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Subject title

STUDY AND REALIZATION OF AN AUTOMATIC EGG INCUBATOR

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بِسْمِ اللَّهِ

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DEDICATION

BY NOUSSAIBA

Today will soon be a memory. A special feeling of gratitude that I will share with my beloved ones.

To my caring **dad**, thank you for always having my back and being my safe home, thanks for giving me the freedom to make mistakes and learn from them, love you pops.

To my beautiful **mother**, thanks for always being such an understanding, kind, and loving mother. Thanks for making sure I always had the best opportunities. I am thankful for having you as a mom, I couldn't do it without you mama.

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BY HOUYAM

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I wish myself a happy future and make up for everything I've been through.

Résumé

Ce mémoire se penche sur l'étude et la réalisation d'un incubateur d'œufs, en se concentrant sur sa conception, sa fonctionnalité et son application pratique. L'objectif de cette recherche est de développer un système efficace et fiable qui offre des conditions optimales pour l'incubation des œufs, assurant des taux d'éclosion réussis et favorisant la croissance d'une progéniture saine. Cette thèse comprend une analyse complète de divers aspects liés à l'incubation des œufs, notamment le contrôle de la température, la gestion de l'humidité et la ventilation et les systèmes. En combinant exploration théorique et mise en œuvre pratique, cette étude vise à apporter une contribution au domaine de l'aviculture et à aider les couvoirs à améliorer leurs processus d'incubation.

Mots clés

Incubateur d'œufs, régulation, température, humidité, ventilation, contrôle, automatisme, efficacité.

Abstract

This master's thesis delves into the study and realization of an egg incubator, focusing on its design, functionality, and practical application. The aim of this research is to develop an efficient and reliable system that provides optimal conditions for the incubation of eggs, ensuring successful hatching rates and promoting the growth of healthy offspring. This thesis encompasses a comprehensive analysis of various aspects related to egg incubation, including temperature control, humidity management and ventilation. By combining theoretical exploration with practical implementation, this study aims to contribute to the field of poultry farming and assist hatcheries in improving their incubation processes.

Keywords

Egg incubator, regulation, temperature, humidity, ventilation, control, automation, efficiency

الملخص

تتعمق أطروحة الماستر هذه في دراسة وتحقيق حاضنة البيض ، مع التركيز على تصميمها ووظائفها وتطبيقها العملي. الهدف من هذا البحث هو تطوير نظام فعال وموثوق يوفر الظروف المثلى لحضانة البيض ، وضمان معدلات فقس ناجحة وتعزيز نمو النسل السليم. تتضمن هذه الأطروحة تحليلاً شاملاً لمختلف الجوانب المتعلقة بحضانة البيض ، بما في ذلك التحكم في درجة الحرارة وإدارة الرطوبة والتهوية. من خلال الجمع بين الاستكشاف النظري والتطبيق العملي ، تهدف هذه الدراسة إلى المساهمة في مجال تربية الدواجن و في تحسين عمليات حضانة البيض

الكلمات المفتاحية

حاضنة البيض، تنظيم ، درجة الحرارة ، الرطوبة ، التهوية ، التحكم ، التشغيل الآلي ، الكفاءة

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General Introduction

The incubation of eggs plays a pivotal role in the successful reproduction of various avian species. It provides a controlled environment that mimics the conditions necessary for embryonic development, leading to the hatching of healthy chicks. Over the years, advancements in technology and a deeper understanding of avian biology have paved the way for the development of sophisticated egg incubation systems. These systems strive to create an optimal environment, ensuring the highest possible hatching rates and the overall health of the offspring.

The objective of this master's thesis is to conduct a study on the design and realization of an egg incubator. By exploring various parameters and factors influencing successful egg incubation, this research aims to propose an innovative and efficient incubator system. The proposed system will address challenges such as temperature regulation, humidity control, air circulation, and monitoring, among others, and automatic reversal.

This study will begin with a review of the literature, studies, past experiences, and current knowledge.

The next phase will involve the design and engineering aspects of the incubator system. The proposed incubator will incorporate advanced temperature control mechanisms, humidity management systems, and a well-designed ventilation configuration to ensure optimal conditions for egg incubation. Additionally, monitoring systems will be integrated to track and record vital parameters, allowing for precise monitoring and adjustments as needed.

Once the design is finalized, a prototype of the incubator system will be developed and implemented. The functionality and performance of the prototype will be evaluated through experiments validating the efficiency and effectiveness of the proposed incubator system. Finally, this study aims to contribute to the field of poultry farming by providing a comprehensive understanding of egg incubation processes and proposing an innovative solution for successful egg hatching. The results of this study have the potential to improve the productivity and sustainability of hatcheries, enabling them to meet the growing demands of the poultry industry.

Through this work, we aspire to provide poultry farmers, researchers, and industry professionals with knowledge and practical information on the study and realization of an advanced egg incubator. By combining theoretical exploration with practical implementation, this study aims to make a significant contribution to the field and to open avenues for further advances in avian reproductive technology.

General introduction

This study is structured in four chapters:

- The first consists of an exposition of a general study.
- The second chapter includes general information on Arduino.
- The third chapter includes all that is components.
- The fourth chapter includes the realization part.

Finally, a conclusion that summarizes the recommendations needed to improve the incubation process.

CHAPTER I

General study to the incubations

1. Introduction :

The incubator is a conditioned enclosure. Today it is found in many applications in scientific laboratories, agriculture, ovens, industry etc.

The incubator that we are going to design is specifically intended for the artificial incubation of hens, this operation relies on electronic equipment, which uses modern technology to simulate natural hatching conditions for chicken eggs and help them hatch safely. Professional and amateur poultry farmers use this incubator to increase the hatching success rate and ensure the healthy growth of chicks. In this comprehensive review, we are going to explore in detail the different components and features of an automatic egg incubator.

2. History :

The first artificial incubators are used by the Egyptians, the Chinese, and the Romans.

2.1 The Chinese :

In the scale of civilizations, it is in China that the first traces of artificial incubation can be found, about three thousand years before the Christian era. The Chinese developed this technique to increase the production of ducks and geese, which were considered important sources of food at the time.

The Chinese used artificial incubation methods that involved manual egg rotation and control of temperature and humidity. The eggs were placed in baskets made of wicker or bamboo, which were then kept in warm and humid places, such as near kitchens.

Over the centuries, the technique of artificial incubation improved in China, and the Chinese began to use more sophisticated incubators, such as hot air ovens and wooden boxes equipped with fans[1].

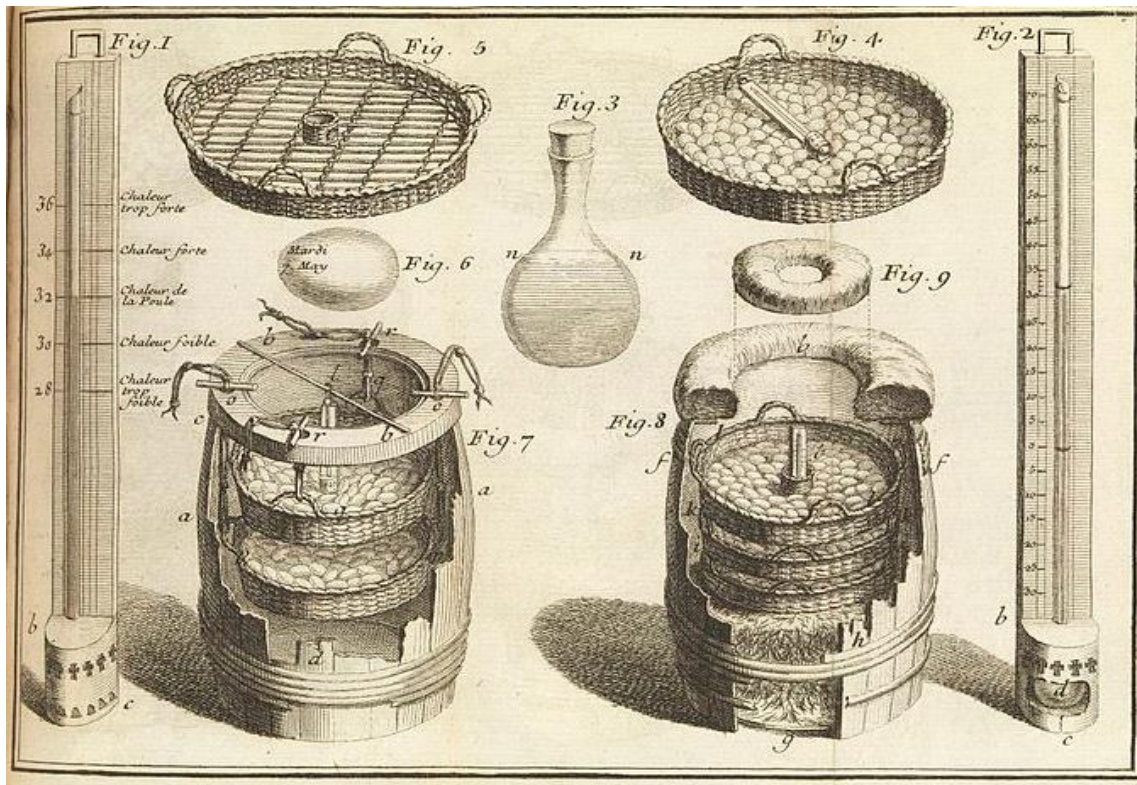


Figure I.1: Method for incubation of poultry eggs

2.2 The Egyptians:

Chicken ovens existed in ancient Egypt, and interestingly, they can still be found in there to this day. functioning manals, monuments built four or five thousand years ago for artificial incubation. manals are usually built of bricks and clay and are often located near villages or towns to facilitate the transportation of eggs. The ovens inside the manal are heated with dried camel dung, which burns slowly and maintains a constant high temperature for egg incubation. Manals can have a capacity of several 10000 of eggs, which shows the importance of this technique for large-scale chick production.

The practice of artificial incubation is an ancient tradition in Egypt and continues to be used to this day in some regions of the country, particularly for the production of chicks for farming and consumption [1].

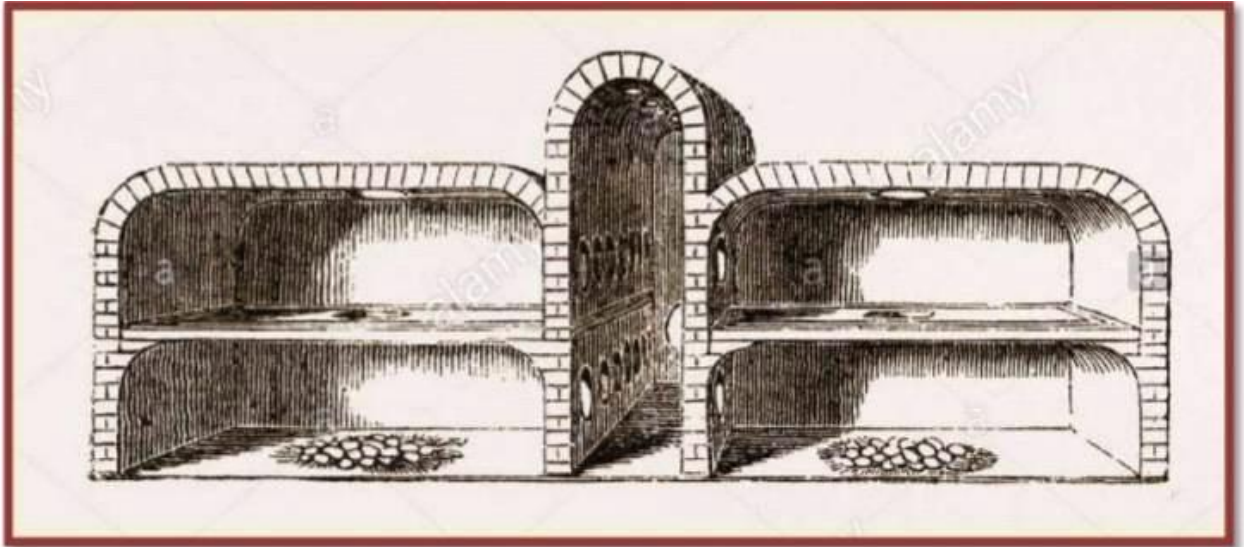


Figure I.2: *The Ancient Egg Hatcheries of Egypt*

2.3 The Romans:

The Roman hatcheries were sophisticated installations that included permanent steam-heated stoves to maintain a constant and high temperature, they also mastered the art of plumbing and central heating, which allowed them to build large-scale facilities for artificial incubation of eggs, they used lead pipes to transport steam into the heated chambers, which was a major technological innovation at the time, in their hatcheries were often located near cities to facilitate the distribution of chicks and eggs, so they established regulations to regulate the production of eggs and poultry, which shows the importance of this industry to the Roman economy.

In summary, the Romans developed sophisticated techniques for artificial egg incubation, which were essential to meet the needs of the poultry industry at the time, despite these rudimentary methods, the overall hatching results were excellent, reaching 60 to 65% of the eggs incubated, a percentage that many modern installations would envy [1].

3. Different types of egg incubations :

Incubation or brooding of eggs refers to the process by which animals cover the eggs with their bodies to maintain the heat that will hatch the clutch. There are two types of incubation: Natural incubation (heat passes from the parents to the eggs through an area of skin in the abdomen) and artificial incubation or incubation (Using machines at regulatory temperatures to hatch the eggs).

3.1 Natural incubation :

The majority of poultry farmers who wish to have a few chicks simply let their hens sit on their eggs naturally. If the hen is indeed the best placed to promote the good development of the chick in the egg.

The brooding process is a completely natural process in the hen, the hen manages everything from A to Z. Certain signs in the hen appear when she is about to brood, she clucks, holds her wings apart, puffs up, and often ruffles its feathers. She goes to the nest frequently and stays there for longer and longer each time, her heat increases, she has a fever on her skin, she loses her belly feathers, and she builds her nest away from the henhouse, to avoid agitation or conflict with other layers. The number of eggs to put under the mother-to-be is expected to be proportional to the size of the hen. She will even take care of turning the eggs regularly so that the embryo does not stick to the wall of the egg. The chicks must come out of the egg on their own.



Figure I.3.4: *Hatching eggs naturally*

3.2 Artificial incubation :

If it is the only way to proceed among professional breeders, it is because there are reasons...

Artificial incubation makes it possible to group chicks together which are all born at the same time and are therefore of the same age. This facilitates the management of the breeding because the chickens have different needs according to their age. By using artificial incubation, breeders can ensure that all chicks have the same needs at the same time and can therefore be fed and cared for more efficiently. Additionally, by using artificial incubation, breeders can control the conditions under which eggs are incubated, which can increase the chances of hatching success. Artificial incubators can be set to maintain constant temperatures and humidity levels, which creates an optimal environment for embryo development.

Finally, artificial incubation can help improve the productivity and profitability of chicken farming. Using this method, farmers can incubate more eggs at one time, increasing the amount of chickens that can be raised at one time. This can help reduce production costs and increase profits, be sure to stop turning to allow chicks to hatch at 21 days of incubation. the humidity should then be increased, once born, the chicks will be left in the incubator until they are completely dry and will then have to be transferred to their rearing room with a suitable heating system.



Figure I. 5: *Artificial incubation*

4. Artificial incubation models:

4.1 Static incubation:

A static incubator is a type of incubator used in the laboratory setting to provide a controlled environment for the growth and development of cells or organisms. It is called "static" because it does not use any moving parts or agitation to mix the contents of the incubator.

Static incubators can come in different sizes and configurations, depending on the specific needs of the experiment or application. They are commonly used in the fields of microbiology, cell culture, and biotechnology, among others.

In a static incubator, temperature, humidity, and gas concentration can be controlled to create an ideal environment for the cells or organisms being cultured. This allows for the precise and reproducible conditions necessary for experimental reproducibility and accuracy.

In summary, static or still-air incubators can be used for hatching eggs, but they require more attention to maintain a consistent temperature throughout the incubator. They are generally less expensive than forced-air incubators but may not be suitable for all types of eggs.

4.2 Dynamic incubation:

In this incubator, the interior air is circulated by a fan. The latter should be placed away from eggs and hatching chicks, and a protective screen should be applied to prevent injury to them. In other models, the upper or lower vacuum sucks in air and then reinjects the air into the other end after the heating and cooling phase.

As a result, the temperature of the entire device is completely uniform. That's why we can place egg trays at different heights. In this type of incubator, the temperature should be set at 37.8°C or 38 degrees Celsius and measured on top of the egg, the dynamic model is more sophisticated than the static model.

4.3 Mixed type:

This last type of incubation mixes the two classes mentioned above, namely starting this incubation under hens and ending in the artificial incubator or the reverse.

5. Definition of the incubator :

The egg incubator is an insulated warm container for hatching eggs and artificially performs the role that a broody hen does in nature. It can be made of wood, metal, or plastic and contains a heating element, an egg incubator is a device used to simulate the necessary conditions for eggs to hatch. It is commonly used for hatching chicken eggs, but can also be used for hatching eggs of other poultry such as quail, ducks, geese, and turkeys, it's a mechanical device that controls temperature to around 100F or 37.7 °C and humidity creating the ideal conditions which allow the chick to grow inside of a fertilized egg, without the need for a broody hen. It enables large numbers of eggs to be incubated in all seasons [2].

6. Types of incubators:

There are three types of incubators

6.1 The ventilated incubator:

The most modern egg incubators are designed with ventilation in mind, they typically have vents or small holes in the incubator's walls that allow fresh air to enter while allowing stale air to exit, some incubators also have a fan that helps to circulate air throughout the incubator, which promotes more even temperature and humidity distribution [2].



Figure I.6: *The ventilated incubator*

6.2 The static incubator:

Also this device is not equipped with a ventilation system, the heating resistance is located above the eggs, and the thermometer is almost in the same row with the eggs placed on the lower support. The latter is the equivalent of a nest. The upper part has a higher temperature rate than the lower part. This device is equipped with two vents, one for the air inlet to the incubator and the other for the exhaust [2].

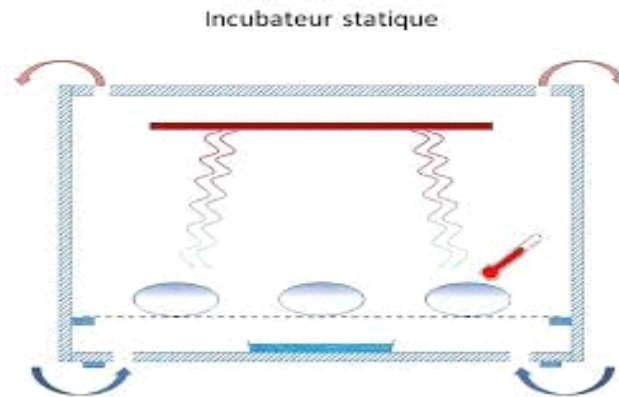


Figure I.7 : *The ventilated incubator*

6.3 The contact incubator:

This is the latest generation incubator. It is equipped with a temperature-controlled inflatable membrane located directly above the egg. Expansion and deflation of the membrane will cause the egg to change position [2].



Figure I.8 : *The contact incubator*

7. Incubator models :

7.1 The manual incubator:

Ideal for beginners and/or for hatching small quantities of eggs, the manual incubator is simple to use.

- Egg turning is done manually.
- It is generally equipped with a small resistance, a thermostat, and a fan to distribute the heat.



Figure I.9: *The manual incubator*

7.2 The semi-automatic incubator:

A semi-automatic incubator is an incubator that requires some manual intervention, for example, the way the eggs are turned, meaning you must turn each egg by hand usually around 3 or 4 times a day.



Figure I.10: *The semi-automatic incubator*

7.3 The automatic incubator:

The automatic incubator is suitable for experienced breeders with many hens.

- Egg turning is automatic.
- Accurate digital display thermostat.
- The hygrometry is regulated.
- Grid to place the eggs.
- Several trays were provided for eggs.
- Good heat distribution.
- Independent light switch.

The other options for the most efficient: stratified materials with good finishes, wet bulb hygrometry, inspection window, air renewal by means of ventilation holes, adjustable ventilation, electronic thermostat, and programmed incubation calendar.



Figure I.11: *The automatic incubator*

8. Important parameters affecting incubation:

8.1 Temperature:

The incubation temperature is the most important parameter for seeing eggs hatch. If there are any problems during incubation, the incubation temperature is the first parameter to check.

- For most poultry species, the optimum incubation temperature is between 37.0 and 38.0°C (although it is possible to hatch at temperatures between 35.0 and 40.2°C).
- Embryos are more sensitive to high temperatures than to low temperatures.
- From the 19th day of incubation, the temperature must drop by 1°C, because the chicks already produce heat themselves [3].

The following figure shows a diagram of the solutions to stabilize the temperature in an incubator.

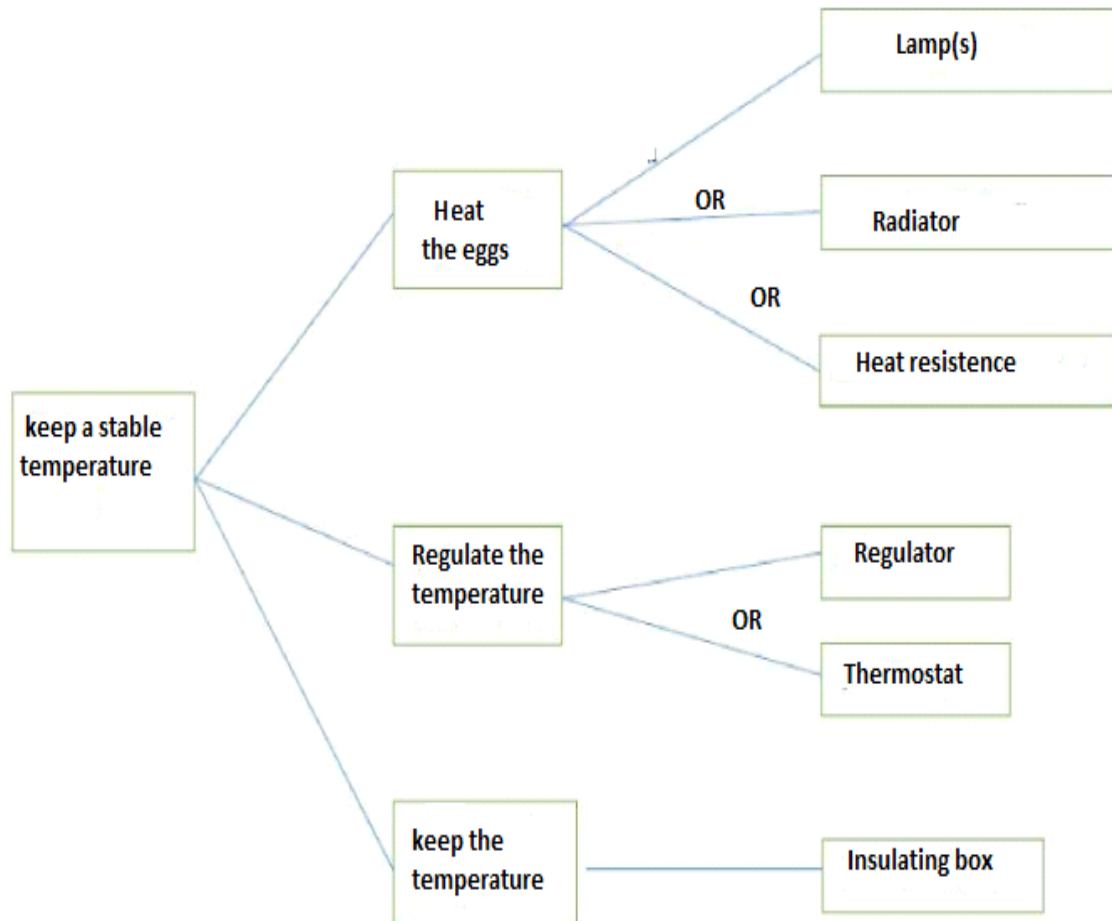


Figure I.12: *Diagram of the solutions to have a stable temperature*

8.2 Humidity:

- The humidity in the incubator is an important factor for successful incubation. To achieve maximum hatchability, the air in the incubator should be neither too dry nor too humid.
- The correct humidity is that which will allow the egg to lose approx 15% of its weight during incubation and what the egg loses is water in the form of gas.
- The best result of the incubation is a relative humidity of 55% to 65% during the 18 days and a maximum relative humidity of 75% during the last three days of incubation.
- If the humidity in the incubator is too low, the embryos will lose more water than necessary. Successful hatching chicks will be dehydrated; their development will have been disrupted and they will die of thirst.

- If the humidity is too high, the embryos will not lose enough weight. If the chick hatches successfully, it will appear bloated, have difficulty standing and will die in the hatching egg [4].

The figure below is about how an egg look like at day 18 with proper incubator humidity.

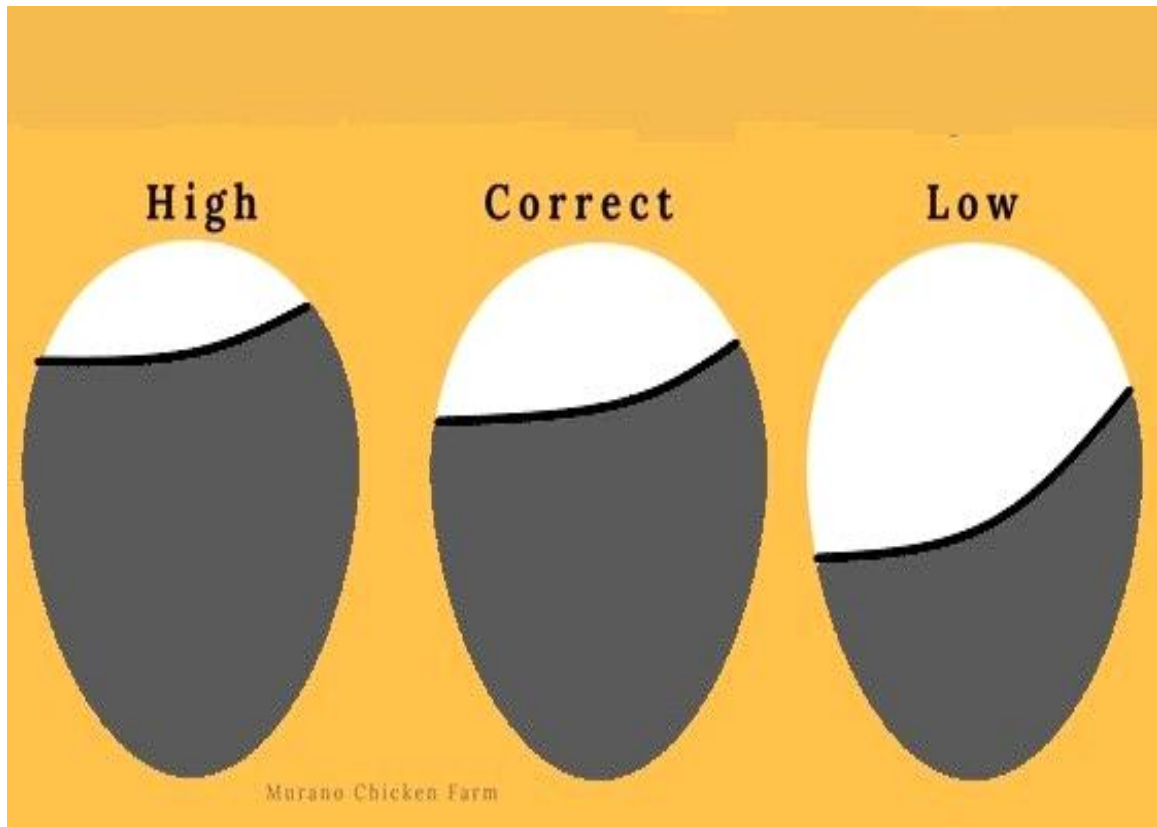


Figure I.13: *Incubator humidity*

8.3 Air circulation:

Gas exchange during incubation plays a critical role in embryo development and viability, hatch outcomes and chick growth .It brings oxygen O₂ into the embryo and eliminates excess carbon dioxide CO₂. Air renewal is essential for the covering phase. This is achieved by adjusting the air inlet and outlet of the incubator. In addition, the helps regulate temperature and humidity in the incubator.

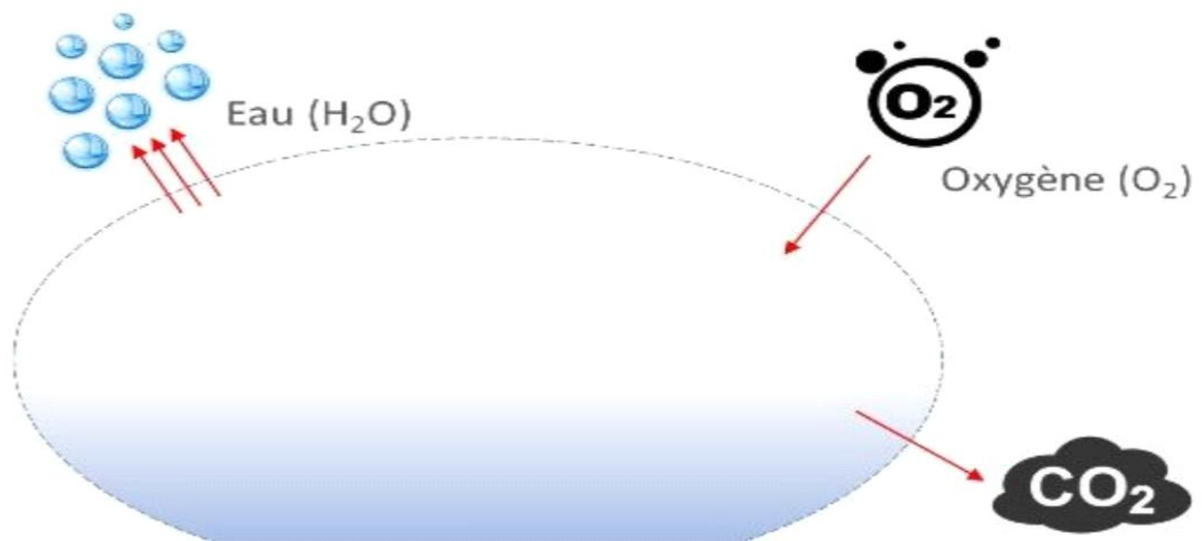


Figure I.14: Air circulation in the incubator

8.4 Ventilation:

Ventilation in the incubator is also an important parameter to consider. It helps to prevent the accumulation of carbon dioxide and moisture in the air, which could have a negative effect on embryo development. A good ventilation also helps to maintain a uniform temperature throughout the incubator. To ensure adequate ventilation, an efficient ventilation system must be designed in a way that does not create too strong air currents that could disturb the developing embryo [4].

8.5 Flipping:

When using an incubator to hatch chicken eggs, it is important to regularly turn the eggs at least 7 times a day. The purpose of this process is to ensure that the embryo inside the egg does not stick to the shell and develop abnormally, it is also important as it helps maintain a uniform temperature throughout the egg. Moreover, turning the eggs also helps to evenly distribute the moisture inside the egg, which is essential for the development of the embryo.

The egg switches between two possible positions, it is at an angle of 45° from the vertical. It is good to completely remove the incubation tray, flip the eggs 180° degrees, and then place the tray back in the opposite position [4].

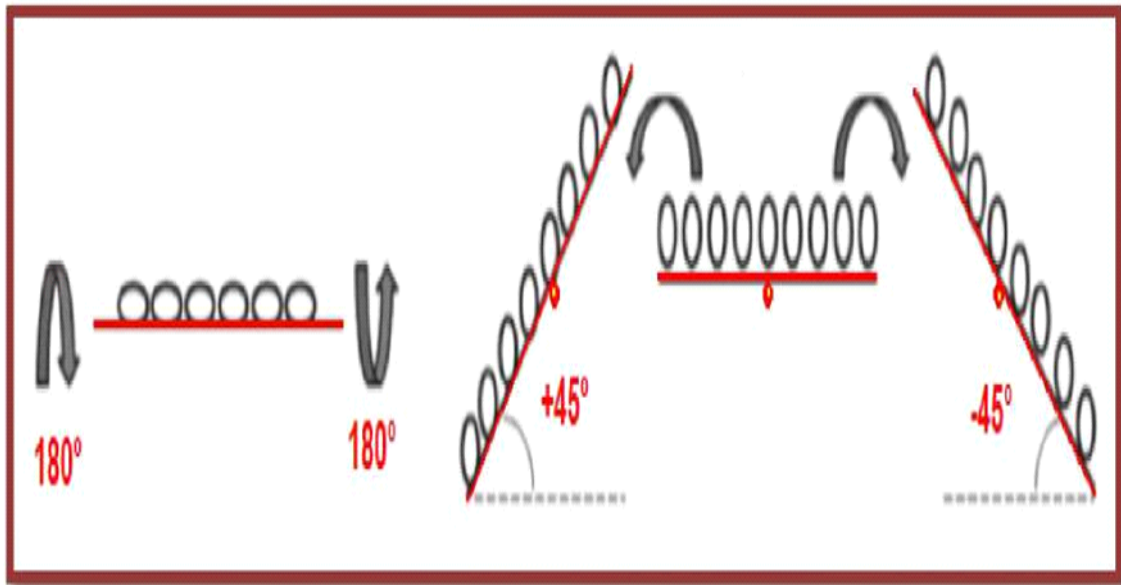


Figure I.15: Turning the eggs



180° flip



45° flip

Figure I.16: The two methods of egg turning

8.6 Hatching:

Hatching is when the chick breaks the shell and comes out of the egg. This process can take several hours or even several days, it can start on the 19th day and end on the 23rd day after hatching, it is important to quickly remove chicks from the brooder and transfer them to an appropriate living space to avoid accidents [5].



Figure I.17: *Hatching chicks*

9. Stages of artificial incubation:

9.1 Sorting eggs:

Egg sorting is an ancient method of grading eggs based on their quality and freshness. This technique has been used for centuries by farmers to achieve a higher hatching success rate. It's done according to several criteria, such as egg freshness, adequate weight and egg size. Eggs that do not meet these criteria should be rejected.

Use eggs that are 3 to 4 days old and weigh between 30 and 70 grams (depending on the breed) for the best hatching results. However, these eggs must be fertilized and come from healthy and nutritious hens.



Figure I.18: *Sorting eggs*

9.2 Egg disinfection:

Disinfecting eggs for incubation is standard practice in the poultry industry. This step is essential to prevent bacterial contamination and ensure a high hatching success rate. It should be done as soon as possible after egg collection. However, it is not recommended to wash the eggs with water, otherwise the thin protective layer covering the eggs and protecting them from microbial attack will be removed. Different disinfection methods are used. This should be done in a room between 22-26°C for 20-30 minutes [4].



Figure I.19: *Disinfected eggs*

9.3 Egg storage:

During this storage period (with a maximum duration of about 8 days), the eggs must be kept in a ventilated room but protected from drafts, sunlight, and dust, with temperature varying from 12° to 15° C. Take care not to store the eggs for longer than 8 days, otherwise, they will lose their hatching potential. During storage, the eggs are placed in a natural horizontal or vertical position with the tip of the egg facing down. To prevent the yolk from sticking to the shell, it is recommended to turn the egg 180° twice a day, morning and evening.

In order to limit water loss due to evaporation, which will reduce hatchability and chick vigor, the relative humidity of the storage room should be maintained between 70% and 85% [6].



Figure I.20: *Hatching egg storage*

9.4 Preheating Eggs:

Preheating the eggs before loading is an important step in the incubation cycle. Numerous examples have shown that poor preheating could lead to early embryonic mortality, a poor hatch window, as well as embryonic malformations.

This step makes it possible to homogenize the hatching and to avoid the introduction of a cold mass into the incubator which will have been left to preheat empty at 37.7 °C for one day. It is therefore recommended for all eggs. Preheating consists of warming the eggs by placing them near the incubator and allowing their temperature to equilibrate with the ambient temperature of the hatchery [7] .



Figure I.21: *Preheating the eggs before the incubation step*

9.5 Egg candling:

To have chicks, it is important to ensure that the eggs are in good condition and that an embryo is developing properly inside and to achieve this, we use the egg candling technique. The latter consists of looking through the inside of the egg using an egg candler.

The egg candler is a device whose shape is reminiscent of a flashlight. It produces an intense and quite strong light which passes through the shell and reveals the internal structure of the egg. It has different tips adapted to the size of the eggs of different species of birds. The candling is used to eliminate unfertilized eggs and dead embryos during incubation [8].

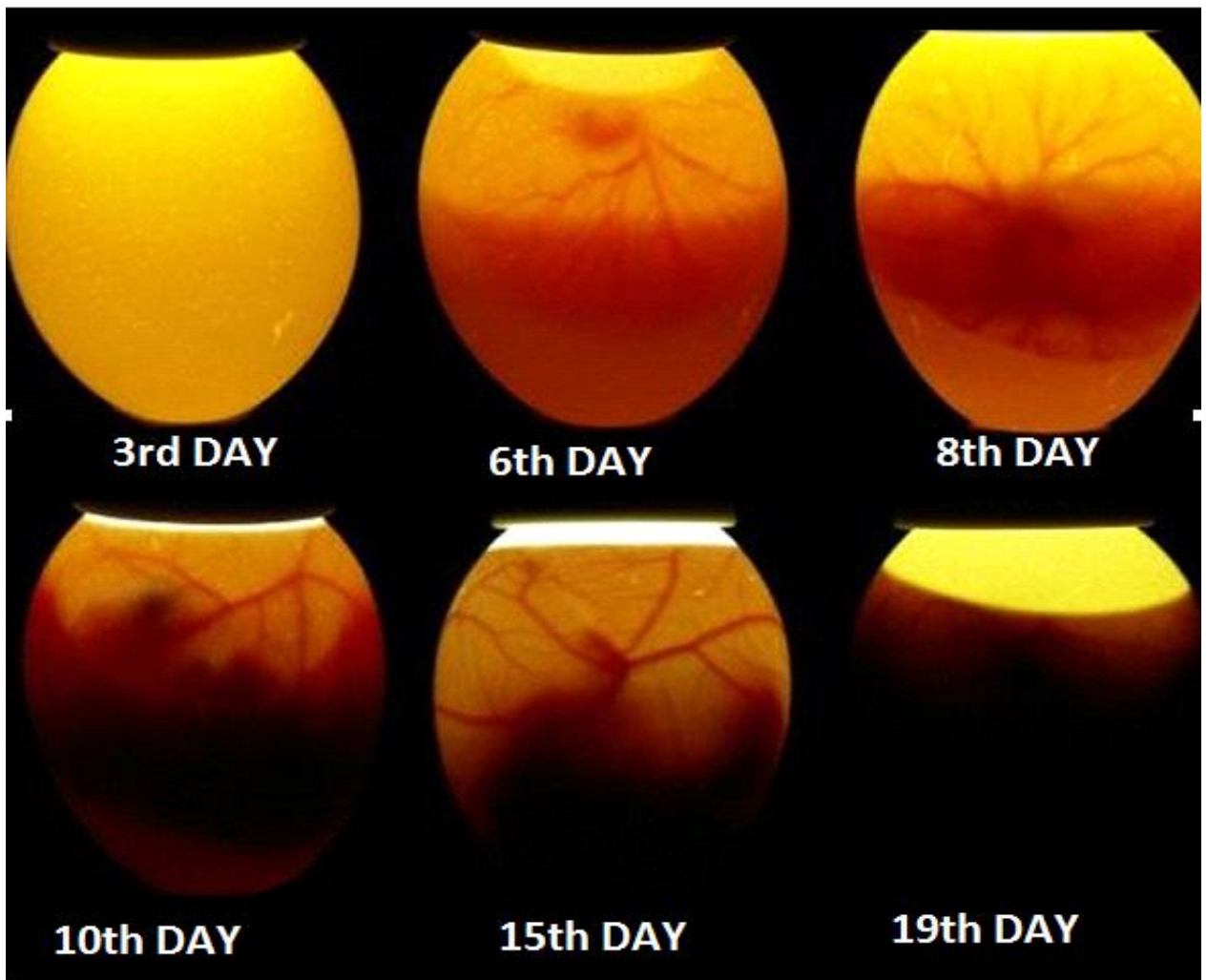


Figure I.22: *Candling of a chicken egg*

9.6 Egg hatching:

After the last light check, if the device is present, the eggs can be transferred to the incubator, otherwise the eggs in the incubator can continue to hatch. In any case, for incubation to proceed normally, the relative humidity (maximum 75% to 60%) must be increased to 75% within the first 18 days. From the 18th day, no other operation was carried out before incubation.

After 20 days of brooding, you can see a small hole appear, the shell will start to crack. The chick begins to break the shell with its beak in order to get out. At the 21st day the hole in the shell is more important, we hear the chick communicate more and we see it breathing. After a while, the chick manages to come out of its shell [9].



Figure I.23: *A hatching egg*

10. Conclusion :

In this chapter, we have explained the operation of egg incubators as well as the steps to follow from incubation to hatching.

Natural incubation remains the most active but it gives too low a production. Indeed artificial incubation is recommended to satisfy and serve the needs of the population. The proper functioning of its incubators is based on the proper regulation of temperature and humidity.

To produce a competent brooder and be able to give an appropriate performance, it is necessary to choose the electronic elements such as the Arduino, sensors, controller.... etc. In Chapter II we will present the Arduino and its environment.

Chapter II

Arduino environment

1. General presentation:

Arduino is a range of open source electronic circuits based mostly on a microcontroller from the manufacturer Atmel. These circuits integrate the necessary components to allow quick and easy use of the microcontroller. This simplification aims to make the creation and programming of interactive objects or devices accessible to everyone. These objects can contain all sorts of sensors, light indicators or switches that one wishes to bring into play.

Among other things, Arduino boards are equipped with standardized connectors for connecting compatible modules called shields.

The latter are circuits of a size more or less similar to that of the Arduino and which are stacked on these connectors. They offer hardware extensions that allow you to add original features to your project. In addition to these connectors, the boards all have USB connectors allowing easy programming of the microcontroller they embed.

Arduino is used in many applications such as industrial and embedded electrical engineering ,model making, home automation but also in different fields such as contemporary art and the piloting of a robot, motor control and lighting effects, communicating with the computer, controlling mobile devices (model making).

2. The ranges of the Arduino board :

As stated previously, there are many different Arduino boards, but they all have elements in common, Currently, there are more than 20 versions of Arduino modules, in order we quote some of the popular ones to clarify the assessment action of this scientific and academic product [10].

exemples :

- **The Arduino Nano**, a small program cardUSB port aid this version using an ATmega168 microcontroller (ATmega328 for a newer version).



Figure II.1: *Arduino Nano*

- the **Arduino uno** , based on the ATmega328 microcontroller.



Figure II.2: *Arduino Uno*

- **The Arduino Mega**, using an ATmega2560 microcontroller , and has all the memory at 256 KBS. It also incorporates the new ATmega8U2 (ATmega16U2 in USB revision 3 chipset).

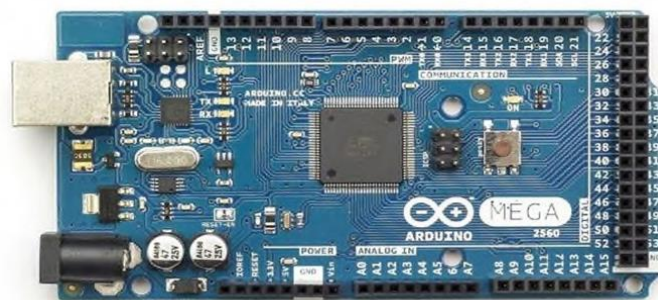


Figure II.3: *Arduino Mega*

- **The Arduino Leonardo**, used an ATmega3U4 chip that eliminates the need for a USB connection and can be used as a keyboard.

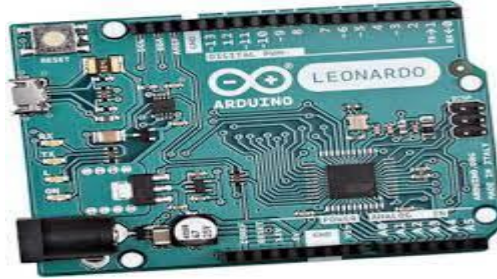


Figure II.4: *Arduino Leonardo*

- **The Arduino LilyPad**, a minimalist design for wearable application using an ATmega168 microcontroller.

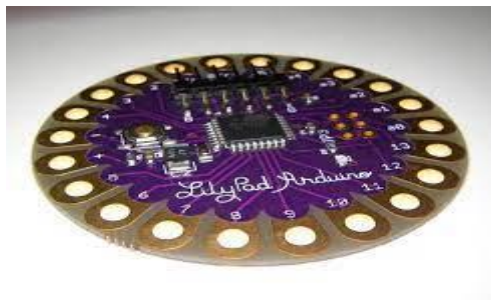


Figure II.5: *Arduino LilyPad*

- **The Arduino micro**, based on aTmega32U4 microcontroller.



Figure II.6: *Arduino micro*

- **The Arduino NG plus**, with a USB interface for programming and using an ATmega168.



Figure II.7: *Arduino NG plus*

- **The Arduino Esplora**, looks like a visual game controller, with a stick and built-in sensors for noise, light, temperature, and acceleration.



Figure II.8 : *Arduino Esplora*

Among these types, we have chosen an Arduino UNO board (Basic board). The main interest of this card is to facilitate the implementation of such a command which will be detailed later.

3. Why Arduino Uno :

Actually, Arduino comes with a big community that is developing and sharing knowledge with a wide range of audiences. Quick support is available pertaining to the technical aspects of any electronic project. You don't need to arrange extra peripherals and devices as most of the functions are readily available on the board that makes your project economical in nature and free from a lot of technical expertise.

In the same way, the Arduino system simplifies the way of working with microcontrollers while offering interested parties several advantages cited as follows:

- **The price (discounted):** Arduino boards are relatively inexpensive compared to other platforms. The cheapest version of the Arduino module can be assembled by hand, (pre-assembled Arduino boards cost less than 2500 Dinars)
- **Multi-platform:** the Arduino software, written in JAVA, runs on Windows, Macintosh and Linux operating systems. Most microcontroller systems are limited to Windows.
- **A clear and simple programming environment:** The Arduino programming environment (the Arduino IDE software) is easy to use for beginners, yet flexible enough for advanced users to take advantage of as well.
- **open Source :** Arduino software and the Arduino language are released under an open source license, available to be completed by experienced programmers. The programming software for Arduino modules is a multi-platform JAVA application, serving as a code editor and compiler, and which can transfer the program through the serial link (Bluetooth or USB depending on the module).
- **Open source and extensible hardware:** Arduino boards are based on Atmel ATMEGA8, ATMEGA168, and ATMEGA328 microcontrollers, and module schematics are released under a Creative Commons License, and experienced circuit designers can make their own version of Arduino boards, complementing and improving them. Even relatively inexperienced users can make the breadboard version of the Arduino board, the goal of which is to understand how it works to save the cost.

4.Arduino Board :

It contains everything necessary for the operation of the microcontroller, to be able to use it and get started, you just have to connect to a computer using a USB cable or power it with a mains adapter or a battery, but this is not essential, the power supply being supplied by the USB port.

The ATmega328 is the brain of our project. He will receive the program that we will create and will store it in its memory before executing it. Thanks to this program, he will be able to do the necessary tasks to manage the incubator.

4.1 Arduino board architecture :

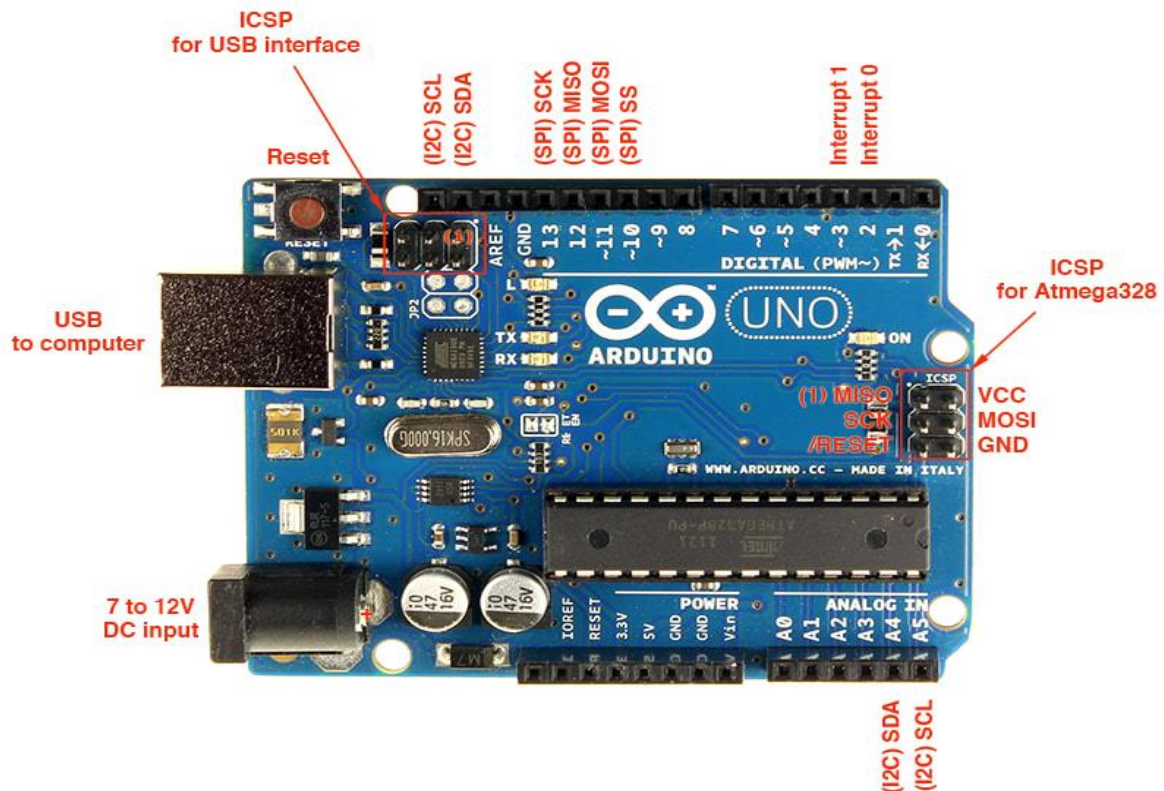


Figure II.9 : Arduino Uno Board

4.2 Arduino Uno definition:

The UNO model from the ARDUINO company is an electronic card whose heart is an ATMEL microcontroller reference ATmega328. The ATmega328 is an 8-bit microcontroller from the AVR family whose programming can be done in C/C++ language.

Arduino Uno Pinout consists of 14 digital pins starting from D0 to D13. It also has 6 analog pins starting from A0 to A5. It also has 1 Reset Pin, which is used to reset the board programmatically. In order to reset the board, we need to make this pin LOW. It also has 6 Power Pins, which provide different voltage levels.

Out of 14 digital pins, 6 pins are used for generating PWM pulses of 8-Bit resolution. PWM pins in Arduino UNO are D3, D5, D6, D9, D10, and D11.

A development environment (IDE), based on open-source tools, is provided. In addition, loading the compiled program into the memory of the microcontroller is very simple (via USB port) [11].

4.3 The ATmega328 Microcontroller :

It is an ATMEL microcontroller from the 8-bit AVR family. It is perhaps most commonly implemented on the popular Arduino development platform, namely the Arduino Uno, Arduino Pro mini, and Arduino Nano models.

Atmega328 microcontroller is placed on the board that comes with a number of features like timers, counters, interrupts, PWM, CPU, and I/O pins and is based on a 16MHz clock that helps in producing more frequency and number of instructions per cycle.

This microcontroller is made up of a set of elements that have a specific function. It is in fact made up of the same elements as on the computer motherboard. Globally.

- The architect internal structure of this programmable circuit is essentially composed of 3 types of memories :

Flash Memory:(32KB) This is the one that will contain the program to run. This memory is erasable and rewritable program memory of **32 Kb**.

SRAM: This is the so-called "live" memory, it will contain the program variables. It is said to be "volatile" because it is erased if the power supply to the microcontroller is cut. Its capacity is **2 KB**.

EEPROM: (**1kb**) This is the microcontroller's hard disk. It records information that needs to survive over time, even if the card has to be stopped. This memory is not erased when the microcontroller is turned off or when it is reprogrammed.

4.4 Features of the Arduino Uno :

Parameter Name	Parameter Value
Microcontroller	Atmega328
Crystal Oscillator	16MHz
Operating Voltage	5V
Input Voltage	7-12V
Input voltage (limits)	6-20 V
Digital I/O Pins	14 (D0 to D13)
Analog I/O Pins	6 (A0 to A5)
Flash Memory	32 KB (0.5KB is used by the bootloader)
SRAM	2 KB
EEPROM	1 KB
ICSP Header	Yes
Power sources	DC Power Jack & USB Port
Length	68,6 mm
Weight	25 g

Table II.1: *Features of the Arduino Uno*

4.5. Simplified diagram of the Arduino UNO board :

The pins of the microcontroller are connected to connectors according to the diagram below [12].

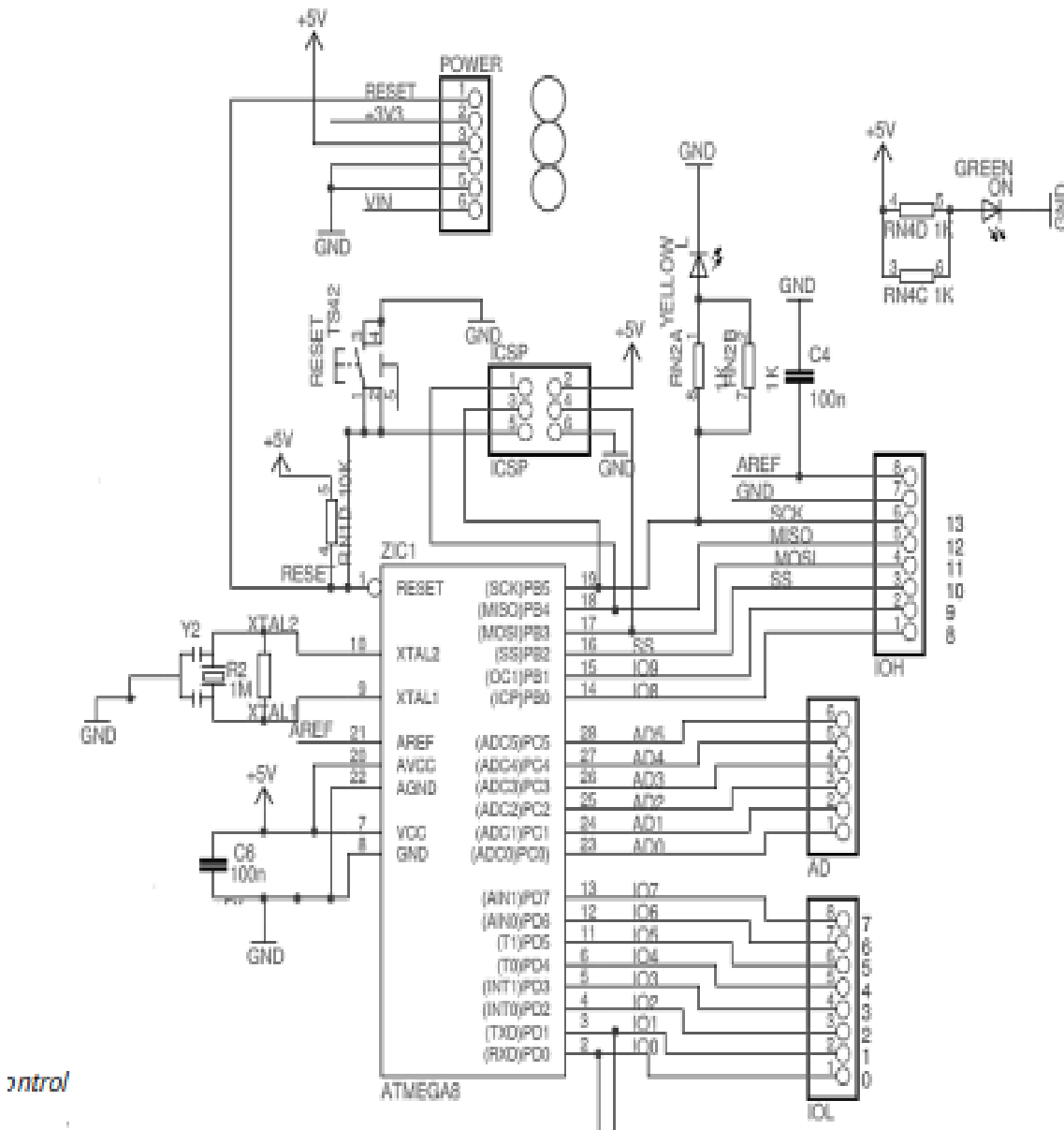


Figure II.10 : Structure of the ARDUINO-UNO board

4.6. the Components :

4.6.1. Quartz oscillator :

A quartz oscillator is an electronic element that has the particularity of having a quartz inside which vibrates under the piezoelectric effect. The electromechanical properties of quartz are such that it is possible to vibrate quartz at a very precise frequency. This is the Arduino clock, it clocks its operation. On the top of the component, we can read 16.000H9H. This means the frequency is 16 MHz.

4.6.2. Power supply :

The microcontroller generally present on Arduino boards is powered by a voltage of 5V. Depending on the card model, the input voltage may vary from 7V to 12V.

Arduino Uno has a maximum current rating of 40mA, so the load shouldn't exceed this current rating or you may harm the board.

Only 5 V is required to turn the board on, which can be achieved directly using a USB port or external adopter, however, it can support an external power source up to 12 V which can be regulated and limited to 5 V or 3.3 V based on the requirement of the project.

USB support has a voltage around 5V while Vin and Power Jack support a voltage ranges between 7V to 20V. It is recommended to operate the board on 5V. It is important to note that, if a voltage is supplied through 5V or 3.3V pins, they result in bypassing the voltage regulator which can damage the board if the voltage surpasses its limit [11].

4.6.3. The USB port:

It has two actions

- Power the board with electrical energy (5V).
- Load the program on the board.

4.6.4.Reset :

The reset is a physical function allowing the microcontroller, as its name suggests, to reset its state.

A reset pin is present in the board that resets the whole board and takes the running program in the initial stage. This pin is useful when the board hangs up in the middle of the running program; pushing this pin will clear everything up in the program and starts the program right from the beginning [11].

4.6.5. Visualization :

- 'ON' LED: indicates that the board is powered.
- 'Tx' and 'Rx' LEDs: used to visualize the activity on the serial channel (while transmitting and receiving data or charging the program in the microcontroller through the USB port).
- 'L' LED: it is connected to pin 26 of the microcontroller (port 13 from Arduino) and is used to test the hardware. This LED flashes a few seconds after initializing the card (and after connecting the card to the PC).

4.6.6. Arduino Uno board input/output:

The Arduino Uno development board is equipped with 6 analog inputs, and 14 digital inputs/outputs, 6 of which can provide PWM output, and each input/output of the development board cannot provide more than 20mA current in outputs.

❖ Analog inputs:

The analog inputs are used to measure a variable voltage (between 0 and 5 V) which can come from various sensors or interfaces (potentiometers, etc.).

❖ Digital inputs/outputs:

Receive or send the "0" or "1" signal converted to 0 or 5 V. The behavior of these connectors (input or output) is usually determined when the program is initialized, but it can also be changed in the main body of the program.

❖ Analog outputs:

AT MEGA chips cannot output variable voltages. Fortunately, 6 of the digital outputs (3, 5, 6, 9, 10, 11) can generate a PWM signal. It is a process for fixing voltage values.

4.7. Advantages :

Arduino Uno comes with a wide range of applications. A larger number of people are using Arduino boards for developing sensors and instruments that are used in scientific research. Thanks to its ease of use, Arduino is used in many applications such as industrial, on-board electronics, model making, and home automation, but also in different fields such as contemporary art or entertainment.

And also some other advantages:

- Clear and simple programming environment.
- Cheap!

- Cross-platform: runs on Windows,....
- Numerous libraries available with various functions implemented.
- Open source and extensible software and hardware.
- Many tips, tutorials, and examples online (forums, personal website, etc...)
- Existence of “shield” (shields in French): these are additional cards that connect to such as large user community, free and broad ranges of libraries of codes.
- It is an open-source platform where anyone can modify and optimize the board based on the number of instructions and tasks they want to achieve.
- The Arduino module to increase the possibilities such as color graphic display, ethernet interface, GPS, etc...

5. Breadboard:

A breadboard is a device that allows us to quickly build our electronic circuits and connect components without the need to solder them. It is composed of holes spaced 2.54mm apart, which allow components to be inserted and connected to each other in order to build the circuit to be tested By convention :

Black = ground

Red = power supply (+5V, +12V, 5V...).

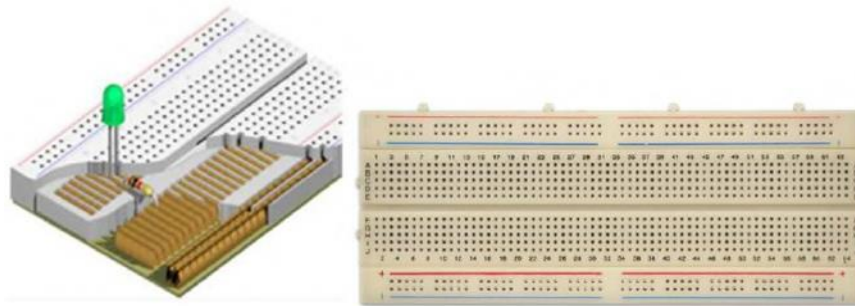


Figure II.11: *A breadboard*

6.The connecting wires:

To make the connection between the electronic components and the breadboard, we will use fairly thin colored wires.



Figure II.12: *The connecting wires*

7. Conclusion:

In this chapter, we have covered the most important part of our incubator, which is the hardware part that includes the physical components. We have provided a detailed explanation of the main part on Arduino. In the next chapter, we will develop different sensors and some essential components in the manufacture of the incubator. We will provide a detailed explanation of the role of each component.

CHAPTER III

Material and method

1. Introduction:

Sensors play an essential role in our modern world. They are present in our daily lives, whether in smartphones, cars, or even in smart homes.

They play a crucial role in egg incubators, helping to create an optimal environment for incubating and hatching eggs. Egg incubators are devices designed to maintain specific conditions of temperature, humidity and sometimes rotation, in order to promote the development of embryos until they hatch.

In this chapter, we will talk about general information about the sensors, study the hardware part of our incubator, and see its main electronic components.

3. Parameters to be set in automatic egg incubator:

2.1 Temperature Control:

In most incubators, temperature control is achieved using two heating resistors, which are:

- A primary resistor: used to regulate the temperature inside the incubator.
- A secondary resistor: used to support the primary resistor in case it becomes insufficient [13].

2.2 Humidity Control:

Humidity is regulated by containers filled with water placed on the bottom of the incubator and heat using a resistor.

Humidity control can also be done automatically carried out by a humidifier that transforms water into tiny droplets, which will then evaporate inside the incubator [13].

2.3 Egg Turning:

Egg turning is manually or automatically performed at least twice a day using a motor, which is an essential component in an electric incubator because it provides the power needed to move the supports [13].

2.4 Ventilation:

When the temperature inside the incubator increases, we need to turn off both the primary and secondary resistors. If the temperature remains high, we need to activate the fan to lower the temperature.

It is also necessary to start the fan from time to time to change and refresh the air inside the incubator to reduce the CO₂ level [13].

3. Definition of sensor:

A sensor is a device that detects and responds to some type of input from the physical environment. The input can be light, heat, motion, moisture, pressure or any number of other environmental phenomena. The output is generally a signal that is converted to a human-readable display at the sensor location or transmitted electronically over a network for reading or further processing.

Sensors can be used in a variety of applications, ranging from consumer devices such as mobile phones and cars, to industrial and medical equipment such as automated machines and health monitoring devices. Sensors are essential for real-time data collection, detection of environmental changes, and monitoring the performance of different systems [14].

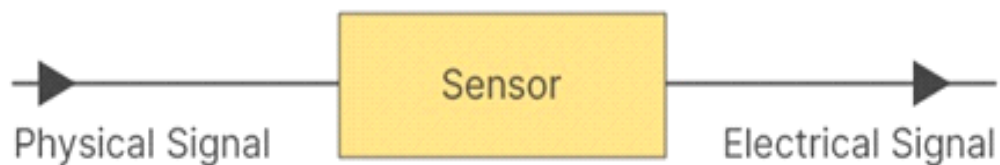


Figure III.1: *How does the sensor work*

4. The main components of a sensor:

4.1 Sensing element:

This is part of the sensor that directly interacts with the physical phenomenon or parameters being measured.

4.2 Transducer:

This component converts the physical parameters into an electrical signal that can be processed and measured.

4.3 Signal conditioning circuit:

This circuit processes and filters the electrical signal from the transducer to improve its accuracy and stability.

4.4 Output:

This is the final components that provides the signal in a format that can be easily interpreted by a user or a control system. It may be an analog voltage or current, or a digital signal [16].

5. Classification of sensors:

Sensors can be classified in different ways based on their operating principles, physical properties, and applications. These can be classified into two categories:

5.1 Active sensors:

Active sensors are sensors that require an external energy source to operate. This energy source can be provided by a battery or an electrical power supply.

Active sensors can measure a variety of physical quantities such as temperature, pressure, humidity, and light. They are often used in industrial and medical applications where precise measurements are required [15].

5.2 Passive sensors:

Passive sensors are sensors that do not require external energy to operate. Instead, they use the energy of the measured signal to operate.

Passive sensors can measure a variety of physical quantities such as motion, sound, and heat. They are often used in security applications such as motion detectors [15].

6. Types of sensors:

There are 3 types of sensors:

6.1 Logic sensor TOR (tout ou rien) :

Also called TOR (tout ou rien) sensor, is a type of sensor that detects the presence or absence of a signal. This signal corresponds to binary information, which has only two logic levels: 0 or 1.

6.2 Analog sensors:

An analog sensor produces an output as a continuous signal, usually voltage or current. The analog output can take an infinite number of values in a continuous range.

6.3 Digital sensors:

Digital sensor produces an output in the form of discrete digital values that represent the measured quantity.

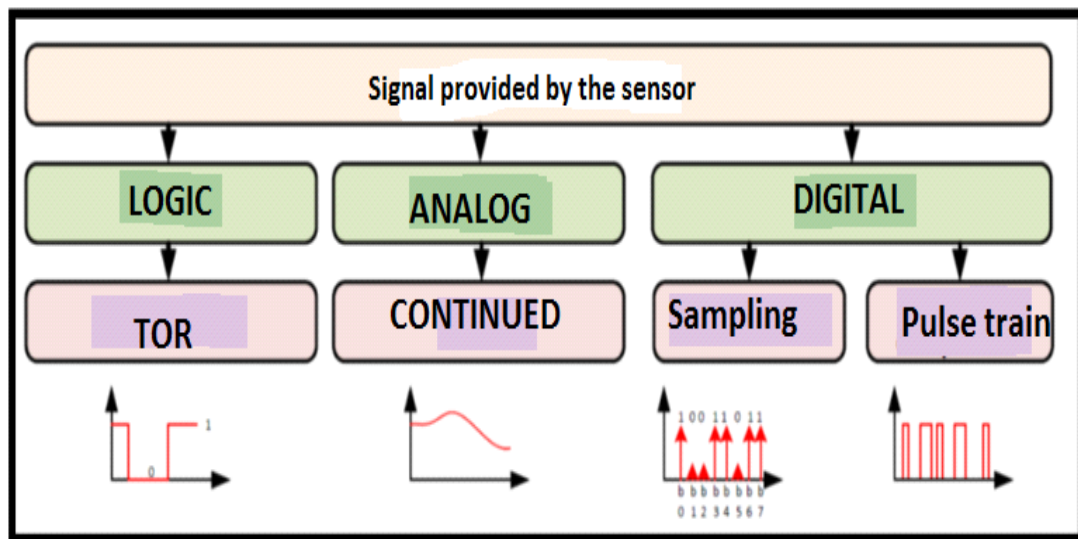


Figure III.2: Signal provided by the sensor

7. Type of detection:

- Detection with contact (the sensor must come into physical contact with a phenomenon to detect it).
- Detection without contact (the sensor detects the phenomenon in the vicinity of it).

8. The main sensors used for the achievements in our project:

8.1 DHT11 sensors:

The DHT11 sensor is a humidity and temperature sensor used to measure the amount of relative humidity in the air and the ambient temperature. It is commonly used in electronic projects and environmental monitoring systems.

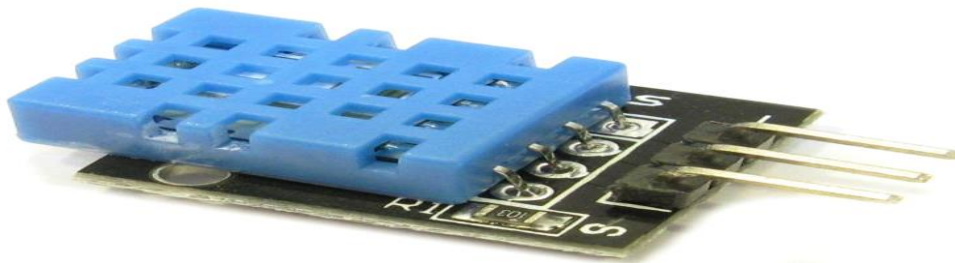


Figure III.3: DHT11 Sensor

8.1.1 Features of DHT11:

- Operating voltage: 3 to 5.5 volts.
- Operating current: less than 2.5 mA.

- Data output frequency: 1 time every 2 seconds.
- Temperature measurement range: 0°C to 50°C \pm 2°C.
- Humidity measurement range: 20-90%RH.

8.2 BH1750 sensor:

The BH1750 sensor is a digital light sensor used to measure the intensity of ambient light. It is also known as a brightness sensor or illuminance sensor. It works by measuring the light that enters a photoelectric cell integrated into the sensor. The photoelectric cell converts the light into an electrical signal, which is then amplified and converted into a digital output. The digital output is typically transmitted to a microcontroller or computer to be processed and analyzed [17].



Figure III.4: *Light sensor BH1750*

8.2.1 Features of BH1750:

- Operating voltage: 3 to 5.5 volts.
- Measurement range: 0 to 65,000 lux.
- Low current consumption.

9. The components used for the achievements in our incubator:

9.1 LCD Display 20X4 :

This is an LCD(Liquid Crystal Display) screen with four lines of 20 characters each, which means it can display up to 80 characters at once. The display is used to show the time, temperature, and humidity.



Figure III.5: LCD 20x4

9.1.1 Features of LCD 20X4:

- White characters on a blue background.
- Operating voltage 5V.
- Type: 4-lignes X 20-characters.

9.2 Relay :

A relay is an electromechanical device used to control the opening or closing of an electrical circuit. It acts as an electrical switch that is controlled by an electrical signal from another source, typically a microcontroller or sensor.

They are used in many applications, including:

- Control of electrical loads: Relays are used to control high-power loads such as motors, appliances, lighting, etc.
- Circuit protection: Some relays are designed to detect abnormal conditions such as overloads, short circuits, or voltage variations, and protect equipment and circuits from damage.



Figure III.6 : Relay

9.3 Humidifier:

A humidifier is a device that sprays water or liquid in the form of fine droplets into the air. It is often used in spaces to increase air humidity.



figure III.9: Humidifier

9.4 Ventilator:

The purpose of the incubator Ventilator is to ensure proper air circulation inside the incubator, eliminating excess moisture and heat. It is specifically designed to maintain optimal temperature and humidity conditions, promoting the hatching of eggs.



Figure III.10: Ventilator

9.5 Stepper motor:

A stepper motor is an electric motor that converts electrical signals into discrete mechanical movement; it is designed to rotate in incremental steps rather than continuously.

Stepper motors are commonly used in applications that require precise positioning, such as egg incubators, 3D printers, robots, etc. They provide precise control of movement, fast response to input signals, and the ability to maintain a position without electrical power.

9.6.1 Features of Stepper motor:

- Rated voltage: 110 / 220 / 230 V AC.
- Input power: 4W.
- Input current: 0.06A.
- Rotation speed: 2 / 20 rpm.

9.7 Lamp:

The role of the lamp in an egg incubator is to provide the necessary heat source to maintain a constant and appropriate temperature for egg incubation. Temperature is a crucial factor for the development and hatching of eggs, and the lamp plays an essential role in creating and maintaining the required conditions.



Figure III.11 : *Lamp*

10. Conclusion:

By combining these components appropriately, an egg incubator can create an optimal environment for egg incubation, thereby promoting successful embryonic development and high hatch rates.

Chapter IV

Realization of the incubator and a control system

1.Introduction :

After mentioning the electronic components in the previous chapter, in this chapter, we will develop the necessary steps to achieve our goal and facilitate the realization of our project “automatic egg incubator based on Arduino “.

In this part, we will start with the mechanical part then we will illustrate the IDE environment, a program established in C/C++ language. Used on the Atmega328 microcontroller, and how we make the prototype through the Arduino Uno which is connected to sensors and actuators.

2. Specifications document:

The specifications document is a technical document that provides all the information about the different elements used for a realization of a project.

This realization of an egg incubator with a capacity of 10 chicken eggs, having the following dimensions: Length (L): 50 cm, Width(W): 30 cm and Height (H): 34 cm. Regarding the material, we will use a plastic box .The incubator will be equipped with an automaic system that ensures precise control of temperature and humidity. It will be equipped with a temperature and humidity sensor that allows for temperature adjustment within a range of 37.5°C to 38°C and humidity adjustment between 50% and 60%. To ensure a regular egg rotation, an automatic rotation system will be implemented, performing at least one rotation every 2 hours. The incubator will be equipped with additional features such as integrated ventilation to ensure proper air circulation inside, an automatic humidification system to maintain the desired humidity level, as well as a transparent box that allows observation of the eggs without disrupting the incubation process.

Finally, the maximum budget allocated for this project is 20 000 DA.

3. System architecture :

Our system is composed of two main parts.

3.1Hardware part:

This part consists of all the equipment we used and those proposed for the control of our system. Among them, we mention:

DHT11 sensor: For measuring temperature and humidity in our incubator.

BH1750 sensor: Is used to measure the light intensity inside the incubator.

LCD20X4: It displays the current temperature, humidity, and amount of light. This allows users to easily monitor incubation conditions without having to open the incubator.

Relay: Control high-power electrical circuits in the incubator.

Lamp: The lamp is used to provide a heat source in the egg incubator. It emits radiant heat which maintains a constant temperature inside the incubator.

Fan: It provides even air circulation to maintain uniform conditions in the egg incubator.

Humidifier: The humidifier adds moisture to the air when the humidity level is too low, ensuring optimal conditions for incubation.

Stepper motor: Used to automatic egg turning, it receives command signals to perform precise rotations at regular intervals.

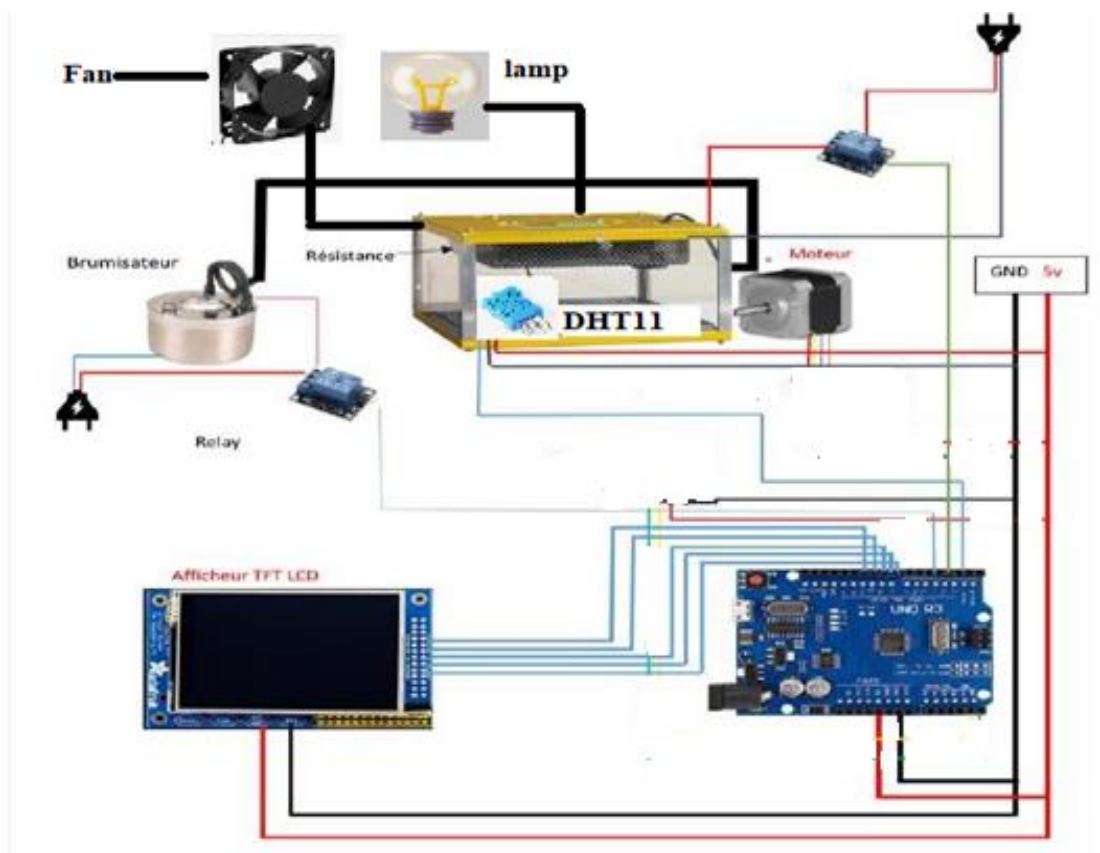


Figure IV.1: Overall diagram of the assembly

3.1.1 Main diagram of the system :

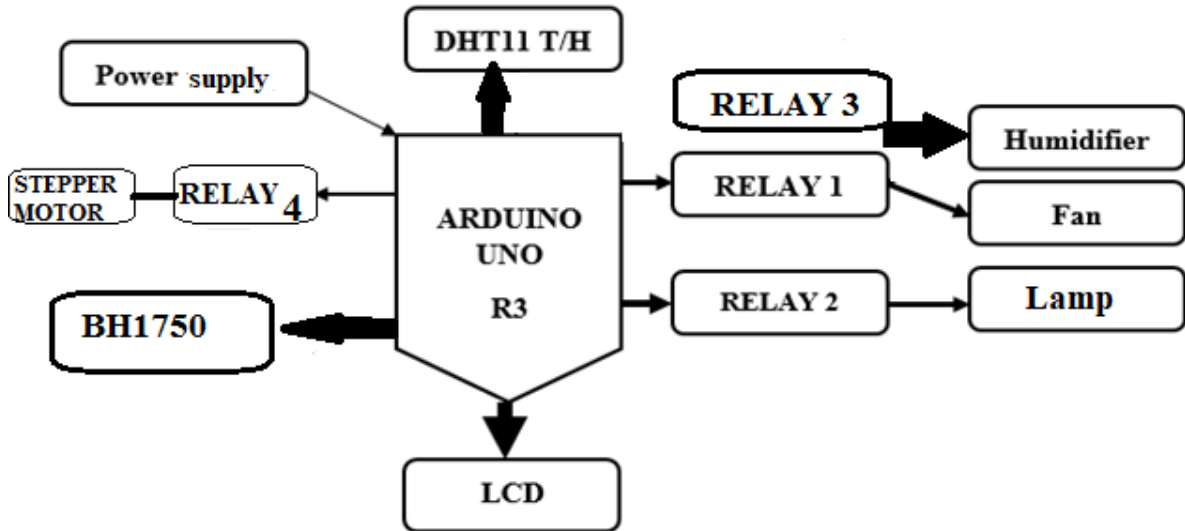


Figure IV. 2: Diagram of the system

3.2 Software part:

Our project's brain is the Arduino, which is the most important part of our prototype. It connects the user to the sensors and transmits orders to the actuators to execute them.

3.2.1 The Environment of Programming:

The Arduino IDE (Integrated Development Environment) is a programming software used to write, edit, and convert programs for Arduino boards. The Arduino IDE is written in Java and provides a user-friendly interface for developing Arduino applications.

With the Arduino IDE, you can write code using the syntax of the Arduino programming language, which is based on the C/C++ programming language. The Arduino IDE includes a pre-built function library called "Wiring" that facilitates the programming of hardware-specific features for the Arduino board.

3.2.2 The Interface:

When opened, the visual interface of the software is shown in the following figure:

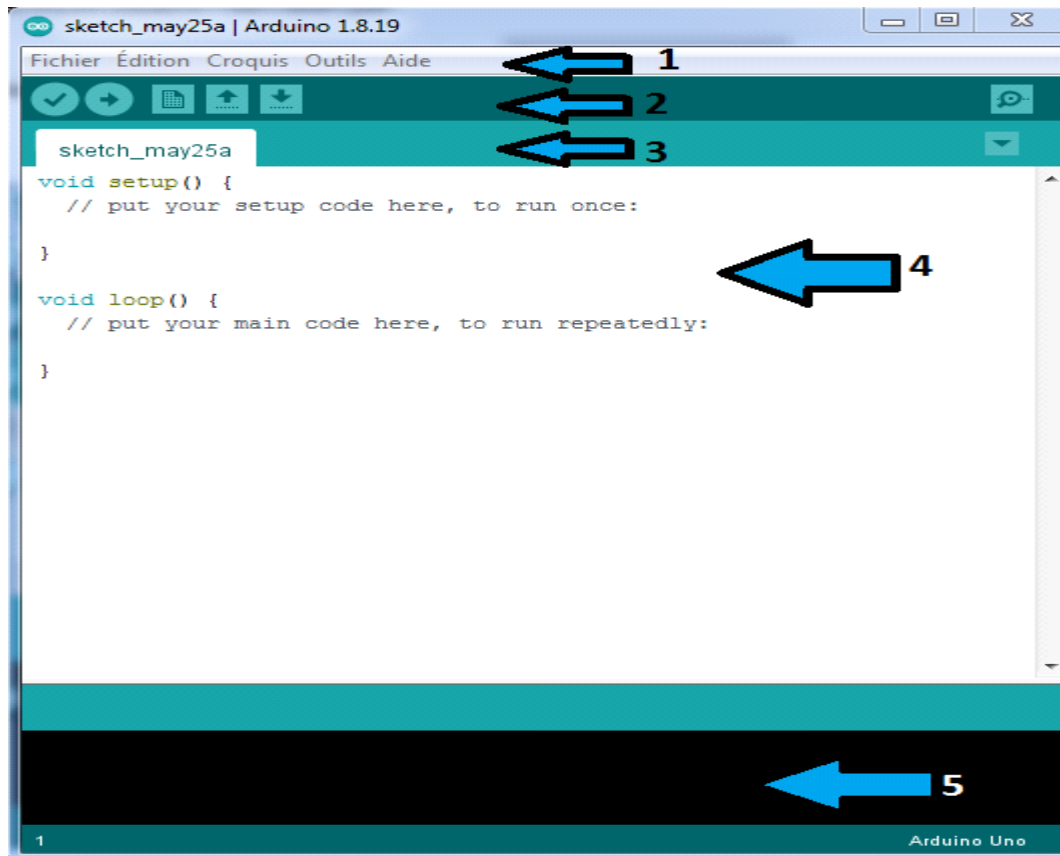


Figure IV.3: *Interface IDE Arduino*

- ✓ The visual interface of the software has the following five elements:

Menu bar: It is a horizontal bar at the top of the software window that contains various menus, such as file, edit, view, tools, and help. Each menu provides a list of options and commands to perform different actions within the software.

Toolbar: The toolbar is a row of icons or buttons below the menu bar that provides quick access to commonly used actions. These actions may include functions like opening and saving files, compiling and uploading code, or other specific tasks related to the software's functionality.

Tabs for sketches: The software allows you to work with multiple sketches or code files simultaneously. Each sketch is represented by a tab, which you can click on to switch between different code files. This feature helps in organizing and managing multiple projects within the software.

Code Area: This is the central area of the interface where you can write and edit your Arduino code. Syntax highlighting is used to highlight keywords, comments, and functions, making it easier to read and understand the code.

Error and output messages: At the bottom of the interface, there is an area where error messages, output messages, and correction information are displayed. This allows you to diagnose any problem in your code and get information about program execution.

The File menu has a number of things that will be very useful:

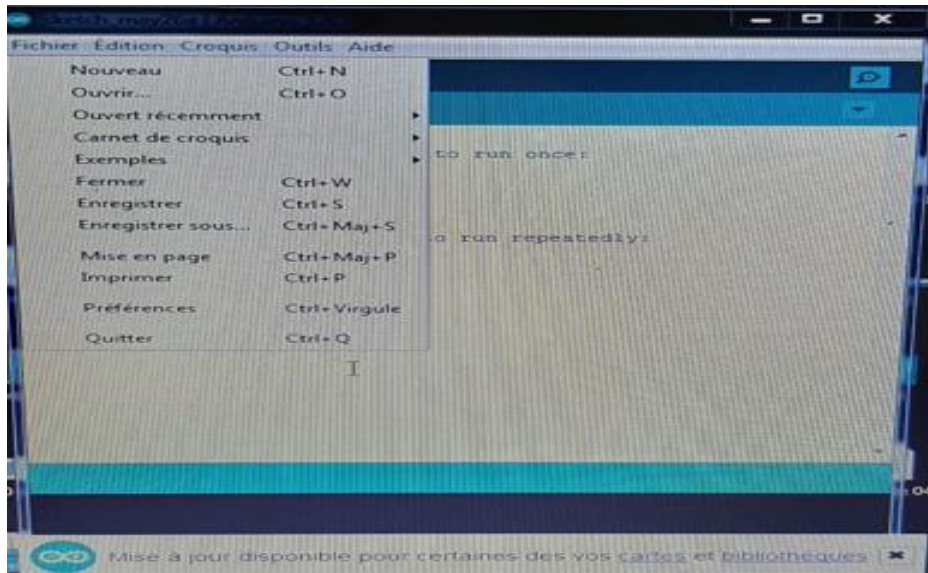


Figure IV.4: *The File menu of the Arduino software*

- **New:** Will create a new program. When you press this button, a new window, identical to this one, is displayed on the screen.
- **Open:** With this command, an existing program can be opened.
- **Save / Save as :** Saves the current document/request or save the current document.
- **Examples (examples):** This is important, a whole list scrolls down to display the names and examples of existing programs.

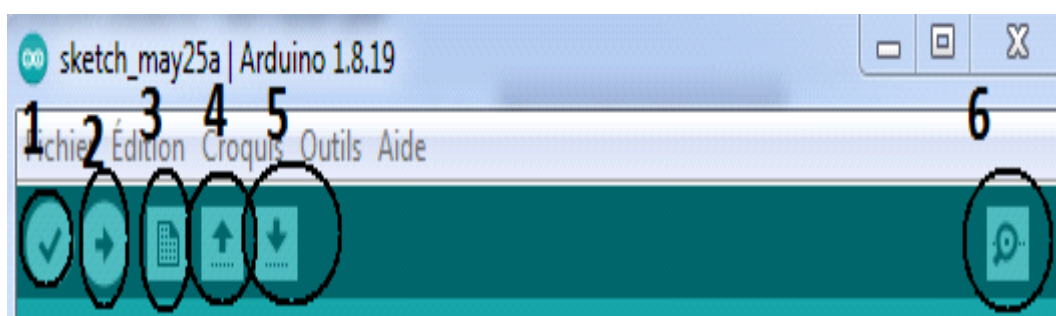


Figure IV .5 : *scrolls list.*



VERIFY: This button allows you to check the program, it activates a module that looks for errors in your program.



UPLOAD: Upload the program into the Arduino board.



NEW: To create a new program (sketch).



OPEN: To open the existing program.



SAVE: To save the program.



VERIFY: To view the data transmitted by the serial port.

3.2.3 The project structure:

An Arduino program has three main parts:

1. Declaration variables parts, constants, words, etc...
2. Initialization and input/output configuration part: the setup() function.
3. Main part that runs in a loop: the loop() function.

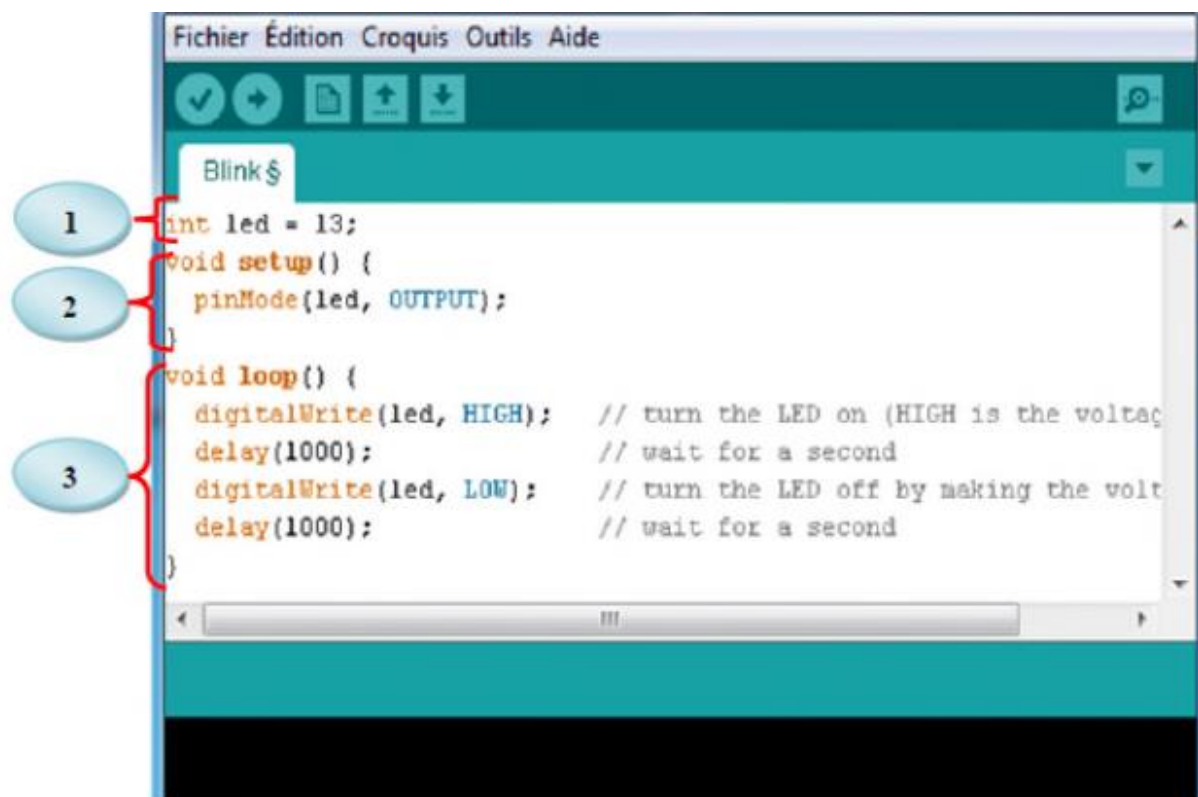


Figure IV .6: Structure of an Arduino C project

4. Practical realization :

The practical realization of the incubator necessitates meticulous attention to detail and precision to guarantee the accurate installation and connection of all its components. This meticulousness is vital to ensure the smooth and efficient functioning of the incubator.

4.1 Components pins out :

LCD 20*04	
VCC	→ 5V
GND	→ GND
SDA	→ A4
SCL	→ A5
DHT11	
VCC	→ 5V
GND	→ GND
DATA	→ PIN 2
BH1750	
VCC	→ 5V
DAT	→ A4
SCL	→ A5
GND	→ GND
ADDR	→ A0
Relay	
Vcc	→ 5v
GND	→ GND
Int1	→ pin7
Int2	→ pin8
Int3	→ pin 10
Int4	→ pin11

TableIV.1:Components pins out

4.2 An LCD try :

First, we proceeded to use it by writing a sentence (Our incubator) and displaying it on the screen. This allowed us to familiarize ourselves with the practical usage of the LCD and gain a better understanding of how we could incorporate it into our project.



Figure IV.7: Connecting LCD to Arduino

```

sketch_may22a
// Adresse I2C de l'écran LCD 2004
#define LCD_ADDR 0x27

// Dimensions de l'écran LCD 2004
#define LCD_COLS 20
#define LCD_ROWS 4

// Création de l'objet LiquidCrystal_I2C
LiquidCrystal_I2C lcd(LCD_ADDR, LCD_COLS, LCD_ROWS);

void setup() {
  // Initialisation de l'écran LCD
  lcd.begin(LCD_COLS, LCD_ROWS);

  // Allumer la rétroéclairage de l'écran
  lcd.backlight();

  // Afficher un message de bienvenue
  lcd.setCursor(0,1);
  lcd.print(" OUR INCUBATOR");
}

void loop() {
  // Exemple de mise à jour de l'affichage
  lcd.setCursor(0, 1);
  lcd.print(" ");

  delay(1000); // Attendre 1 seconde
}
Téléversement terminé

```

Figure IV.8: Lcd program on IDE

4.3 A test on LCD with DHT11 :

Then, we performed the necessary programming to display the measured values of temperature and humidity by the DHT11 sensor on the LCD screen.

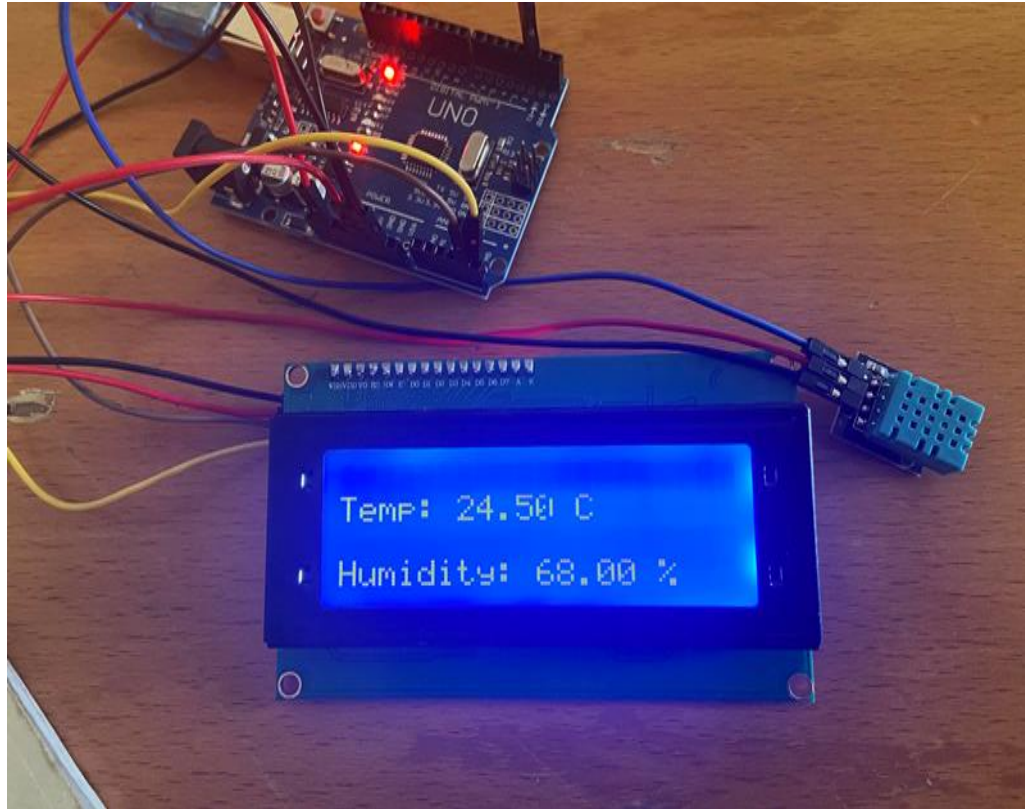


Figure IV.9: Connecting DHT11 to Arduino and LCD

```
void setup() {  
  lcd.begin(20, 4); // Initialisation de l'écran LCD  
  rtc.halt(false); // Démarrage du module RTC  
  
  // Configuration de l'heure et de la date si nécessaire  
  /*  
  rtc.setDOW(WEDNESDAY); // Définition du jour de la semaine  
  rtc.setTime(12, 0, 0); // Définition de l'heure (HH, MM, SS  
  rtc.setDate(31, 12, 2023); // Définition de la date (DD, MM,  
  */  
}  
  
void loop() {  
  // Lecture de l'heure et de la date depuis le module RTC  
  int second, minute, hour, day, month, year;  
  rtc.getTime(hour, minute, second);  
  rtc.getDate(day, month, year);  
  
  // Affichage de l'heure et de la date sur l'écran LCD  
  lcd.setCursor(0, 0);  
  lcd.print("Date: ");  
  lcd.print(day);
```

Figure IV.10 : DHT11 program on IDE and LCD display

4.4 A test on LCD with BH1750:

Then, we also displayed the values acquired from the BH1750 sensor on the LCD screen.

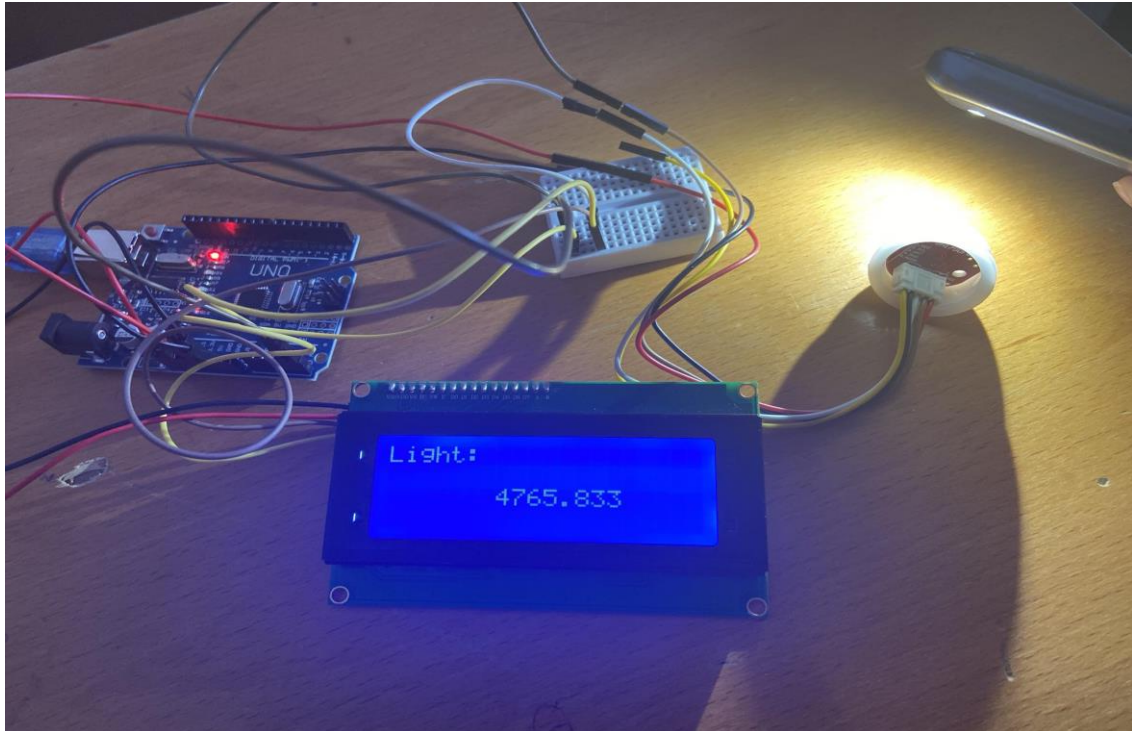


Figure IV.11: Connecting BH1750 to Arduino and LCD display

```
Fichier Edition Croquis Outils Aide
DHT_Unified_Sensor$
const int LCD_ADDRESS = 0x27;

// Set the LCD dimensions (change if using a different size)
const int LCD_COLS = 20;
const int LCD_ROWS = 4;

// Create an instance of the LCD object
LiquidCrystal_I2C lcd(LCD_ADDRESS, LCD_COLS, LCD_ROWS);

// Create an instance of the BH1750 object
BH1750 lightSensor;

void setup() {
  lcd.begin(LCD_COLS, LCD_ROWS); // Initialize the LCD
  lcd.backlight(); // Turn on the backlight

  lightSensor.begin(); // Initialize the light sensor

  lcd.print("Light: "); // Display initial text on LCD
}

void loop() {
  float lux = lightSensor.readLightLevel(); // Read the light level in lux

  lcd.setCursor(7, 2); // Set cursor position for light value
  lcd.print(lux, 3); // Display the light level on LCD

  delay(1000); // Delay for 1 second (adjust as needed)
}
Téléversement terminé
```

Figure IV.12: Program on IDE and LCD display

- Next, we used an electrical relay, one for the fan and another one for the misting system.
- We used an additional electrical relay for the lamp.

4.5 Turning mechanisms:

Egg turning is programmed to occur multiple times a day, usually every two hours. This ensures that all sides of the egg are evenly exposed to heat and humidity, promoting uniform embryo development. A good turning mechanism should be gentle and gradual to avoid damaging the delicate embryos inside the shell.

4.6 Stepper motor :

The turning is provided by a rotisserie motor, which has the advantage of being able to rotate for a long time, meaning it turns in small steps with a uniform motion, and converts electrical signals into mechanical motion in successive steps.

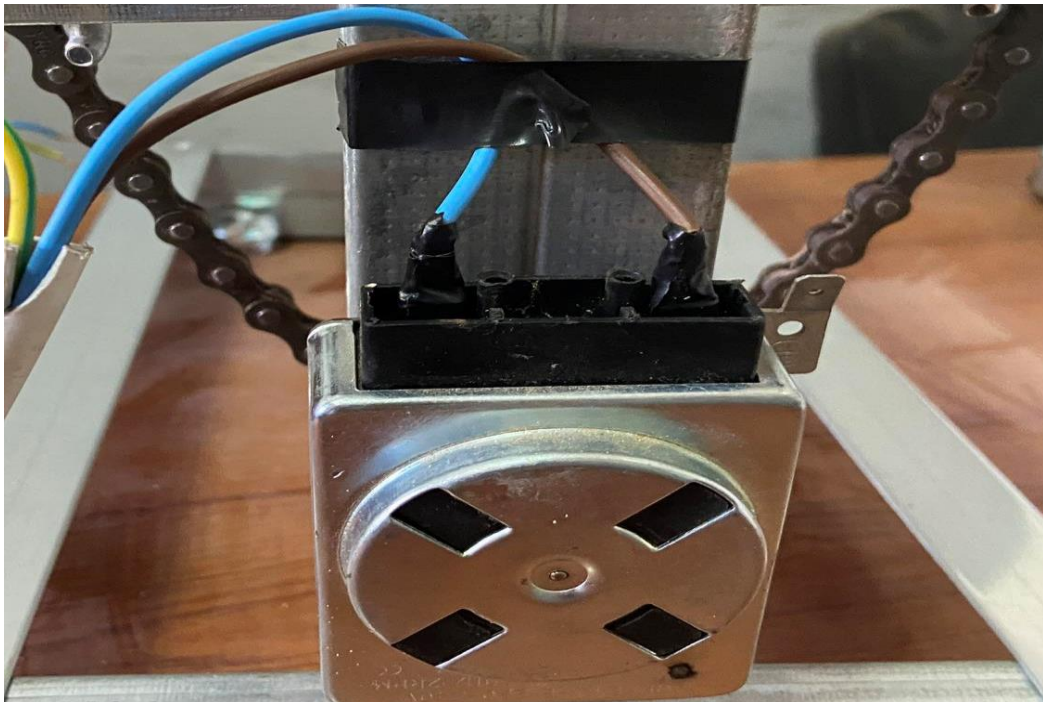


Figure IV.13 : Stepper motor



Figure IV .14: *Turning trolley*

4.7 Egg holder :

The incubator is equipped with a specially designed tray or grid to hold the eggs in place during the turning process. The eggs are usually placed on their pointed side, as this promotes optimal embryonic development.

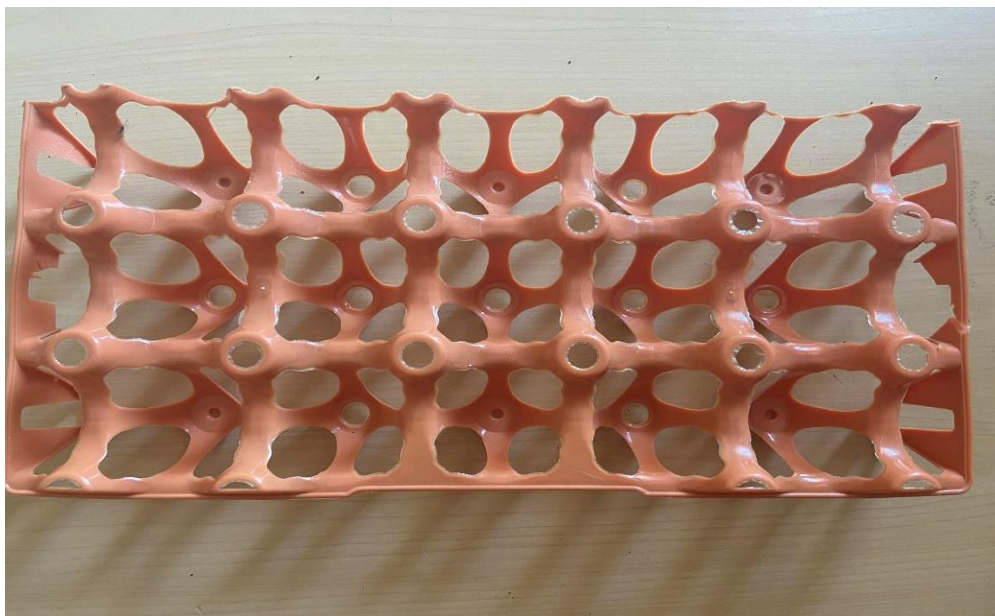


Figure IV.15: *Egg holder (tray)*

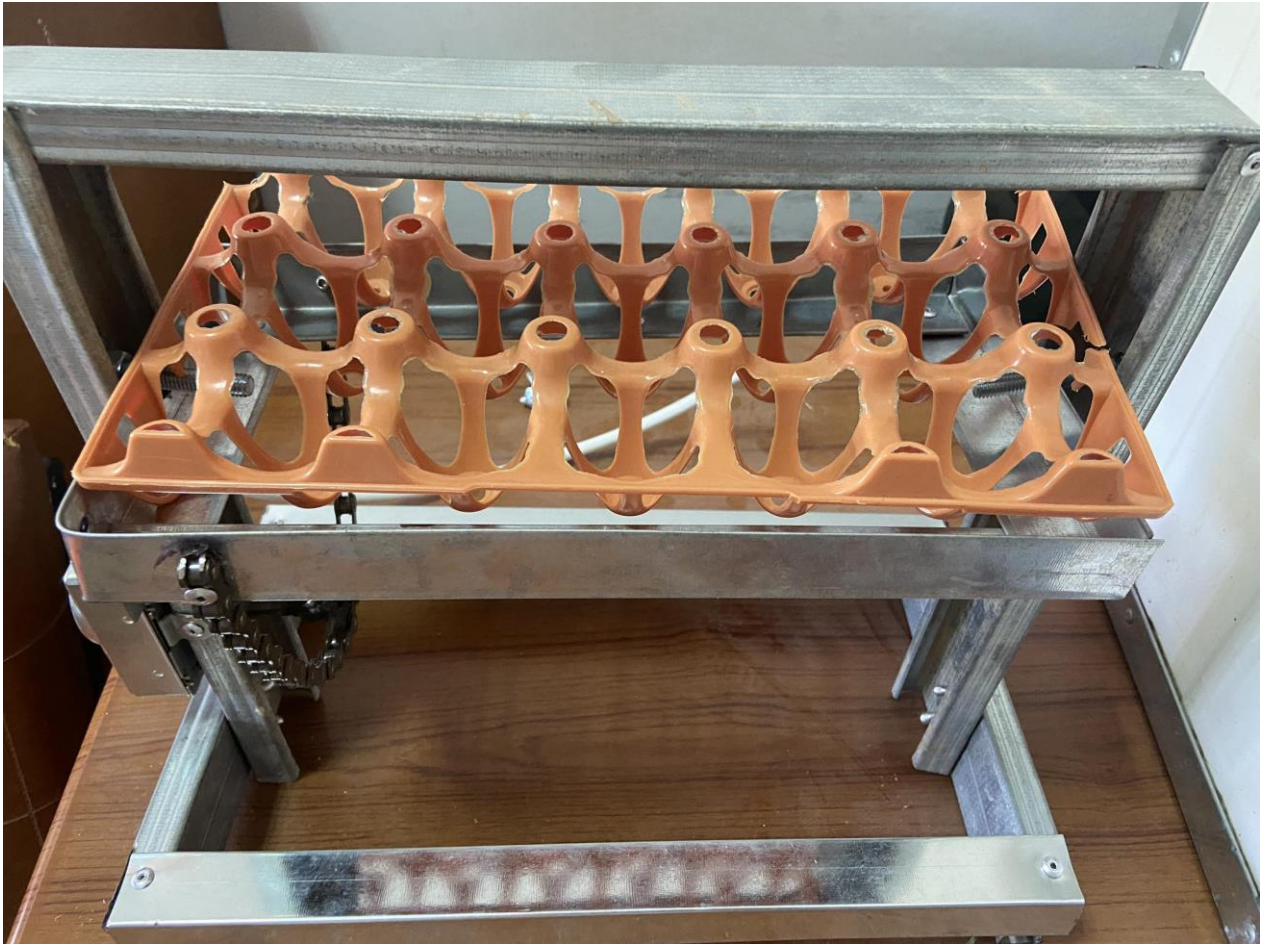


Figure IV.16: *Automatic egg turner*

4.8 The different steps:

The following steps will outline the parts we have gone through.

Step 1: Preparing the box:

- We bought a plastic box to use as a contain
- We have ensured that the container has sufficient capacity to accommodate the components
- We have checked if that the box is sealed tightly, guaranteeing a stable temperature inside.

Step 2: Installation of the LCD screen in the incubator

- We Choose a suitable location inside the incubator to install the LCD display.
- We have ensured that it is clearly visible and easily accessible for convenient reading.

Step 2: Placement of sensors

- The temperature and humidity sensors were placed next to the eggs turner, where they can measure humidity and temperature accurately.
- We have ensured to securely attach the sensors inside the brooder using heat-resistant tape and cannot move while the incubator is in operation.

Step 3: Connecting the sensors to the Arduino

- We connect the sensor's pins to the appropriate pins of the Arduino with a wires
- We have checked the specific connections for each sensor, to follow the directions provided.

Step 4: Installation of the sensor's pins

- We Choose an appropriate heating element, such as a heat bulb.
- We have positioned the bulb inside the box and made sure that it does not come into contact with the eggs and making risk.
- We Connected the bulb to a power source.
- We have ensured that the temperature sensor is properly calibrated and can be adjusted as needed for egg incubation.

Step 5: Setting up the ventilation system

- We installed the fan inside the brooder to ensure adequate air circulation.
- We have positioned the fan to promote even heat distribution throughout the brooder.
- We confirmed that the fan isn't too close to the eggs to avoid drying them out.
- We connected the fan to a power source.

Step 6: Installation of the humidification system

- We added a humidifier to the water container to maintain an appropriate level of humidity for egg incubation.

Step 7: Installation of the egg holder and the turning system:

- We Used a suitable tray to support the eggs inside the incubator.
- We Made sure that the rack is stable and secure to prevent the eggs from falling or breaking.

Step 8: Tests and adjustments

- Before using the incubator, we conducted tests to verify the proper functionality of all components.
- We Checked the temperature, humidity and air circulation inside the incubator.
- We made necessary adjustments to achieve and maintain optimal incubation conditions.

4.9 The final outcome of an incubator:

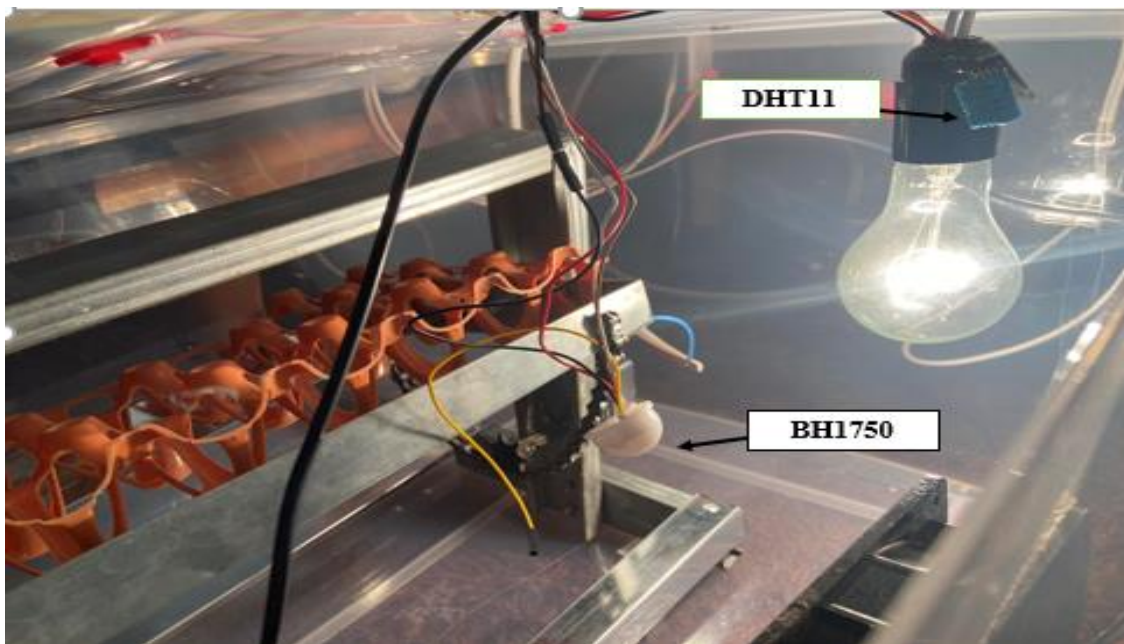


Figure IV.17: Inside the incubator

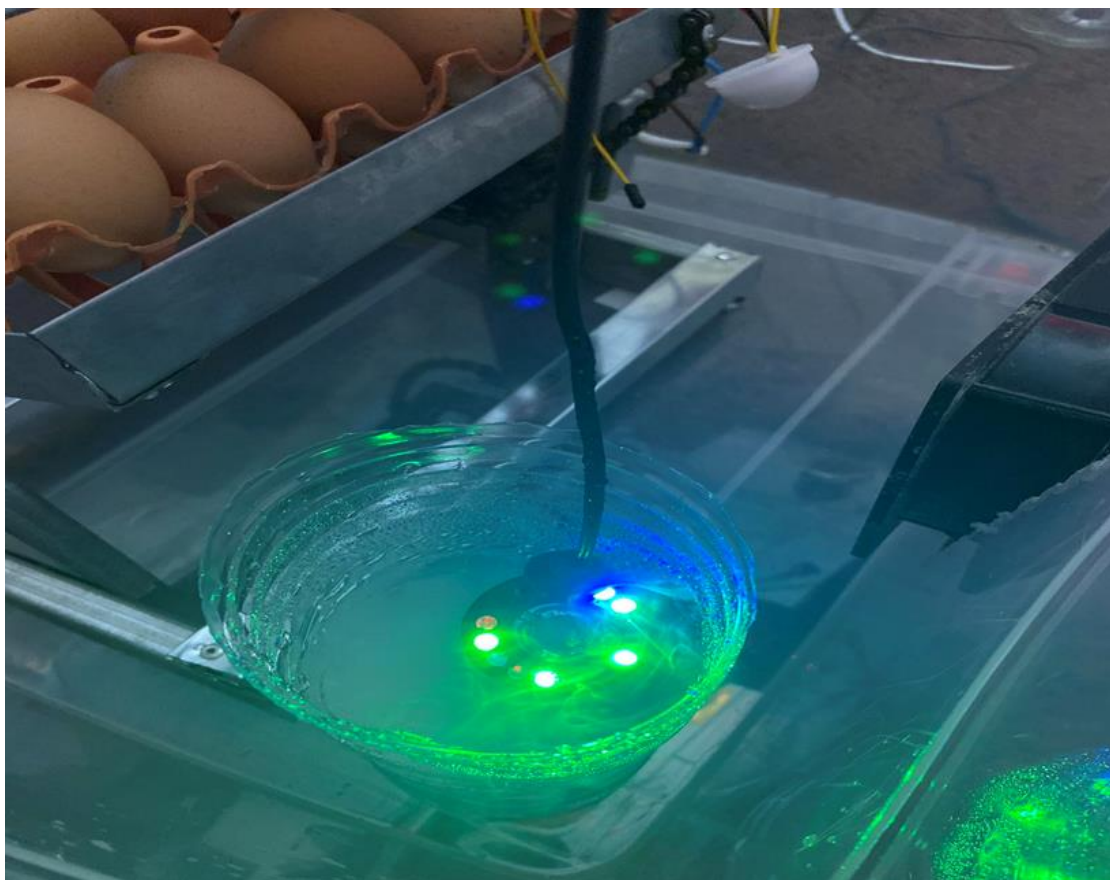


Figure IV.18: An increased humidifier

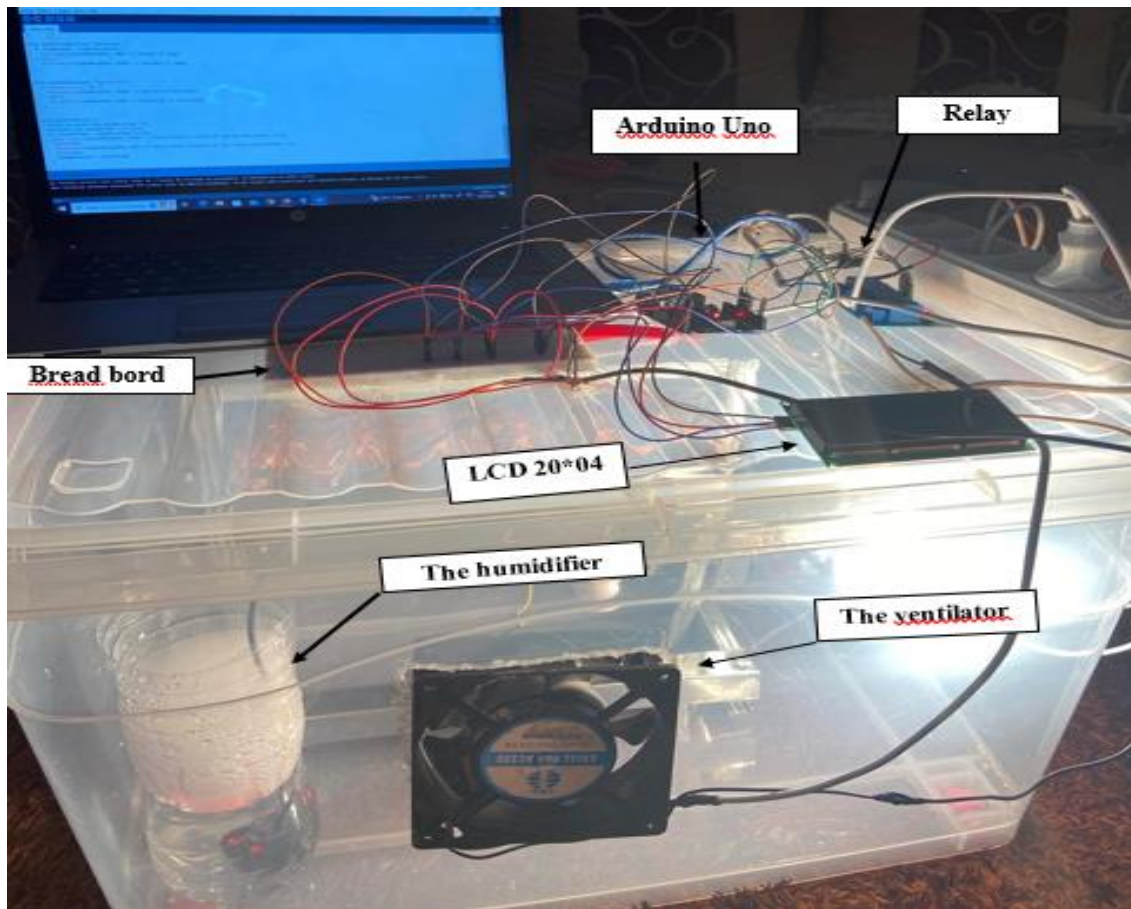


Figure IV.19: *The overall outcome*

5.Regulation:

Regulation plays a crucial role in the optimal functioning of an egg incubator by ensuring consistent and appropriate conditions for incubation. In this section, we will discuss the key aspects of regulation in our egg incubator, including temperature, humidity, and light.

5.1. Temperature Regulation:

- The temperature sensor is placed inside the egg incubator to continuously measure the ambient temperature.
- The Arduino compares the temperature value measured by the temperature sensor with the predefined setpoint temperature (37° in our incubator).
- Depending on the nature of the deviation, the microcontroller activates either the heating system or the cooling system.

* If the temperature is lower than the setpoint, the microcontroller activates the heating system to increase the temperature.

* If the temperature is higher than the setpoint, the microcontroller activates the cooling system to increase the temperature.

- The Arduino constantly monitors the temperature and adjusts the power supplied to the heating or cooling system to maintain the temperature at the target value.

5.2. Humidity Regulation:

- The relative humidity sensor is used to measure the humidity level inside the egg incubator.
- The Arduino compares the humidity value measured by the humidity sensor with the desired range of relative humidity (60% in our incubator).
- If the humidity level is lower than the desired range, the Arduino proceeds to the next step.
- Depending on the nature of the deviation, the microcontroller activates the misting system or deactivates it.

* If the humidity level is lower than the desired range, the microcontroller activates the misting system to increase the humidity. Fine water particles are dispersed in the incubator to raise the relative humidity level.

*If the humidity level is higher than the desired range, the Arduino deactivates the misting system.

- The Arduino continuously monitors the humidity level and adjusts the frequency and duration of misting to maintain the relative humidity within the desired range.

5.3. Lighting regulations:

- A light sensor is placed inside the egg incubator to measure the degree of ambient light continuously.
- The Arduino compares the light value measured by the light sensor with the predefined setpoint(60000).
- If the light level is lower than the desired range, the Arduino activates the lamp.
- If the light level is higher than the desired range, the Arduino deactivates the lamp.

6. Conclusion :

In this chapter we have illustrated the different stages of the practical realization of our system: the connection and the programs of the different sensors and actuators, as well as the realization of the incubator and we have finally presented the overall assembly.

General conclusion

This thesis presented an in-depth study and the realization of an egg incubator, focusing on the design, functionality, and practical application of such a system. Through an in-depth exploration of various parameters and factors influencing egg incubation success, this research aims to provide an innovative and effective incubator solution that contributes to the field of poultry farming.

The proposed system consistently provides the conditions required for successful egg incubation. This work has allowed us to have a complete understanding of egg incubation processes, practical and innovative ideas. However, it is important to recognize that the field of egg incubation continues to evolve and there is still room for further advancements. Other technical considerations may arise depending on the desired complexity and the specific constraints of the project, such as thermal insulation, ventilation, and lighting.

Recommendations and Perspectives:

Future research could focus on improving the design and functionality of the incubator system, exploring alternative technologies and materials, and integrating additional features for improved efficiency and automation. The desired perspectives, which are always within the framework of the achievements of reliable incubators, are oriented at the level of the following ideas:

- **Use of recycled materials:** Explore the possibility of using recycled or salvaged materials to construct the incubator. For example, cardboard boxes, plastic bottles, or other readily available materials can be used to create a sturdy and economical structure.
- **Possibility of using renewable energy sources to power the incubator.** For example, integrating solar panels to power the incubator's electrical system, thereby reducing its environmental impact and energy cost.
- **Safety and reliability:** When designing and building the incubator, it is important to guarantee the safety of the eggs as well as the reliability of the system. Protective measures against overheating, power failure, or malfunction should be considered.
- **Self-cleaning system:** Incorporate automated cleaning mechanisms to facilitate the maintenance and hygiene of the brooder. This can include automatic waste-emptying

- mechanisms, removable trays or easy-to-clean surfaces, reducing the manual labor required.

Technical-economic study:

The objective of this study is to evaluate the approximate cost price of the manufactured product. It should be noted that the prices displayed correspond to the year 2023 and to the city of ORAN.

component	price
Plastic box	1700 DA
Arduino Uno	2500 DA
Stepper motor	600 DA
Sensor BH1750	1000 DA
SENSOR DHT11	1200 DA
Electrical resistance (Lamp)	120 DA
Ventilator	600 DA
LCD display	3500 DA
2 Relay module	800 DA
Humidifier	1700 DA
Egg turner support	3000 DA
Bread board	200 DA
Connecting wires	400 DA
Total Price	17320 DA

Table .3 : *Technical-economic study*

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <DHT.h>
#include <BH1750.h>

#define DHTPIN 2
#define DHTTYPE DHT11

DHT dht(DHTPIN, DHTTYPE);
BH1750 lightMeter;
LiquidCrystal_I2C lcd(0x27, 20, 4); // Adresse I2C pour l'écran LCD 2004

const int humRelayPin = 7;
const int extractRelayPin = 8;
const int lightRelayPin = 9;
const int fanRelayPin = 10;
const int motorRelayPin = 11;
const int lightThreshold = 50; // Seuil de luminosité en lux

void setup() {
  lcd.begin(20, 4);
  lcd.print(" Couveuse");
  lcd.setCursor(0, 1);
  lcd.print(" Automatique");
  delay(2000);

  lcd.clear();
  lcd.print("Initialisation...");
```

```
pinMode(humRelayPin, OUTPUT);  
pinMode(extractRelayPin, OUTPUT);  
pinMode(lightRelayPin, OUTPUT);  
pinMode(fanRelayPin, OUTPUT);  
pinMode(motorRelayPin, OUTPUT);
```

```
dht.begin();  
lightMeter.begin();
```

```
lcd.clear();  
delay(2000);  
}  
lcd.clear();  
lcd.print("Humidite: ");  
lcd.print(" %");
```

```
lcd.setCursor(0, 1);  
lcd.print("Temperature: ");  
lcd.print(temperature);  
lcd.print(" C");  
lcd.print(" lx");
```

```
controlHumidifier(humidity);  
controlExtractor(humidity);  
controlLight(lightLevel);  
controlFan(temperature);  
controlMotor();
```

```
delay(5000);  
}
```

```
void controlHumidifier(float humidity) {  
  if (humidity < 60) {  
    digitalWrite(humRelayPin, HIGH); // Activer l'humidificateur  
  } else {  
    digitalWrite(humRelayPin, LOW); // Désactiver l'humidificateur  
  }  
}
```

```
void controlExtractor(float humidity) {  
  if (humidity > 60) {  
    digitalWrite(extractRelayPin, HIGH); // Activer l'extracteur  
  } else {  
    digitalWrite(extractRelayPin, LOW); // Désactiver l'extracteur  
  }  
}
```

```
void controlFan(float temperature) {  
  if (temperature > 37) {  
    digitalWrite(fanRelayPin, HIGH); // Activer le ventilateur  
  } else {  
    digitalWrite(fanRelayPin, LOW); // Désactiver le ventilateur  
    digitalWrite(motorRelayPin, LOW); // Faire tourner le moteur AC dans l'autre sens  
    pendant 10 ms  
    delay(10);  
    lastMotorTime = currentTime;  
  }  
}
```

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