TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK ENGINEERING CAMPUS

PULCHOWK, LALITPUR

INDUSTRIAL ATTACHMENT AT GREEN TECH NEPAL PVT. LTD.

SUBMITTED BY:

BIBEK SHRESTHA (076BME004)

BIPIN K.C. (076BME006)

SUBMITTED TO:

THE DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR BACHELOR DEGREE IN MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

LALITPUR, NEPAL

December, 2023

LETTER OF APPROVAL

Kiran Kumar Rauniyar

Production Engineer

Green Tech Nepal Pvt. Ltd,

Jwagal, Lalitpur

Subject: Approval of Internship Completion Report

Dear Sir,

We hope this letter finds you well. We are writing to inform you that we have completed our internship at Green Tech Nepal Pvt. Ltd., and our internship completion report is ready for submission as part of the requirements for Bachelor Degree in Mechanical Engineering. We would like to express our sincere gratitude for your guidance and support throughout the internship. Your insights and mentorship have been valuable in shaping our learning experience. We have attached a copy of the internship completion report for your review. Upon your approval, we will proceed with the submission to fulfill the academic requirements.

If you have any feedback or suggestions, please feel free to let us know. We are open to incorporating any recommendations to enhance the quality of the report.

Thank you once again for your time and support.

Approved By: Sincerely,

……………………………. Bibek Shrestha (076BME004)

Er. Kiran Kumar Rauniyar Bipin K.C. (076BME006)

Production Engineer

ABSTRACT

The following report is a summary of all the technical and managerial concepts we gained during our one-month internship at Green Tech Nepal Pvt. Ltd, Lalitpur. This report includes the background of the company, background and objective of the internship as well as the assignments we did in the company as an Engineering Intern. This report specifically includes the design of heat pump dryer system for mushroom drying. This report could be useful to students, academicians or researches.

ACKNOWLEDGEMENT

First of all, we would like to express my deepest gratitude to the Department of Mechanical and Aerospace Engineering, IOE, Pulchowk Campus, Lalitpur, for providing us with the opportunity to learn the industrial applications of Mechanical engineering with a provision of industrial attachment.

Similarly, we would like to thank the Head of Department, **Dr. Sudip Bhattarai** sir, for facilitating this growth opportunity. We would also like to thank **Er. Lakshman Motra** sir, Deputy Head of Department, for his noble support and guidance for the industrial attachment. We would also like to thank **Er. Vishwaprasanna Amatya** sir, for his counsel and guidance during the internship. We would also like to thank **Ms. Yasoda Adhikari**, Mechanical Department administrator, for helping with formal procedures involving the internship.

We are deeply indebted to Green Tech Nepal Pvt. Ltd. for providing us an internship opportunity for a month. We express our sincere thanks to **Er. Kiran Rauniyar** sir, for his continuous supervision, counsel and guidance during the internship. Similarly, we would like to thank **Er. Roshan Gautam** sir, for his supervision of our work during the internship. We are thankful to all the members and staffs for their help and supervision during our internship.

Finally, we would also like to extend our thanks to all our friends and seniors who helped us with their valuable suggestions during internship and also during the report preparation.

Bibek Shrestha (076BME004)
Bipin K.C. (076BME006)

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LIST OF ABBREVIATIONS

PAN	Permanent Account Number
MEP	Mechanical Electrical and Plumbing
BPF	By Pass Factor
COP	Coefficient of Performance
HFC	Hydrofluorocarbon
R134a	Refrigerant 134a
GWP	Global Warming Potential
SAHP	Solar Assisted Heat Pump
RH	Relative Humidity
HPD	Heat Pump Dryer
ADC	Analog to Digital Converter
MEMS	Micro Electromechanical System

Chapter: 1 INTRODUCTION

1.1 Company Background

Green Tech Nepal P. Ltd. has been established by the effort of energetic, dedicated and qualified professionals from the field of mechanical engineering and civil engineering. The company is operated and managed by a broad spectrum of expertise working in different sectors of research and development, Infrastructure technology, ropeway technology, energy and engineering. The company has got human resources and facility to cater the present need of esteemed customers in field of engineering works related to Design, Fabrication and Installation of Steel Structures. The company has also developed its expertise to provide services in Hydro-mechanical Fabrication and Ropeway projects.

The main objective of the company is to offer to valuable customers a special integrated system accepting the accountability in terms of quality at every stage of production and services rendered.

In the hydropower sector, in addition to the manufacturing services, the company also aims to provide the services like survey, design, estimation, supply and installation of min/micro hydro power projects equipment. With the special experiences of the Founding Members in Ropeway Technology, the company intends to provide its manufacturing and Installation services in the field of Ropeway Projects too.

1.2 Scope of Internship

The scope of work for the internship encompassed a comprehensive exploration of the design and fabrication of a food drying system utilizing a heat pump. The undertaken tasks were diverse and targeted key areas in the project's development. Initial efforts were dedicated to extensive research on various food drying methods, allowing for a nuanced understanding of the principles governing effective dehydration. Subsequently, a thorough study of refrigeration system principles provided a solid foundation for the design phase. The internship also involved meticulous heat and cold load calculations, ensuring precise control over temperature conditions during the drying process. Psychometric chart analysis played a pivotal role in optimizing the system's efficiency. Leveraging advanced technology, 3D design and modeling were employed for experimental calculations, allowing for a visual representation and validation of the proposed system. Additionally, a market analysis was conducted to gauge the experimental values in comparison to existing solutions, providing valuable insights into the system's potential impact in real-world applications. The scope of work collectively aimed at contributing to the advancement of food drying technology while fostering a holistic understanding of the interdisciplinary aspects involved in the project.

1.3 Objectives of Internship

1.3.1 Main objective

To undertake an internship at Green Tech Nepal Pvt. Ltd and get technical and managerial insights of a research and development industry.

1.3.2 Specific objectives

1. To understand how the company functions.
2. To design and fabricate a Heat Pump Drying System.
3. To get knowledge about the Heat pump System and analysis software and tools like SolidWorks, HVAC Solution, Duct Resizer for design

1.4 Limitations of Internship

1. Unable to participate to fabrication of systems due to time limitation.
2. Detailed information about the organizational structure and industrial work flow could not be collected since the company is at its research and development phase.
3. Results alone cannot be verified analytically, Experimental setup is required.

Chapter: 2 ORGANIZATION AND MANAGERIAL ASPECTS

2.1 Company Profile:

Company Registration		
1	Registration No.	56950/065/066
2	Registration Authority	Office of Company Registrar, Ministry of Industry, Commerce and Supplies
3	Date of Registration	2065/7/26 (22 October 2008)
4	Type of Company	Private Limited Company
5	Registered Address	Madhyapur Thimi Municipality, Ward No. 4, Bhaktapur District
Industry Registration		
6	Registration No.	12004/1265
7	Registration Authority	Office of Cottage and Small Industry, Ministry of Industry
8	Date of Registration	2069/3/20 (4 July 2012)
9	Registered Address	Satungal, Chandragiri Municipality, Kathmandu District
Income Tax Registration (PAN Registration)		
10	PAN Registration No.	303207465
11	Registration Authority	Inland Revenue Office, Bhaktapur
12	Date of Registration	2065/8/16 (1 December 2008)
13	Current Address (Factory)	Satungal, Chandragiri Municipality, Kathmandu District
14	Current Address (Office)	Jwagal, Kupandole, Lalitpur
15	Contact Details	Tel. : +977-1-5546859 Fax: +977-1-5011213 Email:gtechnepal@gmail.com, info@greentech.com.np
16	Capital Structure	Authorized Capital: Rs. 10,000,000.00 Issued Capital: Rs. 10,000,000.00 Paid up Capital: Rs. 4,000,000.00
17	Objectives of Company	- Construction of Civil, MEP and Mechanical Structures. - Manufacturing, fabrication and installation of Steel Structure Buildings, Truss, Bridges, etc. to Government and Non-Government Organizations.

		- Manufacturing, fabrication and Installation of electro-mechanical parts, components and machines related to renewable energy technologies such as hydro energy, solar energy, wind energy, etc. - Survey, design and feasibility study of renewable energy projects. - Survey, design and feasibility study of aerial goods ropeways. - Improvise traditional tuins, ghirlings and ropeways to transform into modern systems and technical standards. - Manufacturing, fabrication and installation of steel structures such as telecom towers, overhead transmission towers, truss and bridges. - Installation, Repair and Maintenance of industrial type Electro-Mechanical systems. - Buy and sell of fabricated parts/components/machineries within the scope of works of the company. - Involve in design and development works on rural infrastructure development technologies.
18	Banker	Nabil Bank Ltd.

Table 2-1: Company profile

2.2 Organizational Structure:

The organizational structure of the company is of horizontal type. It's organizational structure can be presented as:

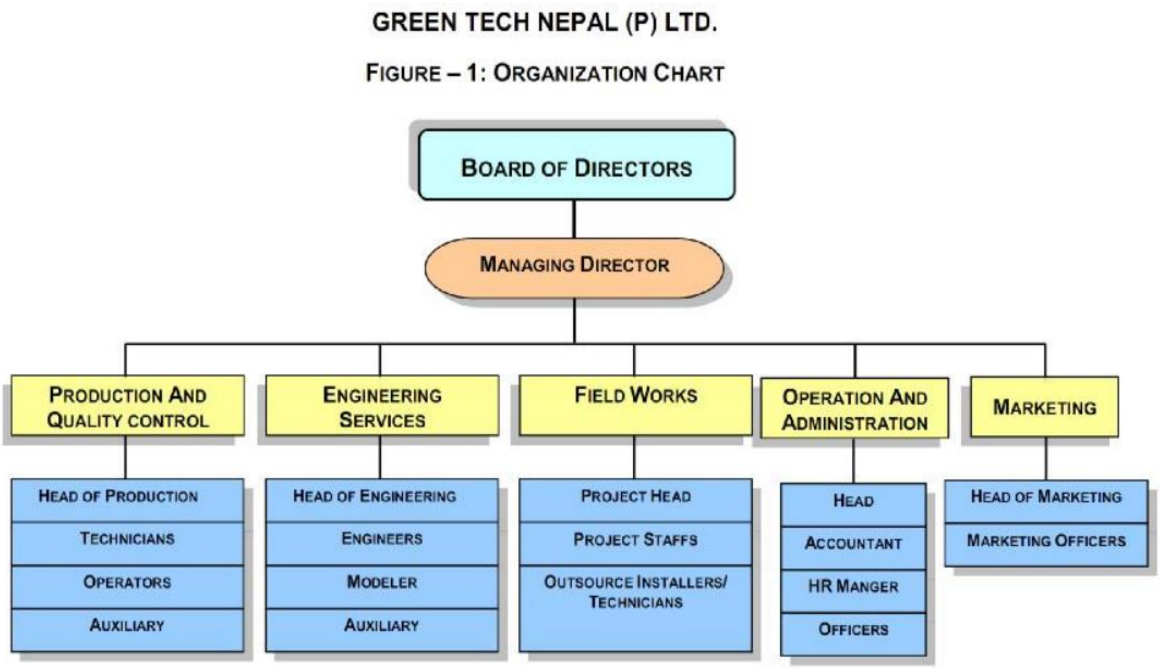


Figure 2-1: Organizational Structure

Organization Chart presented above depicts the departments that is under the operation inside the Green Tech Nepal. In addition to above chart, one system exist here which incorporates involvement of an individual into multiple departments.

Advantages:

- Positive energy towards Research and Development.
- Direct Feedback System.
- Friendly relationship between employees.

Disadvantages:

- For larger organization, workload increases for manager.
- Organizational Structure is unsystematically organized.

2.3 Areas of Expertise:

Green Tech Nepal Pvt. Ltd. was established to provide its engineering and manufacturing services mainly to the hydro power sector. From the inception of the company, it has commissioned numerous small scale hydropower projects and their sub-components. After completing its 5 years of golden and energetic period in providing services in hydro power sector, the board of the company has decided to expand its business to one step further by looking for the opportunities in other sectors as well. The company then started marketing its services within the vicinity of the previously conducted business area, and found various potential sectors such as solar industry by providing manufacturing service of the solar supporting structure, repair and maintenance of hydro power plant equipment, consulting services on specialized tasks and products development, R&D and product development based on the client requirement, material ropeways for the construction sectors, etc.

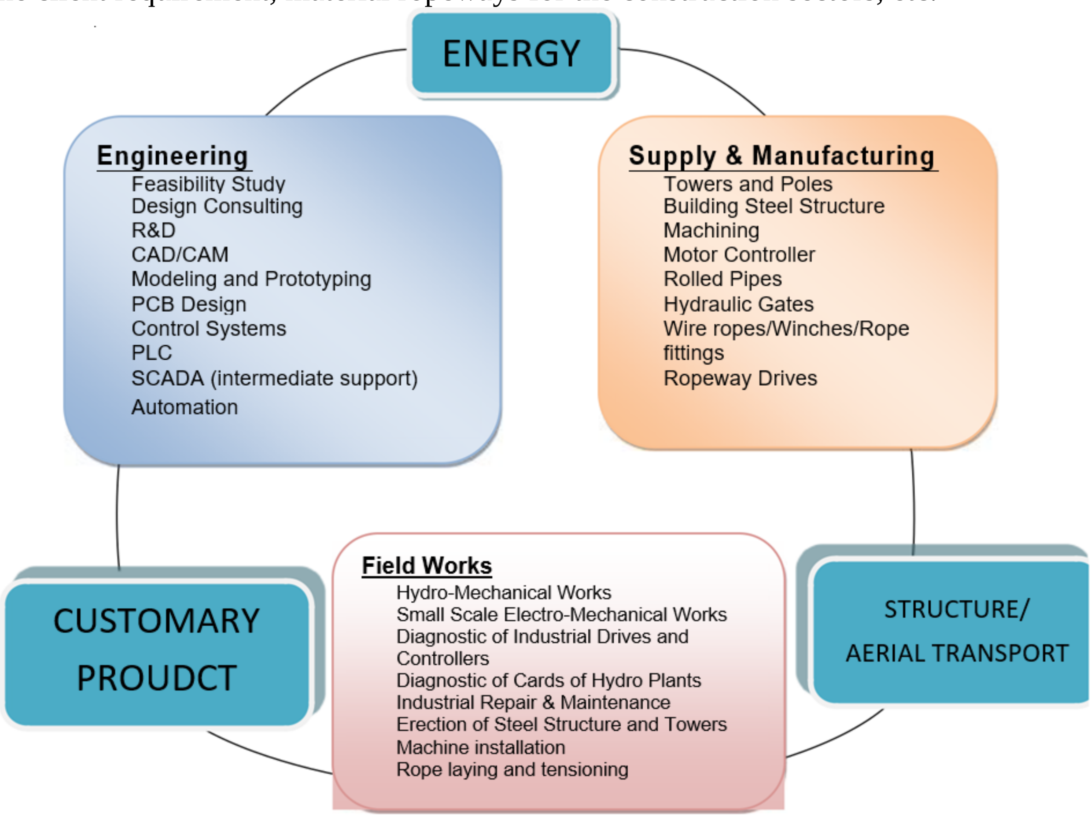


Figure 2-2: Area of Expertise

The company has now resources to deliver its sustainable services of engineering, supply & manufacturing and field works in the sectors of energy, customary product development and aerial transportation system.

2.4 Human resources:

The human resources of the company are from different field like management, civil engineering, electrical engineering, mechanical engineering and electro-mechanical installation technician. The company is producing some new human resources as on the job training facilities to non experience persons. The managing director heads the company and run as per the company's rules and regulations. Further, all the major decisions are made with the approval from director level to executing level, however others decisions in management level are made as per the board meetings’ decisions. The engineers are responsible for the whole technical issues and electromechanical technicians are given responsibilities of work execution at field level. The company appoints experts and others as per requirement in special cases.

2.4.1 Key Personnel

S.N.	Name	Key Qualifications	Expert	Experience	Position
1	Kiran Kumar Rauniyar	· B.E. Mechanical Engineering · Electro Mechanical Design Training, AHEC, Roorkee	· Hydro-mechanical components design · Expert in manufacturing processes · Design of steel structures · Ropeway projects	12 years	Production Engineer
2	Krishna Nakarmi	· Head Supervisor, BYS, Balaju (2030-2050 B.S.) · Research works on T15 Cross Flow turbine development in BYS	· Research and Development on Cross Flow turbines · Design and development of Pelton Turbines	>30 years	Managing Director

Table 2-2: Key personnel

2.4.2 List of Technical Manpower

S.N.	Name	Qualification	Training	Experience	Position
1	Ashish Ghimire	Mechanical Engineer (Fabrication and Erection Expert)	Weld Test (NDT)	10 years	Production Engineer
2	Ganesh Ram Sinkemana	Mechanical Engineer (Rigging and Material Handling Expert)	Ropeway Installation	15 years	Erection Engineer
3	Lok Nath Chalise	Vocational Training in Mechanical (4 years)	NHE, Mechanics	10 Years	Production Sub-Engineer
4	Kamal Devkota	Overseer, Mechanical, Balaju Technical Institute	Balaju Technicial Institute	8 Years	Worksop Supervision cum Machinist
5	Resham Lama	Diploma in Mechanical Engineering, WRC, Pokhara		5 Years	Asst-Supervisior
6	Nabin Chaudhary	Diploma in Computer, WRC, Pokhara		8 Years	Electrical Technician
7	Ashok Nakarmi	Under SLC		12 Years	Welder cum Fabricator

8	Binod Chaudhari	Under SLC		5 Years	Helper
9	Krishna Jha	Under SLC		5 Years	Helper

Table 2-3: Technical Manpower

2.5 Quality assurance information

The company has realized that the assurance of quality of total work i.e. output product in a multitasked holder and multi-dimensional administration system is a difficult task. Hydropower and Ropeways being long run projects, client reporting and flow of critical information to various execution levels is a must for quality assurance in broad framework.

Various guideline and standards from government and international agencies are the basic requirement for the quality assurance. The company has developed a system for internal quality assurances like documentation on completed work and reporting to the respective in charge from site for necessary correspondences in written form. The company has also a system of recording completed work and work to be done in a plan way in weekly base with the client dual signature.

The quality depends up on every stages of work like, the survey design, product/equipment, delivery/transportation, installation, local material, workmanship, operation and maintenance. Moreover to make assure the quality of our components to the client the company will give one year warranty against the manufacturing defect of our mechanical components after the official testing and commissioning of the projects.

The company had not obtained so far any such certificate like ISO or others but the services so far provided by the company is a basis to judge the quality assurances of the company.

Chapter: 3 INTERNSHIP ASSIGNMENT

During the one month of internship at Green Tech Nepal, tasks were assigned to us as presented in the Gantt chart. We did activities like research, design calculation, CAD design, etc. Our works were mostly focused on Designing of mushroom drying machine based on heat pump system.

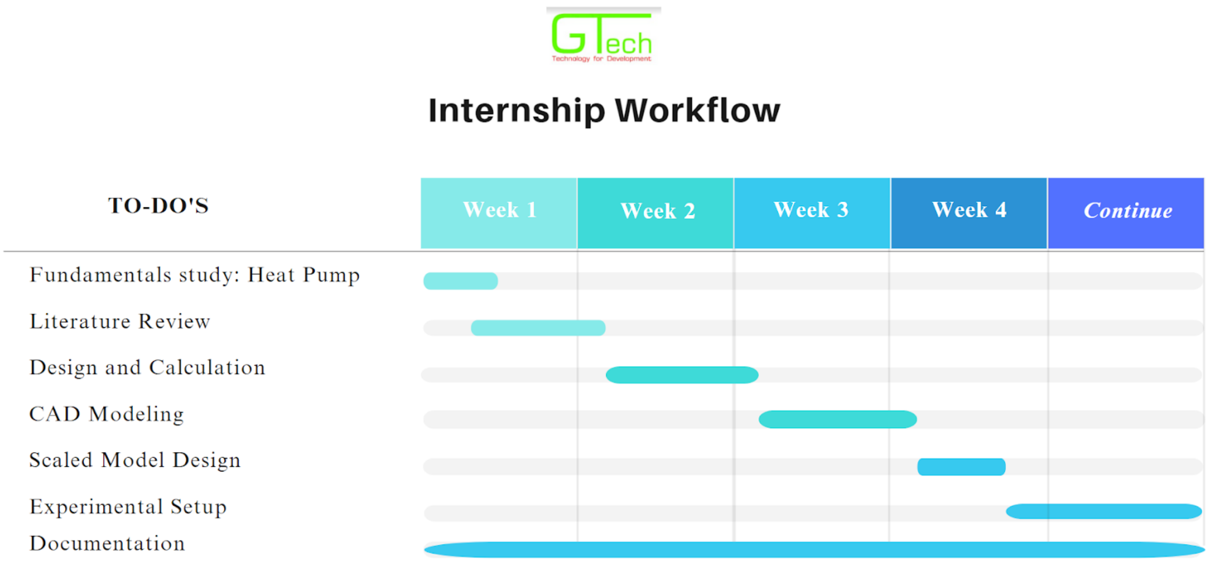


Figure 3-1: Internship Assignment

3.1 Fundamentals Study

3.1.1 Food Drying System:

A food drying system is a method or set of processes designed to remove moisture from food, thereby extending its shelf life by inhibiting the growth of microorganisms and preventing spoilage. Various techniques and technologies are employed in food drying systems, each catering to different types of food and specific requirements. Here's a general overview of a food drying system:

3.1.2 Types of drying system:

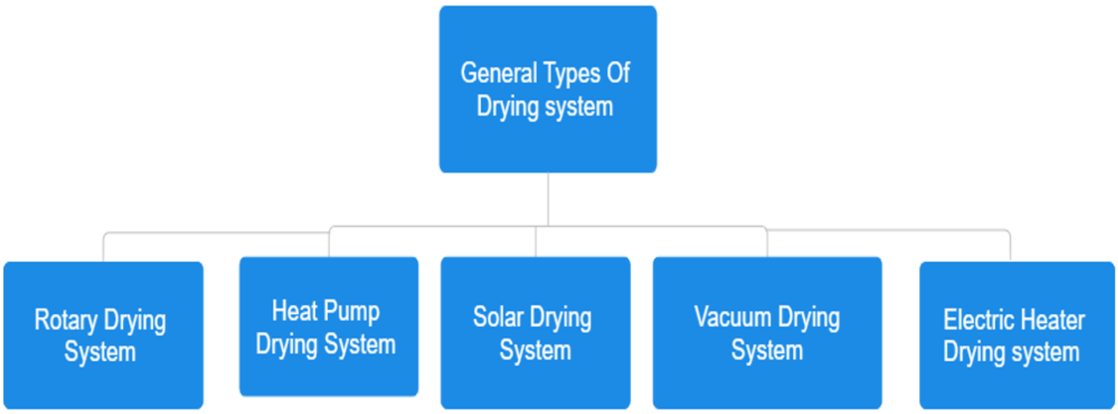


Figure 3-2: Types of drying system

Heat pump drying systems are often considered advantageous over other method for several reasons, making them a popular choice in various drying applications. Here are some reasons why a heat pump drying system might be considered the best in certain situations:

- Energy Efficiency:
  Heat pump drying systems are known for their high energy efficiency. They utilize the principles of thermodynamics to extract heat from the surrounding air or waste heat from other processes. This results in lower energy consumption compared to conventional drying methods.

- Low Operating Costs:
  Due to their energy efficiency, heat pump drying systems can lead to lower operating costs over time. This can be particularly beneficial in commercial and industrial settings where energy expenses are a significant factor.

- Environmental Friendliness:
  The reduced energy consumption of heat pump drying systems contributes to lower greenhouse gas emissions, making them more environmentally friendly compared to some traditional drying methods.

- Temperature and Humidity Control:
  Heat pump drying systems allow precise control over temperature and humidity levels during the drying process. This control is crucial for preserving the quality, color, and nutritional value of the dried products.

- Versatility:
  Heat pump drying systems can be used for a wide range of products, including fruits, vegetables, herbs, and even certain industrial materials. The flexibility and adaptability of heat pump technology make it suitable for various applications.

- Quality Retention:
  The gentle and controlled drying process of heat pump systems helps retain the quality, flavor, and nutritional content of the dried products. This is especially important in food processing applications.

- Reduced Drying Time:
  In some cases, heat pump drying systems can reduce the overall drying time, leading to increased production efficiency and throughput.

- Adaptability to Low-Temperature Drying:
  Heat pump drying systems can operate efficiently at lower temperatures, which is beneficial for drying heat-sensitive materials without compromising product quality.

While heat pump drying systems offer several advantages, it's essential to note that their effectiveness depends on the specific application and requirements. The initial investment cost and system design considerations should also be taken into account when evaluating the suitability of a heat pump drying system for a particular situation.

3.1.3 Heat Pump Fundamentals

A heat pump is a device that transfers heat from a low-temperature source to a high-temperature sink. Heat pumps are used for heating, cooling, and water heating. They are more efficient than traditional heating and cooling systems because they do not create heat, they only transfer it.

Evaporation (Absorption of Heat):
The heat pump begins by evaporating a refrigerant, typically a fluid with a low boiling point. This occurs in an evaporator coil or heat exchanger located in the area where heat is to be absorbed (e.g., inside a building for heating or outdoors for cooling).

Compression (Increase in Temperature and Pressure):
The vaporized refrigerant is then compressed by a compressor. As the refrigerant is compressed, its temperature and pressure increase significantly. This process transforms the low-pressure, low-temperature vapor into a high-pressure, high-temperature gas.

Condensation (Release of Heat):
The high-pressure, high-temperature gas then flows through a condenser coil or heat exchanger in the location where heat is to be released (e.g., inside a building for cooling or outdoors for heating). During this phase, the refrigerant releases heat to the surrounding environment, causing it to condense into a high-pressure liquid.

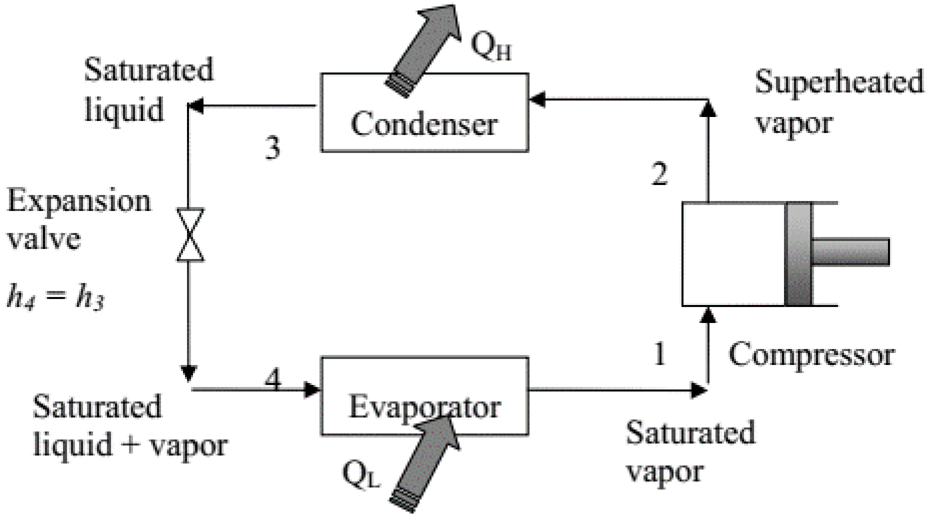


Figure 3-3: Heat pump process

Expansion (Lowering Temperature and Pressure):
The high-pressure liquid then passes through an expansion valve or capillary tube, where its pressure and temperature drop rapidly. This results in the formation of a low-pressure, low-temperature liquid-vapor mixture.

Return to Evaporation (Cycle Repeats):
The low-pressure, low-temperature mixture returns to the evaporator coil to begin the cycle again. This continuous cycle allows the heat pump to absorb heat from one location and release it in another. In heating mode, the heat pump absorbs heat from the outdoor air, ground, or water source and releases it into the indoor space. In cooling mode, the process is reversed, and the heat pump absorbs heat from the indoor space and releases it outdoors.

Study Parameters:

1. Capacity:

Capacity of Heat pump is measured either in Kilowatt-hour (Kwh)/BTUs/HP/Ton, which determines how large of an area the heat pump can effectively heat or cool. . It is also a measure of product of current and voltage. i.e. (Kwh =Ampere hour*volt) supplied to the Heat pump System.

2. C.O.P:

The coefficient of performance (COP) of a heat pump is a measure of its efficiency. It is defined as the ratio of the heat output to the work input. In other words, it is the amount of heat energy that a heat pump can produce for every unit of energy that it consumes. A COP of 1 means that the heat pump is 100% efficient, and it is producing one unit of heat energy for every unit of energy that it consumes. A COP of greater than 1 means that the heat pump is more efficient than 100%, and it is producing more heat energy than the amount of energy that it consumes. This is possible because heat pumps do not create heat, they only transfer it from a low-temperature source to a high-temperature sink.

3. Capillary Tube:

The capillary tube is typically located between the condenser and the evaporator in a refrigeration system. Its primary function is to regulate the flow of refrigerant from the high-pressure side to the low pressure side. Its diameter and length are carefully chosen to create the desired pressure drop, causing the refrigerant to undergo a phase change (from liquid to vapor) as it enters the evaporator. The capillary tube acts as a restriction, controlling the flow of refrigerant into the evaporator, creates a pressure drop in the refrigerant, allowing it to expand rapidly. This expansion leads to a decrease in temperature, which is necessary for the refrigeration process.

4. Bypass Factor:

In heat pumps and air conditioning systems, the bypass factor (BPF) is a measure of the inefficiency of a coil in transferring heat from the refrigerant to the air. It represents the portion of air that flows through the coil without being affected by it. A lower BPF indicates a more efficient coil, while a higher BPF indicates a less efficient coil.

- Coil design: Coils with more rows and fins have a lower bypass factor, as the air has more time to contact the coil surface and transfer heat.

- Airflow rate: A lower airflow rate will also result in a lower bypass factor, as the air has more time to interact with the coil.

5. Refrigerant (R134a):

R134a, also known as 1,1,1,2-tetrafluoroethane, is a hydrofluorocarbon (HFC) refrigerant commonly used in air conditioning and refrigeration systems. Here are some of its key properties:

Physical Properties:

- Chemical formula: CH_2FCF_3
- Molecular weight: 102.03 g/mol
- Boiling point: -26.1°C (-14.9°F)
- Critical temperature: 122°C (252°F)

- Critical pressure: 40.59 bar (588.3 psi)
- Density (liquid): 1.203 kg/m³ (at 25°C)
- Density (vapor): 0.3569 kg/m³ (at 25°C)
- Ozone depletion potential (ODP): 0
- Global warming potential (GWP): 1430 (AR5)

Thermodynamic Properties:

- Heat of vaporization: 222.88 kJ/kg
- Specific heat capacity (liquid): 1.14 kJ/kg°C
- Specific heat capacity (vapor): 0.956 kJ/kg°C
- Viscosity (liquid): 0.000074 Pa·s (at 25°C)
- Viscosity (vapor): 0.000013 Pa·s (at 25°C)

3.1.4 Drying System Design:

A drying system is a group of components that work together to remove moisture from a material. Drying systems are used in a wide variety of applications, including food processing, pharmaceuticals, and manufacturing.

The rate of evaporation depends on several factors, including the temperature, pressure and humidity of the air, the surface area of the material, and the rate of airflow.

3.2 Literature Review

Existing literature is reviewed for the optimal and efficient design of heat pump dryer systems. Many research papers, articles and news were studied from different sources and the results are tabulated in the table below.

3.2.1 Performance Evaluation of Different modes of Drying:

S.N.	Paper Name	Year	Journal	Summary
1.	**Drying Kinetics of Oyster Mushroom (Pleurotus ostreatus) in a Convective Hot Air Dryer**	2011	J. Agr. Sci. Tech. (2011) Vol. 13: 655-664	The study examines the effect of moisture content and drying time on drying rates at different temperatures. The drying rate decreases continuously with time and with decreasing moisture content. The drying experiments were performed at three different air temperatures: 50, 60, and 70°C. Among these temperatures, the drying rate was found to be higher at higher temperatures, and the total drying time was reduced substantially with the increase in air temperature. However, drying at high temperature is not suggested due to harmful effects on food components like proteins, vitamins, color, etc.
2.	**Performance Evaluation of a Mixed-Mode Solar Dryer**	2008	AU J.T. 11(4): 225-231 (Apr. 2008)	The drying rate and system efficiency were 0.62 kg/h and 57.5% respectively. The rapid rate of drying in the dryer reveals its ability to dry food items reasonably rapidly to a safe moisture level. The study suggests that the mixed-mode solar dryer has the potential to improve food preservation in developing countries

Table 3-1: Performance Evaluation of Different modes of Drying

3.2.2 Heat Pump Drying System

S.N.	Paper Name	Year	Journal	Summary
1.	**Mushroom drying with solar**	2013	Energy Conversion and	The paper presents a study on a solar assisted heat pump system (SAHP)

	assisted heat pump system		Management 72 (2013) 171–178	for drying mushrooms. The system uses flat plate collectors and a water source heat pump to provide heat for drying. The study includes experimental results on drying mushrooms at different temperatures and mass flow rates, as well as monitoring and control of the drying process using a computer program and PLC. The authors also discuss the potential of the SAHP system for drying other agricultural and industrial products. Overall, the study shows that the SAHP system is a cost-effective and sustainable solution for drying mushrooms and other products.
2.	**Review of heat pump systems for drying application**	2011	Review of heat pump systems for drying application. , 15(9), 4788–4796.	This study reviews heat pump systems for drying applications, with a focus on the benefits of using heat pump dryers for ensuring the quality of dried products. The paper discusses factors to consider when improving the performance of a heat pump dryer, such as installation cost and drying performance. It also provides references to several studies on the topic, including experimental studies of photovoltaic solar-assisted heat pump systems and chemical and adsorption heat pumps. The paper concludes with a section on compressor performance.
3.	**Herbs drying using a heat pump dryer**	2005	Energy Conversion and Management 47 (2006) 2629–2643	According to the experimental results presented in the paper, the optimal conditions for achieving the highest drying rate and productivity are a drying air temperature of 55 °C and velocity of 2.7 m/s, with a surface load of 28 kg/m². The lowest specific energy consumption was achieved under the same conditions.
4.	**Review of solar assisted heat pump drying systems for agricultural and**	2010	Renewable and Sustainable Energy Reviews 14 (2010) 2564–2579	The paper discusses the various components of a solar assisted heat pump drying system, including the heat pump, solar collector, and storage tank. It also examines the

	marine products			different types of heat pumps that can be used in drying systems, such as air source, water source, and ground source heat pumps. The paper highlights the advantages of using solar assisted heat pump drying systems, including higher drying temperatures, energy efficiency, flexibility, and cost savings. It also discusses the challenges associated with these systems, such as the need for proper system design and maintenance, and the potential for system failure due to weather conditions.
5.	**Calculation Steps for the Design of Different** **Components of Heat Pump Dryers Under Constant** **Drying Rate Condition**	2009	Drying Technology, 26: 864–872, 2008	This paper provides a simplified mathematical model for the design of different components of a batch-type, closed-loop heat pump dryer operating under steady-state and constant drying rate conditions. The mathematical models presented in the paper can be used for the design of different components of heat pump dryers.

Table 3-2: Heat pump drying system

3.2.3 Quality of Dried Mushroom

S.N.	Paper Name	Year	Journal	Summary
1.	**Effects of pretreatments and drying methods on dehydration of mushroom**	2006	Journal of Food Engineering 74 (2006) 108–115	This paper investigates the effects of different pretreatments and drying methods on the dehydration of button and oyster mushrooms. The mushrooms were subjected to various pretreatments and then dried in different dryers. The drying rates were evaluated and drying rate curves were plotted. The results showed that the fluidized bed drying

				system was the most efficient and effective method for drying mushrooms. The study also found that microwave drying may not be a suitable method for drying mushrooms, as it resulted in charring of the edges
2.	**EFFECT OF PRETREATMENTS AND DRYING TEMPERATURES ON THE QUALITY OF DRIED PLEUROTUS MUSHROOM SPP.**	2014	Egypt. J. Agric. Res.,92(3),2014	The paper evaluates the effect of different pretreatments and drying temperatures on the rehydration ratio and color of dried Pleurotus mushroom. The study found that pretreatments such as blanching and soaking in citric acid solution improved the quality of the dried mushroom. The drying temperature also had an impact on the quality of the dried mushroom, with lower temperatures resulting in better color and rehydration ratio. Overall, the study provides useful information for improving the quality of dried Pleurotus mushroom.
3.	**EVALUATION OF DIFFERENT METHODS OF DRYING ON** **THE QUALITY OF OYSTER MUSHROOM (Pleurotus sp)**	2007	ing Technology: An International Journal, 15:6-8, 1995-2004	This paper evaluates the effects of different drying methods on the quality of oyster mushrooms. The three methods evaluated were sun drying, thin layer drying, and fluidized bed drying. The study found that fluidized bed drying resulted in the highest quality mushroom, with the least amount of nutrient loss and the best color and texture. The results of this study may be useful for mushroom growers and food processors looking to optimize their drying methods.
4.	**Nutritional quality of Oyster Mushroom (**	2017	Food Sci Nutr. 2017;1–8	This paper explores the effects of osmotic

	Pleurotus Ostreatus) as **affected by osmotic pretreatments and drying methods**			pretreatments and drying methods on the nutritional quality of dried Oyster Mushroom slices. The experiment involved three levels of osmotic pretreatments (0%, 5%, and 10% salt solution) and three drying methods (sun, solar, and oven drying). The results showed that the nutritional composition of the dried mushroom samples varied significantly depending on the osmotic pretreatment and drying method used. The authors suggest that optimizing pretreatments and drying technologies can help increase the potential of mushroom cultivation and commercialization in countries like Ethiopia where mushroom production is low.

Table 3-3: Quality of Dried Mushroom

All we can observe from the paper is that Solar Assisted Heat Pump for Drying Mushrooms is economical and efficient. The best temperature for drying is 45°C-55°C as it helps to maintain quality and texture of mushroom.

3.3 Design and Calculations:

3.3.1 Basic flowchart of Heat pump dryer:

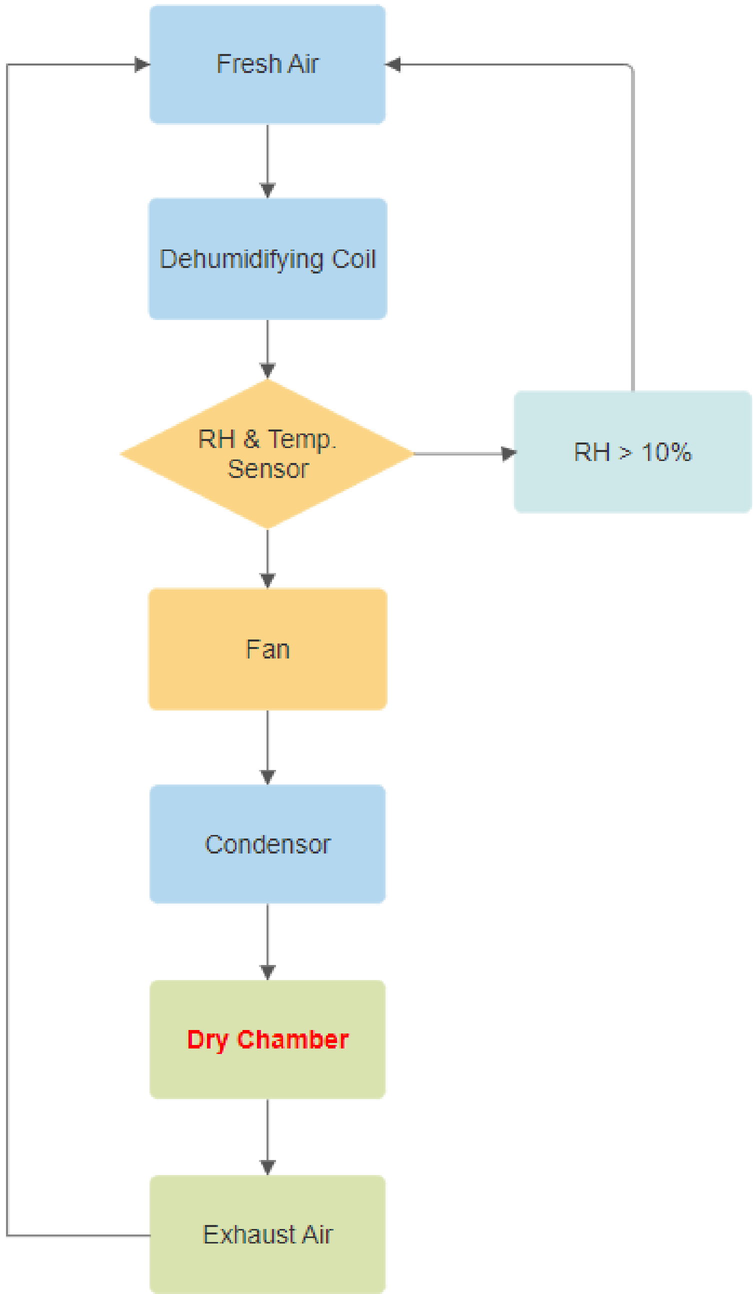


Figure 3-4: Basic flow process

3.3.2 Basic Schematic Diagram:

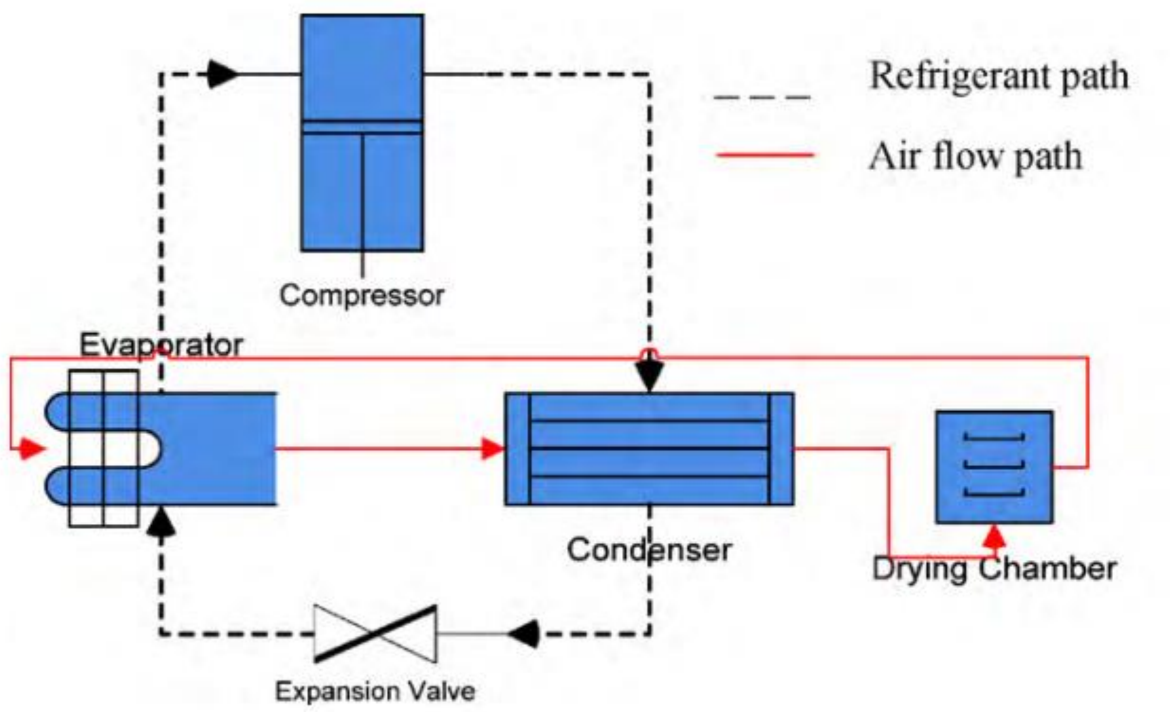


Figure 3-5: Basic Schematic diagram

Working Principle of Drying System:

The setup of the food drying system comprises two integral components: the air circulation system within the drying unit and the refrigeration cycle. Within an insulated chamber, mushrooms are strategically arranged on trays. The refrigeration cycle involves the condenser and evaporator positioned inside a duct to facilitate efficient heat exchange between the circulating air and the refrigerant.

Initially, the air circulation process initiates as the air flows through the condenser, where it absorbs sensible heat, elevating its temperature to the desired level of approximately 55 degrees Celsius. Subsequently, the preheated air traverses the drying chamber, where it surrenders heat to the mushrooms, initiating the evaporation of moisture from the mushroom. The moisture-laden air then progresses through the dehumidification region, where the moisture undergoes condensation. The air, now significantly dehumidified, continues its journey through the closed-loop cycle, facilitated by strategically placed fans. These fans play a crucial role in maintaining a consistent flow rate along the duct, optimizing the drying conditions for the mushrooms. To prevent any deviations in overall temperature, periodic air refreshing is incorporated into the system. This meticulous process persists until the mushrooms achieve the desired dried condition, showcasing the effectiveness of the food drying system in preserving the quality and shelf life of the product.

Performance:

The COP. indicates the performance of HPD. The COP is not an Efficiency but an energy characteristic. It describes what you get over what you spend. The theoretical and the actual COP can be calculated with the following equation, by either inserting theoretical or real Measured values:

$$COP = \frac{Q_{cond}}{W}$$

The heat rejection in the condenser is given by:

$$Q_{cond} = Q_{De_{superheating}} + Q_{condensation}$$

The integration of a heat pump system into a dryer requires an additional energy-consuming unit: a blower. In order to be precise, the energy input for this device must also be included in the calculations. Therefore, the overall COP of a heat pump dryer is defined as:

$$COP_{HPD} = \frac{Q_H}{W_c + W_f}$$

3.3.3 Psychometric Process:

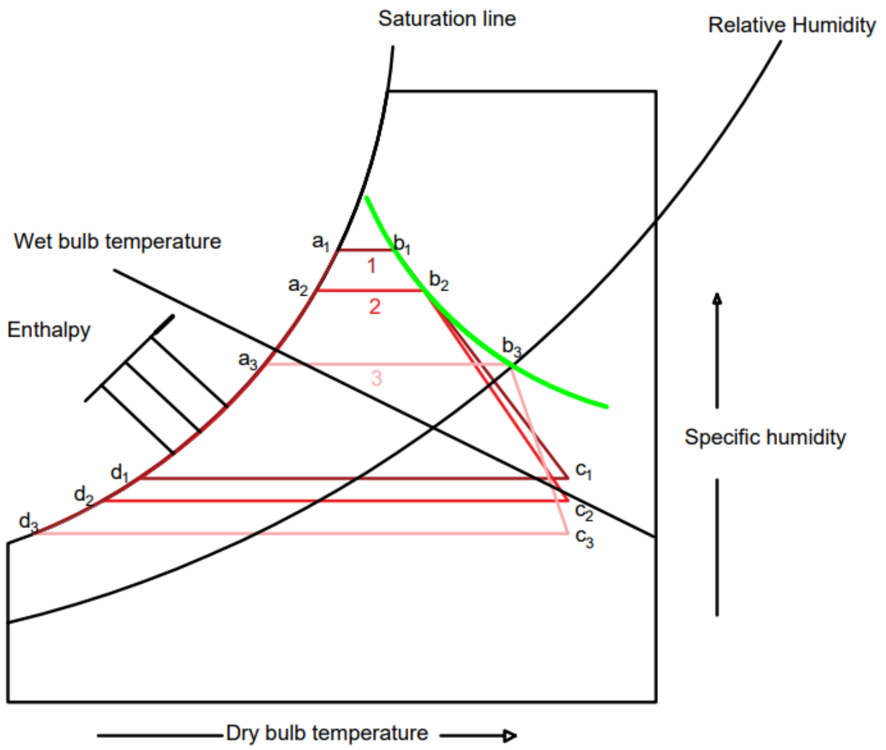


Figure 3-6: Psychometric process

The analysis conducted using the psychometric chart for our heat pump drying system reveals a well-defined cycle that intricately influences the efficiency of moisture removal from mushrooms. The journey begins as air circulates through the condenser, undergoing sensible heating (from point d1 to a1) until it reaches the desired temperature. Subsequently, the air proceeds through the drying chamber (from a1 to b1), where it releases heat to evaporate moisture from the mushrooms. However, as the cycle iterates, a notable trend emerges on the psychometric chart. The rate of moisture removal from the mushrooms experiences an exponential decrease, depicted by the green curve in the figure. This diminishing trend signals a potential limitation in the overall system performance, where the heat exchange from the condenser to the air may return to the evaporator without fully contributing to moisture removal. This observed phenomenon suggests that the moisture removal rate reaches a saturation region, indicating a point of diminishing returns. This saturation poses a challenge to the system's efficiency, as the heat intended for moisture evaporation reaches a point of diminishing effectiveness. To address this, the inverter compressor plays a pivotal role in maintaining and optimizing overall system performance. By dynamically adjusting the pressure ratio, the inverter compressor ensures that the heat exchange process remains effective and responsive to the changing conditions. This adaptability allows the system to overcome the saturation region, sustaining efficient moisture removal from the mushrooms and mitigating the adverse effects of diminishing returns. The inverter compressor's role becomes integral in enhancing the longevity and effectiveness of the heat pump drying system.

3.3.4 Design Conditions and Assumptions:

A Drying Chamber for mushroom should be designed under the following design conditions.

Design Conditions	
Mushroom	100kg
Desired Chamber Temperature (°C)	50±5
Ambient Temperature	25℃
Ambient Humidity	-
Initial Moisture Content	(85-90)%
Final Moisture Content	(5-8)%
Drying Time	6hrs

Table 3-4: Design conditions and assumptions

3.3.5 Chamber Design:

Drying chamber of following dimension was designed on the basis of experimental data.

Dimension: 4’*4.25’*5’

No. of Tray: 17

Total Area: 290 ft^2

Chamber	Length (ft)	Breadth (ft)	Height (ft)	Wall Area (ft^2)
	4	4.25	5	116.5

Table 3-5: Chamber dimensions

Materials: 1mm MS Sheet-1” Thermal Insulation-Aluminum foil

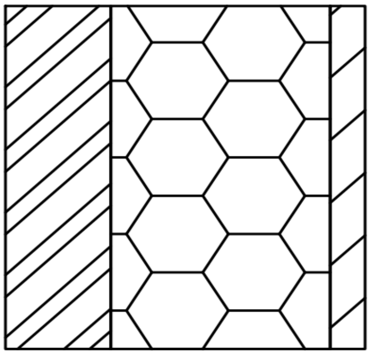


Figure 3-7: Chamber wall composition

3.3.6 Heat loss from Chamber:

The heat lost from the drying chamber surface to the surrounding was calculated using steady state conduction.

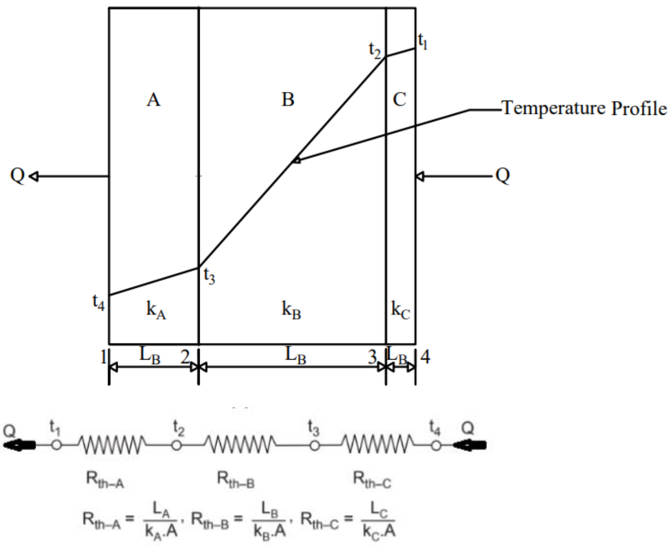


Figure 3-8: Steady state conduction through chamber wall

Where,
L_A, L_B, L_C = Thicknesses of slabs A, B and C respectively (also called path lengths),
k_A, k_B, k_C = Thermal conductivities of the slabs A, B and C respectively,
t_1, t_4 ($t_1 > t_4$) = Temperatures at the wall surfaces 1 and 4 respectively, and
t_2, t_3 = Temperatures at the interfaces 2 and 3 respectively.

Heat flow through the wall is given by,

$$Q = kA\frac{\Delta t}{L}$$

$\therefore Q = U*A*\Delta t$

Where,

$$U = \frac{k}{L}$$

Calculation of Thermal Conductance (U),

Wall Specifications				
Code No	Thickness inch	Description	Resistance (m²·°C/W)	U
A0		Outside surface resistance	0.058135818	17.2010997
-	1mm	1mm Metal Sheet	0.00002	50000
B2	1"	1" Insulation	0.5868363	1.70405273
-	0.024mm	Aluminium Foil	0.000000109	9174311.93
E0		Inside surface resistance	0.121267254	8.24624923
Total			0.766259481	1.30504095

Table 3-6: Thermal conductance of chamber with 1" insulation

Wall Specifications				
Code No	Thickness inch	Description	Resistance (m²·°C/W)	U
A0		Outside surface resistance	0.058135818	17.2011
-	1mm	1mm Metal Sheet	0.00002	50000
B2	2"	2" Insulation	1.174	0.851789
-	0.024mm	Aluminium Foil	0.000000109	9174312
E0		Inside surface resistance	0.121267254	8.246249
Total			1.353423181	0.738867

Table 3-7: Thermal conductance of chamber with 2" insulation

Calculation of Heat Loss from Chamber,

1" Insulation			
U	Area (m^2)	ΔT	Q=U*A*ΔT (W)
1.305	10.82	30	423.603

Table 3-8: Heat loss from chamber with 1" insulation

2" Insulation			
U	Area (m^2)	ΔT	Q=U*A*ΔT (W)
0.738867	10.82	30	239.836

Table 3-9: Heat loss from chamber with 2” insulation

Heat loss from Chamber:

1” insulation: 423.603 W

2” insulation: 239.836 W

3.3.7 Heat required for Drying Mushroom:

Heat required to dry mushroom is calculated using heat equation,

Sensible Heat Equation:

$$Q = ms\Delta T$$

Latent Heat Equation:

$$Q = mL$$

Where,
Q = Heat required
m = mass
s = specific heat capacity
ΔT = Temperature difference
L = specific latent heat

Mass of mushroom (m) = 100kg
Specific heat of mushroom (s_m) = 3146 J/kg.℃
Specific heat of water (s_w) = 4200 J/kg.℃
Latent heat of vaporization (L_v) = 2256200 J/kg.℃
Ambient temperature (t_a) = 25℃
Chamber temperature (t_f) = 55℃
Temperature difference (ΔT) =30℃
Initial water content = (85-90) kg
Final water content = (0.52-1.3) kg
Mass of water to be removed (m_w) = 88 kg
Mass of mushroom (m_m) = 12 kg

∴ Heat required by mushroom to reach 55℃ (Sensible Heat),

$$Q_m = m_m.s_m.\Delta T$$

$Q_m = 12 * 3146 * 30$

∴Q_m = 1132560 J

∴ Heat required by water to reach 55℃ (Sensible Heat),

$$Q_w = m_w.s_w.\Delta T$$

Q_w = 88*4200*30

∴Q_w = 11088000 J

∴ Heat required to remove moisture from mushroom (Latent Heat),

$$Q_r = m_w.L_v$$

$Q_r = 88 * 2256200$

$\therefore Q_r = 198545600$ J

$\therefore$ Total heat absorbed by mushroom to dry,

$Q_d = Q_m + Q_w + Q_r$

$=1132560+11088000+198545600$

$\therefore Q_d = 210766160$ J

Heat Pump Sizing:

Total rate of heat required to dry mushroom including the chamber loss,

$$\dot{Q}_T = \dot{Q}_d + \dot{Q}_c$$

Time of drying (T_d) = 6hours

$\therefore \dot{Q}_d = \frac{210766160}{6*3600}$

$=9757.69$ W

$\dot{Q}_T = 9757.69 + 239.836$ (2" insulation)

$\therefore \dot{Q}_T = 9997.528$ W

COP of heat pump in closed loop ranges from 3.5-4.2

Considering a heat pump of minimum COP-3.5.

Power of compressor = $\frac{\dot{Q}_T}{COP}$

$= \frac{9997.528}{3.5}$

$= 2856.43$ W

3.4 Experimental Setup:

To overcome the limitations in analytical analysis we will utilize experimental data for the project. To make our experiment feasible and economic we scale down our model by 20 times in terms of capacity.

3.4.1 Scaled Model:

For the scaled model of 5 kg capacity we calculate the power of compressor as below:

$$\text{Power of compressor} = \frac{2856.4}{20}$$

$$=142.82\text{W}$$

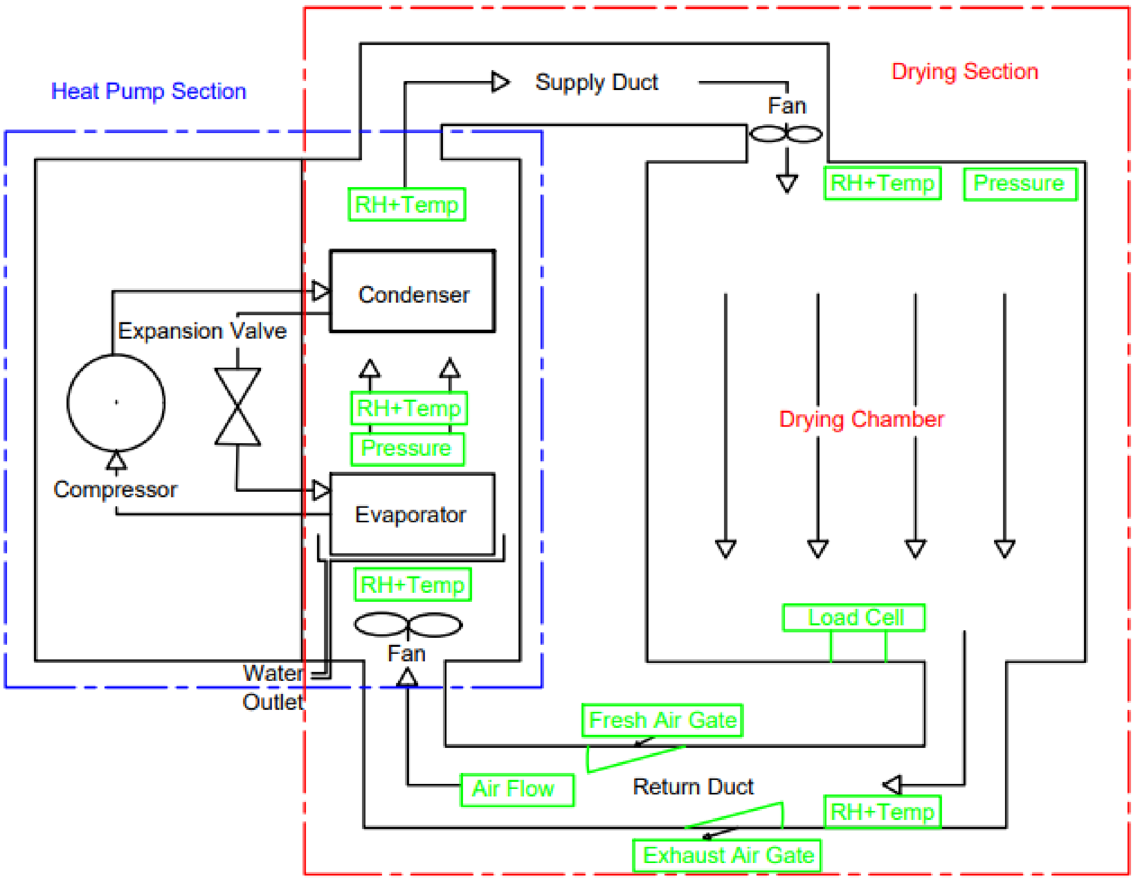


Figure 3-9: Schematic diagram of model

The experimental setup meticulously mirrors the conceptual design outlined earlier, emphasizing the importance of accurate measurements in assessing the system's performance. To capture the nuances of the drying process, a network of sensors has been strategically positioned throughout the system. Temperature and humidity sensors are strategically placed before and after key regions, including the drying chamber, dehumidification area, and the region where sensible heat is added. This multifaceted sensor array enables a comprehensive understanding of the thermal dynamics and moisture content at various stages of the process. Crucially, to validate and optimize the heat exchange process, temperature sensors have been meticulously installed within the condenser and evaporator. This not only ensures the efficiency of the refrigeration cycle but also guarantees that the desired temperature is reached and maintained during the sensible heat addition phase. In the heart of the drying chamber, a load sensor is strategically placed to quantify the moisture content removed from the mushrooms. This real-time data provides invaluable insights into the effectiveness of the drying process. Additionally, air pressure sensors within the drying chamber and duct enhance the precision of the experimental setup, contributing to a more thorough analysis of the system's performance. To maintain the desired air circulation and flow rates, fans have been strategically positioned, underscoring the importance of controlled conditions for effective drying. The confluence of these sensors, load measurements, and air pressure control mechanisms ensures a holistic and data-driven approach to evaluating the food drying system's functionality, aligning seamlessly with the theoretical framework established in the design phase.

3.4.2 Components:

Compressor:

Figure 3-10: BMG110NAMV

Type	Series	Model	Rating	Speed range	Speed	Operating conditions Eva/Cond'=-23.3℃/54.4℃					
						Cooling Capacity			Power	COP	EER
				(rpm)	(rpm)	(kcal/hr)	(w/hr)	(Btu/hr)	(w)	(w/w)	(Btu/w.hr)
BLDC R600a	BMG	BMG110NAMV	220~240V 50/60HZ	1200~4500	4500	225	262	894	144	1.82	6.22
					3000	172	200	683	103	1.93	6.6
					1800	108	125	427	66	1.9	6.48
					1500	88	102	349	53	1.94	6.64
					1200	70	82	279	43	1.92	6.55

Table 3-10: BMG110NAMV Specifications

Condenser:

Figure 3-11: Condenser

FNA-0.36/1.0		
REFRIGERATION CONDENSER		
Capacity (HP)	<1/4	
Refrigerant	R134a, R404a, R410a, R417a, etc.	
Wreath row counts(S*W)	2*4	
Dimension L*W*H(MM)	180*45*210	
Materials	Copper tube aluminium fin	
Tube O.D	3/8”	
Fin Type	?	
FAN		
Diameter of fans	mm	150
Air volume	A	300
Voltage	V	220

Table 3-11: Condenser Specifications

Evaporator:

Figure 3-12: Evaporator

FNA-0.38/1.2		
REFRIGERATION CONDENSER		
Capacity (HP)	>1/4	
Refrigerant	R134a, R404a, R410a, R417a, etc.	
Wreath row counts(S*W)	2*4	
Dimension L*W*H(MM)	205*45*210	
Materials	Copper tube aluminium fin	
Tube O.D	3/8”	
Fin Type	?	
FAN		
Diameter of fans	mm	150
Air volume	A	300
Voltage	V	220

Table 3-12: Evaporator Specifications

Expansion Valve:

Figure 3-13: REG-SB 10 Expansion Valve

Net weight	0.47 Kg
Volume	1.72 Liter
Body material	Steel
Cv value [gal/min]	0.7 gal/min
Flow area [mm2]	16 mm²
Inlet connection size [mm]	10mm
Inlet connection type	Butt weld
Kv value [m³/h]	0.6 m³/h
Max. Working Pressure [bar]	52 bar

Outlet connection size [mm]	10 mm
Product description	Hand Regulating Valve
Refrigerants	R134a, R600, R600a, R410A, R502, R125, etc.

Table 3-13: REG-SB 10 Expansion Valve Specifications

Thermocol:

Figure 3-14: Thermocol

Size	Thermal Conductivity,(W/mK)
2”	0.033-0.047

Table 3-14: Thermocol Specifications

Sensors:

Arduino Mega 2560:

The **Arduino Mega 2560** is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

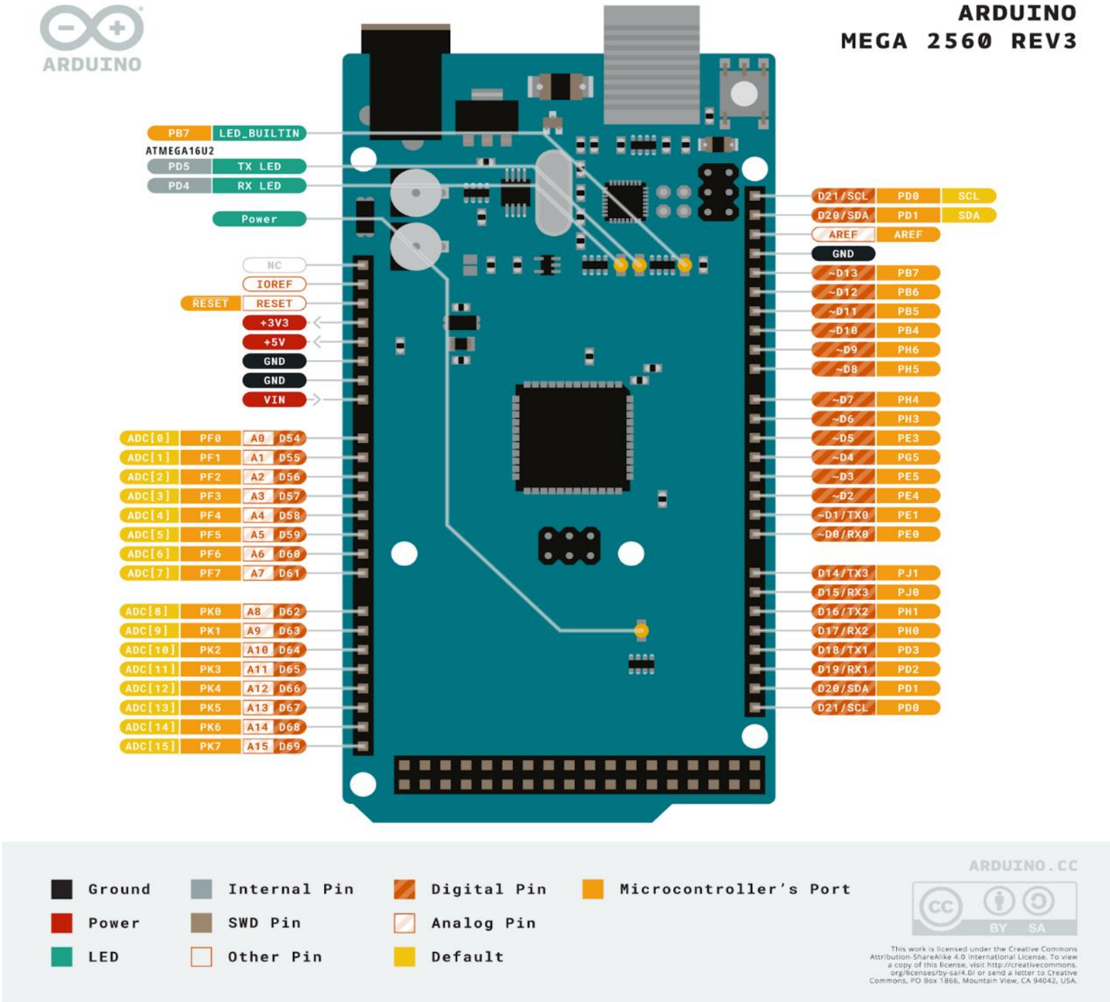


Figure 3-15: Arduino Mega 2560

Technical details:

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA

Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

Table 3-15: Arduino Mega Technical details

Temperature and Humidity Sensor:

The **DHT22** is a low-cost digital temperature and humidity sensor with a single wire digital interface. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed). The sensor is calibrated and doesn't require extra components so you can get the right to measuring relative humidity and temperature. It is quite simple to use but requires careful timing to grab data. You can only get new data from it once every 2 seconds.

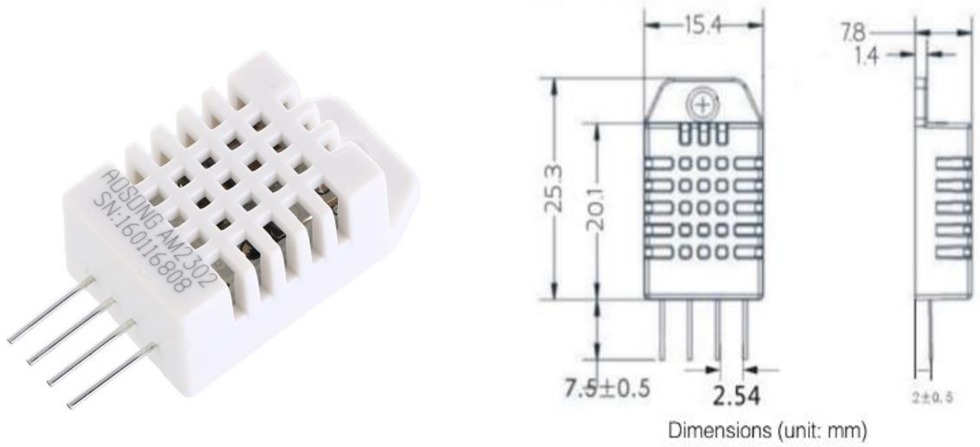


Figure 3-16: DHT 22

Pin	Name	Description
①	VDD	Power (3.3V−5.5V)
②	SDA	Serial data, bidirectional port
③	NC	Empty
④	GND	Ground

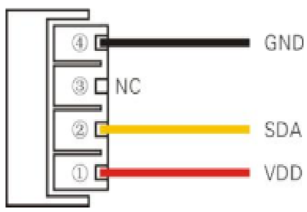


Figure 3-17: DHT 22 Terminal

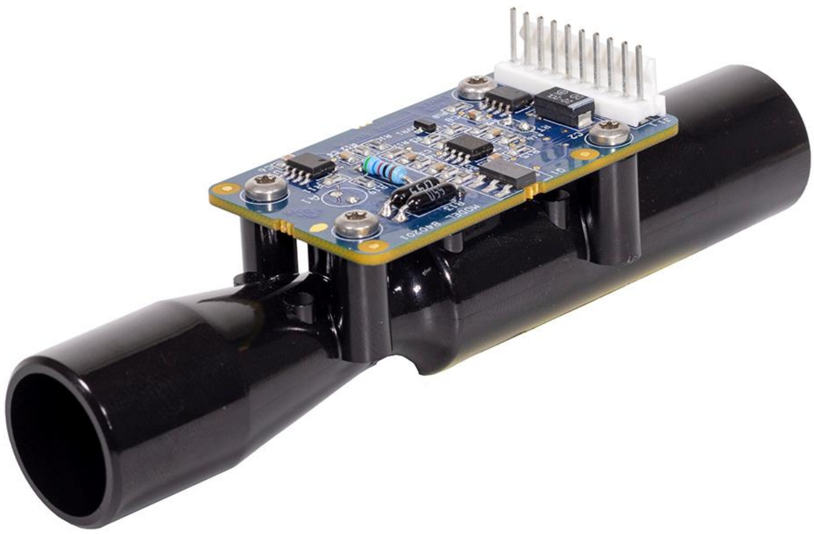
Technical details:

Model	DHT22/AM2302
Power supply	3.3-6V DC
Output signal	Digital signal via 1-wire bus
Sensing element	Polymer capacitor
Operating range	Humidity 0-100%RH; Temperature -40~80Celsius
Accuracy	Humidity +-2%RH(Max +-5%RH); Temperature <+-0.5Celsius
Resolution or sensitivity	Humidity 0.1%RH; Temperature 0.1Celsius
Repeatability	Humidity +-1%RH; Temperature +-0.2Celsius
Humidity hysteresis	+-0.3%RH
Long-term stability	+-0.5%RH/year
Sensing period	Average: 2s
Interchangeability	Fully interchangeable
Dimensions	Small size 14*18*5.5mm; Big size 22*28*5mm

Table 3-16: DHT 22 technical details

Air Flow Sensor:

F1031V Mass Air Flow Sensor adopts thermodynamic principle to detect flow rate of gas medium in the flow channel, with high precision and good repeatability. It comes with built-in temperature sensor to provide temperature compensation for measured data. Meanwhile, the sensor has liner analog voltage output, easy to use. It can be used in applications like ventilator, air purifiers, etc.



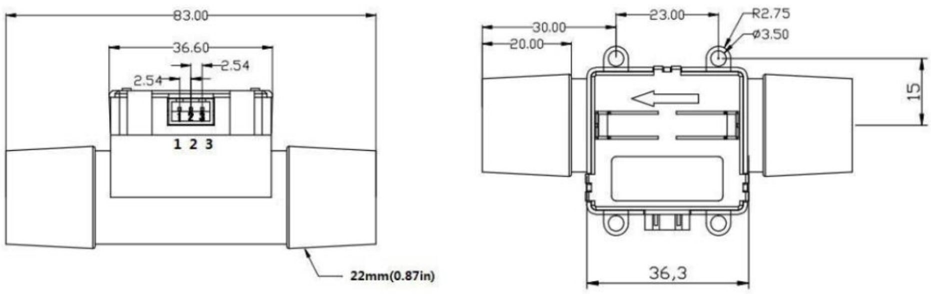


Figure 3-18: Air Flow Sensor

Technical Details:

	Min	Typical	Max	Unit
Full Scale Output	4.34	4.5	4.66	V
Zero Output	0.45	0.5	0.55	V
Operating Current	-	25	-	mA
Accuracy	-	±2.5	±4	%F.S
Repeatability	-	±0.5	±1	%F.S
Output Drift	-	0.12	-	%/°C
Resistance	-	120	-	Pa/60SLM
Response Time	-	50	-	ms
Working Temp	-25	-	65	°C

Table 3-17: F13031V technical details

No.	Name(Color)	Function
1	GND(black/grey)	Negative

No.	Name(Color)	Function
2	VCC(red)	Positive
3	OUT(yellow)	Analog Output

Table 3-18: F1031V terminal

Load Cell + HX711 Load Cell Amplifier:

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. The various types of load cells include hydraulic load cells, pneumatic load cells and strain gauge load cells.

This is a standard load cell for measuring weight up to 10 Kg. The output of the load cell is in mili-volts and cannot be directly measured by a micro-controller. So an ADC with high resolution or an instrumentation amplifier is required to make the output of the load cell readable to a micro-controller.

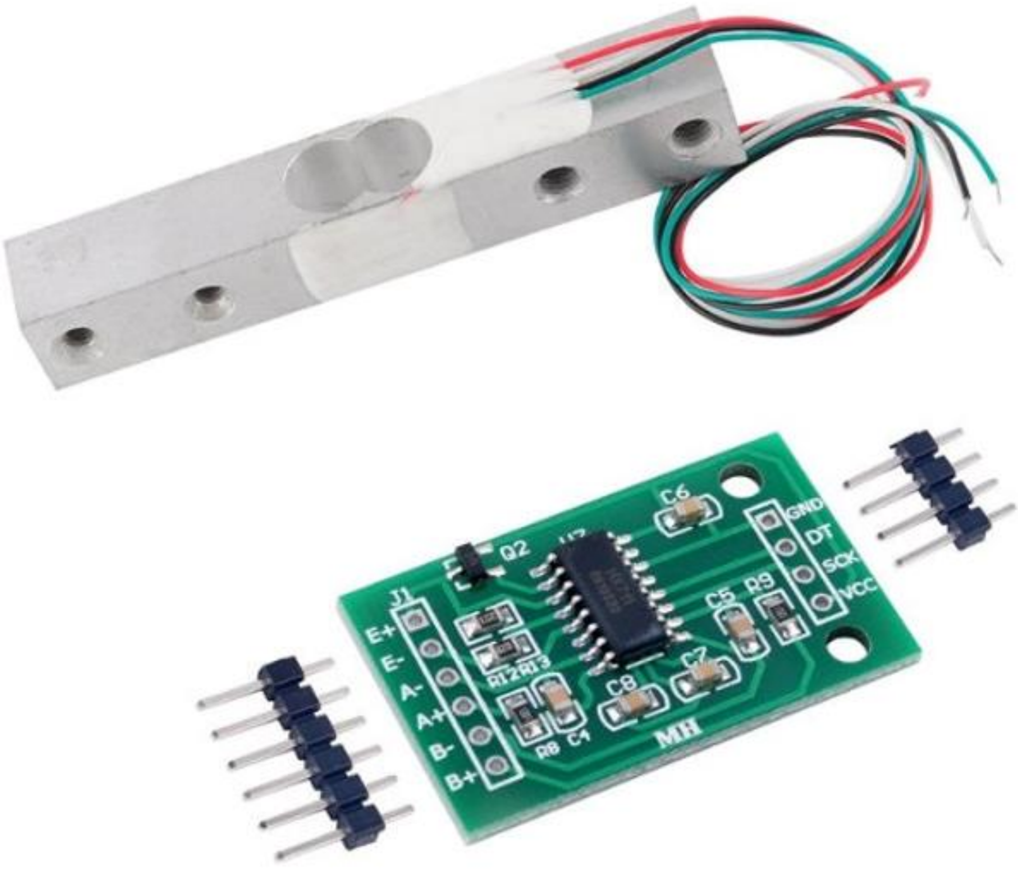


Figure 3-19: Load cell + HX711 Load cell amplifier

Technical details:

Capacity	10KG
Rated output(MV/V)	2.0±0.15
Combined error(%RO)	<±0.030
Creep(%RO/30min)	0.03
Temperature effect on sensitivity(%RO/°C)	0.0016
Temperature effect on zero(%RO/°C)	0.003
Input resistance(O)	402±6
Output resistance(O)	350±3
Insulation resistance(MO<50V>)	5000
Operating temperature range(°C)	-35~+80
Load cell material	Aluminium
Recommended operating voltage	3 ~ 12 VDC
Maximum operating voltage	15 VDC
Input Impedance	1115±10%Ω
Output Impedance	1000±10%Ω
Working Temperature	-20°C ~ +60°C
Compensated Temperature Range	-10°C ~ +65°C
Safety Overload	120%
Total Size	80 x 13 x 12mm (L*W*T)
Thread Hole	M4 Screw
Weight	27g

Table 3-19: Load cell technical details

Air Pressure Sensor 0-40KPa:

MPS20N0040D Air pressure sensor measures pressure in its environment and sends you that information through multi-volt signal to read. This DIP air pressure sensor is suitable for biomedical, meteorology and other fields. The core part is pressure sensor chip which is make by the MEMS pressure technology.

Figure 3-20: MPS20N0040D Air pressure sensor

Technical Details:

Pressure range	40kpa
Electricity supply	5VDC
Linear accuracy	0.25% F
Measure the pressure range	580 PSIG
Work power supply	5 VDC
Input impedance	4 – 6 KΩ
The output impedance	4 – 6 KΩ
Operating temperature	-40 – 85 ° C
Storage Temperature	-40 – 125 ° C
Bias voltage	± 25 mV
Full-scale output voltage	50 – 100 mV
Bridge Resistance	4 – 6 KΩ
Linearity	± 0.3% F.S.
Hysteresis	± 0.7% F.S.
Bias Temperature coefficient	± 0.08% of F.S. / °c
Temperature coefficient of sensitivity	-0.21 % FS/ °c

Table 3-20: MPS20N0040D technical details

3.4.3 3D Layout of Dryer:

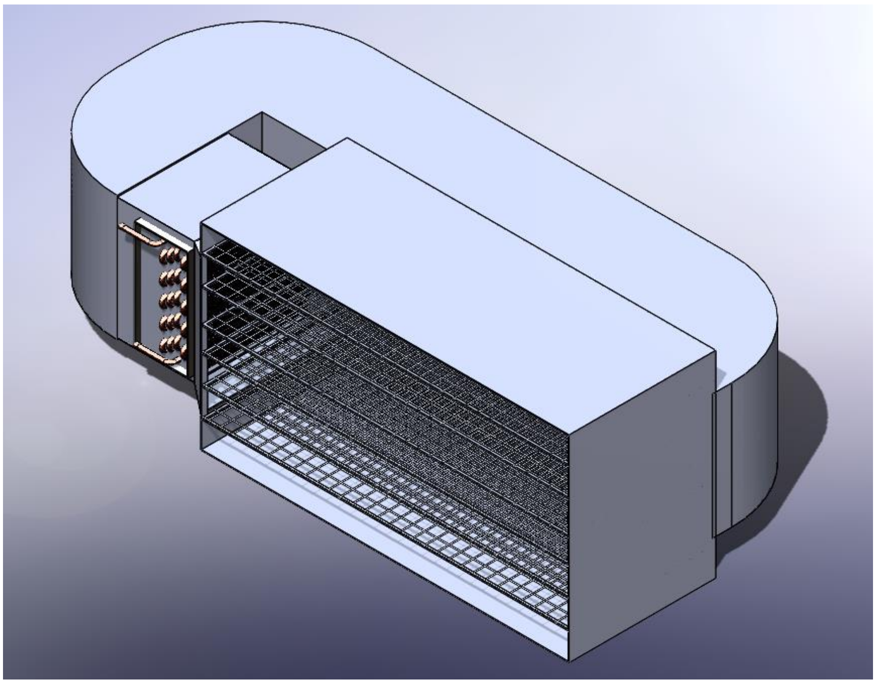


Figure 3-21: Isometric view of dryer model

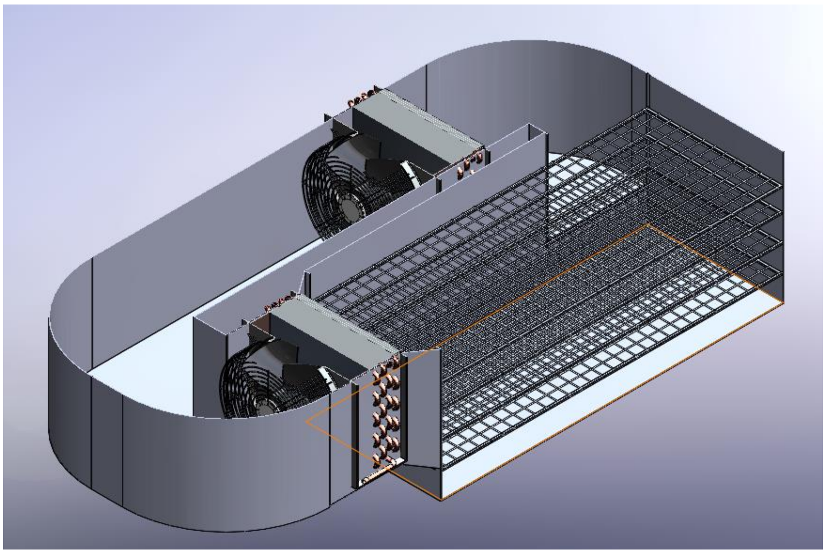


Figure 3-22: Sectional view of model

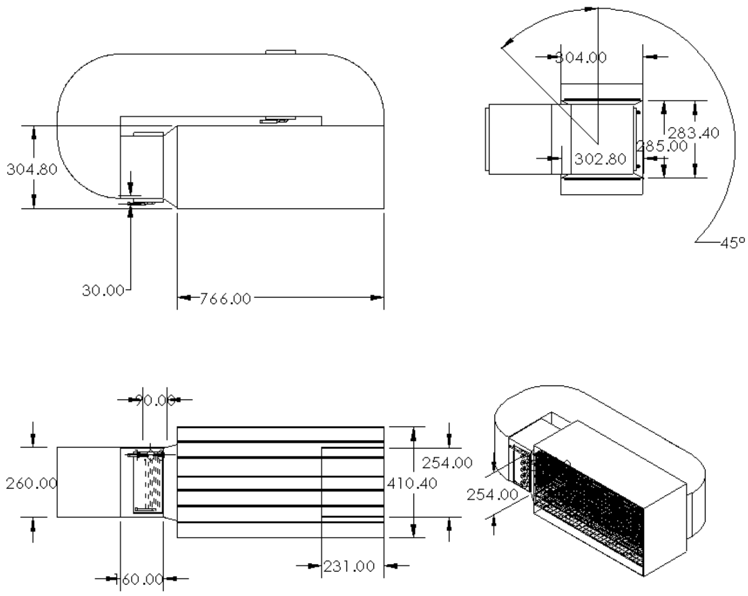


Figure 3-23: Orthographic drawing

3.4.4 Costing:

Components	Quantity	Rate	Total (Rs.)
Compressor (BMG110NAMV)	1	15000	15000
Condenser (FNA-0.36/1.0)	1	4500	4500
Evaporator (FNA-0.38/1.2)	1	4500	4500
Expansion valve	1	4500	4500
Filter	1	100	100
Refrigerant (R600a)	1 (220g)	900	900
Charging line	1	500	500
Copper pipe (3/8”)	10	95	950
Elbow (3/8”)	15	130	1950
Brazing Tool (Torch, can, rod)	10	50	500
Metal Sheet 1mm	30 ft^2	145	4350
Insulation 1”	30 ft^2	60	1800
Aluminium foil	12 ft^2	10	120
Arduino Mega 2560	1	2380	2380
Temperature and R.H. sensor (DHT22)	6	650	3900
Air Flow sensor (F1031V)	1	650	650
Load Cell	1	225	225
HX711 Load Cell Amplifier	1	150	150
Air Pressure Sensor (MPS20N0040D)	2	800	1600
Miscellaneous	-	-	20000
Total	-	-	68575

Table 3-21: Cost of components

Chapter: 4 DISCUSSION AND CONCLUSION

4.1 Discussion:

The focus of the internship at Green Tech Nepal was on the design and fabrication of a food drying system using a heat pump, a cutting-edge technology aimed at efficient and sustainable food preservation. The initial phase involved an in-depth review of research papers, exploring refrigeration system principles, and conducting heat and cold load calculations. Additionally, a comprehensive understanding of psychometric charts was crucial in optimizing the drying conditions. The designed experimental setup comprises two main components: the air circulation system within the drying unit and the refrigeration cycle. By employing a closed-loop system, mushrooms placed in trays inside an insulated chamber undergo a meticulously controlled drying process. The air is sequentially passed through the condenser, the drying chamber, and the dehumidification region, ensuring the efficient removal of moisture. Critical to the success of the system is the use of sensors strategically placed before and after key stages, facilitating the measurement of temperature and humidity. This data, combined with load sensors in the drying chamber and air pressure measurements, provides a comprehensive understanding of the drying process. The syphon phenomenon employed to remove condensed air from the duct ensures the integrity of the closed-loop system. The experimental setup goes beyond theoretical calculations, acknowledging the complexity of real-world conditions. Temperature measurements in the condenser and evaporator verify the effectiveness of the heat exchange rate between air and refrigerant. Fans play a pivotal role in maintaining the appropriate airflow rate inside the duct, further optimizing the drying conditions.

4.2 Conclusion:

In conclusion, the internship at Green Tech Nepal has been an invaluable experience in bridging theoretical knowledge with practical application. The design and fabrication of the food drying system using a heat pump showcase the potential for sustainable and energy-efficient food preservation methods. The experimental setup, with its sophisticated sensor array and closed-loop system, offers a tangible representation of the theoretical principles explored during the internship. The integration of a syphon phenomenon, load sensors, and air pressure measurements ensures the reliability and precision of the experimental results. As the system continues to iterate, the insights gained will contribute to the advancement of food drying technology, addressing the challenges of preserving agricultural produce while minimizing energy consumption. This internship has not only enhanced technical skills in refrigeration system design and experimental setup but has also provided a deeper appreciation for the interdisciplinary nature of sustainable technologies in the field of food preservation. The knowledge gained will undoubtedly be instrumental in future endeavors within the realm of green technologies and sustainable food systems.

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