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Theme

**Passive ventilation of an industrial poultry house
by solar chimney: Case of ELBAYAT Poultry**

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Dedication

Dedication

I dedicate this thesis to my beloved parents who prayed for me and helped me in difficult times, to all my brothers, and my lovely sister

I hope that one day I will be able to give back to them a little of what they have done for that God and me lends them happiness and comfort.

I also dedicate this work to all my family, friends, and all those who are dear to me.

ABDELGHANI.

Dedication

Dedication

*I dedicate this work to my beloved Mom & my oldest brother who is like a father to me, who raised and taught me well so I reached this part of my life, I would also like to dedicate this work to every one of my brothers and sisters, everyone in the family, and every friend of mine,
I wish them all comfort and happiness in their lives.*

OMAR EL FAROUK

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Nomenclature

Nomenclaturevvv

Symbols	Definitions	Units
A	area of smaller opening	(m^2)
A_i	cross sectional area of inlet to air flow channel	(m^2)
A_o	cross sectional area of outlet to air flow channel	(m^2)
A_g	area of glass	(m^2)
A_r	ratio of A_o to A_i A_w area of wall	(m^2)
U	outdoor wind speed	(m/h)
K	coefficient of effectiveness	
C_d	coefficient of discharge of air channel inlet (0.57)	
C_{f1}	specific heat of air	$(J/kg\ K)$
d	gap between absorber wall and glass	(m)
h_c	conductive heat transfer coefficient for glass	$(W/m^2\ K)$
h_g	convective heat transfer coefficient between glass cover and air channel	$(W/m^2\ K)$
h_{rs}	radiative heat transfer coefficient between wall and air channel	$(W/m^2\ K)$
h_{rwg}	radiative heat transfer coefficient between wall and glass cover	$(W/m^2\ K)$
h_w	convective heat transfer coefficient between inclined wall and air channel	$(W/m^2\ K)$
h_{wind}	convective heat transfer coefficient due to wind over glass cover	$(W/m^2\ K)$
H	incident solar radiation on inclined surface	(W/m^2)
K_f	thermal conductivity of air	(W/mK)
K_{ins}	thermal conductivity of wall insulation	(W/mK)
L_g	height of glass	(m)
L_s	stack height	(m)
L_w	height of absorber wall	(m)
m	mass flow rate	(kg/s)
q''	heat transfer to air stream	(W/m^2)
Q	ventilation rate	(m^3/s)
S_1	solar radiation heat flux absorbed by glass cover	(W/m^2)
S_2	solar radiation heat flux absorbed by inclined absorber	(W/m^2)
T_a	ambient temperature	(K)
T_f	mean temperature of air in channel	(K)

Nomenclature

T_{fi}	air temperature at inlet of channel	(K)
T_{fo}	air temperature at outlet of channel	(K)
T_g	mean glass temperature	(K)
T_r	room temperature	(K)
T_{sky}	sky temperature	(K)
T_w	mean temperature of inclined wall	(K)
U_b	Overall heat transfer coefficient between inclined wall and room	(W/ m ² K)
U_t	Overall heat transfer coefficient from top of glass cover	(W/ m ² K)
V	volume of room V wind velocity	(m/s)
D_{wins}	thickness of insulation behind absorber (0.05 m)	
z	inlet height along the inclined plane	

General Introduction

General introduction

The poultry sector is considered one of the most important sectors of the food industry in the world, playing a crucial role in meeting the growing global food needs. Over the years, this sector has witnessed amazing development in various fields, which has led to significant energy consumption. And to the increase in greenhouse gas emissions resulting from the combustion of fossil fuels, as well as environmental pollution. Poultry house energy consumption is a significant concern in modern agricultural practices.

Therefore, it is necessary to resort to the use of environmentally friendly renewable energy systems, which help us meet the needs of cooling, heating and ventilation.

The integration of renewable energy sources in poultry houses holds great potential for reducing energy usage. Among the various energy-consuming components of poultry houses, ventilation systems, responsible for cooling and heating, consume a major portion. In this regard, the utilization of solar chimneys as an alternative to traditional ventilation systems during daylight hours has emerged as a promising solution. (1)

The expansive roof of poultry buildings provides an ideal platform for installing solar chimneys. It is applicable in different regions around the world, as sunlight can be exploited even in areas with low solar intensity, thereby harnessing solar energy to enhance the ventilation process.

This study aims to explore the feasibility and effectiveness of implementing a solar chimney on the roof of an industrial poultry house to improve the ventilation process within an industrial poultry farm and address the challenges associated with energy consumption resulting from the use of mechanical ventilation. (2)

The research methodology of this study focuses on four key chapters, each contributing to a comprehensive understanding of the subject matter.

The first chapter delves into passive (natural) ventilation in buildings, providing a theoretical foundation for exploring the potential of utilizing natural ventilation techniques in poultry houses.

General Introduction

In the second chapter, an in-depth analysis of articles on natural ventilation and solar chimneys is presented. This literature review helps establish the current state of research and identifies key findings and trends related to the use of solar chimneys for ventilation purposes.

The third chapter details the experimental setup designed to study the implementation of a solar chimney in an industrial poultry house. This experimental phase aims to gather data, evaluate the performance of the solar chimney system, and assess its effectiveness in enhancing ventilation.

The fourth chapter focuses on the validation of the experimental findings. The results obtained from the experimental setup are compared with established standards and guidelines to ensure accuracy and reliability. Furthermore, the outcomes of the study are discussed, providing valuable insights into the potential benefits and limitations of utilizing a solar chimney for ventilation in industrial poultry houses.

By investigating the possibility of implementing a solar chimney for enhanced ventilation in an industrial poultry house, this research aims to contribute to the field of energy-efficient agricultural practices. The findings and recommendations generated from this study are then gathered in the general conclusion.

Chapter I:

Passive Ventilation in

Buildings

Chapter I: Passive Ventilation in Buildings

Introduction

With an increased awareness of the cost and environmental impacts of energy use, natural ventilation has become an increasingly attractive method for reducing energy use and cost for providing acceptable indoor environmental quality and maintaining a healthy, comfortable, and productive indoor climate rather than the more prevailing approach of using mechanical ventilation. In favorable climates and building types, natural ventilation can be used as an alternative to air-conditioning plants, saving 10%–30% of total energy consumption (1). This chapter discusses the different techniques used in passive ventilation by focusing on solar chimneys.

1. Definition of passive ventilation

Passive ventilation, also called natural ventilation, is the procedure of entering fresh air into a home from outside. This new air forces the dirty, warm air in the rooms out by the opening in the roof. This can be operated without mechanical assistance. While that was a brief introduction, its practical application and usage are much more involved. Natural ventilation is one of the most practical techniques to decrease energy usage in buildings. It utilizes the natural power of wind and buoyancy to enter fresh air and spread it in buildings for the occupants. Natural ventilation is operated by pressure varieties between one section of a building and another, or between the outside and inside.

Natural ventilation can provide a sufficient supply of breathing air, adequate ventilation of pollutants, enough thermal conditioning, and humidity waste through a good connection to the dynamics of the environment. Designers usually select natural ventilation because it decreases carbon production and is cheaper to install and run than full mechanical ventilation. It also needs less preservation, modifies the occupant's anticipations, and presents more control of their environment. This type of Ventilation provides free night cooling, decreasing daytime temperatures. Natural Ventilation and human comfort are related together.

Since the internal heat gains, which create temperature differences between the interior and exterior are, created by natural processes, including the heat from people, and wind effects are variable, naturally ventilated buildings are sometimes called "breathing buildings".

1.1. Why Is Passive Ventilation Important

Natural ventilation is vital for energy efficiency as it harnesses natural elements like wind and temperature differentials to circulate fresh air in buildings. By relying on these forces, it minimizes the need for energy-intensive mechanical ventilation systems, reducing overall energy consumption. This eco-friendly approach not only lowers operational costs but also aligns with sustainable practices, contributing to environmental conservation. Additionally, natural ventilation enhances indoor air quality, promoting a healthier living or working environment without the energy demands of air purification systems (2)

1.2. What are Passive Ventilation General Rules

Natural ventilation is the process of naturally delivering and removing air from an interior space without the assistance of a fan or other mechanical device. It provides ventilation and space cooling by using external airflow induced by pressure differences between the building and its surroundings. (2)

2. Description

Natural ventilation, unlike fan-forced ventilation, uses the natural forces of wind and buoyancy to deliver fresh air into buildings. Fresh air is required in buildings to alleviate odors, provide oxygen for respiration, and to increase thermal comfort. At interior air velocities of 48.77 meters per minute [m/min], the perceived interior temperature can be reduced by as much as -15[°C]. However, unlike true air-conditioning, natural ventilation is ineffective at reducing incoming air's humidity. (2)

2.1. The effectiveness of Passive ventilation

The impact of Natural Ventilation can increase in the building according to our considerations of the following matters:

- Prevailing wind velocity and direction
- Building conditions and orientation
- Window sizing, location, and functioning
- Surrounding environment
- Outdoor temperature and moisture

2.2. Design Considerations

Chapter I: Passive Ventilation in Buildings

In designing natural ventilation in a new building, the following basic design techniques must be considered:

- External components
- Window types and verification
- Building appearance and dimensions
- Ridge vents
- Building orientation and position
- Air inlets and outlets

3. Types of Passive Ventilation

Two kinds of Natural Ventilation happen rally in buildings. First is wind-based ventilation (also introduced as cross ventilation), and the second is Buoyancy-operated (also known as stack-effect) ventilation. (2)

3.1. Wind-Based Ventilation (Cross-Ventilation)

Wind causes a positive pressure on the windward side and a negative pressure on the leeward side of buildings (figures I.1 and I.2). To equalize pressure, fresh air will enter any windward opening and be exhausted from any leeward opening. In summer, wind is used to supply as much fresh air as possible while in winter, ventilation is normally reduced to levels sufficient to remove excess moisture and pollutants. An expression for the volume of airflow induced by wind is:

$Q_{wind} = K \times A \times V$, where

Q_{wind} = volume of airflow (m^3/h)

The coefficient of effectiveness depends on the angle of the wind and the relative size of entry and exit openings. It ranges from about 0.4 for wind hitting an opening at a 45° angle of incidence to 0.8 for wind hitting directly at a 90° angle.

Sometimes wind flow prevails parallel to a building wall rather than perpendicular to it. In this case, it is still possible to induce wind ventilation by architectural features or by the way, the casement window opens. For example, if the wind blows from east to west along a north-facing wall, the first window (which opens out) would have hinges on the left-hand side to act as a scoop and direct wind into the room. The second window would hinge on the right-

Chapter I: Passive Ventilation in Buildings

hand side so the opening is down-wind from the open glass pane and the negative pressure draws air out of the room.

It is important to avoid obstructions between the windward inlets and leeward exhaust openings. Avoid partitions in a room-oriented perpendicular to the airflow. On the other hand, the accepted design avoids inlet and outlet windows directly across from each other, to promote more mixing and improve the effectiveness of the ventilation. (3)

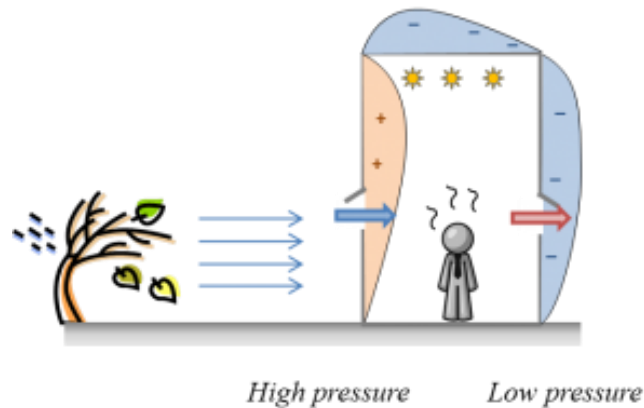


Figure I. 1: Cross-Ventilation (4)

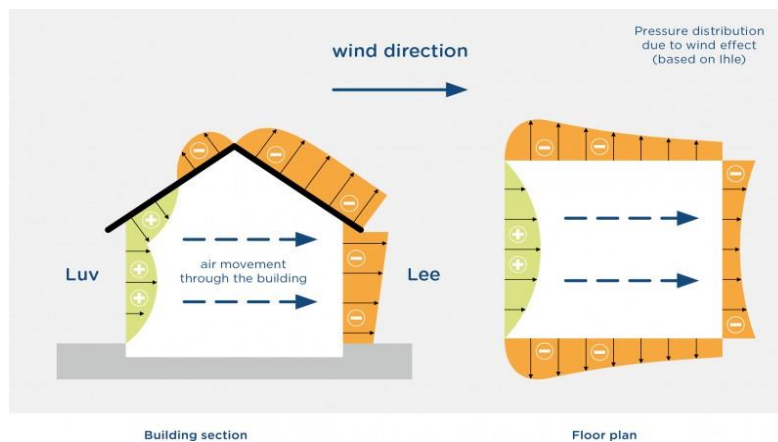


Figure I. 2: Influence of Wind and Thermal Updraft on Ventilation (2)

3.2. Buoyancy-Driven Ventilation

3.2.1. Chimney solar

Also known as, a solar chimney is a sustainable and innovative approach to natural ventilation in buildings. It utilizes the power of sunlight to create a passive airflow system that improves indoor air quality and reduces the reliance on mechanical ventilation. The concept involves constructing a tall chimney-like structure with a glazed roof and dark-

colored walls. As the sun heats the air inside the chimney, it creates a temperature difference, causing the air to rise. The hot air naturally draws in cooler air from lower openings, such as windows or vents, creating a continuous flow of fresh air throughout the building. This process provides effective ventilation and harnesses renewable solar energy, making it an eco-friendly solution. Chimney solar systems are being increasingly adopted in sustainable architecture, offering an energy-efficient and environmentally conscious way to enhance indoor air circulation. (4)

3.3. Mixed mode Ventilation (Hybrid mode ventilation):

Mixed mode ventilation or hybrid ventilation is a sustainable ventilation strategy that can improve indoor air quality and effectively regulate indoor temperature. This enhances occupant comfort and productivity.

Mixed-mode ventilation systems combine the benefits of fresh air ventilation with the added support of mechanical fans and systems to move and change air for a comfortable and healthy indoor climate (figure I.3).

Mixed-mode ventilation systems reduce energy consumption through the reduction of mechanical fan use and, in some cases, the cooling demands. By using key natural ventilation strategies to ventilate during the day or night (night cooling), mixed-mode ventilation reduces the use of mechanical systems and possibly the size of the system.

Like natural ventilation systems with WindowMaster, mixed-mode ventilation systems utilize sensors to monitor indoor temperature, CO₂ levels, and humidity, as well as outdoor conditions. Based on this data, the system will automatically either chose natural ventilation or mechanical ventilation depending on which system is the most optimal to use. The system will then switch back to natural ventilation strategies when appropriate.

For example, if the weather is too cold, too rainy, or too hot, the mixed-mode ventilation system adjusts the building openings appropriately and communicates with the mechanical ventilation system to optimize the indoor environment. The system then takes a holistic approach to ensure occupant comfort and indoor climate health for a high-performance building. (5)

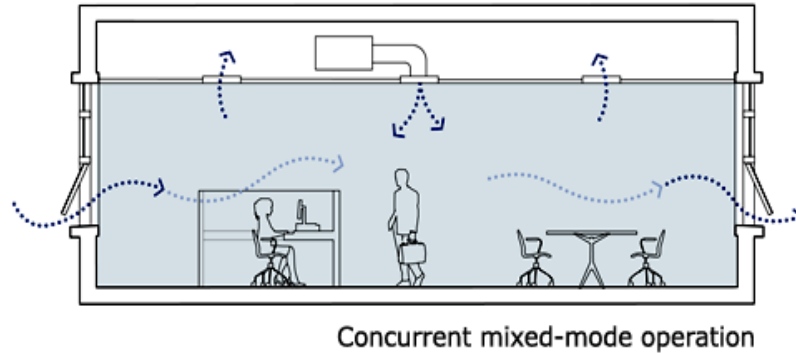


Figure I. 3: Concurrent mixed-mode ventilation (7)

4. Advantages and disadvantages of Passive Ventilation:

It is hard to make certain explanations about the advantages and disadvantages of natural ventilation contrasted to mechanical systems, nearly because they are influenced by some external conditions such as the utilization of the building and climate change. However, this point cannot be passed without talking about it, and some general explanations can be presented.

- Natural ventilation can generally provide a high ventilation rate more economically, due to the use of natural forces and large openings.
- Natural ventilation can be more energy efficient, particularly if heating is not required.
- Well-designed natural ventilation could be used to access higher levels of daylight.

From a technological point of view, natural ventilation may be classified into simple natural ventilation systems and high-tech natural ventilation systems. The latter are computer-controlled and may be assisted by mechanical ventilation systems (i.e. hybrid or mixed-mode systems). High-tech natural ventilation may have the same limitations as mechanical ventilation systems; however, it also has the benefits of both mechanical and natural ventilation systems.

If properly designed, natural ventilation can be reliable, particularly when combined with a mechanical system using the hybrid (mixed-mode) ventilation principle, although some of these modern natural ventilation systems may be more expensive to construct and design than mechanical systems.

Chapter I: Passive Ventilation in Buildings

In general, the advantage of natural ventilation is its ability to provide a very high air-change rate at a low cost, with a very simple system. Although the air-change rate can vary significantly, buildings with modern natural ventilation systems (that are designed and operated properly) can achieve very high air-change rates by natural forces, which can greatly exceed minimum ventilation requirements. (2)

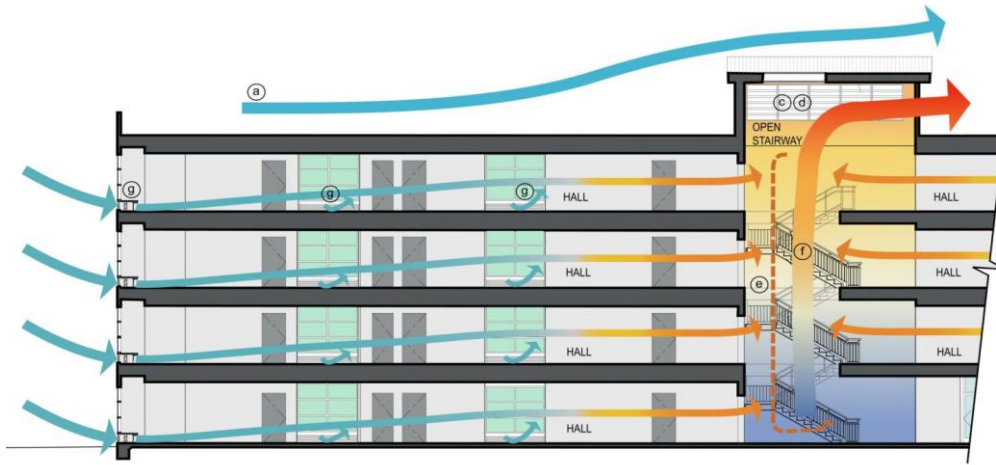


Figure I. 4: Comfortable Airflow in a Building by using Passive Ventilation (2)

- Natural ventilation is variable and depends on outside climatic conditions relative to the indoor environment. The two driving forces that generate the airflow rate (i.e. wind and temperature difference) vary stochastically. Natural ventilation may be difficult to control, with airflow being uncomfortably high in some locations and stagnant in others. There is a possibility of having a low air-change rate during certain unfavorable climate conditions.
- There can be difficulty in controlling the airflow direction due to the absence of a well-sustained negative pressure; contamination of corridors and adjacent rooms is therefore a risk.
- Climate, security, and cultural criteria may dictate that windows and vents remain closed; in these circumstances, ventilation rates may be much lower.
- Natural ventilation only works when natural forces are available; when a high ventilation rate is required, the requirement for the availability of natural forces is also correspondingly high.

Chapter I: Passive Ventilation in Buildings

- Natural ventilation systems often do not work as expected, and normal operation may be interrupted for numerous reasons, including windows or doors not open, equipment failure (if it is a high-tech system), utility service interruption (if it is a high-tech system), poor design, poor maintenance or incorrect management.
- Although the maintenance cost of simple natural ventilation systems can be very low if a natural ventilation system cannot be installed properly or maintained due to a shortage of funds, its performance can be compromised, causing an increase in the risk of the transmission of airborne pathogens. (2)

Conclusion

Passive ventilation can generally provide a high ventilation rate more economically, due to the use of natural forces and large openings, but this source cannot be controlled because we cannot control the external climatic conditions. Natural ventilation is still a relatively good option from the side economically and environmentally beneficial. Although, other options are better than natural ventilation, such as ventilation using a solar chimney.

Chapter II:
Literature review about
solar chimneys

Chapter II: Literature review about solar chimneys

Introduction

A large number of works have been published in recent years in relation to various types of solar chimneys and for different applications. In this chapter, we present the state of the art of solar chimneys and the experimental and numerical research of some researchers that will allow us to formulate and pose the problems of our research.

Emmerich et al (6) studied the application of natural ventilation technology in buildings. The study includes its advantages, and everything related to such technology, and deals with assumptions and issues related to the application of natural ventilation in California, as well as design and analysis tools. The authors touched on the three basic natural configuration types (figure II.1.) : (Wind-driven cross ventilation - Buoyancy-driven stack ventilation - Single-sided ventilation) (6)

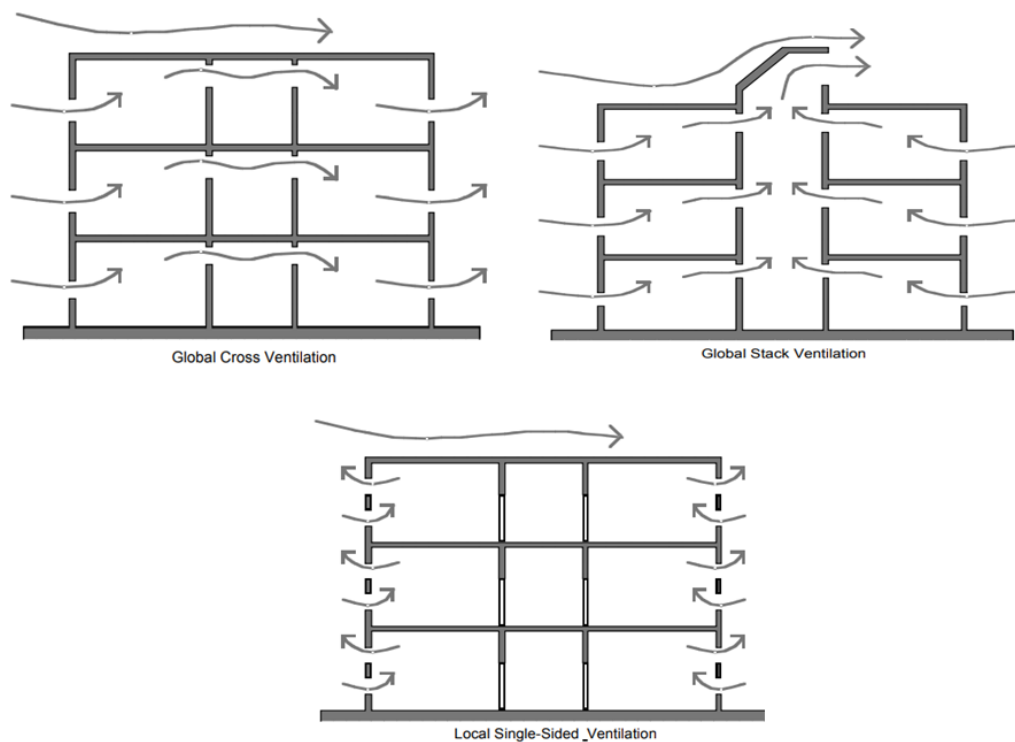


Figure II. 1: The three basic natural configuration types. (6)

A research paper published by Lui et al. (7) containing a study of the process of natural ventilation. The studied solar chimney for building ventilation is classified according to its position:

1. A wall solar chimney or Trombe wall.

Chapter II: Literature review about solar chimneys

2. A roof Solar chimney.
3. An integrated wall and roof solar chimney.

The ventilation process is better using an integrated wall and roof solar chimney technology compared to a solar chimney or trompe-wall.

There are four operation modes for the combined solar chimney: a natural ventilation mode for the summer, an anti-overheating mode for the summer, a space-heating mode for the winter, and a preheating mode for the winter. (7)

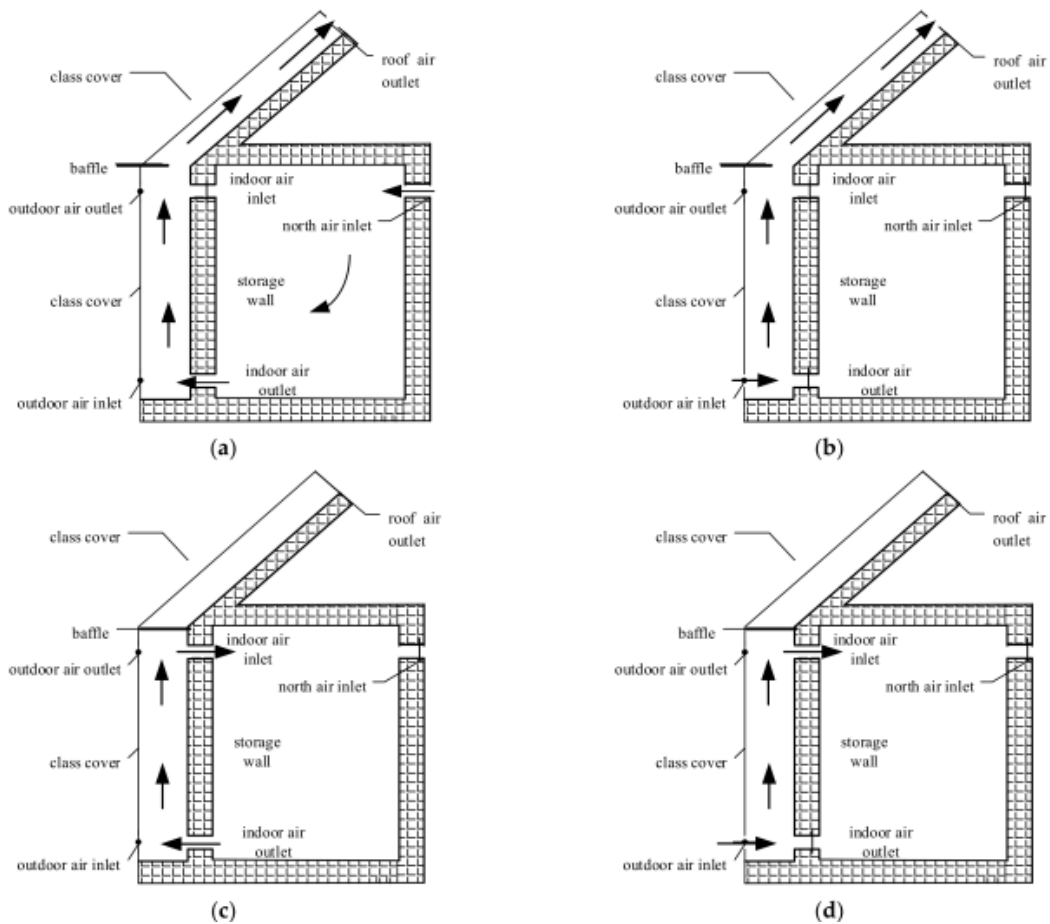


Figure II. 2: Schematic diagram of a combined solar chimney: (a) summer natural ventilation mode; (b) summer anti-overheating mode; (c) winter space heating mode; and (d) winter preheating mode. (7)

Fang et al. (8) studied the heat transfer of wall-mounted solar chimney. The study was a simulation of a one-story house, using Fluent computational fluid dynamics software to simulate the airflow inside the wall-mounted solar chimney numerically. The effect of ventilation efficiency with solar chimney technology in case of a change in Outlet-to-inlet

Chapter II: Literature review about solar chimneys

airflow path cross-sectional area ratio is examined (figure II.3). Results showed that as the value of the outlet-to-inlet airflow path cross-sectional area ratio increased, its inlet velocity also became larger and larger, while the outlet velocity became smaller and smaller. (8)

The results were as follows:

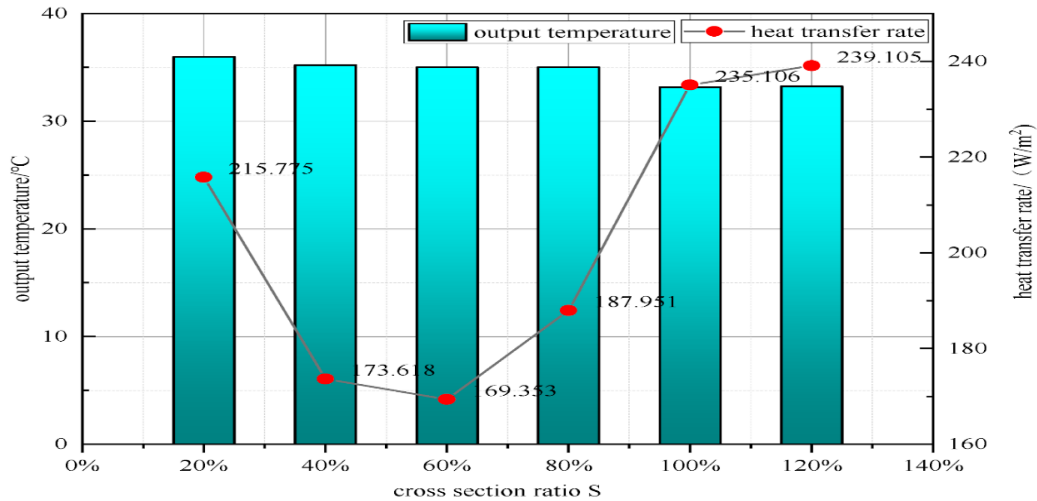


Figure II. 3: Variation in the outlet temperature and heat flux of wall-mounted solar chimney under different S-values. (8)

Solar chimney technology can be used in several fields, including (ventilation - power generation - and food drying). The principle of this technology is the rise of hot air and the descent of cold air (converting solar thermal energy into air kinetic energy), airflow through the chimney, or the effectiveness of this technology in cold seasons. It is less compared to the warm seasons. Charvat et al (9) were built and tested a solar chimney at Bono University to study and verify the performance of this technology under the climatic conditions of the Czech Republic. Results showed the the solar chimney can be developed in terms of design, such as replacing the glass with transparent photovoltaic solar cells and exploiting this Electric energy to obtain natural ventilation supported by a fan.(9)



Figure II. 4: Experimental house with hybrid ventilation. (9)

Khanal et al. (10) presented an overview of the solar chimney research in the 1990s and the factors affecting the effectiveness of the solar chimney. The chimney aspect ratio (stack

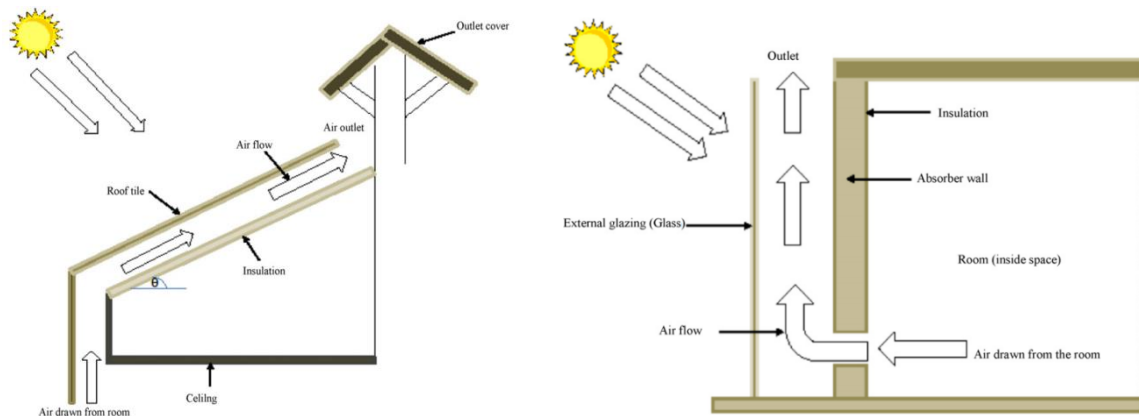


Figure II. 5: Schematic of the solar chimney with vertical absorber geometry, Schematic of inclined roof solar chimney. (10)

height/air gap width), ventilation height (height between inlet and outlet apertures), aperture areas, thermal characteristics of the absorber material, and chimney tilt angle are found to have an important effect. The focus was on two main factors, namely the influence of geometry and the influence of the angle of inclination . (10)

Solar Chimneys in buildings the State of the art

The types of solar entrances in buildings and the different cases in their application and installation were discussed, including the CFD models by Dimoudi (11)

And the factors that affect the effectiveness of the solar chimney, such as the height of the solar chimney, but the increase in the width of the solar smoker had a more effective role than the increase in the length of the entrance.(11)

Chapter II: Literature review about solar chimneys

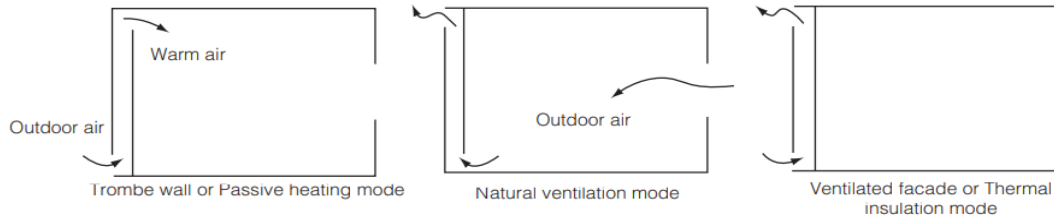


Figure II. 6: Different operation modes of a solar chimney(11)

The factors affecting the solar chimney, its use cases, and some systems that can be integrated with the solar chimney were studied by Zhang et al. (12) . Focus has been placed on achieving optimal design strategies in building the solar chimney on analyzing information that was in two different cases, such as ventilating one room or ventilating multiple rooms on different floors, and some research contributions on the chimney level. Solar by RMIT University. (12)

an investigation conducted by Zhai et al. () about the factors affecting the effectiveness of the solar chimney, including the angle of inclination of the chimney, and the experiment was in several different angles of inclination of the chimney. Significant effect on the efficiency of the chimney compared to the width of the chimney gap. Two types of solar stacks were proposed on the roof, namely a single-roof solar collector (figure II.7) and a double-roof solar collector (figure II.8). The efficiency of the double-roof solar collector was better than the single-roof solar collector. This is in both cases, either in the case of natural ventilation or heating.(12)

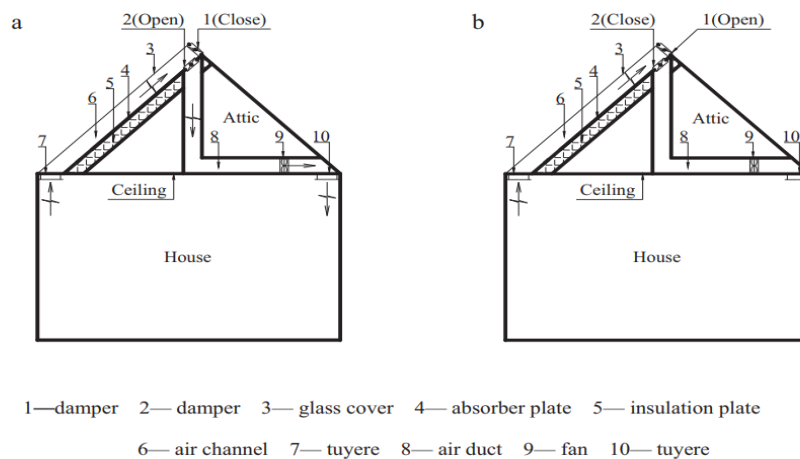


Figure II. 7: Structure of single pass roof solar collector. (a) Space heating mode. (b) Natural ventilation mode. (12)

Chapter II: Literature review about solar chimneys

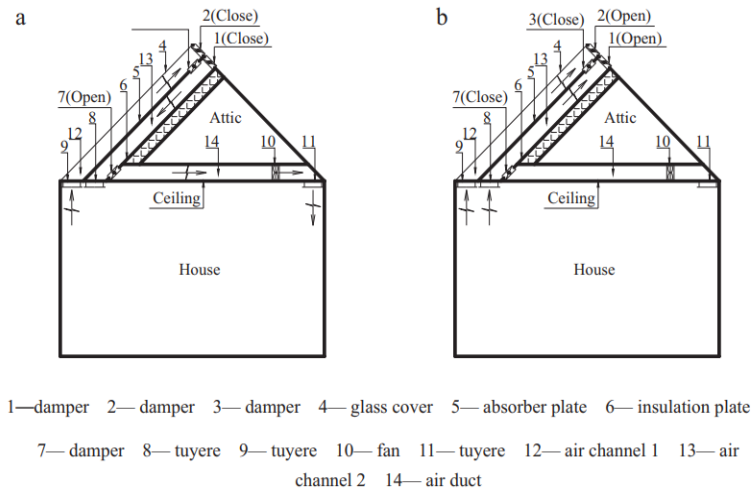


Figure II. 8: Structure of double pass roof solar collector. (a) Space heating mode. (b) Natural ventilation mod. (12)

recently, Boutera et al. (13) published a research paper about the performance of the ground-air heat exchanger in cooling and heating poultry houses (figure II.10). The article also touched on some of the influencing factors that must be taken into account in poultry houses, namely the heating and cooling loads. Results showed that humidity has an important and influential role that has not been addressed yet. The study was conducted on soil temperature in Biskra during two consecutive years 2019 and 2020, and the results showed that the increase in depth leads to an increase in the soil temperature until it reaches a constant value throughout the year. It is possible to benefit from the temperature difference of 27 and 21 at a depth of 5 meters. The results also showed that the diameter of the pipe has an effect on the cooling and heating process of the poultry house. The smaller the diameter of the pipe, the more effective this process. (13)

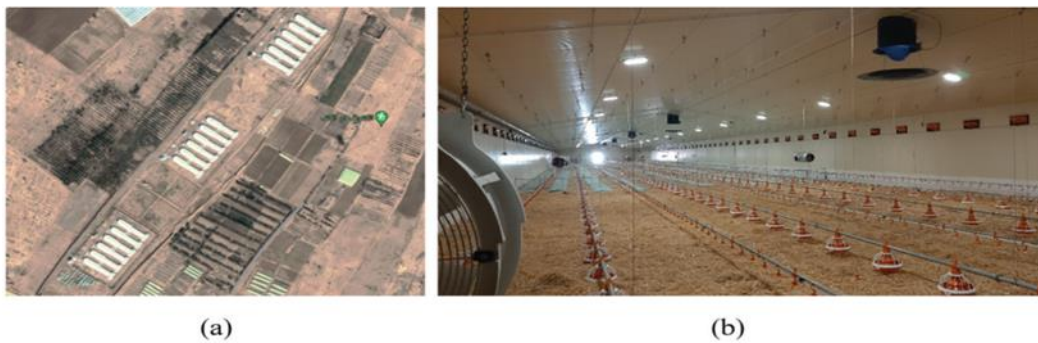


Figure II. 9: (a) Aerial view of the poultry farm and (b) inside view of the poultry house, Salem Poultry Farms, Sidi Okba, Biskra, Algeria. (13)

a study was conducted in Tangier, Morocco, by Laknizi et al. (14) on the energy performance and environmental impact of a ground-air heat exchanger for heating and cooling the poultry house. A simulated analysis was carried out to evaluate the thermal performance, and the results indicated the difference in the energy consumed in the cases of heating or cooling. (14)

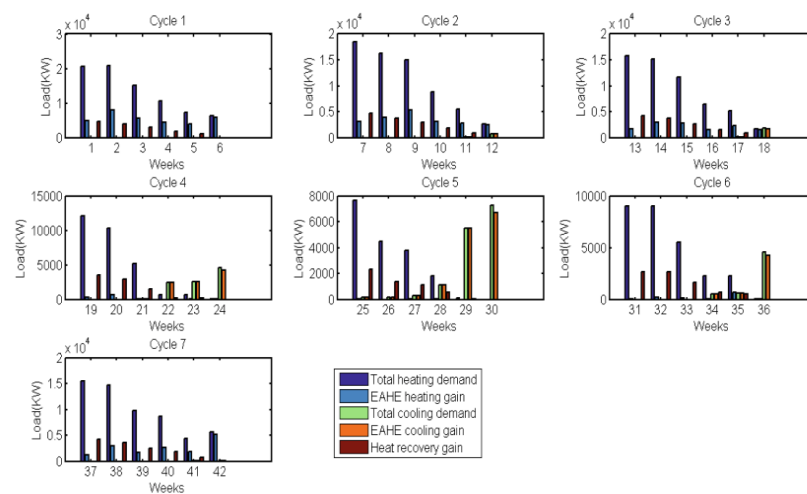


Figure II. 10: Weekly load transfer during the seven full cycles. (14)

Conclusion

In this chapter, an overview of the operational capacity of the solar chimney was presented. Natural ventilation with solar chimney technology is considered the easiest and most effective solution for building ventilation. The airflow process within buildings can be achieved using a solar chimney to improve indoor air quality and regulate temperature and humidity without the need for mechanical tools that consume large amounts of fossil fuels and emit substantial quantities of carbon dioxide, which have negative effects on productivity and the environment.

Chapter III:

**Poultry house ventilation by
solar chimney**

Chapter III: Poultry house ventilation by solar chimney

Introduction

The objective of this chapter is first to study the volumetric flow rate needs of an industrial poultry house and then propose an alternative solution basing on renewable energy to ventilate the building.

This study is divided into two main parts:

- Practical study: was carried out at Al-Hajjah Al-Tijani (ELBAYAT) Farm, where all the information on the poultry house (orientation, dimensions, structure, loads etc.) and on the internal and external conditions of the building was collected.
- Theoretical study: the formulas necessary for the designing of the solar chimney that will be installed on the studied poultry roof. (15)

1. Practical study

In order to collect the scientific information necessary for this study, we carried out an internship period in the institution of Al-Hajjah Al-Tijani (ELBAYAT) Farm, in Aïn Beida, Ouargla.

1.1. Presentation of the study framework: Al-Hajjah Al-Tijani (ELBAYAT) Farm

1.1.1. Description of the internship company

Al-Hajjah Al-Tijani Farm Company for Poultry and Feed is a limited liability company located in Ouargla, Algeria; its owner is **Mr. Belkhair ElBayat**.

The main activities of the company are the production and sale of meat, eggs and feed

1.1.2. The course supervisor

This study was supervised in the company by **Mr. Gourari abdallah** who is an electrical engineer, and he played a major role in the collection of information necessary for the study.

1.1.3. Internship site

The place where the study was conducted is located near the crossroads of Ouargla, Touggourt, Hassi Messaoud. This broiler contains 6 chicken coops (figure III.1), where these broilers are divided into two groups:

Chapter III: Poultry house ventilation by solar chimney

- Group 01: Four Poultry buildings with dimensions [120m x 14m x 5m] each with a capacity from 10,000 to 17.000 of chickens stock.
- Group 02: Two Poultry buildings with dimensions [50m x 14m x 5m] each with a capacity from 6,000 to 7.000 of chickens stock.



Figure III. 1: Al-Hajjah Al-Tijani Farm given by Google Maps
(16)

1.1.4. The systems (heating/cooling) used in Al-Hajjah Al-Tijani Farm

The ventilation and cooling system used in the buildings is the longitudinal ventilation system.

- The system ventilates according to the principle of Length ventilation, where it is in the length ventilation, the fans are in the end wall and the air inlets in the sidewalls. By further increasing or decreasing the speed of fans and opening or closing the air inlets, a wide range of air exchange is possible.

As we know, Ventilation and cooling systems in the poultry sector are essential, for the well-being and survival of the flock.

For proper air conditioning within poultry farms, it is essential to install ventilation, cooling and heating systems that ensure all the necessary requirements for animal welfare.

That is why they use in the poultry of Al-Hajjah Al-Tijani Farm **combiTERM** - indirect exchange hot air generator (Figure III.2), and it is a forced hot air heater, using oil as fuel (diesel). With internal fans that allow hot air to circulate in the building.

Chapter III: Poultry house ventilation by solar chimney



Figure III. 2: The combiTERM - indirect exchange hot air generator

Each building includes

Table III. 1: The machines in one poultry house of the Group01

	N°	Tension [V]	Current [A]	Power [W]
Ventilation	11	380	2.63	1000
Pump	02	220	3.40	750
Lighting	30	220	0.072	16
Heating	01	230	2.60	600



Figure III. 3: Real photo industrial poultry house Al-Hajjah Al-Tijani Farm Company for Poultry and Feed [120m]



Figure III. 4: Real photo industrial poultry house Al-Hajjah Al-Tijani Farm Company for Poultry and Feed [50m]

2. The poultry building of the study

In this part of the study, a poultry house was chosen and considered free of all the ventilating systems mentioned above, in order to calculate ventilation rate needs of this poultry house according to its maximum working conditions. According to the following steps:

- Determination of the geographical coordinates of the poultry house.
- Determination of the maximum working conditions of the poultry house.
- Determination of the dimensions and structure of the building.

2.1. The geographical coordinates of the poultry-building site

The poultry house Al-Hajjah Al-Tijani Farm is located in Aïn Beida, Ouargla with details following geographies

Chapter III: Poultry house ventilation by solar chimney

- Latitude: 31°55'58.2" North.
- Longitude: 5°27'21.8" East.
- Altitude: 124 m. (16)

It belongs to the climatic zone D considered by DTR (17)

2.2. The maximum working conditions of the poultry building

To determine the maximum working period of this **poultry house**, we have coordinated between the maximum indoor and outdoor conditions as follows:

Table III. 2: The maximum indoor and outdoor conditions of the poultry house.

	The maximum interior conditions			The maximum external conditions	
Case 01	The Chickens have the first weeks of growth	Need high temperatures	Need low ventilation rate	Winter	The coldest day of the year
Case 02	The chickens have the last weeks of Growth	Need low temperatures	Need high ventilation rate (to be calculated)	Summer	The hottest day of the year

a. The maximum external conditions:

Meteorological data for Ouargla region and Aïn Beida site were collected during the years 2018 from the database of meteorological station of Aïn Beida (05), and weatherspark website (6), (**figures 3.6, 3.7 and 3.8**).

Chapter III: Poultry house ventilation by solar chimney

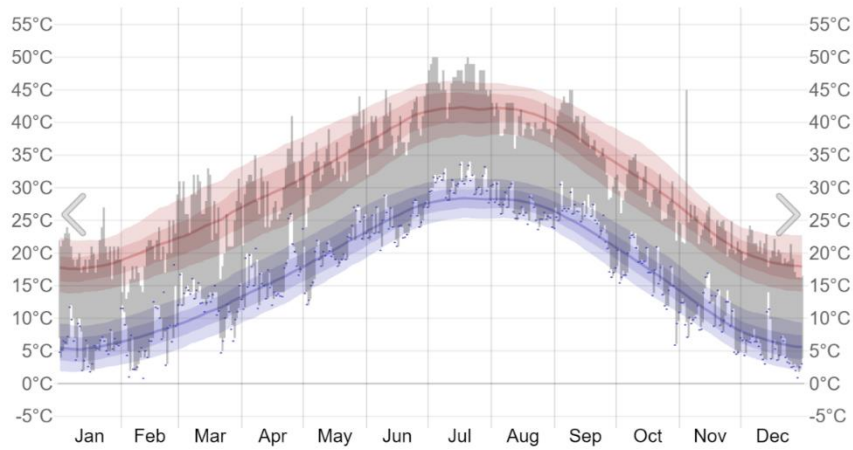


Figure III. 5: Temperature variation for the year 2018, Ouargla, from weatherspark (18)

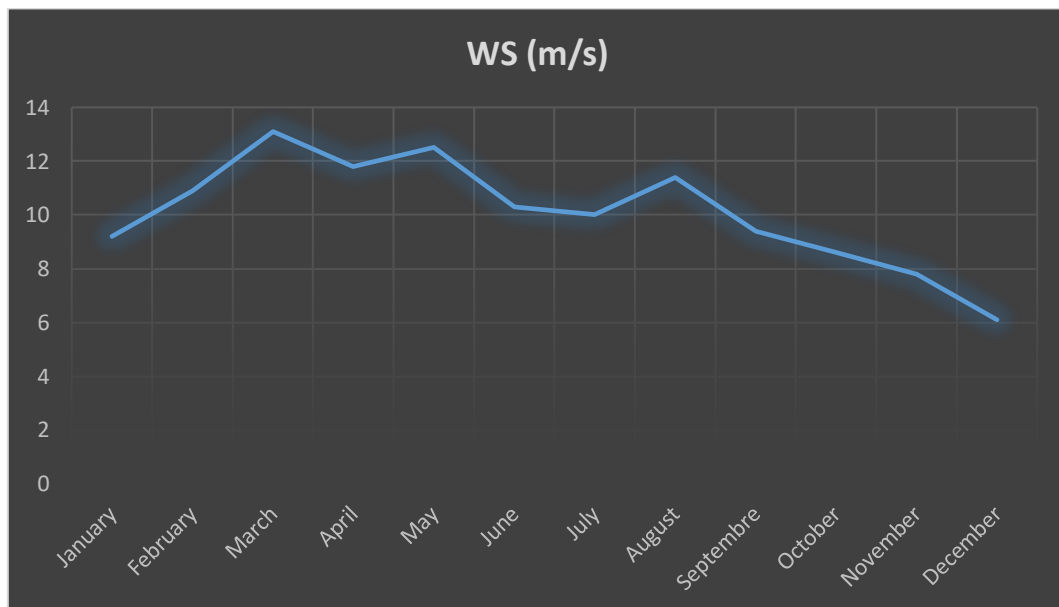


Figure III. 6: Wind Speed in 2018 at Ouargla (19)

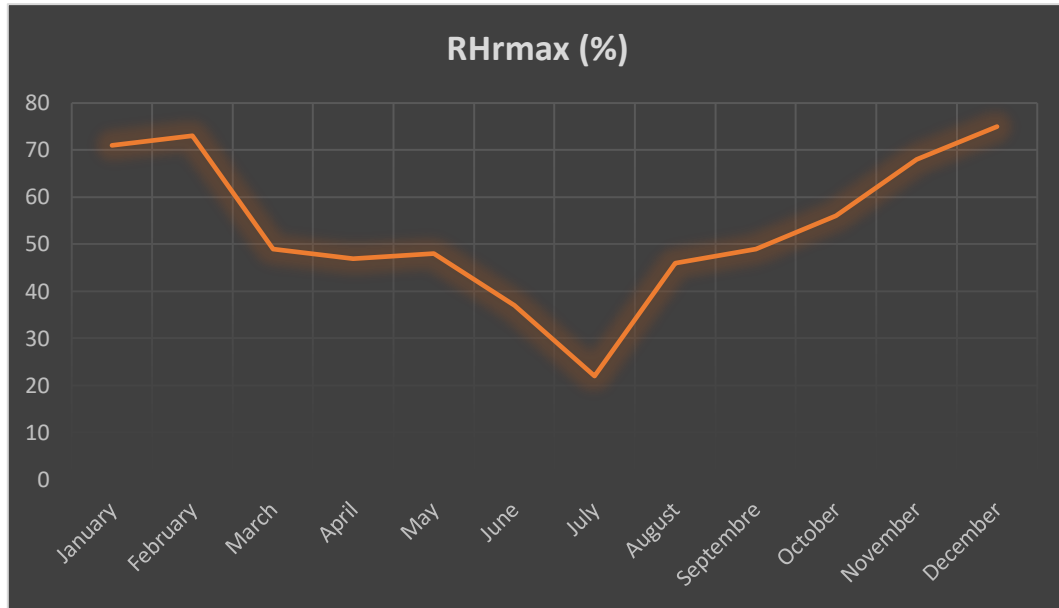


Figure III. 7: Humidity Levels in 2018 at Ouargla (18)

b. External climatic conditions

From figures III.6, we find that the hottest and coldest months in year 2018 are respectively July and December.

From that, we will consider this study in these months of that year.

The external climatic conditions are summarized in the table below:

Table III. 3: The external climatic conditions of the hottest and coldest day of the year.

External conditions	Winter 2018	Summer 2018
The date	December 29 th	July 05 th
Temperature (C°)	4.9	47.4
Relative humidity (%)	30.29	22
Wind speed (m/s)	10	6.1
Time (h)	07:00 AM	03:00 PM

c. The maximum interior conditions:

The internal conditions of the chicken coop are summarized in the table below:

Table III. 4: The internal basic conditions.

Internal conditions	Winter 2018	Summer 2018
The date	December 29 th	July 05 th
Chicken Age (days)	0-07 days	35-40 days
Chicken weight (kg)	0.185	2.857
Required Temperature (C°)	31	18
Required Relative humidity (%)	30-60	50-70
Required Ventilation rate (m ³ /h)	3	1.83

3. Dimensions and structure of the building:

The studied building is 120 m long and 14 m wide with a wall height of 2 m and a roof curvature of the roof consists of two layers of 4 and 5 cm sandwich panels with a 5 cm thick layer between the two panels.

The walls (East) and (West) contain 18 dimension windows [1.2 m × 0.3 m] and a dimension door [1.9 m × 0.9 m]. The wall (North) contains a door of [2.80 m × 2.40m]



Figure III. 8: The Orientation of Al-Hajjah Al-Tijani Farm buildings according to Google Maps (18)

Chapter III: Poultry house ventilation by solar chimney

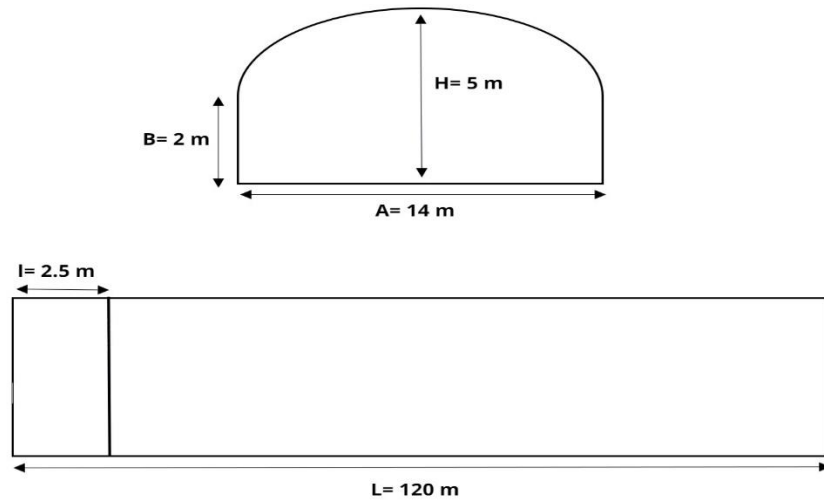


Figure III. 9: Scheme of poultry house and the solar chimney to be installed

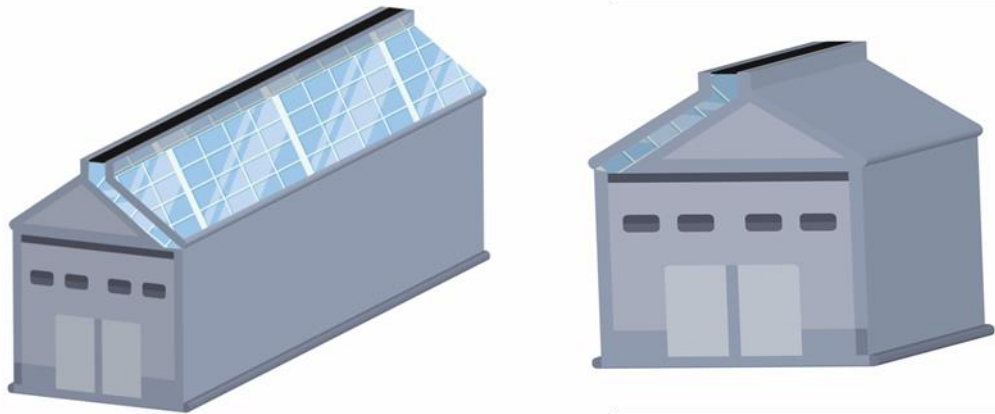


Figure III. 10: Building surfaces and orientation.

	orientation	Surfaces m ²			
		Wall	clean Wall	Door	Window
Wall 1	South	70.54	68.83	1.71	-
Wall 2	East	240	206.76	-	3.24
Wall 3	North	70.54	37.84	12	-
Wall 4	West	240	205.05	1.71	3.24
Floor	-	1400			
Roof	-	1884.95			

4. Theoretical study

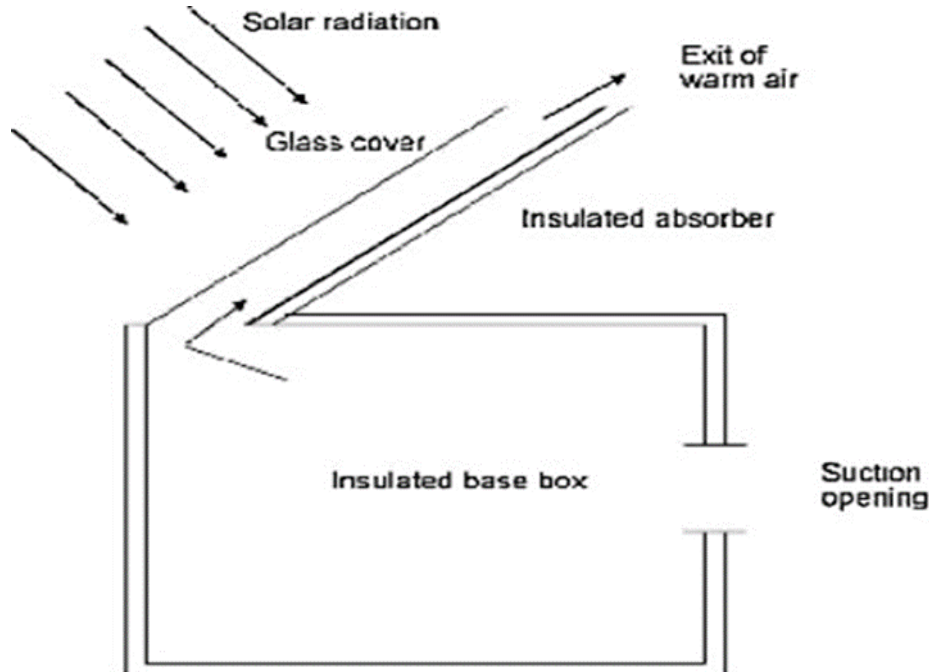


Figure III. 11: A schematic diagram of a solar chimney. (19)

The primary goal of the mathematical model was to anticipate the rate of airflow in the inclined observer solar chimney. In order to evaluate the effectiveness of the solar chimney, the current investigation concentrated on examining the heat transfer that occurs through natural convection. Several factors were taken into account in this study, including the temperatures of the absorber and glass surface, the air inlet and outlet temperatures, the ambient temperature, the flow velocity, and the ratio of the inlet and outlet opening areas. The mathematical solution for calculating the airflow rate involved formulating energy balance equations for the absorber surface, glass surface, and air column, and then solving them to determine the values of T_g , T_w , and T_f .

A solar chimney was chosen as a ventilation system for the studied poultry house of Al-Hjjah Al-Tijani Farm in the previous chapter.

The objectives of this section are:

First, design of solar chimney that can extract the required calculated air mass flow rate.

Second, a validation of the numerical results of the models with those of experimental that we did it in the laboratory.

Third, study Parametric to determine the optimum design parameters of the solar chimney such as appropriate angle, length of chimney, gap between absorber and glass cover.

4.1. Characteristics of chimney solar

Chimney solar, also known as solar chimney or thermal chimney has several unique characteristics that make it a promising technology for generating renewable energy. Some of the key characteristics of chimney solar are:

- **Airflow:** is an essential aspect of chimney solar technology. The airflow in a chimney solar system is created by the natural convection of hot air rising up the chimney. The chimney structure is designed to enhance the natural convection of hot air, and turbines or generators are installed at the base of the chimney to harness the airflow and generate electricity. The airflow is continuous, as long as the sun is shining and heating up the air inside the collector area. Ongoing research is working to optimize the design of chimney solar systems to maximize the efficiency of the airflow.
- **Simple Design:** Chimney solar has a relatively simple design, consisting of a tall structure with a large glass collector area at its base. This makes it easy to construct and maintain, with lower costs compared to other renewable energy technologies. (18)
- **Low Maintenance:** The design of chimney solar requires little to no maintenance once it has been built. This reduces the overall cost of ownership and makes it an attractive option for remote or hard-to-reach areas.
- **Low Environmental Impact:** Unlike other forms of energy generation, such as fossil fuels, chimney solar has a low environmental impact. It produces no emissions, pollutants, or greenhouse gases, and does not contribute to climate change.
- **Scalable:** Chimney solar technology is scalable and can be used in a variety of settings, from individual homes to large industrial complexes. This makes it a versatile option for generating renewable energy on a small or large scale. (18)
- The following assumptions were made during the course of this study:
 1. The entire system was assumed to be in a steady-state condition.

Chapter III: Poultry house ventilation by solar chimney

2. All energy transfer processes through the glass cover, absorber plate, and air channel were simplified to one-dimensional.
 3. The flow inside the air channel was assumed to be laminar.
 4. The absorber and glass surfaces were considered parallel to each other.
 5. The temperature of the air at the inlet of the flow channel was assumed to be equal to the ambient temperature.
- Thermo-physical properties were evaluated at an average temperature. Following these assumptions, energy balance equations were formulated for the glass cover, flow channel, and absorber plate of the solar chimney, as suggested by Hirunlabh et al. and Ong and Chow. (18)

4.2. Development of energy balance equation for glass, air, and absorber

4.2.1. Energy balance for the glass cover

The energy balance equation can be written as:

[Incident solar radiation] + [radiative heat gain by glass cover from absorber wall] = [convective heat loss to air in flow channel] + [overall heat loss coefficient from glass to ambient]

Mathematically it can be expressed as:

$$(h_g A_g + h_{rwg} A_w + U_t A_g) T_g - h_g A_g T_f - h_{rwg} A_w T_w = S_1 A_g + U_t A_g T_g \quad (1)$$

In the equation (1), the areas of the glass and wall (A_w , A_g) can be directly measured. The variables U_t , S_1 , h_g , and h_{rwg} can be calculated as explained in Appendix A. This leaves T_g , T_w , and T_f to be determined.

4.2.2. Energy balance for air

The energy balance for the air between glass cover and the absorber was written as:

[Convection from absorber] + [convection from glass] = [useful heat gain by the air]

This energy balance can mathematically be expressed as:

Chapter III: Poultry house ventilation by solar chimney

$$[h_w A_w (T_w - T_f)] + [h_g A_g (T_g - T_f)] = [q''] \quad (2)$$

To determine the useful heat gain by air for a short length of wall/absorber (L), the following equation can be used. It assumes that the temperature of the glass (T_g) and the wall (T_w) remains constant across the entire area.

$$q'' = m C_{f1} (T_{fo} - T_{fi}) \quad (3)$$

The mean air temperature can be calculated as:

$$T_f = \gamma T_{fo} + (1 - \gamma) T_{fi} \quad (4)$$

In the aforementioned equation, the value of γ (mean temperature approximation coefficient) was adopted as 0.74, as suggested by Ong and Chow (18). Additionally, following the previous assumption, T_{fi} was considered equal to the room temperature (T_r). Therefore, the equation for the useful heat transferred to the moving air stream can be rephrased in terms of mean and inlet air temperatures as presented below:

$$q'' = \frac{m C_{f1} (T_f - T_r)}{\gamma} \quad (5)$$

Rearranging Eq. (2) and substituting the values of q'' we obtained:

$$\begin{aligned} h_g A_g T_g - \left(\frac{h_g A_g + h_w A_w + m C_{f1}}{\gamma} \right) T_f + h_w A_w T_w \\ = - \left(\frac{m C_{f1}}{\gamma} \right) T_r \end{aligned} \quad (6)$$

In the given equation, constants such as C_{f1} and g are fixed values. The areas A_w and A_g can be directly measured. Variables such as m , h_g , and h_w can be calculated as explained in Appendix B. This leaves T_g , T_w , and T_f to be determined.

4.2.3. Energy balance for absorber

Similar to the energy balances for glass cover and air channel, energy balance for the absorber was written as:

$$\begin{aligned} [\text{Solar radiation}] &= [\text{convection to air in flow channel}] + [\text{long wave re-radiation to glass}] + \\ &[\text{conduction to main room}] \end{aligned}$$

Chapter III: Poultry house ventilation by solar chimney

The above equation was rearranged in the following form:

$$-h_{rwg}A_wT_g - h_wA_wT_f + (h_wA_w + h_{rwg}A_w + U_bA_w)T_w = S_2A_w + U_bA_wT_r \quad (8)$$

In the above equation, A_g , A_w can be measured directly, and h_{rwg} , h_w , U_b , and S_2 can be calculated as discussed in Appendix C, leaving T_g , T_w , and T_f to be determine

5. Calculation of mass flow rate through the chimney

Re-arranging the heat balance equation for three parts, i.e. glass, air and absorber, following simultaneous equations have been obtained:

$$h_gA_g + h_{rwg}A_w + U_tA_g)T_g - h_gA_gT_f - h_{rwg}A_wT_w = S_1A_g + U_tA_gT_g \quad (1)$$

$$h_gA_gT_g - \left(\frac{h_gA_g + h_wA_w + mC_{f1}}{\gamma}\right)T_f + h_wA_wT_w = -\left(\frac{mC_{f1}}{\gamma}\right)T_r \quad (2)$$

$$-h_{rwg}A_wT_g - h_wA_wT_f + (h_wA_w + h_{rwg}A_w + U_bA_w)T_w = S_2A_w + U_bA_wT_r \quad (8)$$

These simultaneous equations were solved for T_g , T_w , and T_f by method of determinants, and the mass flow rate in the chimney for a room with two openings and a uniform room air temperature was determined as:

$$m = C_d \rho_1 A_0 \sqrt{\frac{2gL_s \sin \theta (T_f - T_r)}{(1 + A_r^2)T_r}} \quad (9)$$

In equation (9), A_r represents the ratio of outlet area (A_o) to inlet area (A_i). The coefficient of discharge (C_d) was assigned a value of 0.57, as recommended by(19) . The velocity of air in the flow channel, which is ultimately employed to calculate the mass flow rate through the chimney, can be determined by utilizing the mass flow rate equation provided below:

$$v_0 = \frac{m}{\rho_{f1}A_0} \quad (10)$$

A computer program was developed to conduct a simulation study of a solar chimney at various inclination angles installed in the roof of the poultry of study. The program required important inputs such as the solar radiation intensity, surface azimuth angle, and surface tilt with respect to the horizontal plane. These inputs collectively determined the intensity of normal radiation on an inclined surface. To calculate the air flow rate in the inclined chimney, factors such as latitude, hour angle, declination angle, and were

Chapter III: Poultry house ventilation by solar chimney

considered, following the suggestions of Duffie and Beckmann (19). The theoretical model and program that were developed can be utilized to estimate the mass flow rate through a solar chimney for different combinations of its geometric characteristics, locations, and time.

6. Solution method

In each control volume, the difference method is applied to approximate the air temperature gradient as follows:

$$\frac{dT_f}{dx} \approx \frac{T_{f,i} - T_{f,i-1}}{\Delta x}$$

Substituting this equation into Eq. 4. The above Eqs. (1-10) can be written in a 3x3 matrix form $[A] [T] = [B]$. Where:

$$[A] = \begin{bmatrix} (h_g + h_{rwg} + U_t) & -h_g & -h_{rwg} \\ h_g A_g & -\left(\frac{h_g A_g + h_w A_w + m C_{f1}}{\gamma}\right) & h_w A_w \\ -h_{rwg} & -h_w & (h_w + h_{rwg} + U_b) \end{bmatrix} \begin{bmatrix} T_g \\ T_f \\ T_w \end{bmatrix}$$
$$= \begin{bmatrix} S_1 + U_t T_g \\ -\left(\frac{m C_{f1}}{\gamma}\right) T_r \\ S_2 + U_b T_r \end{bmatrix}$$

The above linear system was solved using the “inv” statement as $T=B*\text{inv}(A)$ for each x coordinate.

To solve the above system, we used the inverse matrix of A $[A^{-1}]$ such that $[A] \times [A^{-1}] \times [T] = [B] \times [A^{-1}]$, in order to calculate the unknown temperatures T_g' , T_w' , and T_f' .

Conclusion:

In this chapter, we conducted an experimental and numerical study on the solar chimney to evaluate the performance of the ventilation system. The aim of this research was to determine the rate of additional efficiency achieved by the experimental system and then verify the credibility of the numerical study. By using the obtained results, we can assess the feasibility of applying this system in different geographical areas and under various climatic conditions.

Chapter IV

Results and discussions

Chapter IV: Results and discussion

Introduction

In this chapter, we present the main results of this thesis. We start with the validation of the developed model, then, we illustrate the required mass flow rate for a poultry operating on its maximum capacity. Basing on this latter, the present chapter study the capability of the solar chimney to provide the required volumetric airflow rate required for the ventilation of the poultry house. Finally, the CO₂ mitigation of the proposed system compared to the classical ventilation system was estimated

1. Validation

The calculation code of the airflow and temperature inlet and outlet of the solar chimney (temperature of glass, temperature of air channel, and temperature of absorber) was validated with the experimental data obtained by our setup realized in the department of renewable Energy University of Ouargla. In addition, the model was also validated against the results of Jyotirmay Mathur et al.(19) From the National Institute of Technology, Jaipur, India.

Table 4.1. Shows the comparison results between our numerical model and our experimental setup as well as the results of Mathur et al. (19)

Table IV. 1: Model Validation

	Radiation (W/m ²)	Ambient temperature (K)	T of glass (K)	T of air channel (K)	T of absorber (K)	Flow velocity (m/S)
Theoretical (19)			333.40	315.80	375.06	0.18
Experimental (19)	750	313	337.29	320.75	361.36	0.22
Present work			319.73	313.62	375.70	0.17
Relative error (present work)			5.21	2.22	3.97	20.72
Relative error Mthur2006			1.15	1.54	3.79	19.99

The results from the table 4.1 demonstrated a significant convergence between our numerical code and the experimental and numerical results. Considering a maximum relative error of around 4% in terms of temperatures and 20% in terms of air velocity. Despite this, it can be stated that our numerical code has been validated and can be introduced and improved in future research endeavors.

2. Ventilation rate needs of the poultry house:

In this section of this chapter, we will focus on the design and operation of a poultry house, considering various parametric variables that significantly impact its functionality and the well-being of the birds. These parametric variables include:

Table IV. 2: The specific characteristics used in Al-Hajjah Al-Tijani Farm

Poultry house Length (m)	120
Poultry house Width (m)	14
Poultry house Height (m)	5
Poultry house capacity	17000

Figure IV.1. the evolution of the required volumetric flow rate as function of bird's number. It is noted that the poultry house needs to be ventilated according to the number of chickens present in the house. The greater the number of chickens in the house, the more ventilation must be increased for the safety of chickens and can reach 51000 m³/h. This last value will be used as an extreme air volumetric flow rate of the studied poultry house. Consequently, the relationship between the number of chickens and ventilation is a direct relationship.

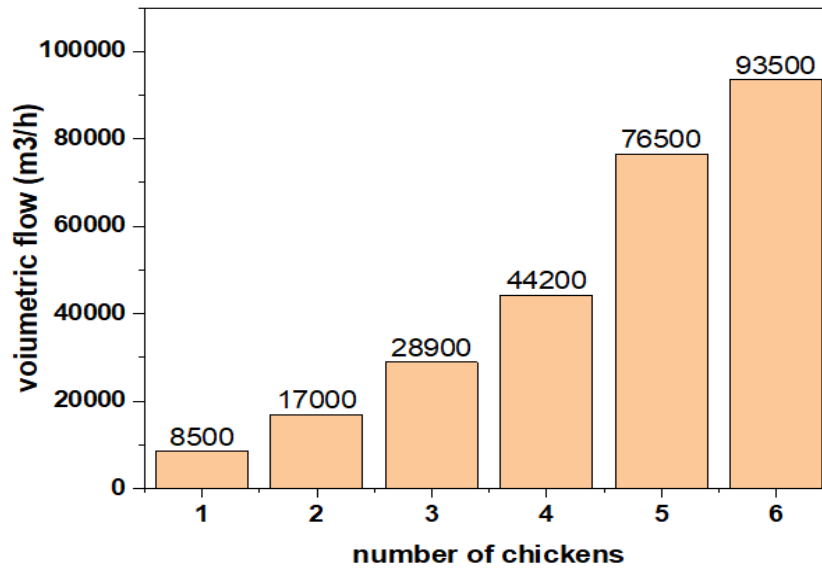


Figure IV. 1: The required ventilation rate according to the number of chickens

Figure IV.2. Illustrates the evolution of the required air volumetric flow rate as a function of one bird age. According to **Figure IV.2.**, air requirements for chickens increase with the weeks of bird growth. Chickens need ventilation in the first week much less compared to the last week. That is, the system must provide the appropriate amount of air for each stage of growth. For that, the study presented graphical results of figures 5.2 and 5.3 makes it possible to determine the maximum air volumetric flow rate of the solar chimney to be used to provide the maximum air flow in the poultry which corresponds to the chickens number and in each week according to the growth of chickens.

To ensure optimum comfort conditions the ventilation system needs to provide in the extreme cases, the airflow requirements for ventilating the poultry house based on the recommended internal conditions.

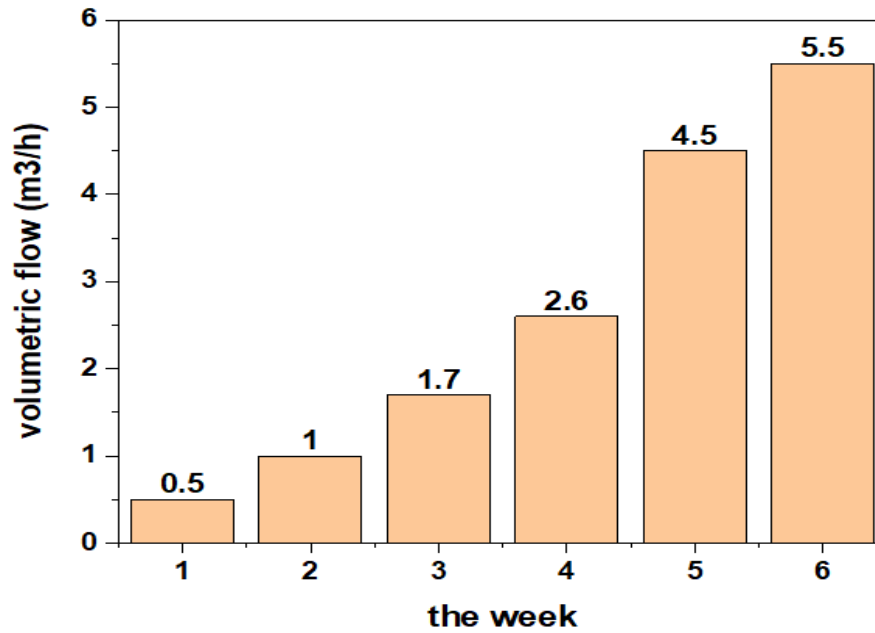


Figure IV. 2: Lowest ventilation rate needed on depending the weeks of growth of the chicken.

Characteristics of the solar chimney on which the study was conducted :

- The Length 120 (m)
- The Width 7.6 (m)
- The inclination of the chimney 60°

Figure IV.3. Describes the effect of the gap between absorber and glass of the solar chimney on the volumetric flow of air in the poultry house. It is observed that the gap between the glass and the absorber plate in a solar chimney plays a significant role in the efficiency of the solar chimney and the volumetric airflow rate. We observe a change in the airflow rate with a change in the gap length between the glass and the absorber. The flow rate is better at a gap length of 0.5 between the glass and the absorber than at 0.1, with a 30% improvement. Therefore, we have chosen a gap length of 0.5 between the glass and the absorber for use in this study.

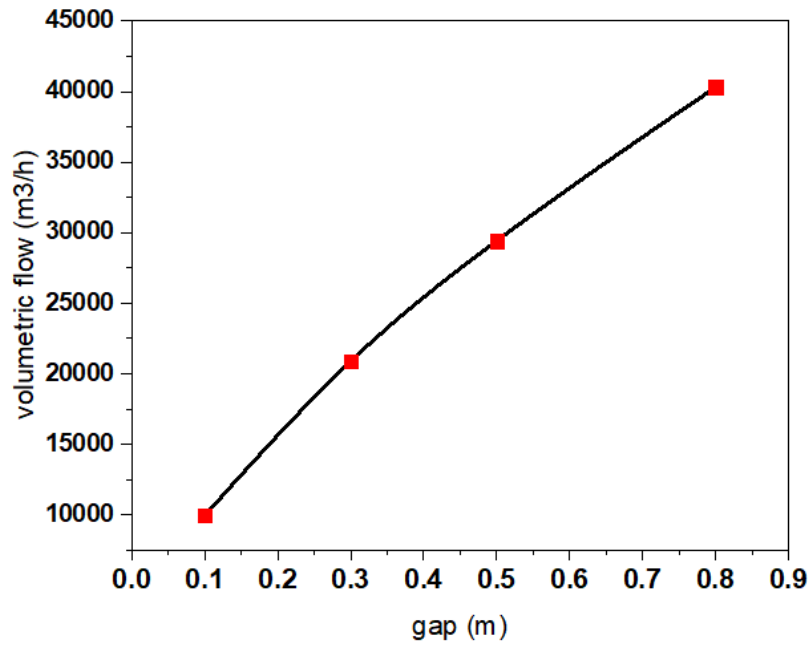


Figure IV. 3: Effect of the gap between absorber and glass of the solar chimney on the volumetric flow of air in the poultry house.

Characteristics of the solar chimney on which the study was conducted :

- The Length 120 (m)
- The Width 7.6 (m)
- The gap between absorber and glass 0.5(m)

Figure IV.4. Shows the effect of the inclination angle of the solar chimney on the volumetric flow of air on poultry house. Results indicate that the tilt angle of the solar chimney plays a significant role in the efficiency of the solar chimney and the volumetric airflow rate. When the solar chimney is tilted at an angle of 60%, the airflow rate is better than when the solar chimney is tilted at an angle of 30%. This gives us the best position for the solar chimney according to the 60- degree angle, which provides us with good volumetric flow.

Chapter IV: Results and discussion

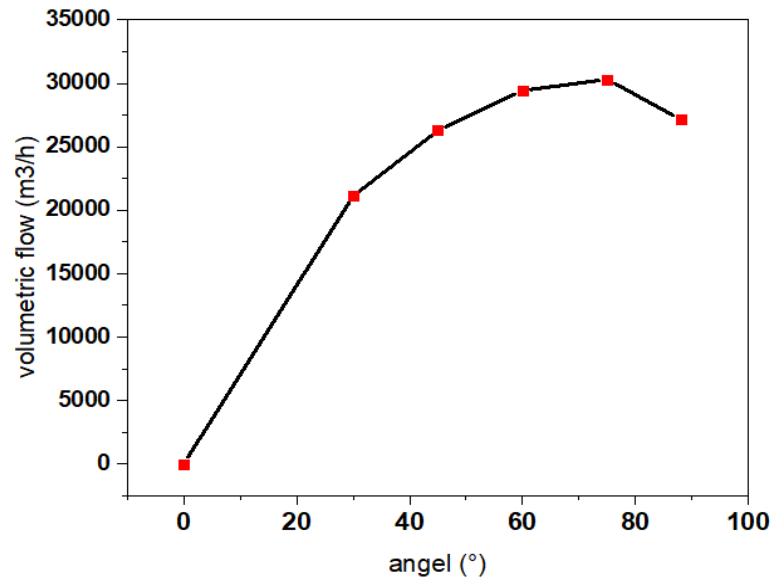


Figure IV. 4: Effect of the inclination angle of the solar chimney on the volumetric flow of air on poultry house.

Characteristics of the solar chimney on which the study was conducted :

- The Length 120 (m)
- The inclination of the chimney 60°
- The gap between absorber and glass 0.5(m)

Figure IV.5. Displays the effect of the length of the solar chimney on the volumetric flow of air on poultry house. It is observed that the length of the solar chimney plays a significant role in the efficiency of the solar chimney and the volumetric airflow rate. When 7.6 m is taken as the length of the solar chimney, the airflow rate is better than when the width of the solar chimney is 3 m. From the curve of figure 5.5, we see that as the width of the solar chimney that we will install increases, the volumetric airflow rate increases. Therefore, we have chosen a length of 7.6 m for the solar chimney to be used in this study.

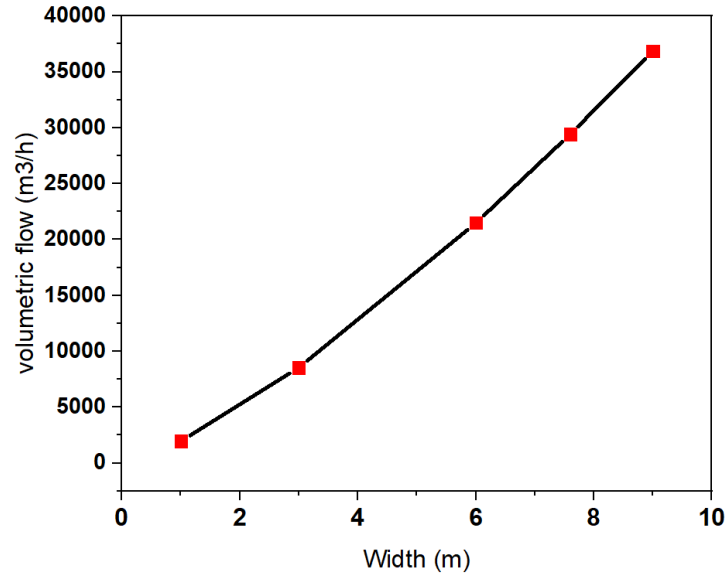


Figure IV. 5: Effect of the width of the solar chimney on the volumetric flow of air on poultry house.

Characteristics of the solar chimney on which the study was conducted :

- the Length 120 (m)
- the Width 7.6 (m)
- The inclination of the chimney 60°
- the gap between absorber and glass 0.5(m)

Figure IV.6. Presents the effect of the solar radiation of the solar chimney on the volumetric flow of air on poultry house. We observe that the solar radiation incident on the solar chimney plays a significant role in the efficiency of the solar chimney and the volumetric airflow rate. When the solar radiation is $1000 \text{ (W/m}^2\text{)}$, we obtain a better airflow rate than when the solar radiation is $600 \text{ (W/m}^2\text{)}$. From the curve, we see that as the solar radiation incident on the solar chimney increases, the volumetric airflow rate increases.

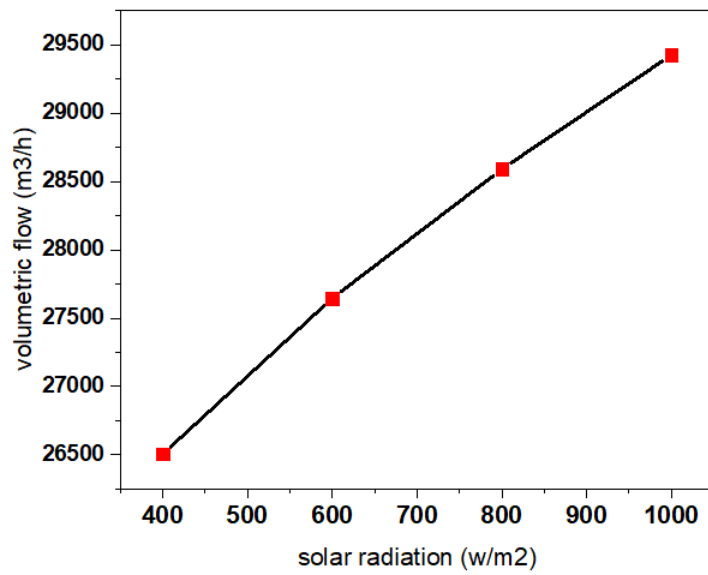


Figure IV. 6: Effect of the solar radiation of the solar chimney on the volumetric flow of air on poultry house.

Figure IV.7. Shows the CO₂ emissions of the classical poultry building (in blue) compared to mitigation of the CO₂ of poultry building equipped by solar chimney on its roof. It is noteworthy to mention the extent to which the solar chimney reduces CO₂ emissions, which have adverse effects on the environment. The solar chimney system was able to reduce CO₂ emissions by 85% on hot days. Additionally, the solar chimney system was able to reduce CO₂ emissions by 88% on cold days.

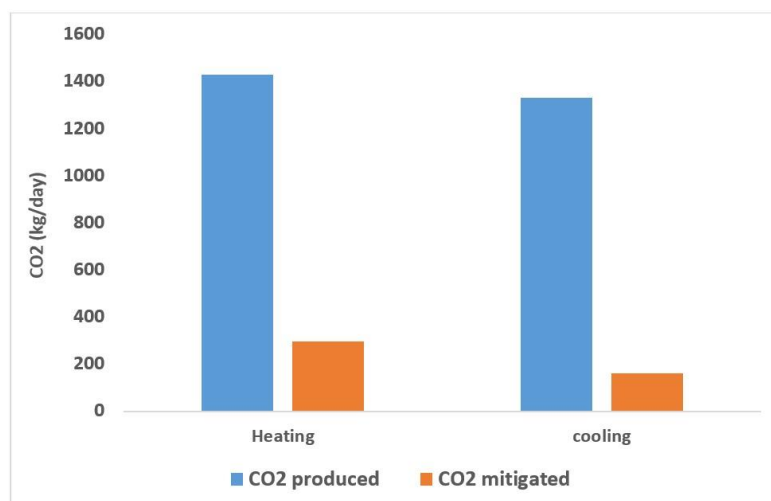


Figure IV. 7: The emissions and mitigation of the CO₂.

Chapter IV: Results and discussion

Characteristics of chimney solar of case study

Width (m)	Length (m)	Gap (m)	The inclination of the chimney	number of chickens
7.6	120	0.5	60	17000

Conclusion

Based on the results obtained in this chapter, there are many variables that can be modified during the design of the solar chimney. Depending on the conditions in which we worked in the Ouargla region, we found that these measurements are optimal for designing a highly efficient solar chimney.

General Conclusion

General conclusion

It is clear that renewable energy will have a greater presence in the future due to its multiple characteristics in terms of cost, simplicity, and abundance that it will impose on traditional energy sources. The Algerian Sahara is among the most picturesque places in the world where the annual global sunshine is at its peak. A solar chimney is a very simple system that does not require great technology to build; all of its components are very simple and inexpensive. Solar chimneys are a modern way to ventilate buildings without causing a polluting effect on the environment and without relying on fossil fuels or temporary energy sources. Several studies have been conducted to develop this technology. For that, the present thesis studied the passive ventilation of an industrial poultry house by solar chimney; the research aims to evaluate the efficiency of the solar chimney in achieving passive ventilation of industrial poultry house and to determine whether the system can meet the minimum ventilation requirements necessary to provide a suitable environment for the chickens in the building. The experimental study conducted at the University of Ouargla contributes to assessing the effectiveness of the solar chimney in ventilating industrial buildings. The main objective of our study was to investigate the possibility of achieving a ventilation rate that meets the needs of chickens in a chicken house.

The ventilation requirements for a poultry house with a capacity of 17,000 chickens were calculated at the Al-Hajjah Al-Tijani (ELBAYAT) farm located in the Ouargla region of Algeria.

The maximum ventilation needs of the poultry house were calculated for extreme winter working conditions, which correspond to the maximum outdoor conditions (the coldest day) and maximum indoor conditions related to the age of the chickens (ventilation needs are less in the first weeks). The maximum ventilation requirements were also calculated for extreme summer working conditions, which correspond to the maximum outdoor conditions (the hottest day) and maximum indoor conditions related to the age of the chickens (ventilation needs are greatest in the recent weeks).

To conduct this study, detailed meteorological and geographical information of the area, as well as internal and external information of the building, its structure, and its area were collected.

After calculating the ventilation needs of the chicken coop, a solar chimney was designed to cover part of this demand.

General Conclusion

The effect of the inclination of the solar chimney, its length, solar radiation and other parameters were studied to define the main characteristics of the system to be installed.

- The results of the parametric study also showed that it is better to have a solar chimney of 120 m of width (full length of the poultry), 7.6 m of length, inclination of 60° and a gap of 0.5 m, depending on the amount of air required for the chickens.
- Using the design parameters selected in a typical poultry house and under specific climatic conditions, the performance of the solar chimney showed that the poultry house could be ventilated during both hot and cold seasons.
- Another benefit of using a solar chimney is its positive environmental impact. The system can reduce greenhouse gas emissions by about 162 (kg) carbon dioxide per day during cold seasons and about 297 (kg) of carbon dioxide per day during hot seasons.

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Abstract:

The objective of this study is to evaluate the performance of passive ventilation in an industrial poultry house by utilizing a solar chimney. ELBAYAT poultry house was taken as a case study in the region of Ain beida Ouargla (Algeria). A numerical model of an inclined solar chimney is developed using MATLAB to perform a parametric study on the proposed system's performance. In addition, a solar chimney small-scale prototype installed in the Department of Renewable is used to validate the developed model. The study focuses on examining various parameters and their effects on the airflow within the building. These parameters include the gap between the absorber and the glass, the angle of the chimney, and the length of the chimney. The airflow is analyzed to determine the system's efficiency in providing adequate ventilation for the poultry house. Experimental measurements are conducted and compared with the model's predictions to validate the accuracy of the numerical model. The comparison helps assess the reliability of the model and its ability to accurately represent the real-world performance of the passive ventilation system. By combining experimental measurements and numerical simulations, this study provides valuable insights into the effectiveness of the solar chimney as a passive ventilation solution for industrial poultry houses. The findings contribute to the knowledge and understanding of renewable energy applications in the agricultural sector, specifically in optimizing ventilation systems for improved poultry house environments.

Keywords: passive ventilation, solar chimney, industrial poultry house, renewable energy, numerical model.

Résumé:

L'objectif de cette étude est d'évaluer les performances de la ventilation passive dans un poulailler industriel en utilisant une cheminée solaire. Le poulailler ELBAYAT a été pris comme cas d'étude dans la région d'Ain beida Ouargla (Algérie). Un modèle numérique d'une cheminée solaire inclinée est développé à l'aide de MATLAB pour réaliser une étude paramétrique sur les performances du système proposé. De plus, un prototype de cheminée solaire à petite échelle installé au Département des énergies renouvelables est utilisé pour valider le modèle développé. L'étude se concentre sur l'examen de divers paramètres et de leurs effets sur le flux d'air à l'intérieur du bâtiment. Ces paramètres incluent l'écart entre l'absorbeur et le verre, l'angle de la cheminée et la longueur de la cheminée. Le débit d'air est analysé pour déterminer l'efficacité du système à assurer une ventilation adéquate du poulailler. Des mesures expérimentales sont effectuées et comparées aux prédictions du modèle pour valider l'exactitude du modèle numérique. La comparaison permet d'évaluer la fiabilité du modèle et sa capacité à représenter avec précision les performances réelles du système de ventilation passive. En combinant mesures expérimentales et simulations numériques, cette étude fournit des informations précieuses sur l'efficacité de la cheminée solaire en tant que solution de ventilation passive pour les poulaillers industriels. Les résultats contribuent à la connaissance et à la compréhension des applications des énergies renouvelables dans le secteur agricole, en particulier dans l'optimisation des systèmes de ventilation pour améliorer l'environnement des poulaillers.

Mots clés : ventilation passive, cheminée solaire, poulailler industriel, énergie renouvelable, modèle numérique.

الملخص

الهدف من هذه الدراسة هو تقييم أداء التهوية السلبية في مزرعة دواجن صناعية باستخدام مدخنة شمسية. تم إجراء الإعداد التجريبي في "حظيرة دواجن البيات"، مع إجراء التقييم في قسم الطاقة المتجددة بجامعة ورقلة. بالإضافة إلى ذلك، تم تطوير نموذج رقمي باستخدام برنامج "الماتلاب" لإجراء دراسة عددية على أداء النظام المقترح. تركز الدراسة على فحص العوامل المختلفة وتأثيراتها على تدفق الهواء داخل المبنى. تتضمن هذه المعلمات الفجوة بين الماص والزجاج وزاوية المدخنة وطول المدخنة. يتم تحليل تدفق الهواء لتحديد كفاءة النظام في توفير تهوية مناسبة لبيت الدواجن. للتحقق من دقة النموذج العددي، يتم إجراء القياسات التجريبية ومقارنتها مع تنبؤات النموذج. تساعد المقارنة في تقييم موثوقية النموذج وقدرته على تمثيل الأداء الواقعي لنظام التهوية السلبية بدقة. من خلال الجمع بين القياسات التجريبية والمحاكاة العددية، توفر هذه الدراسة رؤى قيمة حول فعالية المدخنة الشمسية كحل تهوية سلبية لمنازل الدواجن الصناعية. تساهم النتائج في معرفة وفهم تطبيقات الطاقة المتجددة في القطاع الزراعي، وتحديداً في تحسين أنظمة التهوية لتحسين بيوت الدواجن.

الكلمات المفتاحية: تهوية سلبية، مدخنة شمسية، بيت دواجن صناعي، طاقة متجددة، نموذج رقمي، تدفق هواء، دراسة بارامترية، تحقق تجريبي.