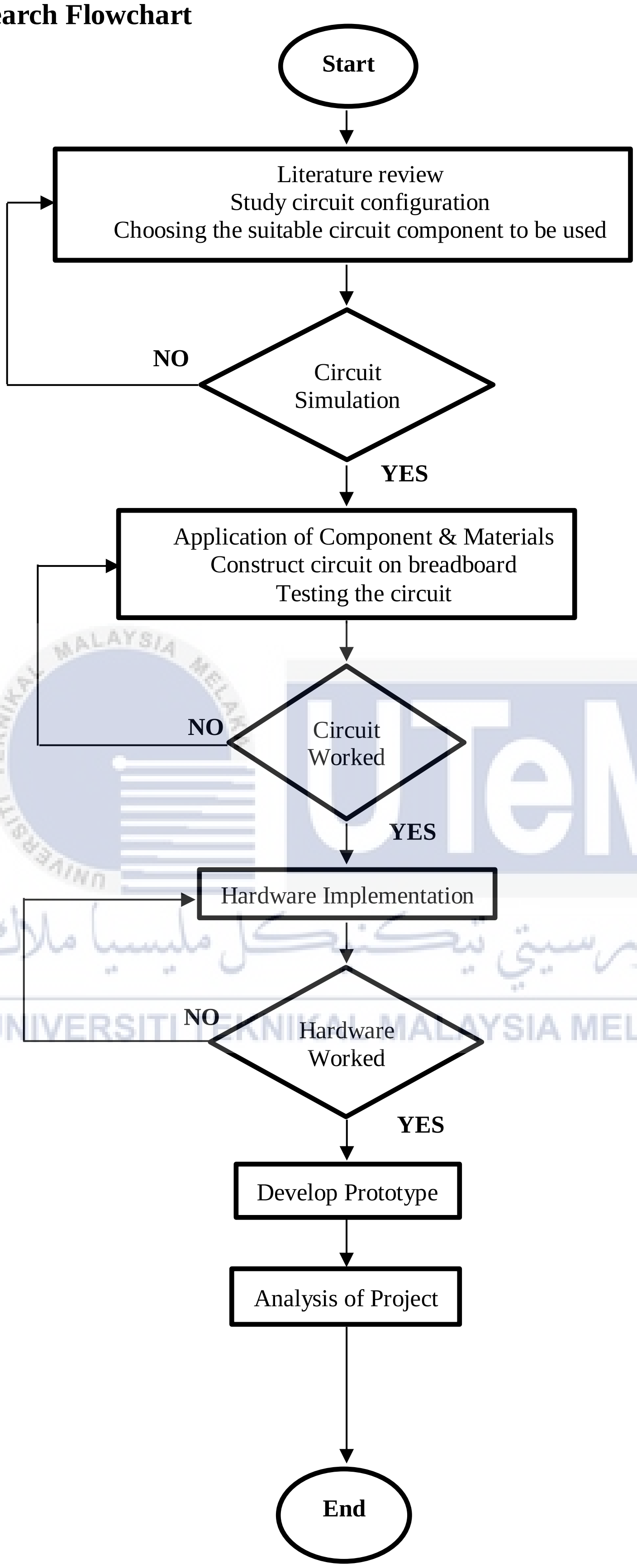

Figure 3.2: Flowchart of research methodology

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3.3 Project Flowchart

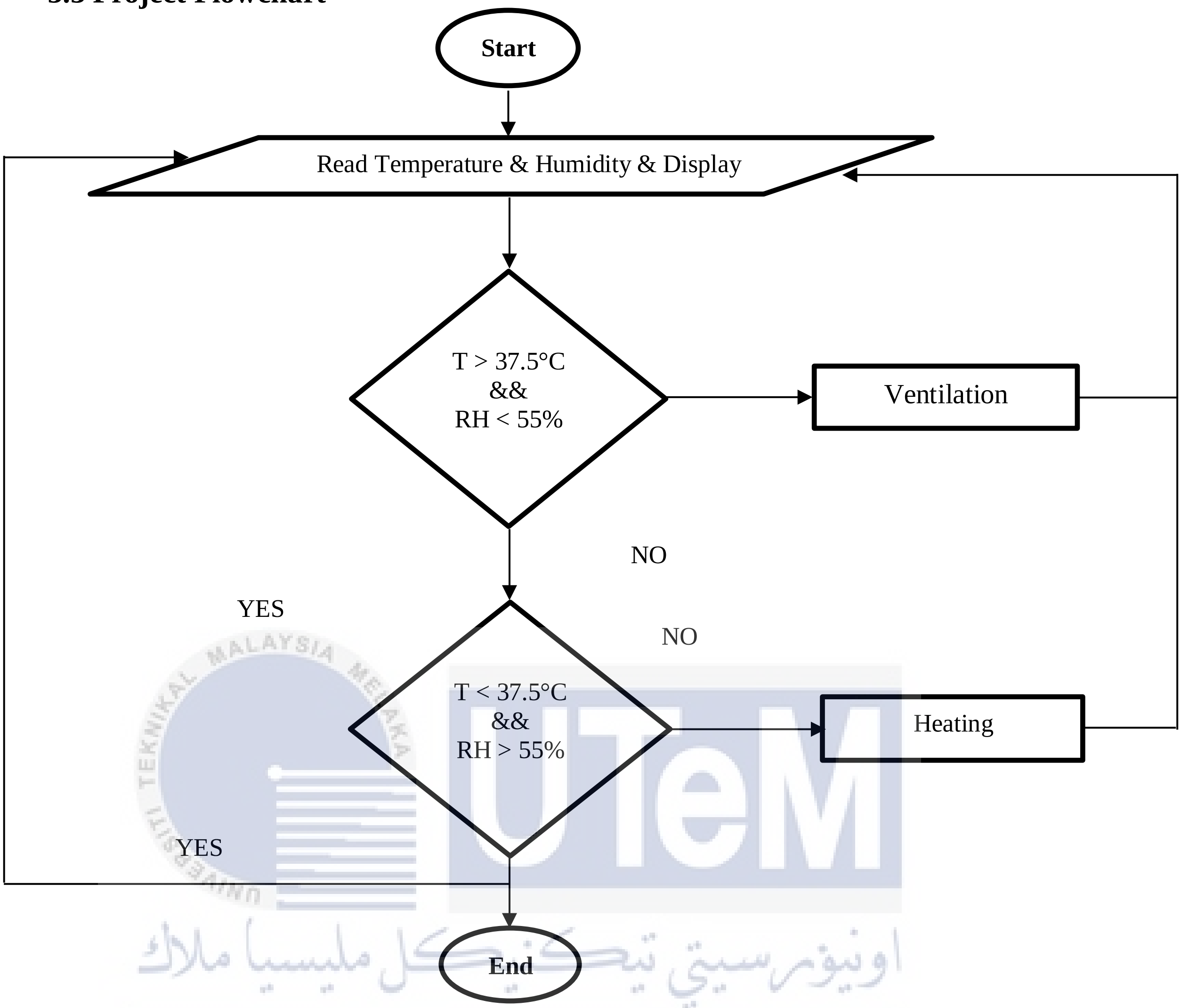

Figure 3.3: Flowchart of the circuit

According to Figure 3.2, the research begins by dug up some background studies for research on previous project. Then, it was continued with a circuit simulation before testing circuit on breadboard. If the circuit properly functioned, hardware was implemented to build the required circuit controller. Lastly, prototype was developed and once it was completed, the analysis for the heating elements was started. Based on Figure 3.3, the incubator functioned based on sense and detection of temperature and humidity value. From the sensing and detection, the LCD displayed the output of DHT11 sensor. If the temperature is out of reference range of the temperature and humidity, ventilation or heating element was triggered. Then, the temperature was regulated till the threshold was achieved.

3.4 Product Block Diagram

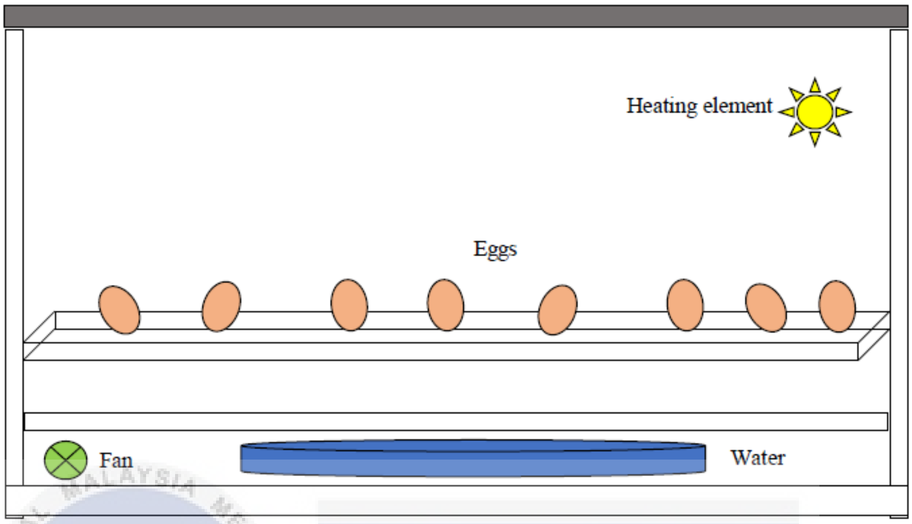

Figure 3.4: Product model

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Figure 3.4 shows the product model of the incubator which consist of heating elements (LED bulb, incandescent bulb, heating mat), water container and AC fan or cooler that was built in a polystyrene box. The heating elements was placed in the same incubator or prototype which mean the incubation process is done 3 times. Meanwhile, for the egg tilting features setting, it was rotated manually for 18 days about 4 times every 6 hours daily. There also have 2 different places which are one with tilted features and another one was non-tilted. Those two differences were to determine the necessary of egg tilting mechanism during incubation process. This incubator is suitable up to 6 number of fertile eggs for the tilted features while 4 number of fertile eggs for non-tilted features. The egg was hatched successfully when the sequence completed.

3.5 Arrangement of Circuit and Components

3.5.1 Operation of DHT11 Sensor

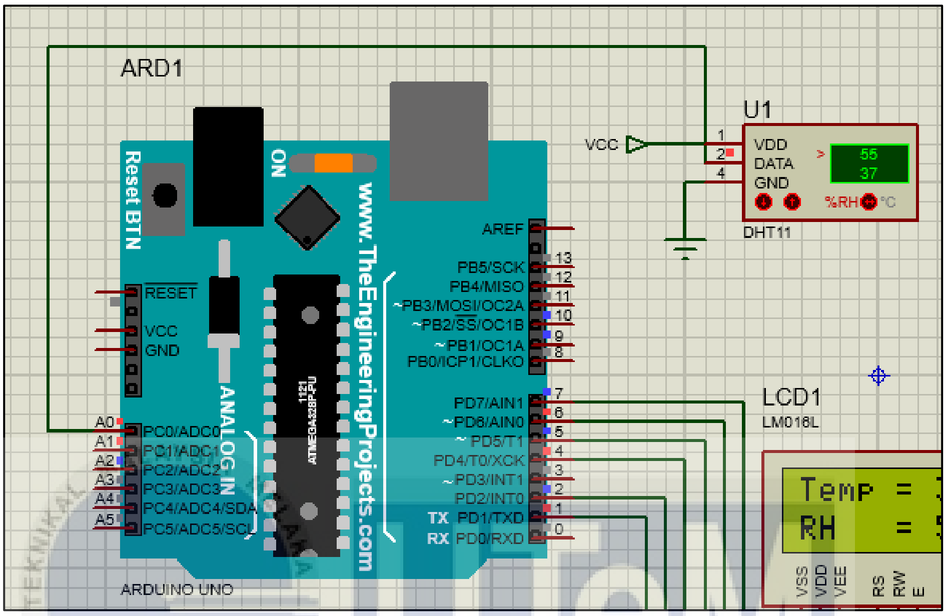

Figure 3.5.1: DHT11 sensor circuit

Figure 3.5.1 shows a sensor that was connected to Arduino, VCC and ground while input data is connected to analogue pin A0. It contains of a relative humidity detection and surrounding temperature sensor. To determine relative humidity, it uses sense of humidity equipment which detect the moisture and its rate. Other than that, for determine heat level this sensor has its own features. Thermistor is actually potentiometer which resistance is directly proportional to temperature's changes. "NTC" defined as "Negative Temperature Coefficient", which if temperature increase, resistance will decrease.

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3.5.2 Operation of LCD System Display

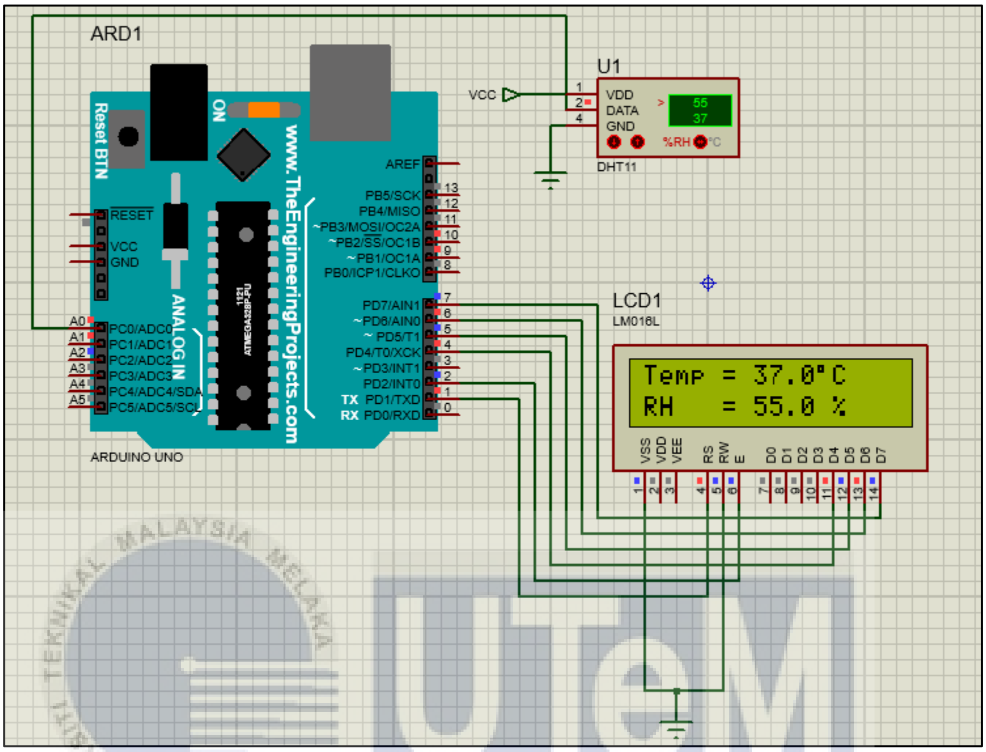

Figure 3.5.2: LCD system display circuit

LCD board is made of various layers. It contains of polariser, glass polarised, and its connections is conductive. The LCD board has glass polarised containing of crystal of liquid substances amongst them. If external source get pass one of the glasses polarised and voltage is supplied on the molecules of liquid crystal, it arranges itself in certain style which can propagate from one layer until two glasses polarised, affected data in screen display [11]. Based on the connection, RS pin is connected to Arduino pin 1, RW to ground, E pin to pin 2, pin D4 to pin 4, pin D5 to pin 5, pin D6 to pin 6 and pin D7 to pin 7 and as shown as Figure 3.5.2.

CHAPTER 4

RESULTS AND DISCUSSION

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As for result, overall project applied concept of detection, monitoring, heating and ventilation system without automated egg tilting. This study's findings comprised a vary kind of heating elements that were tested and analysed throughout a various temperature range. Although 25% of four fertile eggs that were not rotated can be successfully hatched, egg tilting device is still essential. In comparison to incandescent light bulbs and heating mats, LED bulbs are the best heating elements for the hatching process since it can provide a wide range of maximum temperatures. According to the findings, two of the eggs hatched earlier than the others, in days 19 and 20, since they were the first to get or achieve the necessary temperature and relative humidity. It is proof that the findings are positive, and this incubator is quite effective, because 65 percent of the eggs successfully hatched.

4.1 Prototype

Figure 4.1: Prototype of Project

Based on Figure 4.1, it shows the setup of smart incubator system within circuit combination on the right side and egg placement with DHT11 sensor on top of it. The surrounding of incubator absorbs heat and humidity while overall condition in the incubator was detected by DHT11 sensor. Once DHT11 detected the insufficiency, the LCD displayed the value the of temperature and humidity. If the value of temperature and humidity are out of desired range, AC fan turn on to blow out the hot air and stabilize back the condition in the incubator. Eggs was tilted 4 times manually a day to ensure overall surface of eggs receive balance heat distribution. The setup was looped until incubation process is completed.

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4.2 Financial Consideration

Table 4.2: List of Hardware Cost

No.	Components/Materials	Quantity	Amount Price
1	Breadboard	1	RM 6.00
2	LCD 16x2	1	RM 15.00
3	DHT11 Sensor	1	RM 9.00
4	Arduino UNO	1	RM 25.00
5	Bulb 18 Watt Bulb 15 Watt Bulb 10 Watt	1	RM 15.00 RM 12.00 RM 8.00
6	Heating Mat 10 Watt	1	RM 19.80
7	AC Fan and Plug	1	RM 40.00
8	Adaptor 12V 1A	1	RM 15.00
	TOTAL		**RM 164.80**

Based on Table 4.2, the cost on making this project is quite expensive but still affordable but if egg tilting mechanism features added, it will become hugely expensive. Light bulb and heating mat have different value of power specifications. After utilized those heating elements, light bulb produces consistent heat level into surrounding of incubator than heating mat. Meanwhile, AC fan is rarely used so the price will be costly. AC fan was used because ventilation system was needed along the hatching process. Adaptor 12V is used since Arduino need consistent value of voltage and current supplied to run smoothly. Using power supply such as battery or powerbank are not practical because of the need to recharge as it degrades over time.

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4.3 Monitoring System and Heating Mat Applications

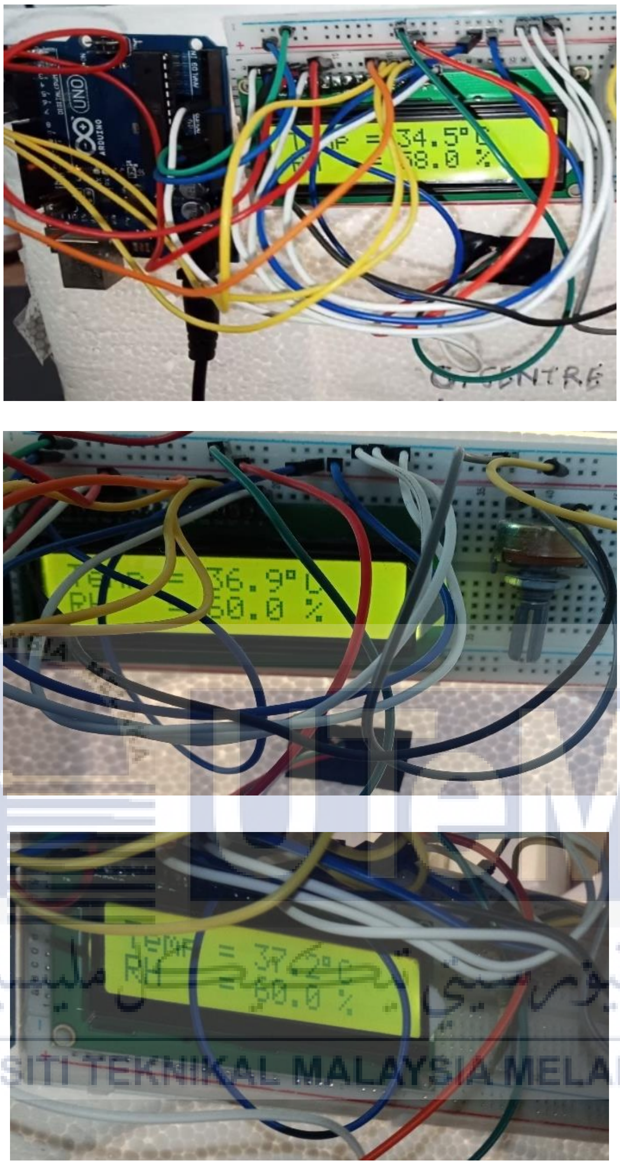

Figure 4.3.1: LCD Value Variations

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Based on Figure 4.3.1, LCD pin RS is connected to Arduino pin 1, RW to ground (GND), E pin to pin 2, pin D4 to pin 4, pin D5 to pin 5, pin D6 to pin 6 and pin D7 to pin 7. The value of temperature and humidity are varies depends on detection by DHT11 sensor. If the lid of the incubator opened, temperature immediately turn drops due to the incubator experience thermal equilibrium [8]. Weather also effects some changes to DHT11 sensor which is included as internal factor that varies temperature value.

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Figure 4.3.2: Heating Mat Applications

According to Figure 4.3.2, the heating mat as one of the heating elements is placed vertically to supplied heat in the incubator. It can be seen by the monitoring system which is LCD display, the value stated was 33.8°C for temperature and 52.0% RH for humidity. Both values are not ideal or optimum for incubation process. Due to that, this 10-watt heating elements which cost RM 19.80 is not suitable for hatching eggs. Higher power value for heating mat is required in range between 20 watts to 30 watts for poultry but the cost is hugely expensive.

4.4 Temperature and Humidity Supplied Daily (Light Bulb)

Table 4.4: Average of Temperature and Humidity for Light Bulb

Day Count	Average Temperature Measurement for 24 hours	Average Humidity Measurement for 24 hours
1	36.5℃	57.4%RH
2	37.8℃	54.9%RH
3	38.1℃	54.5%RH
4	36.9℃	56.8%RH
5	37.5℃	55.5%RH
6	37.0℃	56.1%RH
7	38.5℃	53.6%RH
8	38.3℃	54.2%RH
9	37.5℃	55.6%RH
10	36.7℃	57.1%RH
11	37.0℃	56.3%RH
12	36.7℃	56.9%RH
13	37.5℃	55.4%RH
14	38.3℃	54.3%RH
15	38.5℃	53.3%RH
16	37.0℃	56.4%RH
17	37.5℃	55.6%RH
18	36.9℃	56.8%RH
19	38.1℃	54.6%RH
20	37.8℃	54.8%RH
21	36.5℃	57.2%RH

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The hatching process took around 19 to 21 days. In Table 4.4, during the incubation process, average value of temperature supplied was between 36.5℃ to 38.5℃ while humidity range between 53.3%RH to 57.4%RH. Within the heating elements such as light bulb, temperature surrounding is vary affected by the temperature outside the incubator. AC fan needed to be turn on once the value of temperature and humidity is outside optimum range. Water supplied must be updated regularly to ensure incubation process going smoothly.

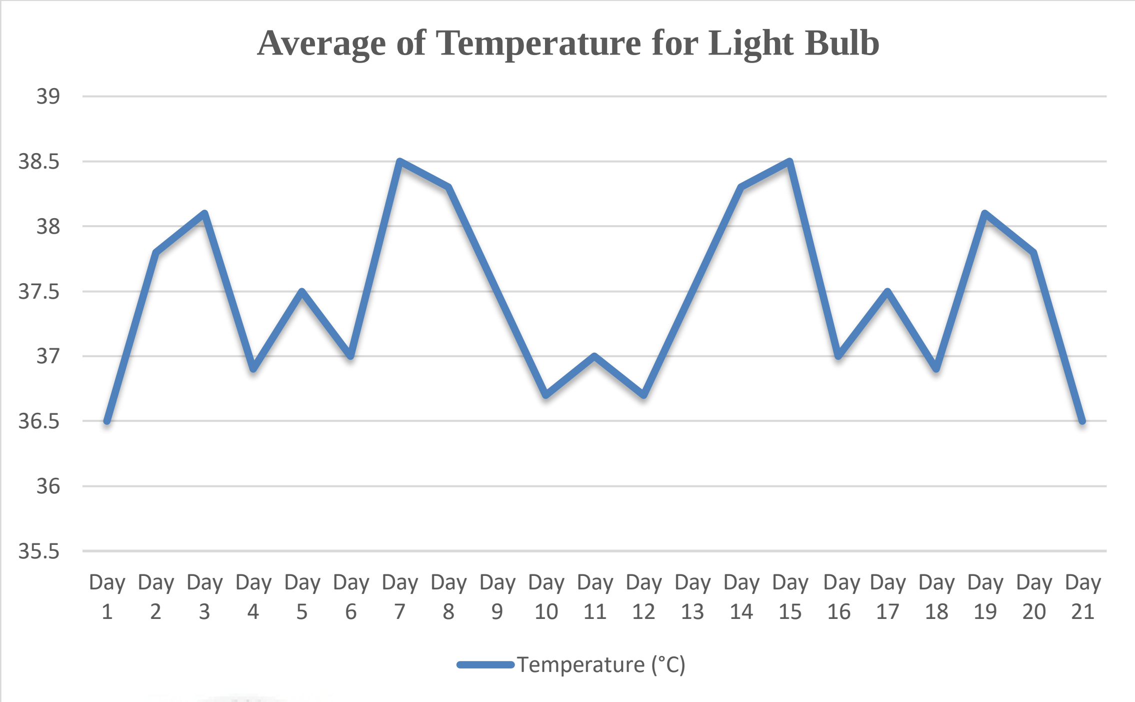

Figure 4.4.1: Line Chart Average of Temperature for Light Bulb

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According to Figure 4.4.1, maximum average value of temperature supplied is 38.5°C. The average value of temperature is higher compared to using heating mat because value of heat distribution is higher by LED bulb. Besides that, by using heating mat for heating elements in incubation, the heat distribute is different because mostly heating mat utilization only can achieved maximum up to 35°C. The ideal temperature needed is 37.5°C with some tolerance, so applying heating mat as heating elements is not practical because it has limit heat level. Due to that, hatching process cannot be done successfully.

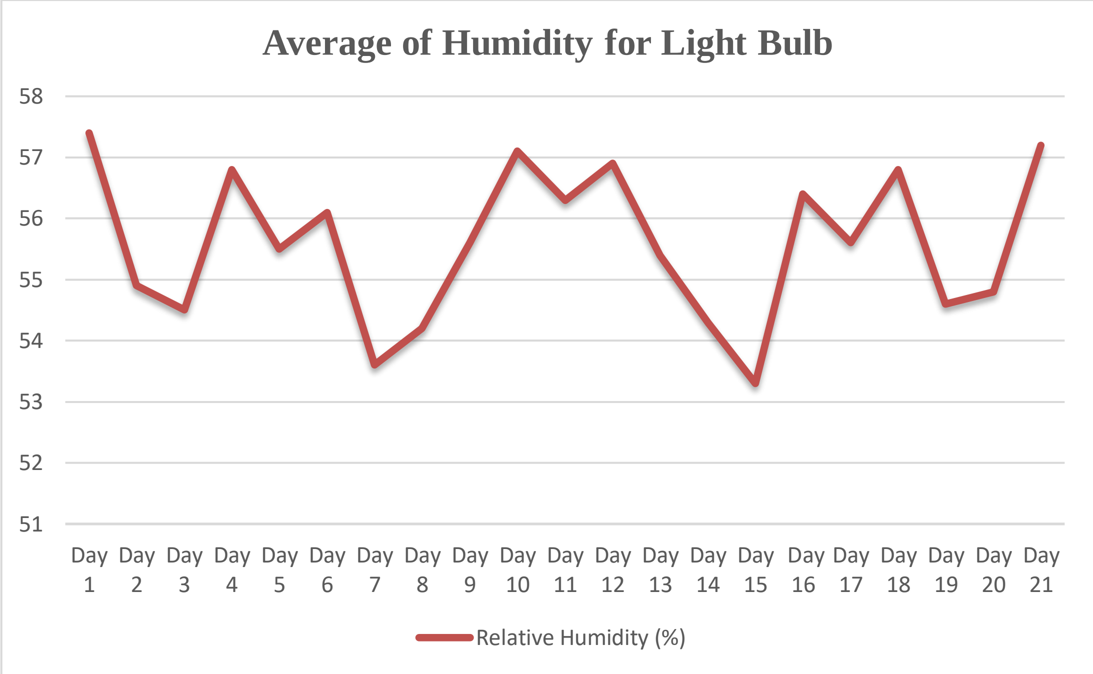

Figure 4.4.2: Line Chart Average of Humidity for Light Bulb

Referring to Figure 4.4.2, the maximum average value of humidity produced is 57.4%RH. The average value of relative humidity is higher compared to using LED bulb because value of heat distribution is lower by heating mat. Furthermore, by using LED bulb as heating elements in incubation, the heat distribute is higher because mostly LED bulb utilization can provide maximum up to 42.5°C. The optimum value of relative humidity needed is 55%RH with some tolerance, so applying LED bulb as heating elements is relevant and suitable because it can regulate humidity inside incubator wisely. Due to that, it is recommended to use light bulb for hatching process.

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4.5 Temperature and Humidity Supplied Daily (Heating Mat)

Table 4.5.1: Average of Temperature and Humidity for Heating Mat

Day Count	Average Temperature Measurement for 24 hours	Average Humidity Measurement for 24 hours
1	32.4℃	62.1%RH
2	32.8℃	61.3%RH
3	33.0℃	60.7%RH
4	33.5℃	59.9%RH
5	33.9℃	59.6%RH
6	34.8℃	58.7%RH
7	35.0℃	58.0%RH
8	34.3℃	59.2%RH
9	34.0℃	60.3%RH
10	33.8℃	60.6%RH
11	33.5℃	60.7%RH
12	33.2℃	60.8%RH
13	32.9℃	61.3%RH
14	32.8℃	61.7%RH
15	32.5℃	62.4%RH
16	35.0℃	58.3%RH
17	34.7℃	58.9%RH
18	34.4℃	59.4%RH
19	33.8℃	59.6%RH
20	33.2℃	60.7%RH
21	32.6℃	61.1%RH

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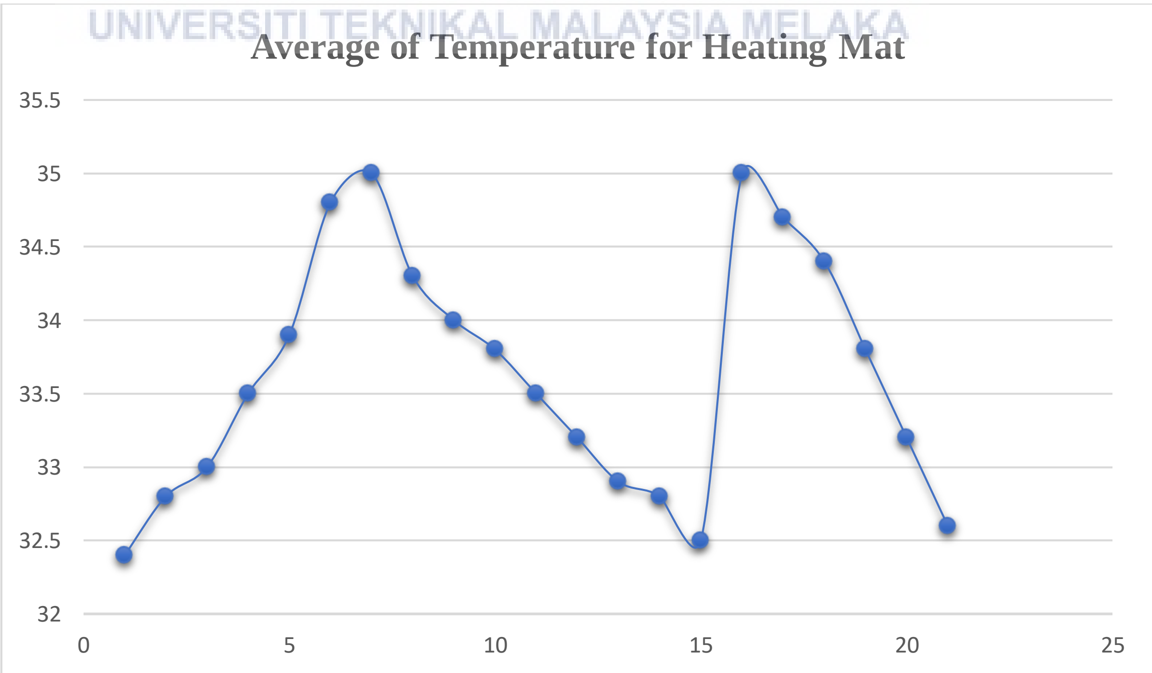

Figure 4.5.1: Chart Average of Temperature for Heating Mat

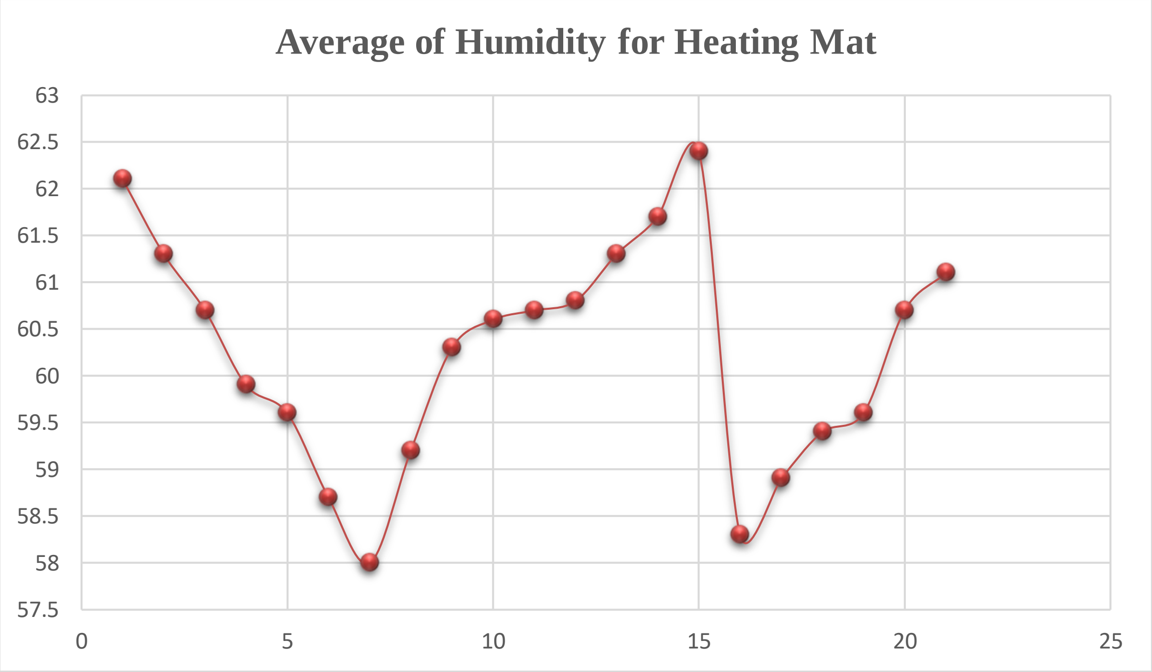

Figure 4.5.2: Chart Average of Humidity for Heating Mat

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Based on combination of Table 4.5.1, Figure 4.5.1 and Figure 4.5.2 it can be concluded that heating mat is not suitable for hatching process. It can be seen that when applying heating mat, there was no sign of embryo at all under 10 days incubation period. The eggs become defected because of insufficient supplied of heat and humidity. The value of humidity by utilizing heating mat is too high and did not relevant for hatchability. Besides, the temperature also is too low which mean those two factors affected chicken eggs growth.

4.6 Parameter and Variables Analysis

Table 4.6.1: Bulb Variations Comparison

Types of Bulbs	Bulb Specifications	Maximum Temperature Produce
Light Emitting Diode	18 Watt	42.5°C
Incandescent Light	10 Watt	36.8°C
	15 Watt	39.6°C

Table 4.6.2: Heating Elements Variations

Types of Heating Elements	Specifications	Range Temperature Produce	Egg Progress/Condition
Heating Mat	220V - 240V 10 Watt	32.4°C - 35.0°C	No sign of embryo in 10 days
Incandescent Light Bulb	220V - 240V 10 Watt	34.1°C - 36.8°C	Sign of embryo detected in 10 days
	220V - 240V 15 Watt	36.7°C - 39.6°C	Sign of embryo detected in 7 days
Light Emitting Diode Bulb	220V - 240V 18 Watt	37.4°C - 42.5°C	Sign of embryo detected in 7 days

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According to Table 4.6.2, there are 3 types of heating elements used in this smart incubator system with different power specifications. It can be seen maximum temperature range produce varies based on power value. The higher the power in watts the higher value of temperature can be produce. Heating mat with 10 watts are not suitable for incubation because it has low maximum temperature produce which led to no sign of embryo detected in 10 days hatching duration. For light bulb, they are relevant for hatching because it has constant heat supplied as shown in table 4.6.1.

4.7 Egg Incubation Development Progress

Table 4.7.1: Egg Hatchability Efficiency

Number of Egg per Entry	**Egg Tilting Features**	**Rate of Hatching**		
		Fully Hatch	Die with Embryo	No Embryo
6	Tilted	4 (65%)	1 (17.5%)	1 (17.5%)
4	Non-Tilted	1 (25%)	1 (25%)	2 (50%)

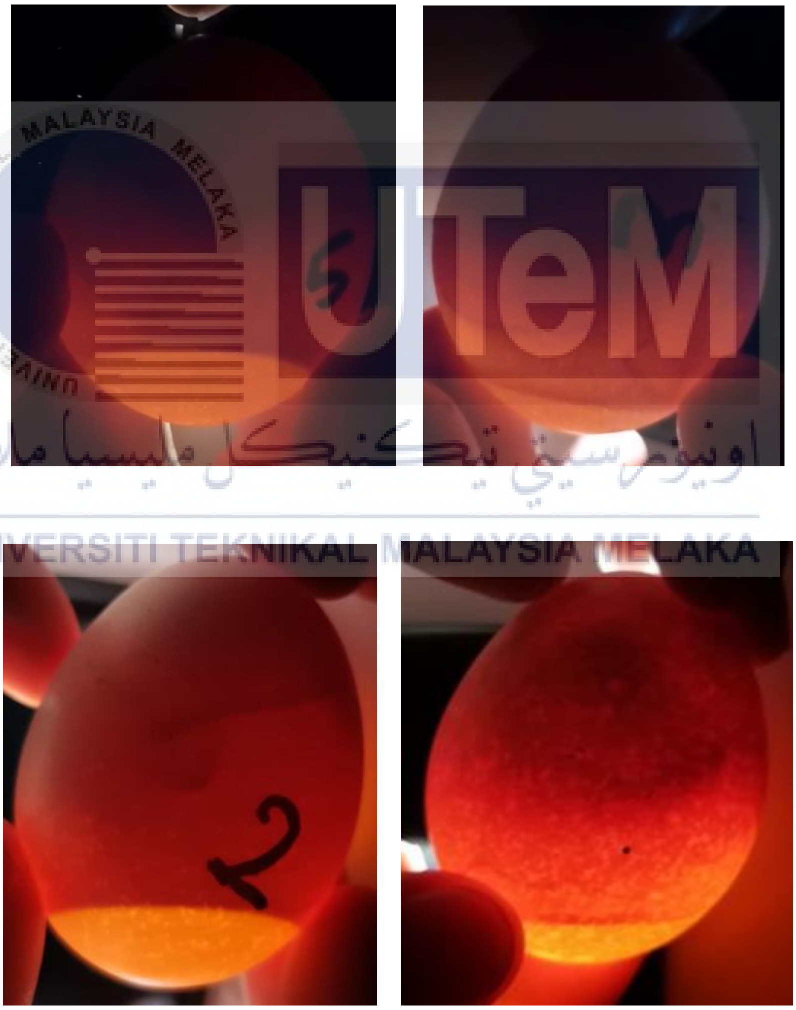

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Figure 4.7.1: Egg Embryo Early Staging

Figure 4.7.2: Egg Embryo Mid Staging

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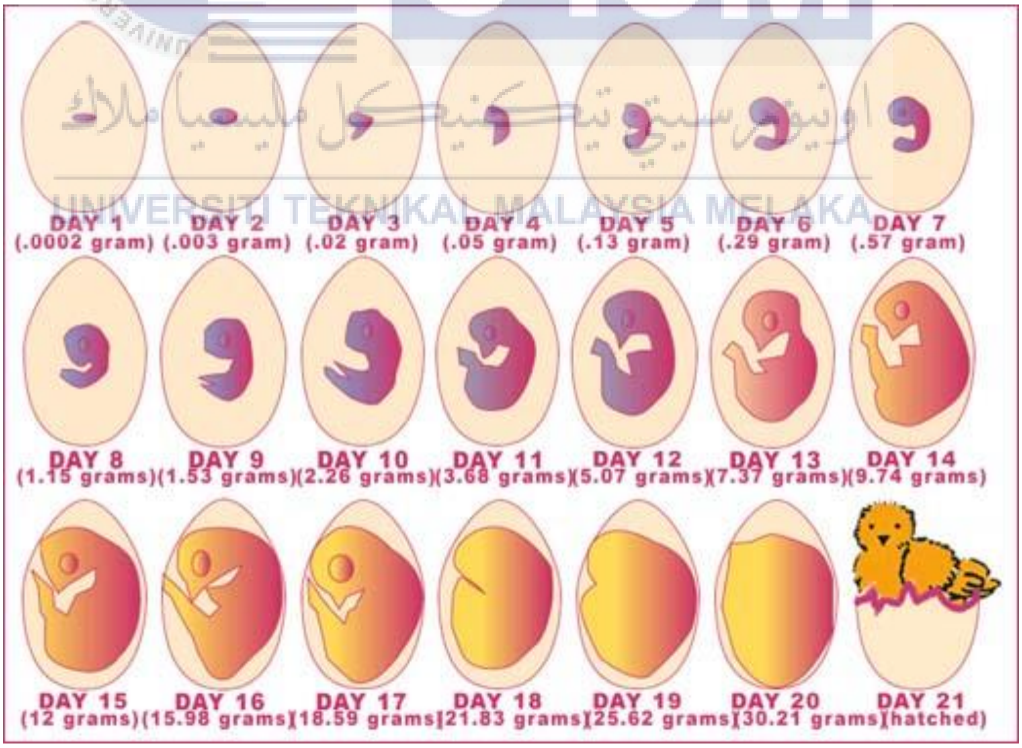

Figure 4.7.3: Overall Stage of Egg Hatching[8]

$$\% \, Hatchability = \frac{Number\ of\ eggs\ hatch\ out}{Number\ of\ fertile\ eggs} \qquad \text{(Eq. 4.7.1)}$$

During incubation period, there are 21 days took to totally complete of hatching process. By referring Equation 4.7.1, percentage of hatchability is determine by number of eggs which hatch out over number of fertile eggs. As an example, the total number of eggs that successfully being hatched is divide by number of eggs per entry in a certain time. In a meanwhile, based on Figure 4.7.3, chicks development has three phase which are first phase is between day 1st to day 7th, second stage is between day 8th to day 14th while last stage is between day 15th to day 21st. It has been prove if in between first phase to second phase, there is no sign of embryo detected in eggs, it can be assume as defected egg.

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Every light bulb has its own specifications as shown in Table 4.6.1 which also has different maximum temperature value produce. LED bulb with highest value of power supplied is the best heating elements because it has wide range of heat level while Incandescent light bulb with 10 watts only can achieved up to 36.8°C. As shown by Table 4.7.1, 4 out of 6 eggs with tilting features managed to be hatch which is equal to 65% while 1 out of 4 non-tilted eggs is fully hatched. This mean without any rotation of eggs at all the incubation process still going on but after all the egg tilting mechanism is still required to obtain higher rate of hatchability. Based on Figure 4.7.1 and Figure 4.7.2, the growth of fertile eggs started with early staging with existence of black mark or spread dark spot and then mid staging with embryo detected.

Figure 4.7.4: Crack-hatched and freshly hatched chicken eggs

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Based on Figure 4.7.4, it can be seen the flow of egg hatching phase. It is started by having crack as their marks to hatch from inside and no more rotation is needed. Egg labelled as number 3 got crack and hatch first while egg number 1 follow the sequence. Those freshly hatched chicks hatch with tilting hatch early 2 days than normal period. The date of each chick completely being hatch are different. It can be proven by some of them, their embryo is seen late than usual period. Several also did not have any sign of embryo yet. However, during hatching period, eggs in an incubator are highly recommend being placed on their sides, which is the way them in nature [3].

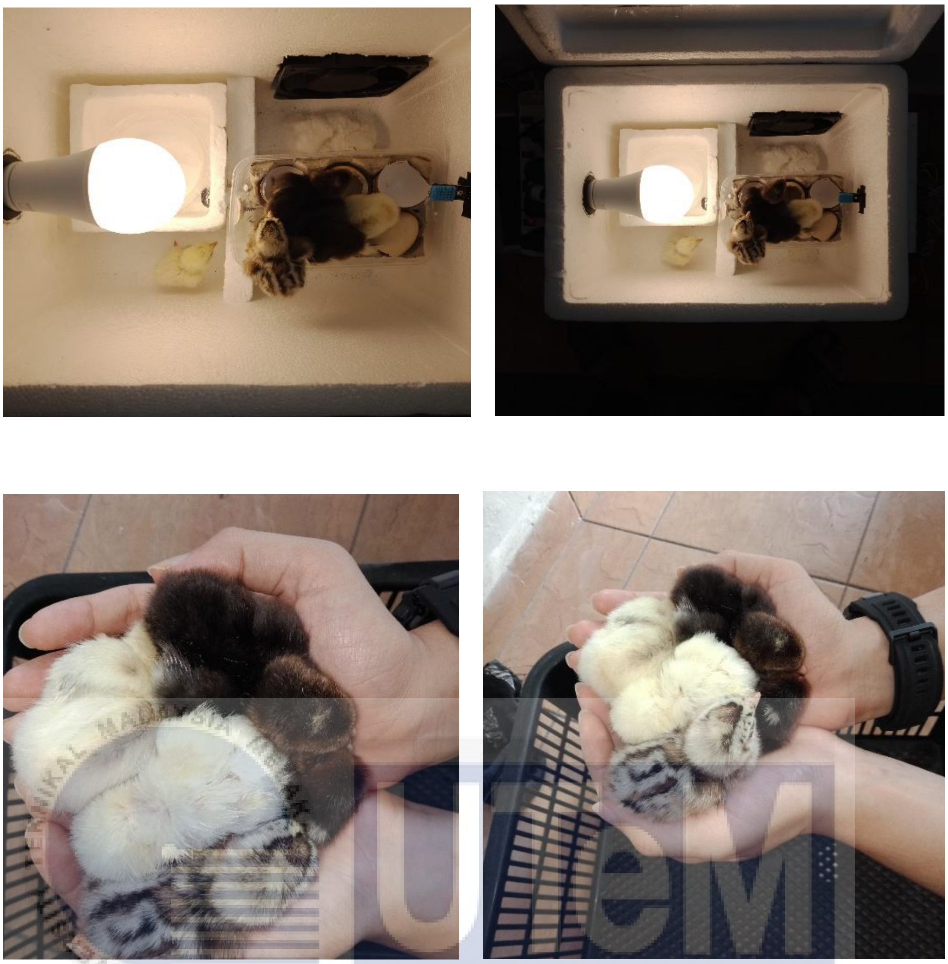

Figure 4.7.5: Chicks that successfully being hatch

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The date of each chick completely being hatch are different. Two out of ten eggs are hatch on the days 19 which is 2 days earlier from normal due date. While other three got hatch on the days of 21. Some of them have died within their embryo existence while others did not have any sign embryo at all. In the incubator six eggs is put on egg tilting features while four eggs do not have any egg rotation mechanism but still one out of four is successfully hatch. When applying heating mat, after 10 days in incubator, there are no sign of embryo detected at all. The occurrence is due to heat distribution and heat absorption is totally different when heating elements have different specifications. As shown in Figure 4.7.5, total 4 out 6 eggs were successfully hatched.

Figure 4.7.6: Different amongst chicks

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Every chick that hatches, their size could be different due to several factor. One of factor that affected size of egg is according to the broody hen’s age where is the older of hen, the larger eggs she laid. Moreover, by referring Figure 4.7.6 the size of black chicks is smaller because it hatches earlier than yellow chicks which it can be the chicks with premature born. Hence, the remaining eggs that unsuccessfully being hatch can be due to infertile egg or having infection and disease which is classified as internal factor.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

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5.1 Conclusion

In conclusion, the system developed are to ensure that the condition for incubation process is ideally provided and egg spoilage can be reduced. At the end of this project, a fully automated smart incubator system developed and assembled while the performance of the incubator was analysed according to the percentage of successfully hatched egg. Rate of efficiency is determine by total number of eggs which hatch out over total number of fertile eggs. Moreover, the chicken egg hatching incubator is successfully designed to have condition control, ventilation, heating and indication capability. This project could be applied to factory farming as an efficient emerging technology. It is developed to provide the biggest outcome at the smallest price and facilitate human task. It is a smart incubator system which produce heat and moisture at optimum scale while ensure relevant conditions along the incubation process. This smart incubator is the effective way to replace broody hen for egg hatching. Hence, it also comes out with more uniform heating and accurate temperature control. It has a low noise and low power consumption. Throughout this process of incubation, the hardship is to maintain the hygiene of incubator. From the analysis, it is found that, the best heating elements for incubator is LED bulb since it has wide range of maximum temperature that was produced compared to the incandescent light bulb and heating mat. Chicks managed to be hatch by heating elements of light bulb at the exact temperature value of 37.5°C and 55% RH. From the results, 2 eggs of them hatched earlier which is in days of 19 because it receives or achieve the desired value of temperature and relative humidity first compared to others. By the way, within the development of this smart incubator, it helps a lot for overall process during incubation process. It is prove that the results are positive, and this incubator is very effective because out of 6 eggs, 65% of them managed to be hatch successfully. Within the utilization of heating mat, there was no sign of embryo detected in 10 days of incubation process due to low range of temperature produced. Besides, when using incandescent light bulb, the result shows sign of embryo detected but in different period of days. The low power specifications of incandescent light bulb produced late sign of embryo compared to high power value. However, if LED bulb used as heating elements, process of incubation constantly met it requirements.

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5.2 Future Recommendations

Some suggestions are recommended here for future research works and development in order for enhancing the system:

1. Apply technology of Internet of Things (IoT) system of control and monitoring system using Blynk Application which can be accessed through the website or via smart phone applications. With IoT implementation, this project can move in line with industrial revolution.
2. Using solar energy or photovoltaic (PV) source as a power supply for poultry egg incubator due to the incubator needs 24 hours of supply to maintain the temperature and humidity of surroundings.
3. Utilize arduino integrate with NodeMCU ESP8266 and ESP32 Cam which is webcam to obtain display and control system of poultry incubator. The interface between microcontroller system with webcam is really helpful because anytime and anywhere can monitor the condition of incubator live.
4. Develop automated water supply and refill features. By this, the basic needed which is water and oxygen for incubation process does not need any regular routine.

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APPENDICES

Appendix A

```
#include <LiquidCrystal.h>
#include "DHT.h" // include DHT library code

// LCD module connections (RS, E, D4, D5, D6, D7)
LiquidCrystal lcd(1, 2, 4, 5, 6, 7);

#define DHTPIN A0             // DHT11 data pin is
connected to Arduino pin A0
#define DHTTYPE DHT11         // DHT11 sensor is used

DHT dht(DHTPIN, DHTTYPE);     // Initialize DHT library

int motor1pin1 = A1;
int motor1pin2 = A2;

void setup() {
  // set up the LCD's number of columns and rows
  lcd.begin(16, 2);
  dht.begin();

  // put your setup code here, to run once:
  pinMode(motor1pin1, OUTPUT);
  pinMode(motor1pin2, OUTPUT);

  pinMode(9, OUTPUT);
  pinMode(10, OUTPUT);
}

void loop() {

char temperature[] = "Temp = 00.0 C";
char humidity[]    = "RH   = 00.0 %";

  // Read humidity
  int RH = dht.readHumidity() * 10;
  //Read temperature in degree Celsius
  int Temp = dht.readTemperature() * 10;
```

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```
  // Check if any reads failed and exit early (to try
again)
  if (isnan(RH) || isnan(Temp)) {
    lcd.clear();
    lcd.setCursor(5, 0);
    lcd.print("Error");
    return;
  }

  if(Temp < 0){
    temperature[6] = '-';
    Temp = abs(Temp);
  }
  else
  temperature[6]   = ' ';
  temperature[7]   = (Temp / 100) % 10  + 48;
  temperature[8]   = (Temp / 10)  % 10  + 48;
  temperature[10]  = Temp % 10 + 48;
  temperature[11]  = 223;    // Degree symbol ( °)
  if(RH >= 1000)
    humidity[6]    = '1';
  else
  humidity[6]      = ' ';
  humidity[7]      = (RH / 100) % 10 + 48;
  humidity[8]      = (RH / 10)  % 10 + 48;
  humidity[10]     =  RH % 10 + 48;

  lcd.setCursor(0, 0);
  lcd.print(temperature);
  lcd.setCursor(0, 1);
  lcd.print(humidity);

  // put your main code here, to run repeatedly:
  //Controlling speed (0 = off and 255 = max speed):
  analogWrite(9, 100); //ENA pin
  analogWrite(10, 200); //ENB pin

  //Controlling spin direction of motors:
  digitalWrite(motor1pin1, HIGH);
  digitalWrite(motor1pin2, LOW);
  delay(1000);

  digitalWrite(motor1pin1, LOW);
  digitalWrite(motor1pin2, HIGH);
  delay(1000);
}
```

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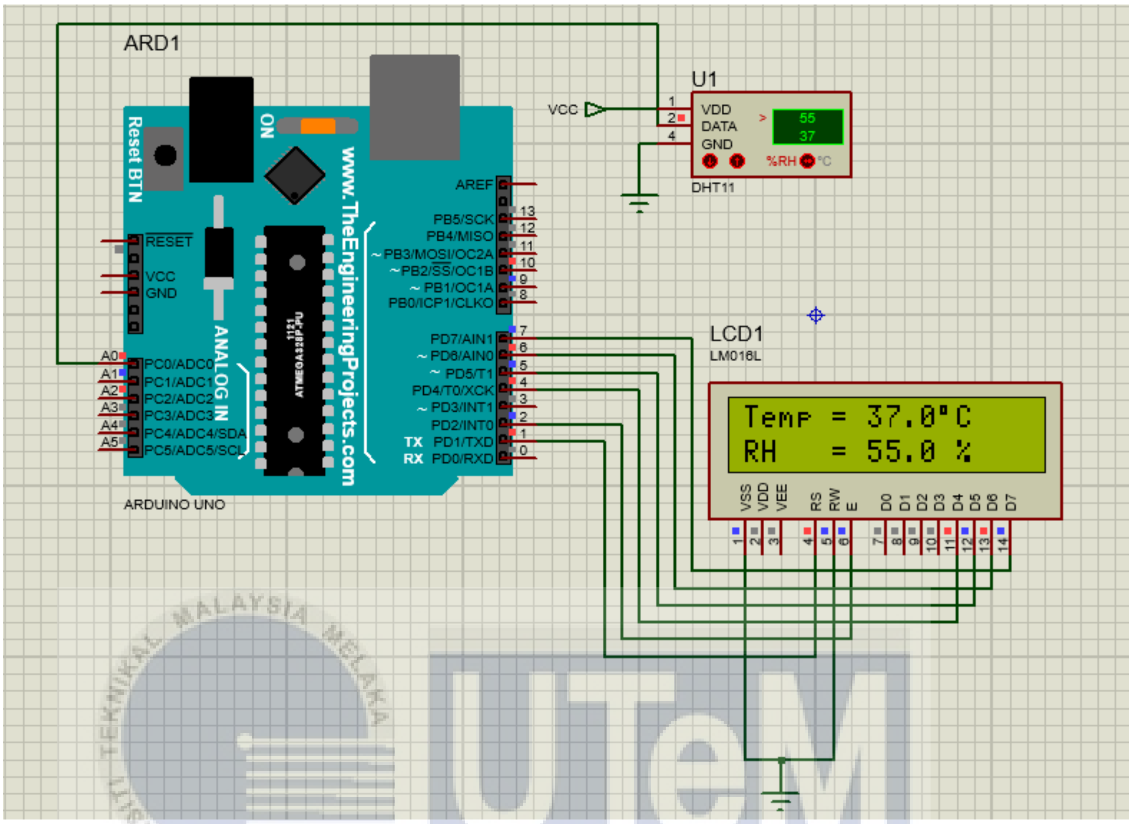
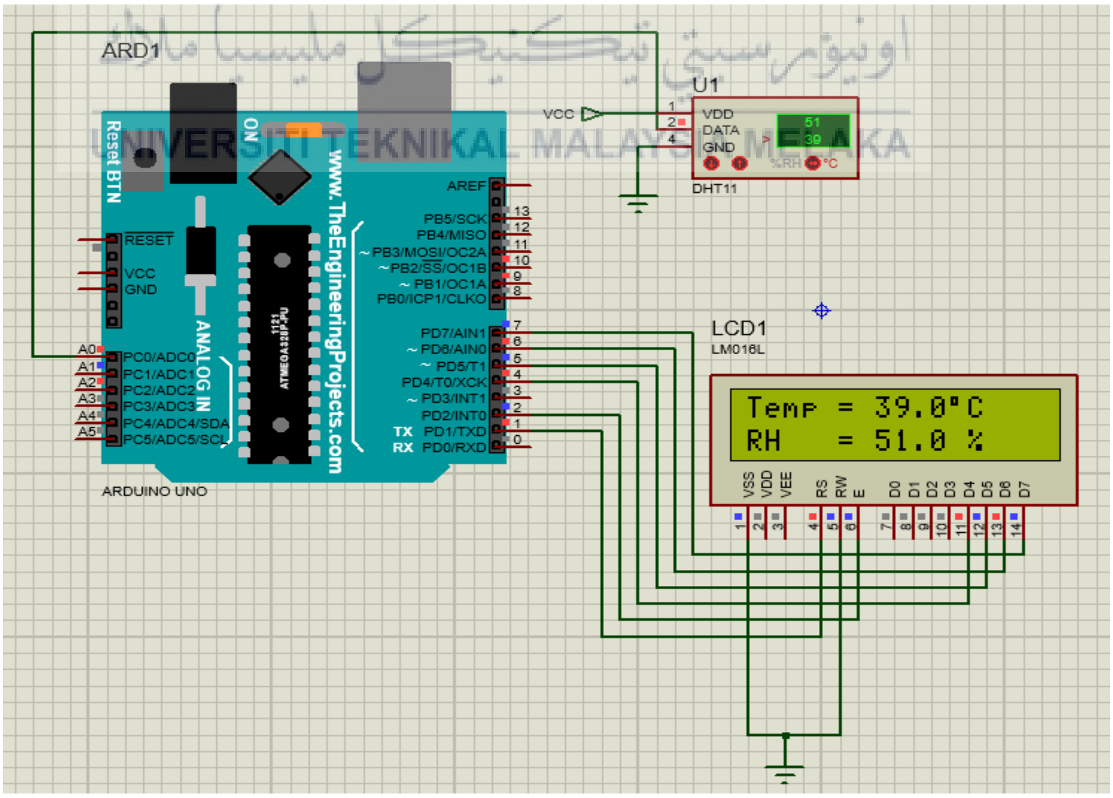
<u>Appendix B</u>





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