AN AUTOMATIC HOT AIR-DRYING MACHINE

A Dissertation

By


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## DECLARATION

We hereby declare that thesis title "AN AUTOMATIC HOT AIR-DRYING MACHINE" submitted to the Department of Mechanical Engineering, Dhaka, in partial fulfillment of the Bachelor of Science in Mechanical Engineering, is our original work and was not submitted elsewhere for the award of any other Degree or Diploma or any other publication.

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## CERTIFICATION OF ACCEPTANCE

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Engineering program has completed his thesis paper entitled (study of an automatic hot air drying machine system design in Bangladesh) under my supervision. He has completed the report as a partial fulfillment of the requirement for the degree of B.sc-in mechanical engineering program Sonargaon University.

The report has been prepared under my guidelines and is a record of the bona fide work carried out successfully.

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## ACKNOWLEDGEMENT

Thanks to the Almighty, the creator and Sustainer who has given us strength and opportunity to complete the thesis title , (AN AUTOMATIC HOT AIR-DRYING MACHINE ). We would like to express our gratitude and appreciation our supervisor KAZI TAHMID RAHMAN for his guidance in the execution of the thesis. For keeping us on our toes. And for his kind understanding .Our acknowledgement also goes out to the thesis presentation assessor. We would like to thanks our Honorable Head, Faculty of Science and Engineering a also. Finally, we express our greetings to all our friend and teacher who have influenced and encouraged of as to develop this thesis.

## ABSTRACT

An automatic drying machine was made with the help of available material. The drying of clothes is an energy-intensive process, and a lot of effort is put into energy saving .Its efficiency was investigated with respect to how fast it was able to dry up the clothe .Hence a set of experiments were performed to determine the worthiness of this drying machine . Energy analysis of the drying process with special interest paid to leakage and the efficiency of the heat exchanger, identification of signals that can be used for calculating the remaining drying time .The experiments showed that the drying machine works fine as per its objectives .The main advantage of this system is that it can work all round the year, with a built-in auxiliary heating system. Also, with no moving parts, it consumes less power. It can easily be built with commonly available materials.

## CONTENTS

### Table of Contents


CHAPTER 1 ........ 1

INTRODUCTION ........ 1

1.1 INTRODUCTION: ........ 1

1.2 HEAT........ 1

1.3 TYPES OF HEAT ........ 2

1.3.1 Convection: ........ 2

1.1 Figure [3] ........ 2

1.3.2 Conduction: ........ 2

1.2 Figure [3] ........ 3

1.3.3 Radiation: ........ 3

1.3 Figure [3] ........ 4

1.4 Types of drying ........ 4

1.5 BACKGROUND OF STUDY ........ 4

1.6 PROBLEM STATEMENT ........ 5

1.8 OBJECTIVES OF STUDY ........ 6

1.9 SCOPE OF STUDY ........ 6

2.1. LITERATURE REVIEW ........ 7

2.2 Earliest Dryers: ........ 7

2.2.1First Patented Clothes Dryer: ........ 7

2.2.2First Electric Dryer: ........ 8

2.1 Figure (4) ........ 8

2.2 Figure (4) ........ 9

2.3 Figure (4) ........ 10

2.4 Figure (4) ........ 11

CHAPTER 3 .......... 12
EXPERIMENTAL SETUP AND WORKING PROCESS .......... 12
3.1 BOX .......... 12
3.1 Figure .......... 12
BOX CONFIGURATION:.......... 13
3.2 EQUIPMENT SET UP: .......... 13
3.3 WORKING PRINCIPLE: .......... 13
3.4 ELECTRIC HEATER COIL:.......... 13
TYPE OF HEATER COIL: .......... 14
Coil configuration: .......... 14
WORKING PROCESS : .......... 15
PROPERTISE OF HEATER COIL: .......... 15
3.5 BLOWER FAN: .......... 15
TYPES OF BLOWER FAN:.......... 15
1. Positive Displacement / Rotary Lobe Blowers.......... 15
2. Helical Screw Blowers.......... 15
3. Centrifugal Blowers.......... 15
4. High Speed Blowers .......... 15
5. Regenerative Blowers .......... 16
WORKING PROCESS:.......... 17
Difference between a blower and a fan: .......... 17
3.6 ELECTRONIC TEMPERATURE CONTROLLER: .......... 17
TYPES OF TEMPERATURE CONTROLLER: .......... 17
Temperature controller configuration:.......... 18
Working process:.......... 18
Characteristics of the Controlled Object.......... 18
3.7 ELECTRIC CONTRACTOR: .......... 19
Different types of circuit breakers.......... 19
3.7.1 Based on Voltage .......... 19
3.7.2 By Installation Location .......... 19
3.7.3 Based on External Design .......... 20

3.7.4 By Interrupting Mechanism ........ 20
3.8 FOIL INSULATION: ........ 22
Types of Insulation ........ 22
3.9Working process: ........ 24
3.10 PROPERTIES OF FOIL INSULATION: ........ 25
3.11THERMOMETER: ........ 25
TYPES OF THERMOMETER ........ 25
Thermometer working process: ........ 26
Chapter 4 ........ 27
MACHINE DESIGN AND SELECTION ........ 27
4.1 Hot air drying machine designs ........ 27
4.1.1Drying Chamber ........ 27
4.1.2Blower ........ 28
4.1.3Air Heater ........ 28
4.1.4Air Exchange ........ 28
4.2 CIRCUIT DIAGRAM OF HOT AIR DRYING MACHINE SYSTEM ........ 29
4.3 LOAD DETERMINATION ........ 29
4.4 BOX SIZING ........ 29
4.5 SELECTION OF ELECTRONIC TEMPERATURE CONTROLLER ........ 30
4.6 SELECTION OF ELECTRIC HEATER ........ 30
4.7 SELECTION OF COOLING FAN ........ 30
4.8 OPERATING AND MAINTENANCE COST ........ 31
4.9 Foil insulation: ........ 31
SELECTION OF INSULATION: ........ 31
CHAPTER 5 ........ 33
DATA ANALYISIS AND CALCULATION ........ 33
5.1 CONFIGURATION OF INSTRUMENT: ........ 33
5.2 CONFIGURATION OF BOX: ........ 33
5.3Data calculation: ........ 33
5.4Curve ........ 38

CHAPTER 6 .......... 40

APPLICATION AND USES OF HOT AIR DRYING MACHINE .......... 40

6.1: APPLICATION AND USE HOT AIR DRYING MACHINE .......... 40

6.2 PURPOSE OF HOT AIR DRYING MACHINE .......... 40

6.3 ADVANTAGE OF HOT AIR DRYING MACHINE .......... 40

6.3.1Use it any time of the day .......... 40

6.3.2Ready-to-wear clothes .......... 41

6.3.3Wash bulky items with ease .......... 41

6.3.4Save laundry time .......... 41

6.3.5Prevent build-up of mold .......... 41

6.3.6Great for winter’s .......... 41

6.3.7Required in dusty places .......... 41

6.3.8Stackable .......... 42

6.3.9High capacity .......... 42

6.3.10Aesthetics .......... 42

6.3.11Removes lint .......... 42

6.4 IMPORTANT OF HOT AIR DRYING MACHINE .......... 42

CHAPTER 7 .......... 44

RECOMMENDATION .......... 44

7.1 COST OF HOT AIR DRYING MACHINE SYSTEM .......... 44

7.2 INCREASING THE HOT AIR DRYING MACHINE .......... 44

7.3 CITATION OF HOT AIR DRYING MACHINE: .......... 45

7.4 Clothes Dryer Safety Tips .......... 45

CHAPTER 8 .......... 47

CONCLUSION .......... 47

8.1 Research and development of hot air drying machine: .......... 47

REFERENCE: .......... 48

# CHAPTER 1

## INTRODUCTION

## 1.1 INTRODUCTION:

Drying is a separation process that converts a wet solid, semisolid, or liquid feedstock into a solid product by evaporation of the liquid into a vapor phase with the application of heat. Essential features of the drying process are phase change and production of a solid. Thermal drying is one of the most important unit operations in most industrial sectors. Indeed, it is hard to and a product in daily use that has not undergone drying as a stage of its manufacture. Drying is an essential operation in the chemical, agricultural, biotechnology, food, polymer, ceramic, pharmaceutical, pulp and paper, and wood processing industries. Drying is extremely energy-intensive and in many cases has important implications as the thermal energy needed for drying is obtained by combustion of fossil fuels, leading to emission of carbon dioxide. Well-designed modern drying equipment with high thermal efficiencies is becoming increasingly important. One of the most widely used drying systems is ash drying and is also known as pneumatic drying. Flash dryers are most commonly direct drying units and are also known as convective dryers. Pneumatic or ash dryers may be classier as gas–solid transport systems that are characterized by continuous convective heat and mass transfer processes. Hot air pro-diced by indirect heating or direct ring is the most common drying medium in these systems. In direct ash dryers, the gas stream transports the solid par-tickles through the system, and makes direct contact with the material to be dried. This gas stream (drying medium) also supplies the heat required for drying and carries away the evaporated moisture. Super-heated steam can also be used as drying medium yielding sometimes to higher efficiencies and often to higher product quality. The large surface area for heat and mass transfer and the high convective heat and mass transfer coefficients, which take place at these units, result in high drying rates and as a result, high drying capacity. The size of particulates to be dried is usually in the range of 10–500 mm. One of the features of these types of dryers is the relatively short contact time between the hot air and the particulate materials (0.5–10 s) at the drying section. Because of this the material temperature stays always low in the drying process.**[1]**

## 1.2 HEAT

In thermodynamics, heat means energy which is moved between two things when one of them is hotter than the other. That is, heat is defined as a spontaneous flow of energy (energy in transit) from one object to another, caused by a difference in temperature between two objects.[2]

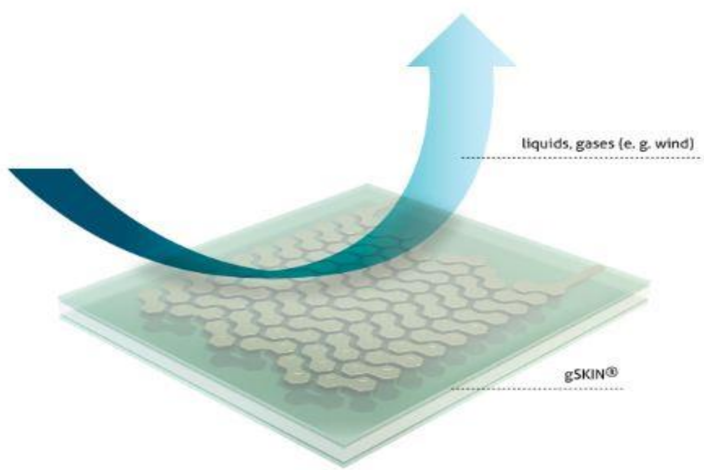
## 1.3 TYPES OF HEAT

1. Convection
2. Conduction
3. Radiation

### 1.3.1 Convection:

Convection is heat flux through liquids and gases. Heat Flux Sensors can measure convective heat flux .Examples of convective heat flux are:

- Feeling much colder when it is windy.
- Feeling much colder in water of 25°C than in air of 25°C.
- Sensing principle in heat flux based mass flow sensors.



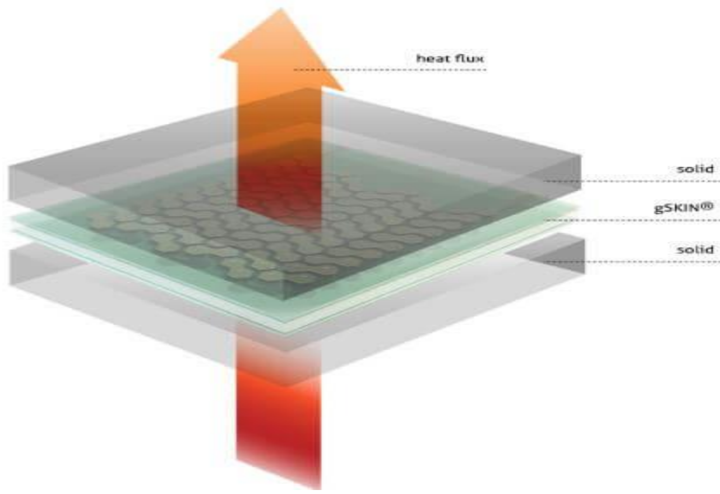

**1.1 Figure [3]**

### 1.3.2 Conduction:

Conduction is heat flux through solid materials .Heat Flux Sensors can measure conductive heat flux .Examples of conductive heat flux are:

- Touching a hot cup of coffee

- Thermal influences in precision instruments.
- Measurement of heat output from chemical reactors.

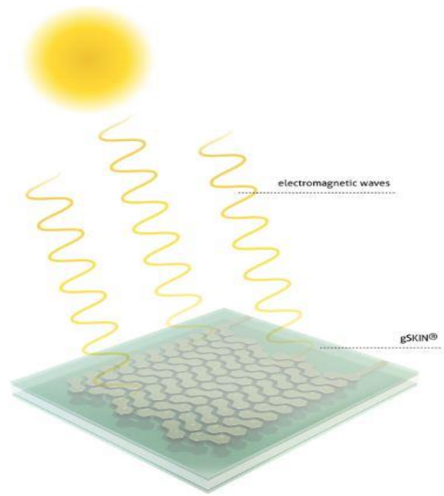



**1.2 Figure [3]**

**1.3.3 Radiation:**

Radiation is heat flux through electromagnetic waves .Heat Flux Sensors can measure radioactive heat flux. Examples of radioactive heat flux are**:**

- Measurement of solar power.
- Feeling hot when standing close to fire.




**1.3 Figure [3]**

## 1.4 Types of drying

These include:

- Clothes drying.
- Convection drying.
- Bed dryers.
- Drum drying.
- Freeze Drying.
- Microwave-vacuum drying.
- Shelf dryers.
- Spray drying.
- Infrared radiation drying.

## 1.5 BACKGROUND OF STUDY

Formerly, drying clothes usually use natural way by using the energy from the sunlight and the wind, but nowadays the technology is plentifully developed upward and the clothes dryers that use the electric energy or other energy come to use extensively, especially in the urban area where limited sunlight and restricted air flow for house types such as high rise condominiums and apartments, natural drying is prohibited in some housing areas for aesthetic reasons and conventional domestic electric dryers are too expensive and inefficient Decreasing energy losses and heat recovery are important research topics, nowadays. Many cabinet dryers widely use, especially those who are busy working. Besides that, most of laundries today have their own dryer cabinet. It is not just because to run their operation at all the time, but they also can prevent the risk to the cloths that might lose or dirty. Cabinet dryer on the market nowadays is using electrical power as a source in generating heat. The other alternative of heat source that can be used for drying machine is heat waste. Heat waste is the capture of energy contained in fluids or gases that would otherwise be lost from a facility. Heat sources may include heat pumps, chillers, and steam condensate lines, hot air associated with kitchen and laundry facilities, power-generation Equipment and wastewater drain lines. There are two basic requirements for heat waste; Heat waste demand must be great enough to justify equipment and maintenance costs. ii. The heat waste temperature must be high enough to serve as useful heat source.Large facilities such as hospitals and military bases often have the perfect mix of heat waste and demand for clothes dryer to effectively use heat waste recovery for clothes dryers. Also large quantities of hot flues are generated from boilers, kilns, oven and furnaces. If some of the heat waste could be recovered then a considerable amount of primary fuel could be saved. However, the limited sources for the study is only heat waste from the residential such as wood, kitchen stove, natural gas, residential refrigerators and air conditioning. The study will continue with the heat waste from residential and adopting the following measures as outlined in this study.

## 1.6 PROBLEM STATEMENT

Design and analyze the clothes dryer machine using heat waste normally include an exploration on starting and growing a study about the clothes dryer machine and heat waste. The elements that need to be considered are evaluating heat waste, and developing new products and parcel of most designs and analyze clothes dryer machine. The design must be considerate on the economic, ergonomic and environmentally friendly. There are also must be energy efficient and less power consumption. Currently, power consumption becomes an important issue addressed by our government. They focused more on energy efficient and less power consumption. Therefore, the use of electric cloth dryer can be replaced by utilizing other heat source such as heat waste. The relationship between energy efficiency and less power consumption has attracted a lot of interest given. It will focus on energy saving features in the residential as well as in industrial and commercial sectors. Energy efficiency standards have been implemented as a voluntary basis since 2005. The increase in energy prices is a reality for Malaysian, but also for many other countries all over the world. Switching to energy saving solutions is the answer for reducing costs and the impacts of the energy sector on the environment. There are also to improve competitiveness of products and services in the global market. Efforts are being made to activate promote the utilization of renewable energy resources. Further applications of new energy sources are planned for the immediate future. Heat waste technologies will be developed with emphasis on utilizing cost effective methods as well as strengthening of the cabinet. The heat waste means free heat is just being wasted without any benefit. There is badness in releasing heat to the environment that will cause of global warming. This problem can overcome by manipulating the heat waste to flow into a cabinet dryer and remove the moisture from cloths. The heat will cost zero, which mean no energy efficient and less power consumption.

## 1.8 OBJECTIVES OF STUDY

For the purpose of the study, two objectives have been set up to guide the research. They are as follows;

i. To design and analyze cloth drying machine by utilizing heat waste.
ii. To analyze performance of the drying machine.

## 1.9 SCOPE OF STUDY

In scaling the cloth dryer machine to a correct extent, the study of concept of drying machine (cabinet) that can be utilized waste heat in its operation has been focused on residents. The design of the drying machine must be analyzed using Computational Fluid

# .CHAPTER 2

## LITERATURE REVIEW

## 2.1. LITERATURE REVIEW

The first electric dryer was invented in the early 20th century. Inventor J. Ross Moore was tired of hanging his clothing outside, especially during the winter. To help keep his wardrobe out of the freezing weather, he built a shed to house his clothes while they dried. In addition, he added a stove. The clothing would hang on the line in front of the fire and dry. This was the beginning of the development of electric dryers. For the next three decades, Moore worked to eventually build a gas and electric unit, but couldn't find anyone to help him get his idea manufactured. The drum-type model was built and eventually picked up by Hamilton Manufacturing in Wisconsin. The new dryers were sold under the name June Day beginning in 1938. In England and France during the end of the 18th century, clothes dryers were being made. Called ventilators, these large contraptions were made of metal. The drum had ventilation holes in it that allowed heat into it while it was hand cranked over an open fire. This invention was used for decades. As time moved on, America caught onto the idea of these ventilators. Unfortunately, the clothing consistently smelled of smoke, was covered in soot and occasionally caught on fire during the drying process. As you can imagine, this wasn't an ideal situation. George T. Sampson of Ohio decided that the ventilator invention needed to be

tweaked. Instead of using heat from an open fire, he chose to place a rack over a stove. This heat source was much better, as it didn't dirty the clothing or catch it on fire! On June 7, 1892, Sampson was granted a patent for his idea. These "dryers" were used well into the 19th century.

## 2.2 Earliest Dryers:

The earliest clothes dryers were made in England and France in the late 18th and early 19th centuries. Known as "ventilators," they were large metal drums with ventilation holes, powered by hand cranks, and used over open fires. Their invention can't be traced to any one person, but perhaps no one would have wanted the credit, since the clothes always smelled of smoke, were often covered with soot and sometimes caught fire.

### 2.2.1 First Patented Clothes Dryer:

An American inventor, George T. Sampson of Dayton, Ohio, came up with a better ventilator-type dryer. It had a rack and used heat from a stove, rather than an open fire. He was granted a patent for his invention in on June 7, 1892. [22]

### 2.2.2 First Electric Dryer:

Inventor J. Ross Moore lived on a North Dakota farm in the early 20th century. Tired of hanging wet clothes outside in the frigid winters, he built a shed, installed a stove and hung the clothes there to dry. Over the next 30 years, Moore developed his idea for an automatic clothes dryer. He finally built a drum type model that worked. He developed both gas and electric models but, due to financial difficulties, needed to find a manufacturer to produce them. After many rejections, he struck a deal with Hamilton Manufacturing Company of Two Rivers, Wis. Hamilton began selling the new automatic clothes dryer, named the "June Day," in 1938.

**1700s**

In 1799, a Frenchman known as Poncho invented the ventilator, a precursor to the modern tumble dryer. This early clothes dryer was a rotating metal drum with holes bored into it. Wet clothes were placed inside the drum which was then positioned over an open fire and cranked by hand.

**2.1 Figure [4]**

**1800s**

On June 7, 1892 an African American named George T. Sampson received a patent for a device similar to Potion's ventilator. Sampson's invention used the heat from a stove rather than an open fire.

**2.2 Figure [4]**

**1900s**

1915 saw the invention of the first electric clothes dryer, which was similar to those invented by Poncho and Sampson, but it could also sense when the clothes were dry. In 1935 J Ross Moore, a North Dakota man trying to protect his mother from having to hang clothes outside in the dangerous winters, constructed an oil-heated drum in an outside shed, thereby inventing the first version of the modern clothes dryer. He patented his invention to run on either gas or electricity, but he saw very little financial gain, as money troubles forced him to sell the patent to the Hamilton Manufacturing Company in 1936. The Huebsch Manufacturing Company, which had patented an open-air dryer in 1931, introduced the stacked dryer to the market place in 1941 and continued their run in 1954 when they introduced a coin-operated dryer for Laundromats. The American Dryer Corporation got into the game in 1965 with two different coin-operated models designed for Laundromats. Fourteen years later they introduced the first computerized dryers.

**2.3 Figure [4]**

**1990s**

The 1990s saw the arrival of environmentally friendly and allergy reducing dryers. Equipped with sensors rather than timers, the dryers were designed to turn off the moment the clothes were dry, to save energy. They were also equipped with HEPA/ULPA filters to reduce airborne particles.

**2.4 Figure [4]**

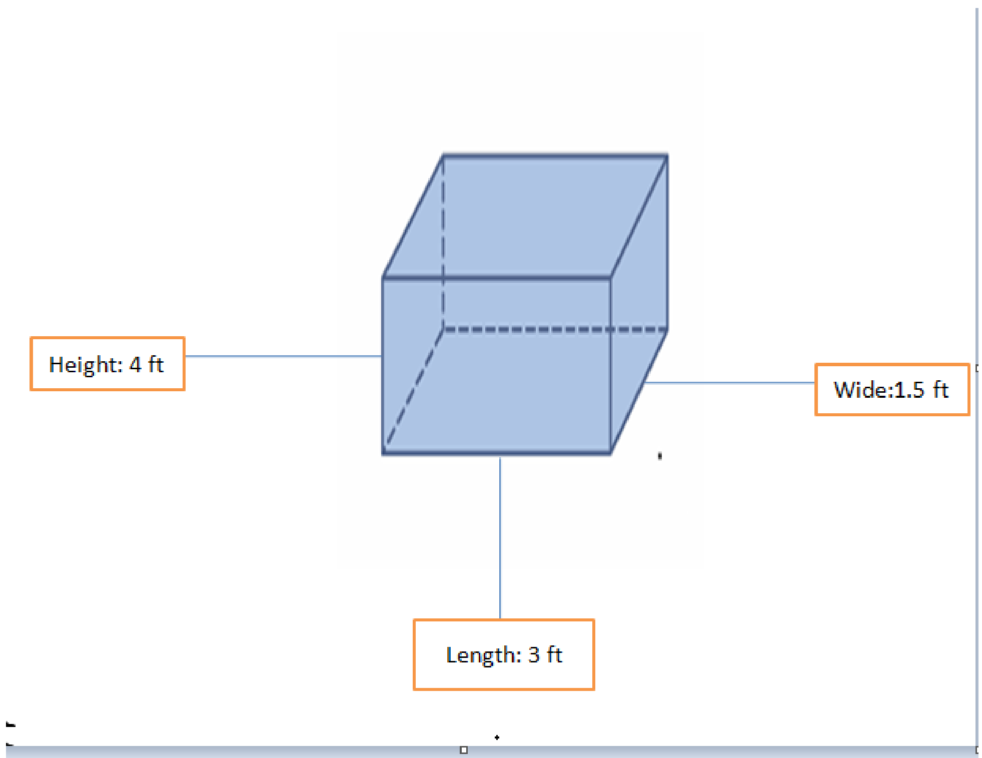
### III. IMPROVEMENTS

In 1946, dryer manufacturers moved controls to the front of the dryer, added a timer, an exhaust for moist air, temperature controls and a cool-down cycle. In 1958, a 30-inchwide dryer using a negative pressure system was first offered to the public. This system is still used in dryers. In 1959, dryness sensors were first used to shut off the power when the load was dry. In 1965, dryers with permanent-press cycles were introduced. In 1972, manufacturers put electric starters on gas dryers. In 1974, microelectronic controls were put on dryers to time drying cycles. In 1983, the first clothes dryers with delayed start timers allowed users to run dryers in off-peak hours. In1985, clothes dryers were offered with all-Spanish instructions on labels, consoles and manuals. Other models offered large type, big graphics and over-sized controls[16]

# CHAPTER 3

## EXPERIMENTAL SETUP AND WORKING PROCESS

### 3.1 BOX




**3.1 Figure**

## BOX CONFIGURATION:

- Length: 4 ft
- Wide: 3 ft
- Height : 1.5 ft
- Material : wood
- Weight : 36 kg

## 3.2 EQUIPMENT SET UP:

At first made the box with wood material then insulation the box with foil insulation .Fan is hanger with box wall from below 4 inch .And the other hand electric heater coil is hanger to the roof of the box. Fan and heater coil distance is 6 inch.

## 3.3 WORKING PRINCIPLE:

A electric heater coil is a heating element which attached to the heating unit it self. when electricity pass through the coil then resistors work by converting electrical energy to heat energy in the other words , it get hot when electricity flows through .The coil heat energy is increasing high then the fan generates air and passes over the heater coil .And air is become hot and supply to the surface .The wet clothes take the hot air and increase the temperature then clothes water convert to gases and remove moisture from the clothes then clothes is dry.

## 3.4 ELECTRIC HEATER COIL:

A heating element converts electrical energy into heat through the process of joule heating. Electric current through the element encounters resistance, resulting in heating of the element. Unlike the Pettier effect, this process is independent of the direction of current.

## TYPE OF HEATER COIL:

- Space heating
- Duct heating
- Pipe heating
- Metal heating
- Tank heating
- Forced air
- ovens

**FIGURE:**

**3.2 Figure: Electric heater coil**

## Coil configuration:

- Capacity : 1100 W
- Diameter : 15.24 CM

- Voltage : 230 VAC
- Number of shell:  3

## WORKING PROCESS   :

A typical heating element is usually a coil, ribbon (straight or corrugated), or strip of wire that gives off heat much like a lamp filament. When an electric current flows through it, it glows red hot and converts the electrical energy passing through it into heat, which it radiates out in all directions.

## PROPERTISE OF HEATER COIL:

Essential requirements of good heating element High-specific resistance so that small length of wire may be required to provide given amount of heat. High-melting point so that it can withstand for high temperature, a small increase in temperature will not destroy the element

## 3.5 BLOWER FAN:

An air blower is a machine used for generating flow of air at substantial pressure. Centrifugal blower Air enters axially and leaves the blade radial direction.

## TYPES OF BLOWER FAN:

The beginnings of modern blowers go back to the mid-1800s, with engineering brothers Philander and Francis Roots. In an attempt to repair a water motor, one brother spun a motor's shaft, and this caused the impellers to spin, creating so much air that the other brother's hat flew off. An iron foundry superintendent witnessed this and pointed out that he could use this machine to melt iron. Inspired, the Roots brothers created their first blower.

Today, blowers ventilate mines, charge internal combustion engines, and perform many other tasks. There are six main kinds of blowers, each with specific characteristics and uses.

1. Positive Displacement / Rotary Lobe Blowers
2. Helical Screw Blowers
3. Centrifugal Blowers
4. High Speed Blowers

5. Regenerative Blowers

**FIGURE:**

**3.3 Figure: Blower fan**

Cooling fan configuration:

- Size : 120× 120 × 36
- Voltage : 230 V
- Capacity : 3.7 W

## WORKING PROCESS:

The pressure of an incoming airstream is increased by a fan wheel, a series of blades mounted on a circular hub. Centrifugal fans move air radically the direction of the outward flowing air is changed, usually by 90°, from the direction of the incoming air. This helps create higher pressure airflow than axial fans.

## Difference between a blower and a fan:

A fan moves large amounts of gas with a low increase in pressure: you'll find these in your home. A blower is a machine used for moving gas with a moderate increase of pressure: a more powerful fan, if you will. By changing the angle of the blades, a blower will be able to push air in any direction you want it.

## 3.6 ELECTRONIC TEMPERATURE CONTROLLER:

Electronic controls allow for independent temperature control of the fresh food and freezer which result in less severe temperature fluctuations. Top-Freezers: Consists of electronic controls and three electronic temperature sensors.

## TYPES OF TEMPERATURE CONTROLLER:

- Open loop control
- Close loop control


**3.5 Figure: Temperature controller**

## Temperature controller configuration:

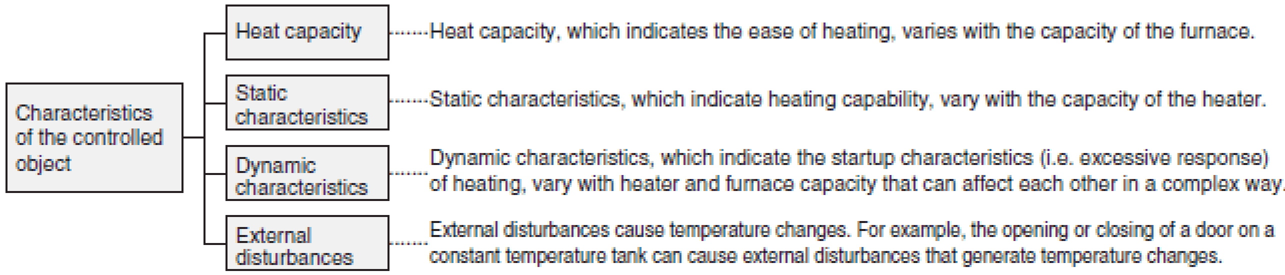
- Type :JTC – 903
- Temperature : 0 to 400 C
- Voltage : 220 VAC
- Freq : 50/60 HZ

## Working process:

The temperature controller takes an input from a temperature sensor and has an output that is connected to a control element such as a heater or fan. It compares the actual temperature to the desired control temperature, or set point, and provides an output to a control element.

## Characteristics of the Controlled Object

Before selecting a Temperature Controller or temperature sensor, it is necessary to understand the thermal characteristics of the controlled object for proper temperature control.




**3.6 Figure**

## 3.7 ELECTRIC CONTRACTOR:

A controller is a comparative device that receives an input signal from a measured process variable, compares this value with that of a predetermined control point value (set point), and determines the appropriate amount of output signal required by the final control element to provide corrective action within a device.

## Different types of circuit breakers

### 3.7.1 Based on Voltage

- Low voltage circuit breakers-These breakers are rated for use at low voltages up to 2 kV and are mainly used in small-scale industries.
- High voltage circuit breakers-These breakers are rated for use at voltages greater than 2 kV. High voltage circuit breakers are further subdivided into transmission class breakers
  - Those which are rated 123 kV and above
  - Medium voltage class (lesser than 72 kV) circuit breakers

### 3.7.2 By Installation Location

- Indoor circuit breakers-These are designed to use inside the buildings or in weather-resistant enclosures. They are typically operated at a medium voltage with a metal clad switchgear enclosure.

- Outdoor Circuit breakers-You can use these breakers outdoors without any roof due to their design. Their external enclosure arrangement is strong compared to the indoor breakers and can withstand wear and tear.

### 3.7.3 Based on External Design

- Dead tank circuit breakers-The breakers whose enclosed tank is at ground potential are known as dead tank circuit breakers. Their tank encloses all the insulating and interrupting medium. In other words, the tank is shorted to ground or it is at dead potential.
- Live tank circuit breakers-These breakers have a tank housing interrupter that is at a potential above the ground. It is above the ground with some insulation medium in between.

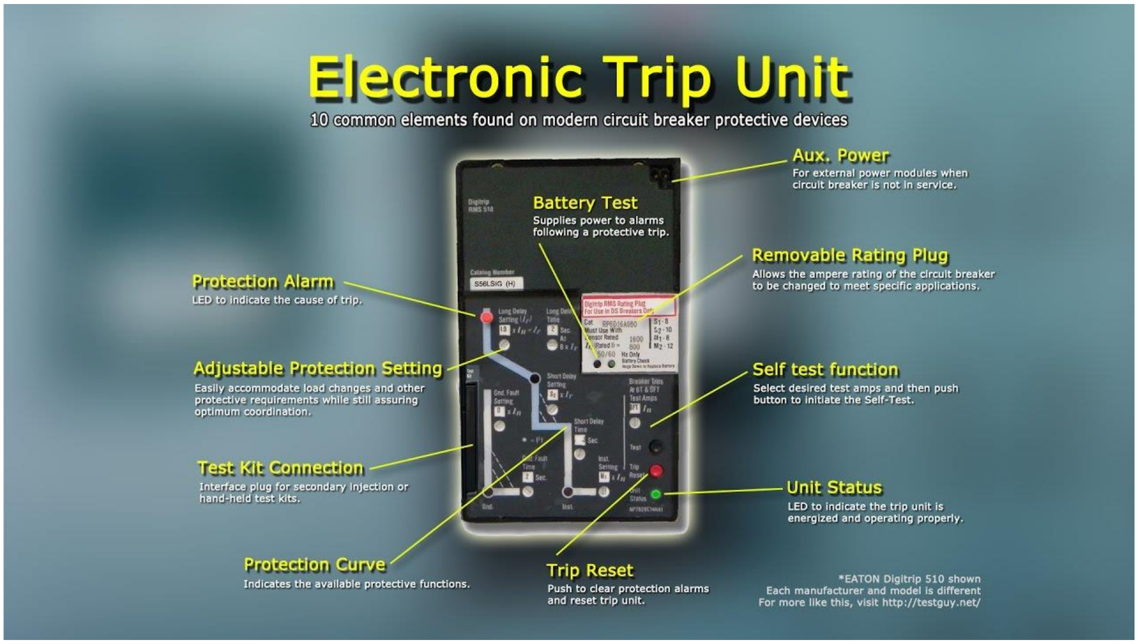
### 3.7.4 By Interrupting Mechanism

- Air circuit breaker– This breaker uses air as an insulating and interrupting medium. The breaker is sub-classified into two types
    - Low voltage circuit breaker whose value lies below 1000 V
    - High voltage circuit breaker whose value is 1000 V and above. It is further classified into oil circuit breakers and the oil-less circuit breaker
- Oil circuit breaker-It uses oil as an interrupting and insulating medium. These breakers are divided into two types based on the pressure and amount of oil used.
- Vacuum circuit breakers-These breakers use vacuum as the interrupting medium due to its high dielectric and diffusive properties.
- MCB (Miniature Circuit Breaker)-The current ratings for this breaker are less than 100A and has only one over-current protection built within it. The trip settings are not adjustable in this circuit.
- MCCB (Molded Case Circuit Breakers)-Current ratings for these breakers are higher than 1000A. They have earth fault protection along with current protection. The trip settings of the Molded Case Circuit Breaker can be adjusted easily.
- Single pole circuit breaker – This breaker has one hot wire and one neutral wire that operate at 120 V. When there is a fault, it will interrupt just the hot wire.
- Double pole circuit breaker-This is used for 220 V. There are two hot wires and both the poles need to be interrupted.
- GFI or GFCI circuit breaker (Ground fault circuit interrupter)-These are safety switches that trip on ground fault current. The GFCI breaker interrupts the electrical circuit when it detects the slightest variance between phase and neutral wires.

- Arc Fault circuit interrupter (AFCI)-The AFCI breaker interrupts the circuit during excessive arc conditions and prevents fire. Under the normal arcing condition, this breaker will be idle and won't interrupt the circuit.[34]


**3.7 Figure: Electric contractor**

**Configuration of electric contractor:**




**3.8 Figure [16]**

## 3.8 FOIL INSULATION:

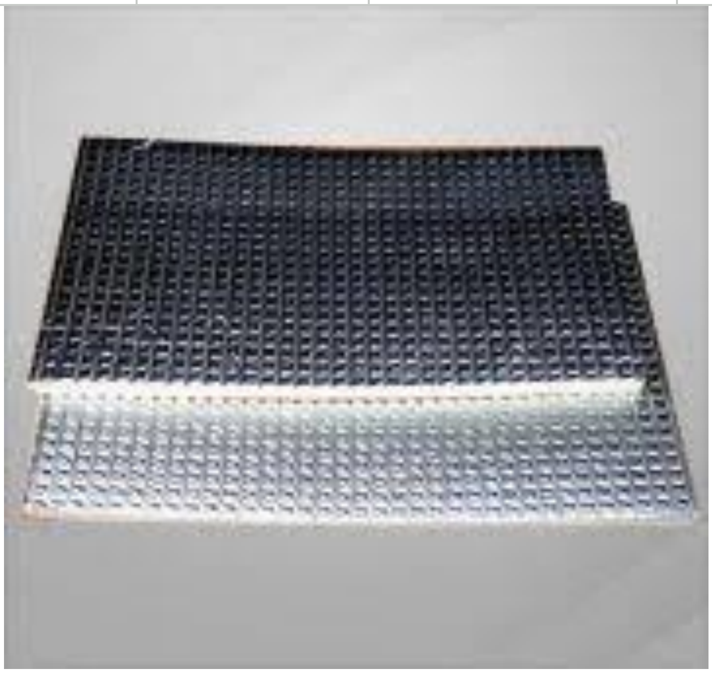
Foil insulation is a thin blanket made up of one or more layers of aluminum and plastic substrate, which reflects heat rather than merely slowing it down or resisting it as other insulations do.

## Types of Insulation

| TYPE | MATERIAL | WHERE APPLICABLE | INSTALLATION METHODS | ADVANTAGES |
|---|---|---|---|---|
| **Blanket: bats and rolls** | Fiberglass<br><br>Mineral (rock or slag) wool<br><br>Plastic fibers<br><br>Natural fibers | Unfinished walls, including foundation walls<br><br>Floors and ceilings | Fitted between studs, joists, and beams. | Do-it-yourself.<br><br>Suited for standard stud and joist spacing that is relatively free from obstructions. Relatively inexpensive. |
| **Concrete block** | Foam board, to be placed on outside | Unfinished walls, including | Require specialized | Insulating cores |

| | | | | |
|---|---|---|---|---|
| **insulation**<br><br>**and insulating concrete blocks** | of wall (usually new construction) or inside of wall (existing homes):<br><br>Some manufacturers incorporate foam beads or air into the concrete mix to increase R-values | foundation walls<br><br>New construction or major renovations<br><br>Walls (insulating concrete blocks) | skills<br><br>Insulating concrete blocks are sometimes stacked without mortar (dry-stacked) and surface bonded. | increases wall R-value.<br><br>Insulating outside of concrete block wall places mass inside conditioned space, which can moderate indoor temperatures.<br><br>Autoclaved aerated concrete and autoclaved cellular concrete masonry units have 10 times the insulating value of conventional concrete. |
| **Foam board or rigid foam** | Polystyrene<br><br>Poly isocyanurate<br><br>Polyurethane | Unfinished walls, including foundation walls<br><br>Floors and ceilings<br><br>Unvented low-slope roofs | Interior applications: must be covered with 1/2-inch gypsum board or other building-code approved material for fire safety.<br><br>Exterior applications: must be covered with weatherproof facing. | High insulating value for relatively little thickness.<br><br>Can block thermal short circuits when installed continuously over frames or joists. |
| **Insulating concrete forms (ICFs)** | Foam boards or foam blocks | Unfinished walls, including foundation walls for new construction | Installed as part of the building structure. | Insulation is literally built into the home's walls, creating high thermal resistance. |
| **Loose-fill and blown-in** | Cellulose<br><br>Fiberglass<br><br>Mineral (rock or slag) wool | Enclosed existing wall or open new wall cavities<br><br>Unfinished attic floors<br><br>Other hard-to-reach places | Blown into place using special equipment, sometimes poured in. | Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions. |
| **Reflective** | Foil-faced Kraft paper, plastic film, | Unfinished walls, ceilings, and | Foils, films, or papers fitted between wood- | Do-it-yourself. |

| | | | | |
|---|---|---|---|---|
| **system** | polyethylene bubbles, or cardboard | floors | frame studs, joists, rafters, and beams. | Suitable for framing at standard spacing.<br><br>Bubble-form suitable if framing is irregular or if obstructions are present.<br><br>Most effective at preventing downward heat flow, effectiveness depends on spacing. |



**3.9 Figure: Foil insulation**

Foil insulation configuration:

- Size : 10 mm (wide)
- Layer : two part
- Color : silver
- Type : foam board

## 3.9Working process:

- Because aluminum foil reflects light, it can be used for insulation, especially in areas that need to be guarded against heat. ... Aluminum foil can keep things like wires or pipes insulated, as it traps air when it is wrapped around an object. This can be achieved with several objects, though, and not just aluminum foil.

- High Density 99.4% pure aluminum foil can reflective 97% radiant heat from the sun uncontinuous and never flow air stay in the air bubble cell can slow down the heat conduction and block heat convection it will not be unaffected by humidity and ensure the best living condition both in extreme hot and cold climate.

## 3.10 PROPERTIES OF FOIL INSULATION:

Foil is a solid metal. It transmits no light and is a total barrier to light including the UV spectrum. Reflects approximately 98% of radiant heat and light. Aluminum is insignificantly magnetic and therefore provides excellent electrical shielding.

## 3.11THERMOMETER:

A thermometer is a device that measures temperature or a temperature gradient. A thermometer has two important elements: (1) a temperature sensor (e.g. the bulb of a mercury-in-glass thermometer or the parametric sensor in an infrared thermometer) in which some change occurs with a change in temperature; and (2) some means of converting this change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer or the digital readout on an infrared model). Thermometers are widely used in technology and industry to monitor processes, in meteorology, in medicine, and in scientific research.

## TYPES OF THERMOMETER

- Forehead strips.
- Wearable thermometers.
- Pacifier thermometers.
- Ear thermometers (tympanic)
- Forehead thermometers (temporal)
- Digital thermometers.

- Mom's hand or lips.(24)

**3.10 Figure thermometer**

## Thermometer working process:

A thermometer has a glass tube sealed at both ends and is partly filled with a liquid like mercury or alcohol. As the temperature around the thermometer's bulb heats up, the liquid rises in the glass tube. When it is hot, the liquid inside the thermometer will expand and rise in the tube.(26)

# Chapter 4

## MACHINE DESIGN AND SELECTION

## 4.1 Hot air-drying machine designs

We have discussed earlier the importance of drying in a cleaning process. Despite the several hardware options available, hot air dryers remain the "go to" in industrial cleaning processes today. Today's blog will discuss the basic design concept of hot air dryers and how they function. The main components of hot air dryers are a drying chamber where the work is placed for drying, a heat source and a fan to circulate heated air.

## Basic components:

- Hot Air Dryer
- Drying Chamber
- Blower
- Air Heater lower
- Air Exchange

## Basic Hot Air Dryer

These basic components can be arranged in a myriad of ways depending on the application and the space available.

### 4.1.1 Drying Chamber

Typically, the drying chamber is at least partially enclosed. A lid prevents excessive leakage of hot air to the environment. The chamber is constructed of materials that will resist the shedding of particles that would otherwise contaminate the parts being dried. Unpolished stainless steel is ideal. In cases where thermal leakage to the environment is a concern (in a clean room for example) the drying chamber and associated ductwork can be insulated. Most drying chamber lids do not provide a tight seal although it would be easy to argue the importance of sealing the chamber to prevent contamination of parts during drying as we will discuss later.

#### 4.1.2 Blower

The blower, as the chamber, should be relatively immune to damage due to humidity and chosen to prevent particle shedding during operation. The blower is the largest potential source of particle contamination in the typical dryer because of its moving parts. The use of electrically driven "squirrel cage" blowers is common although there are many other options available including simple fans. The blower must be able to withstand high temperatures as the return air from the drying chamber will be hot. The flow capacity of the blower should be based on the application. In some cases, air velocity is key while in others, temperature is the primary important factor in drying effectiveness. Search "drying" in the search box below for additional background on this issue.

#### 4.1.3 Air Heater

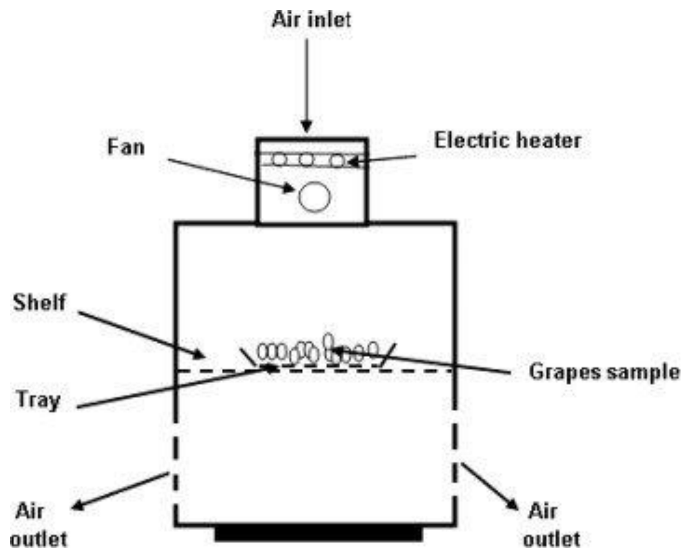
The next major component of the basic dryer is a source of heat. As is the case with the blower, the air heater should be relatively immune to humidity and should not generate particles. The air heater has the second largest potential for particle generation in the drying system. Although electric heaters dominate in dryers, other sources of heat including steam and gas are used occasionally (especially in larger systems). The heater should have sufficient capacity to raise the temperature in the dryer in a relatively short period of time but should not be so powerful that excessive cycling is required for temperature control in normal operation. Excess capacity may result in temperature spikes due to the "thermal inertia" of the heater. Finally, the heater should be chosen to provide as little resistance to the flow of air as possible.

#### 4.1.4 Air Exchange

As discussed in previous blogs, moisture in the form of humidity is created as water evaporates from the surfaces of parts being dried. In a totally closed system, the moisture in the air will eventually reach a saturation point (100% relative humidity) resulting in a decrease in drying efficiency despite adequate temperature and air flow. In order to prevent this, some means of exchanging humid air for less humid air must be provided. In the illustration above, a bleed-off is provided after the blower to exhaust humid air. A damper is provided to control the amount of air exhausted. Makeup air, then, is ideally acquired through a filtered inlet in the "suction" line going to the blower. In the case of a drying chamber that is not totally sealed, some makeup air may also be acquired as it directly enters the chamber. In this case, of course, the air is unfiltered and may introduce particles into the dryer. This may or may not be important depending on the application.

The above has described the basics of a hot air dryer. As you may assume there is a lot more to talk about when it comes to hot air dryers and a lot of both valid and unfounded theories about the best way to configure them. I'll cover these and more in future blogs.

## 4.2 CIRCUIT DIAGRAM OF HOT AIR DRYING MACHINE SYSTEM




**4.1 Figure [23]**

## 4.3 LOAD DETERMINATION

So power requirement of various type of load are given bellow:

| Load | Rated power |
|---|---|
| Cooling Fan | 3.5 W |
| Electric Heater | 1100 W |

## 4.4 BOX SIZING

- height –length-wide : (4-3-1.5) fit

The following characteristics are needed for a hot air drying system:

- Long lifetime

- Low maintenance cost
- Long time heat absorb
- Low cost
- Reliability
- Low heat loss

## 4.5 SELECTION OF ELECTRONIC TEMPERATURE CONTROLLER

- The controller of this temperature controller is comparatively good responsible then other receivers.
- Easier to mark  low temperature level
- Easier to mark high temperature level
- Good regulation
- Adjust with system temperature

## 4.6 SELECTION OF ELECTRIC HEATER

- High melting point
- Long life
- High specific resistance
- Low level rust
- Does not create fire

## 4.7 SELECTION OF COOLING FAN

- Obviously, the static pressure of cooling fan is the dominant factor for a high-resistance heat sink assembly.

- No clumps of cooling fans or cables.

- The cooling air distributions of grate cooler exercise a great influence on the clinker cooling efficiency and power consumption of cooling *fans*.

- The optimal cooling air distributions are compared by heat recovered energy consumption of cooling *fans* and heat efficiency of grate cooler.

- And all of them are selected from the Pareto optimal solutions based on energy consumption of cooling *fans* minimization.

## 4.8 OPERATING AND MAINTENANCE COST

- Raw materials and other supplies
- Energy
- Rent and insurances
- Deflection of natural resources
- Contingencies
- The above mentioned items are identified in the technical study and should also be reflected in the financial analysis
- Sunk cost
- These are those costs which have been incurred on the project before its appraisal
- Shadow price
- These price are the values of project inputs and outputs reflecting their relative scarcity or availability.

## 4.9 Foil insulation:

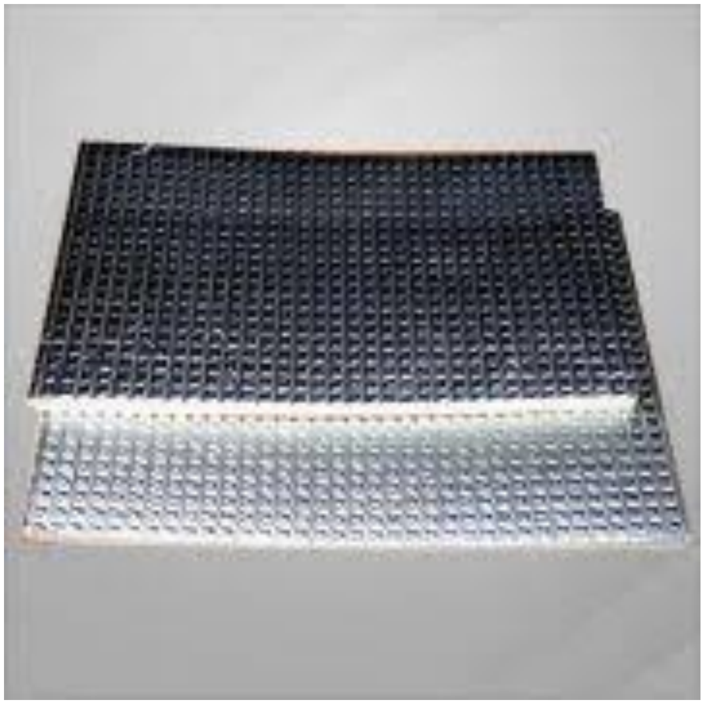
Foil insulation is a thin blanket made up of one or more layers of aluminum and plastic substrate, which reflects heat rather than merely slowing it down or resisting it as other insulations do.

## SELECTION OF INSULATION:

- Foil insulation is a solid material
- It is transmit no light
- Reflects approximately 98% of radiant heat and light
- Foil insulation is long life
- It is flexible
- Foil insulation is good reliability
- Heat loss is low
- Foil insulation has two layers

- It is cheap and plentiful.

Figure:



**4.2 Figure:  Foil insulation**

# CHAPTER 5

## DATA ANALYISIS AND CALCULATION

### 5.1 CONFIGURATION OF INSTRUMENT:

| | |
|---|---|
| FOIL INSULATION | 10 mm |
| COIL HEATER | 1100 W |
| TEMPERATURE CONTROLAR | 0 to 400 C |
| FAN | 230 V |

### 5.2 CONFIGURATION OF BOX:

| | |
|---|---|
| LENGTH | 4 ft |
| WIDE | 3 ft |
| HEIGHT | 1.5 ft |
| MATERIAL TYPE | wood |
| WEIGHT | 36 kg |

### 5.3Data calculation:

| | |
|---|---|
| Length | 4 ft |
| Wide | 3 ft |
| height | 1.5 ft |
| Coil tem. | 62 ℃ |
| Surface ave. tem. | 47℃ |

For convection heat flow,

Q =h×A×ΔT×t

$\frac{Q}{t}$ = hA ×(T1-T2)

1100=h×3.6576(62-47)

h=20.0 W\$m^2$.K

**Typical values of heat transfer coefficient**

| Flow type | (W/$m^2$ K) |
|---|---|
| Forced convection; low speed flow of air over a surface | 10 |
| Forced convection; moderate speed flow of air over a surface | 100 |
| Forced convection; moderate speed cross- flow of air over a cylinder | 200 |
| Forced convection; moderate flow of water in a pipe | 3000 |
| Forced Convection; molten metals | 2000 to 45000 |
| Forced convection; boiling water in a pipe | 50,000 |
| Forced Convection - water and liquids | 50 to 10000 |
| Free Convection - gases and dry vapors | 5 to 37 |
| Free Convection - water and liquids | 50 to 3000 |
| Air | 10 to 100 |
| Free convection; vertical plate in air with 30°C temperature difference | 5 |
| Boiling Water | 3.000 to 100.000 |
| Water fowing in tubes | 500 to 1200 |
| Condensing Water Vapor | 5.0 - 100.0 |
| Water in free convection | 100 to 1200 |
| Oil in free convection | 50 to 350 |
| Gas flow on tubes and between tubes | 10 to 350 |

**5.1: Figure heat transfer coefficient [34]]**

| | |
|---|---|
| Length | 2 ft |
| Wide | 2 ft |
| Thickness | 1.5 mm |
| Thermal conductivity ,K | 0.243 w/m.K |
| Temperature 1 | 50 ℃ |
| Temperature 2 | 45 ℃ |
| | |

**For conduction:**

Heat flow

$Q_1 = kA\,\frac{\Delta T}{\Delta x}$

$= kA \times \frac{T1 - T2}{\Delta x}$

$= 0.243 \times 1.2192 \times \frac{50-45}{0.0015}$

=987.552 watt

| Textile fibres | Thermal conductivity, W (m K)$^{-1}$ |
|---|---|
| Cotton | 0.243 |
| Nylon | 0.171 |
| Polyester staple | 0.127 |
| Polyester filament | 0.157 |
| Flax | 0.344 |
| Polypropylene | 0.111 |
| Rayon staple fibre | 0.237 |
| Wool | 0.165 |
| Silk | 0.118 |

**5.2: Figure thermal conductivity for cotton [28]**

| | |
|---|---|
| Length | 3 ft |
| Wide | 1 inch |
| Thickness, d | 1 inch |
| Temperature 1 | 45 ℃ |
| Temperature 2 | 40 ℃ |
| Thermal conductivity , K | 0.17 w/m.K |

Heat flow rate,

$$Q2 = KA\frac{\Delta T}{\Delta x}$$

$$=kA\times\frac{T1-T2}{\Delta x}$$

$$=0.17\times0.023\times\frac{45-40}{0.0254}$$

=0.769 watt

| Material | Thermal conductivity (K), (unit : W/m-K) |
|---|---|
| Diamond | 2300 |
| Silver | 429 |
| Cooper | 401 |
| Aluminum | 237 |
| Human skin | 0.37 |
| Wood | 0.17 |
| Air | 0.026 |

**5.3 Figure thermal conductivity for wood [29]**

Total heat flow rate,

$Q=Q1+Q2$

=987.552+0.769

=988.321 watt.

Working temperature at 50℃. Cloth dimension (length 2 ft, wide 2, ft thickness 1.5 mm) this temperature the cloth dry time 8 min .Input energy 1100 watt, output energy 988.321 watt and heat loss 111.679 watt.

Neglect the wood surface area through the heat flow.

**Nomenclature:**

Q=Heat transfer rate (j/s)

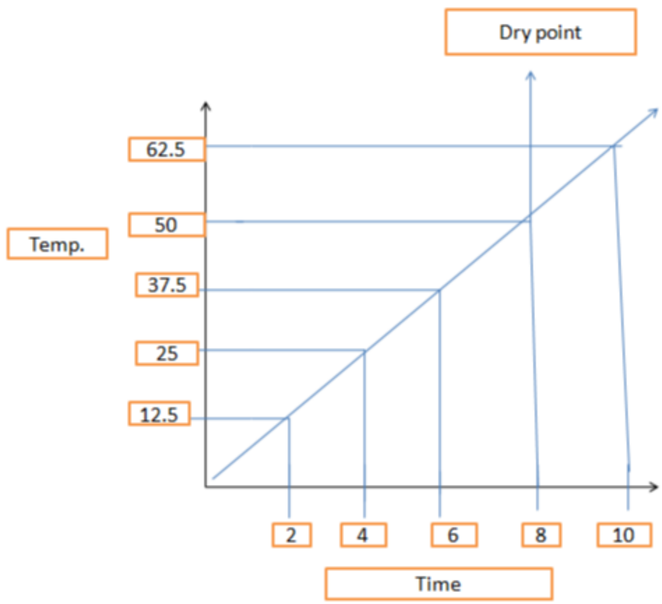
H= Heat transfer co-efficient (W/$m^2$.K)

A= Surface area ( $m^2$)

ΔT= Temperature difference ℃

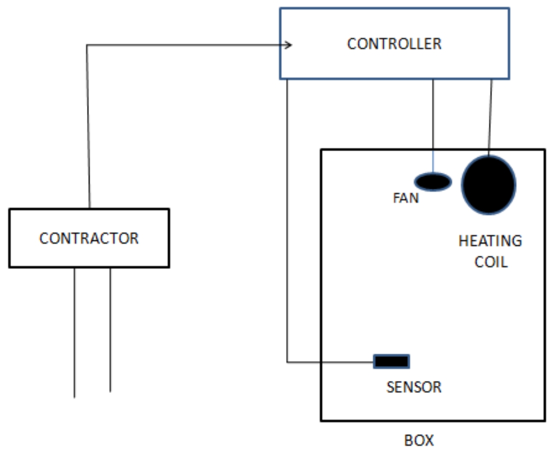
T= Time (s)

## 5.4Curve




**5.4 Figure: temperature and time curve**

**Electric circuit:**




**5.5 Figure: electric circuit**

# CHAPTER 6

# APPLICATION AND USES OF HOT AIR DRYING MACHINE

## 6.1: APPLICATION AND USE HOT AIR DRYING MACHINE

Hot air drying machine is a universal drying equipment which can dry various materials .it is suitable for the heating and drying of raw materials and production in the pharmaceutical , chemical, food, light industry and heavy industry , the clothe industry etc. such as:

1. Pharmaceutical industry: Active pharmaceutical ingredients, crude drug, Chinese medicinal decoction pieces, powder, instant granules, watered pill, packing bottle, etc

2. Chemical industry: pigment, dyestuff.

3. Food industry: vegetable, fruit, meat, fish etc.

4. Light and heavy industries: plastic, resin, electric component, baking finish etc.

5. Clothe industry: such as spinning mills, textile mills etc.

## 6.2 PURPOSE OF HOT AIR DRYING MACHINE

Moisture that is bound chemically cannot be removed by drying. The purpose of drying is to retain the physic-chemical properties of materials, to ensure, in many cases, the preservation of materials over prolonged periods, and to eliminate excess weight in shipping.

## 6.3 ADVANTAGE OF HOT AIR DRYING MACHINE

### 6.3.1 Use it any time of the day

The best thing about a dryer is that you can use it anytime. It doesn’t matter what the weather conditions are. On the contrary, if you hang your clothes outdoors, you will have to wait for the sun to shine bright. Bright colored clothes might even fade in the sun.

### 6.3.2 Ready-to-wear clothes

A dryer's main purpose is drying. The fact is that using a washing machine's drying cycles won't dry your clothes the way a dryer does. A dryer functions in a much faster and efficient way. If you are planning to air-dry garments and if you live in hum id places, your clothes will take even longer to dry.

### 6.3.3 Wash bulky items with ease

Forget hanging heavy items on a clothesline, even running a heat cycle in your washing machine to dry them will definitely not work. Using a dryer is the fastest drying method you can resort to. Heavy items can easily fit inside dryer racks.

### 6.3.4 Save laundry time

If you use a washing machine and a dryer, it can save you a lot of time, especially if you have multiple loads to wash. All you have to do is while you are washing the current load in your washing machine; you can put your previous load in the dryer. You will have your set of clothes ready sooner than you can imagine.

### 6.3.5 Prevent build-up of mold

If you air-dry clothes, the moisture seeps into the air inside your household, making it damp. This can cause the growth of mold, which is hazardous for health. On the other hand, dryer vents out the moisture or condenses it and drains it off.

### 6.3.6 Great for winter's

Wet clothes inside your home during winters means the temperature is going to drop further. This leads to an increase in energy required to keep your home warm. Instead, if you use a dryer, you can get completely dry clothes with a lesser amount of energy spent. Also, there will be no hint of water which can make you prone to getting the chills.

### 6.3.7 Required in dusty places

A clothes dryer is also useful in areas that are dusty and polluted, and where it is not possible to dry your clothes out on a line else, they might get dirty again.

### 6.3.8 Stackable

A clothesline often needs to cover a large area. If you use both a washing machine and a dryer, don't worry about space constraints. You just need to stack the two appliances. You can get more done in lesser time.

### 6.3.9 High capacity

The drum of a dryer is larger than that of a washing machine. It can also accommodate more clothes than your clothesline at a single time.

### 6.3.10 Aesthetics

A clothesline spoils the look of your otherwise well-furnished house. Consider investing in a dryer if you don't want your house to look shabby.

### 6.3.11 Removes lint

The dryer is useful in removing lint.  In case a fabric gets washed with a tissue in a pocket, the tissue disintegrates and is found all over the washed clothes. The clothes dryer can trap all of the destroyed tissue, freeing the clothes of lint and tissue. This is not all. Washing your towels in a dryer makes them fluffier and your clothes need less ironing once a cycle has been run on them.[10]

## 6.4 I MPORTANT OF HOT AIR DRYING MACHINE

It could also helps in preventing germination for a period of time till they get enough moisture, which is an added advantage for grain storage purpose. Importance of grain drying: 1.Drying of grains is important because grains with high amount of moisture deteriorate both in terms of quality and quantity quickly. Certain design features of dryer can be modified which includes

- Providing parabolic reflector on both sides of the collector.
- Increasing the absurdity of the absorber plate.
- Replacing copper plate with aluminum plate.
- Increasing the air flow rates.
- Providing PVT operated electrical heating coil.
- Incorporating PCM based thermal energy storage system in the dryer to maintain

- Required temperature in the evening/night hours.
- Installing a swirl element at the entrance of the drying chamber to give rotation
- effect to the air and fixing bended sheet strips inside the chamber to direct the
- Airflow.
- Increasing collector tilt angle length and breadth to a certain limit to raise the
- Temperature of the dryer.
- Providing dehumidifier before the drying chamber for removing moisture in the
- Air to improve the drying rate.
- Improvements in the performance of the dryers could lead to the performance enhancement of the
- Dryer for use in small scale business enterprises. Neural network model can be used to predict the
- potential of the dryer for different locations and can also be used in a predictive optimal control
- Algorithm. Further study on other modeling software's is needed to uphold confidence in numerical
- Simulation of drying process. [10]

# CHAPTER 7

## RECOMMENDATION

### 7.1 COST OF HOT AIR DRYING MACHINE SYSTEM

| SI. NO | Description of items | BDT |
|---|---|---|
| 1 | Box | 5000 |
| 2 | Electric heater | 450 |
| 3 | Cooling fan | 500 |
| 4 | Temperature controller | 1200 |
| 5 | Magnetic contractor | 400 |
| 6 | Insulation | 1800 |
| 7 | Wire | 200 |
| 9 | Total | 9550 |

### 7.2 INCREASING THE HOT AIR DRYING MACHINE

- Use to good insulation

- Non leakage this plant
- To have minimum load
- To supply adjust level voltage
- Use to good cooling fan , electric heater , magnetic conductor and temperature sensor.
- Using good wire for this plant
- After just time to collect data and analysis
- Maintenance this plant just time.

## 7.3 CITATION OF HOT AIR DRYING MACHINE:

Exceptions to this are freeze and vacuum dryers, which are used almost exclusively for drying heat-sensitive products though they tend to be significantly more expensive than dryers operated near to atmospheric pressure. Another exception is the emerging technology of superheated steam drying .Drying behavior of solids can be described by measuring the function of moisture content loss versus time. Continuous weighing, humidity difference and intermittent weighing are the often used method

## 7.4 Clothes Dryer Safety Tips

A leading cause of dryer fires in homes is the lack of dryer maintenance. Homeowners are reminded to take the following precautions:

### Installation

- Have your dryer installed and serviced by a professional.
- If you are installing your own dryer, follow the manufacturer's instructions before installing the dryer vent. Determine the straightest and most direct venting path to the outdoors to reduce the likelihood of lint accumulation in bends or elbows.
- Use rigid or flexible metal ducting for venting to the outdoors. Plastic or metal foil ducts are more prone to kinking, sagging and crushing, which leads to lint build-up. Plastic ducting is also more prone to ignition and melting.
- Clothes dryers located in closet-type spaces or totally enclosed rooms (e.g. in apartments) should have sufficient incoming air for proper operation (see manufacturer's instructions).

## Permanently:

- Follow the manufacturer's instructions regarding the safe use of the dryer.
- Inspect and clean the lint screen after each load of laundry. The build-up of lint can lead to a fire. Regularly remove lint from metal ducts and exhaust vents. The inside of the dryer cabinet should be cleaned as per manufacturer's instructions.
- Regularly inspect the air exhaust to ensure it is not restricted and the outdoor vent flap opens when the dryer is operating.
- Turn the dryer off if you leave home or when you go to bed.
- Keep the area around the dryer clear of items that can burn.
- Install a carbon monoxide alarm in your home if using a natural gas or propane dryer.
- Ensure there are working smoke alarms on every storey of the home and outside all sleeping areas.

## Safety and frequency:

- Overload the dryer.
- Exhaust the dryer indoors.
- Dry materials or fabrics that have been saturated by chemicals, oils or gasoline (e.g. mops and towels and cloths saturated with wax, flammable solvents or vegetable oils). Even after washing, these substances can start a fire during the drying cycle.
- Dry natural or synthetic rubber, rubber-coated sneakers, galoshes, foam pillows or any garment with foam padding (e.g. blouses with shoulder pads, bras, bicycle shorts)
- Dry garments that have been cleaned with dry-cleaning fluid.
- Use a dryer without a lint filter, or with a lint filter that is loose, damaged or clogged.

# CHAPTER 8

## CONCLUSION

### 8.1 Research and development of hot air drying machine:

Drying R&D has seen nearly exponential growth over the past three decades. Initially driven by the need to conserve energy in this highly energy-intensive operation found in almost all industrial sectors, now the focus is on product quality, environmental impact, safety issues, new products, and processes etc. Drying provides challenging areas for multi- and cross-disciplinary research of fundamental as well as applied nature coupling transport phenomena with material science. An attempt will be made to summarize the new developments in drying technologies, identify recent trends and make predictions about the future trends that may be expected. Also, personal perspectives on models of research appropriate for drying technology will be presented. The need for industry-academia interaction and for a stake of industry in academic research is noted as a key step towards successful transfer of innovative drying technologies to industry. Finally, the weaknesses of the currently popular "closed loop" approach of research in academia, by academia and for academia, resulting on over-emphasis on "high impact-factor" rather than "high impact research" will be discussed. It is hoped that future IDS meetings will increase industry participation by enhancing their impact on industrial adoption of newer more efficient drying technologies. It is essential to make it a worthwhile even essential exercise for industry to participate in these meetings.

## REFERENCE: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