

EXPERIMENTAL INVESTIGATION OF GREEN HOUSE SOLAR DRYER WITH DIFFERENT FLOORS COCONUT DRYING

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in Mechanical Engineering

by

JETHESLIN S (Reg.No.37150083)
JESU INIGO NYGIL J (Reg.No.37150082)



**DEPARTMENT OF MECHANICAL ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with grade "A" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119**

APRIL 2021



SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited with "A" grade by NAAC
Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119
www.sathyabama.ac.in



DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **JETHESLIN S (Reg.No.37150083)** and **JESU INIGO NYGIL J (Reg.No.37150082)** who carried out the project entitled "**EXPERIMENTAL INVESTIGATION OF GREENHOUSE SOLAR DRYER WITH DIFFERENT FLOORS**" under our supervision from September 2020 to April 2021.

Mr. M. PURUSOTHAMAN M.E., (Ph.D.)

Internal Guide

Dr. G. ARUNKUMAR, ME., (Ph.D.)

Head of the Department

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We **JETHESLIN S (Reg.No.37150083)** and **JESU INIGO NYGIL J (Reg.No.37150082)** hereby declare that the Project Report entitled **“EXPERIMENTAL INVESTIGATION OF GREENHOUSE SOLAR DRYER WITH DIFFERENT FLOORS COCONUT DRYING”** done by me under the guidance of **Mr. M.PURUSOTHAMAN, M.E.,(Ph.D.)**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

1)

2)

DATE :

SIGNATURE OF THE CANDIDATES

PLACE : CHENNAI

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my sincere thanks to **Dr. S. Prakash, M.E., (Ph.D.), Dean, School of Mechanical Engineering** and **Dr. G. Arun Kumar, M.E., (Ph.D.), Head of the Department, Dept. of Mechanical Engineering** for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide **Mr. M.PURUSOTHAMAN, M.E., (Ph.D.)**, for his valuable guidance, suggestions and constant encouragement paved way for the successful completion

I also express my thanks to all Teaching and Non-teaching staff members of the Department of Mechanical Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

In modern years, research and development in green house solar drying with different floors coconut drying. Coconut is a conventional food fixing handled in Agro ventures in numerous pieces of Tamil Nadu. Drying of coconut at mechanical level is as of now done in open sun drying, which has issues of cleanliness. While drying, the endosperm of coconut is uncovered and it is defenseless for defilement because of earth. The coconut part having beginning dampness substance of 50-55 percent is decreased to 6 percent during drying activity available to be purchased capacity and to keep up food quality. Sun powered passage dryer is sem. round and hollow passage formed construction covered with UV settled polyethylene sheet. The floor region (10 x 10 m) of the sun powered dryer is white covered to accomplish the most extreme drying proficiency. The outcomes showed that the temperature inside the sun based dryer gets helped up by 15-20°C more than the encompassing. The outcomes likewise uncovered that the coconut being dried in the sun powered dryer was totally shielded from downpour, bugs and dust and the dried coconut pieces were top notch contrasted with open sundried item. Under the meteorological states of India, a characteristic convection nursery sun powered dryer with various floors was planned and tried for its prosperity throughout the mid year and cold weather months, utilizing coconuts as the drying content. The efficiency of even span and parabolic roof style solar greenhouse dryers is studied in this analysis in both active and passive modes under identical operating conditions. To increase the solar insulation effect, dryers were filled with polyethylene sheets. For drying coconut, the output of these dryers is measured. Coconut moisture content was lowered from 50 percent to 11 percent. For both of active and passive mode conditions, the parabolic dryer could dry in 12 to 48hr, respectively and that for the even solar dryer, it could achieve the same state in 48 to 72hr, respectively.

TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	ABSTRACT	v
	TABLE OF CONTENTS	vi
	LIST OF FIGURES	vii
	LIST OF TABLES	ix
1	INTRODUCTION	1
	1.1 AN ARRAY OF SOLAR DRYERS EXIST	1
	1.1.1 THE NATURAL CONVECTION AND FORCED CONVECTION DRYERS	1
	1.2 TYPES OF SOLAR DRYERS	1
	1.2.1 OPEN SUN DRYING	2
	1.2.2 DIRECT SOLAR DRYER	2
	1.2.3 INDIRECT SOLAR DRYER	2
	1.2.4 MIXED MADE SOLAR DRYER	3
	1.2.5 NATURAL CIRCULATION DRYER	4
	1.2.6 FORCED CONVECTION SOLAR DRYER	4
	1.2.7 SOLAR DRYER WITH GREEN HOUSE AS COLLECTOR	5
	1.2.8 GEODESIC DOME SOLAR DRYER	6
	1.3 TYPES OF DIFFERENT FLOORS	7
	1.3.1 MICA FLOORS	7
	1.3.2 FIBRE FLOORS	8
	1.3.3 CRUSHED STONE FLOORS	9
2	LITERATURE SURVEY	10

3	AIM AND SCOPE	15
	3.1 AIM	15
	3.2 SCOPE	15
4	MATERIALS AND METHODS	16
	4.1 FABRICATION OF DRYER	16
	4.2 DETAILS OF INSTRUMENTS	17
	4.2.1 DIGITAL HYGROMETER	18
	4.2.2 EXHAUST FAN	18
	4.2.3 SOLAR POWER METER	20
	4.2.4 INFRARED THERMOMETERS	21
	4.2.5 ANEMOMETER	22
	4.2.6 DIGITAL WEIGHING MACHINE	23
	4.2.7 SOLAR PANEL	24
	4.3 EXPERIMENTATION	26
5	RESULT AND DISCUSSION	27
	5.1 INSIDE AND OUTSIDE OF POLYETHYLENE	27
	5.2 INSIDE AND OUTSIDE GROUND TEMPERATURE	28
	5.3 INLET AND OUTLET VELOCITY	28
	5.4 SOLAR RADIATION OF POLYETHYLENE	29
	5.5 INSIDE HUMIDITY OF POLYETHYLENE	30
6	SUMMARY AND CONCLUSION	34
	REFERENCES	35
	APPENDIX	38

LIFT OF FIGURES

FIGURE NO	DESCRIPTION	PAGE NO
1.1	DIRECT SOLAR DRYER	2
1.2	INDIRECT TYPE SOLAR DRYER	3
1.3	INDIRECT NATURAL CONVECTION SOLAR DRYER WITH CHIMNEY AND STORAGE MATERIAL	4
1.4	SOLAR DRYER WITH GREEN HOUSE COLLECTOR	5
1.5	GEODESIC SOLAR DRYER DOME	6
1.6	MICA SHEET	7
1.7	FIBRE SHEET	8
1.8	CRUSHED SHEET	9
4.1	SIDE VIEW OF GREEN HOUSE SOLAR DRYER	16
4.2	FRONT VIEW OF GREEN HOUSE SOLAR DRYER	17
4.3	EXHAUST FAN	19
4.4	SOLAR POWER METER	21
4.5	INFRARED THERMOMETER	21
4.6	ANEMOMETER	22
4.7	DIGITAL SCALE	23
4.8	SOLAR PANEL	25
4.9	DIFFERENT TYPES OF FLOOR	26
5.1	POLYETHYLENE AND GROUND TEMPERATURE INSIDE AND OUTSIDE VALUES	27
5.2	THE INLET OUTLET VELOCITY	29
5.3	SOLAR RADIATION	30
5.4	INSIDE OUTSIDE HUMIDITY	31
5.5	WEIGHT OF PRODUCT	32
5.6	PRODUCT TEMPERATURE	33

LIST OF TABLES

TABLE NO	DESCRIPTION	PAGE NO
4.1	SPECIFICATION OF THE INSTRUMENT	24

CHAPTER I

1. INTRODUCTION

Drying is one of the methods used to preserve food products for longer periods. The heat from the sun coupled with the wind has been used to dry food for preservation for several years. Drying is one way of adding value to agricultural products with good knowledge and sufficient equipment it can be done properly so that dried products can be locally marketed or even for export with good price. It is a simultaneous heat and mass transfer operation in which moisture is removed from food material is carried out using of hot air. Solar dryers can be used for industrial and domestic drying processes. It is a useful device for energy conservation saves drying time, minimizes drying area and enhances. The quality of dried product, with reduced carbon emissions cost – benefits.

1.1 AN ARRAY OF SOLAR DRYERS EXIST (EMAD, 2012) WHICH INCLUDE

1.1.1 THE NATURAL CONVECTION AND FORCED CONVECTION DRYERS

This drying is intensively practical for wide variety of agricultural product such as coconut, grain, fruit, vegetables, fish, herbs and spices, recycled foods.

Although sun drying is simple and cheap but it forces some problems. It shall be conducted with limited thickness or layer to assume that produce to be dried can receive as much as possible direct light from the sun.

Greenhouse dryer is an enclosed structure having transparent walls and roofs, made up of glass, polyethylene film etc,. This technology improves the product quality and reduces the drying period on the basis of heat transfer it having two types namely greenhouse dryer under passive made and greenhouse dryer under active made. The use of greenhouse dryer is to improve the quality of the product to prevent the infection by insects, microorganisms and bacteria and fall of drying time arrival.

1.2 TYPES OF SOLAR DRYERS

The classification of sun drying procedure and created based on the stage of pre-processing the location of drying or the appreciation to solar radiation.

1.2.1 OPEN SUN DRYING

Depends on environment conditions, such as solar radiation, wind and solar ambient condition. It usually leads to the deterioration of the products because of many detriments, such as reduced quantity due to the wind, wastage, rainfall and animal and another apological impedance.

1.2.2 DIRECT SOLAR DRYERS

These dryers use transparent covers to reduce heat loses while simultaneously giving product protection from rain and dust. The direct solar dryer is shown in figure 1.1.

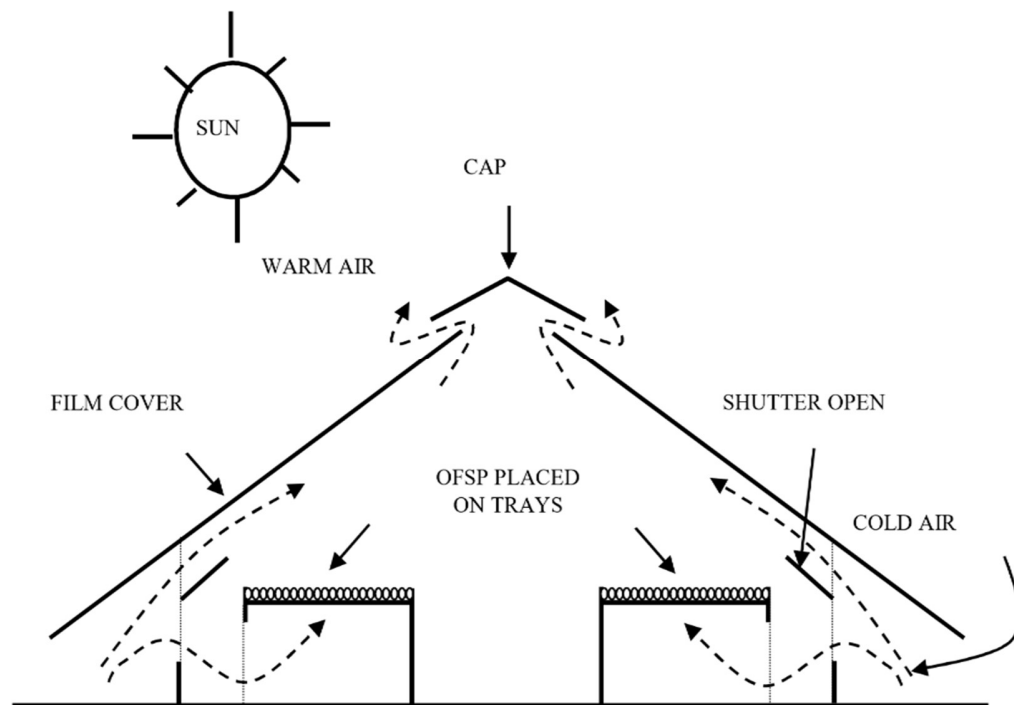


Fig 1.1 Direct Solar Dryer

1.2.3 INDIRECT SOLAR DRYERS

The dryer is capable of giving good output and is ideal for small scale farmers because of its low cost requirement. However, it cannot be applied for commercial drying purposes due to its low throughput. The indirect type solar dryer is shown in fig 1.2.

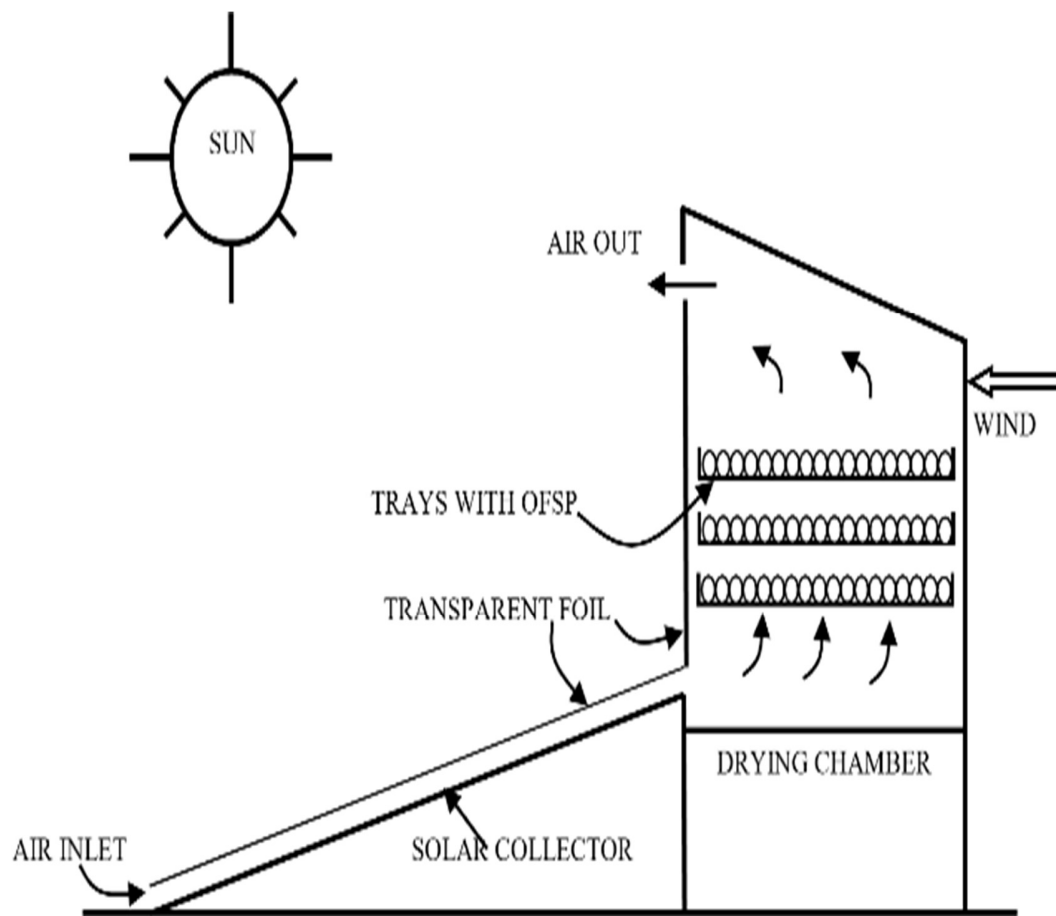


Fig 1.2 Indirect Type Solar Dryer

1.2.4 MIXED MADE SOLAR DRYER

This is also known as a multi – purpose dryer is a natural convection system that consists of a solar flat plate air heater, flexible connector, reduces with plenum chamber, drying chamber and chemistry.

The system gives satisfactory drying efficiencies of 21 to 24% and consumes 6 – 8% energy with the capacity to dry the products to a moisture content of 13% at ambient temperature (25°C)

1.2.5 NATURAL CIRCULATION DRYERS

In type air movement it due to natural circulation. An Indirect natural circulation solar dryer also known as an indirect passive solar dryer has a solar collection, drying chamber and a chimney. The solar collection uses a needle black painted copper plate as an absorbed. A glass cover is fixed over the copper plate with an air graph for the air enter the drying chamber made of wood is fixed with a matte black painted galvanized iron cylindrical chimney. The chimney increases the buoyant force imposed on the air stream, to provide a greater air flow velocity. This type of dryer however has low capacity and a limited drying rate. Its performance is highly dependent on weather conditions limiting its wide scale application. The Indirect natural convection solar dryer with chimney and storage material is shown in fig 1.3.

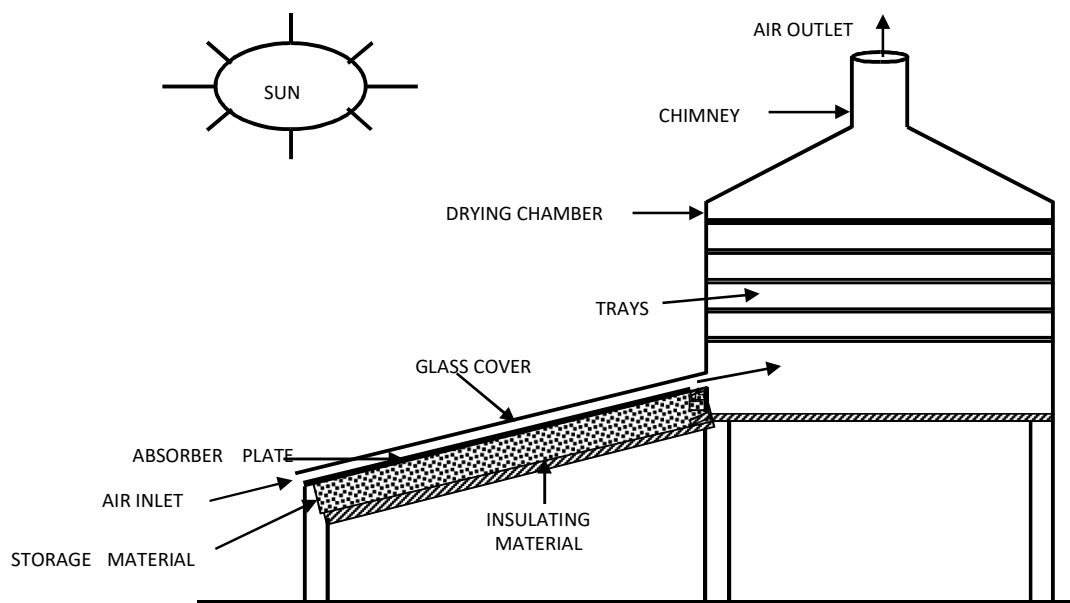


Fig 1.3 Indirect Natural Convection Solar Dryer with Chimney and Storage Material

1.2.6 FORCED CONVECTION SOLAR DRYER

In these types of solar dryer, air is forced into or out of the drying chamber using a blower or fan while is electrically or mechanically operated or hydraulically activated.

1.2.7 SOLAR DRYER WITH GREEN HOUSE AS COLLECTOR

This is solar dryer with greenhouse as a collector linked to a wooden stack chamber as shown in Figure. A plastic film with a fan or blower forms the system that increases the air temperature inside the green house by about 20°C. Heated air inside the green house is forced to pass through the trays stacked in the wooden chamber through the action of an exhaust fan, a chimney effect or a wind driven ventilator. The solar dryer with green house collector is shown in fig 1.4.

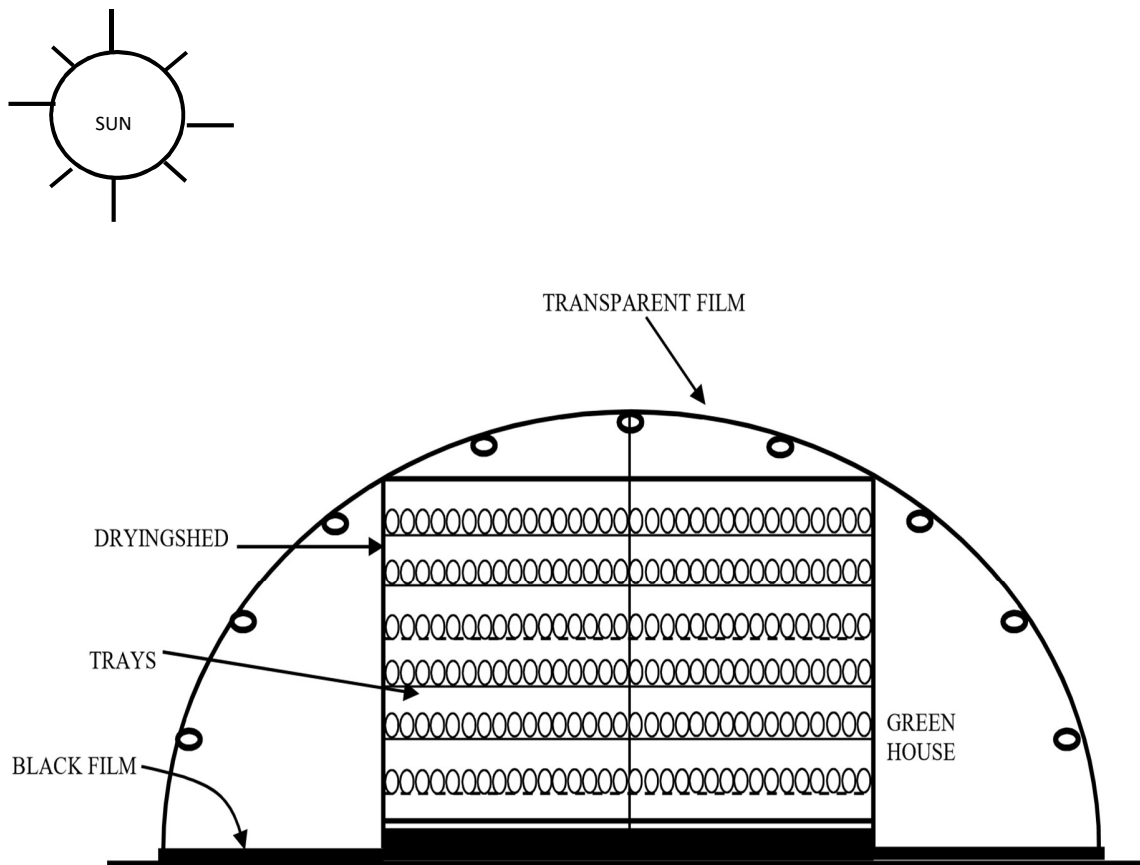


Fig 1.4 Solar Dryer with Green House Collector

1.2.8 GEODESIC DOME SOLAR DRYER

A geodesic dome is a midsized indirect solar dryer designed in the forced air circulation mode. The dryer is covered with poly films or polycarbonate plates while drying trays are placed inside the dome covered with a black absorber sheet. The Geodesic Solar Dryer Dome is shown in fig 1.5.

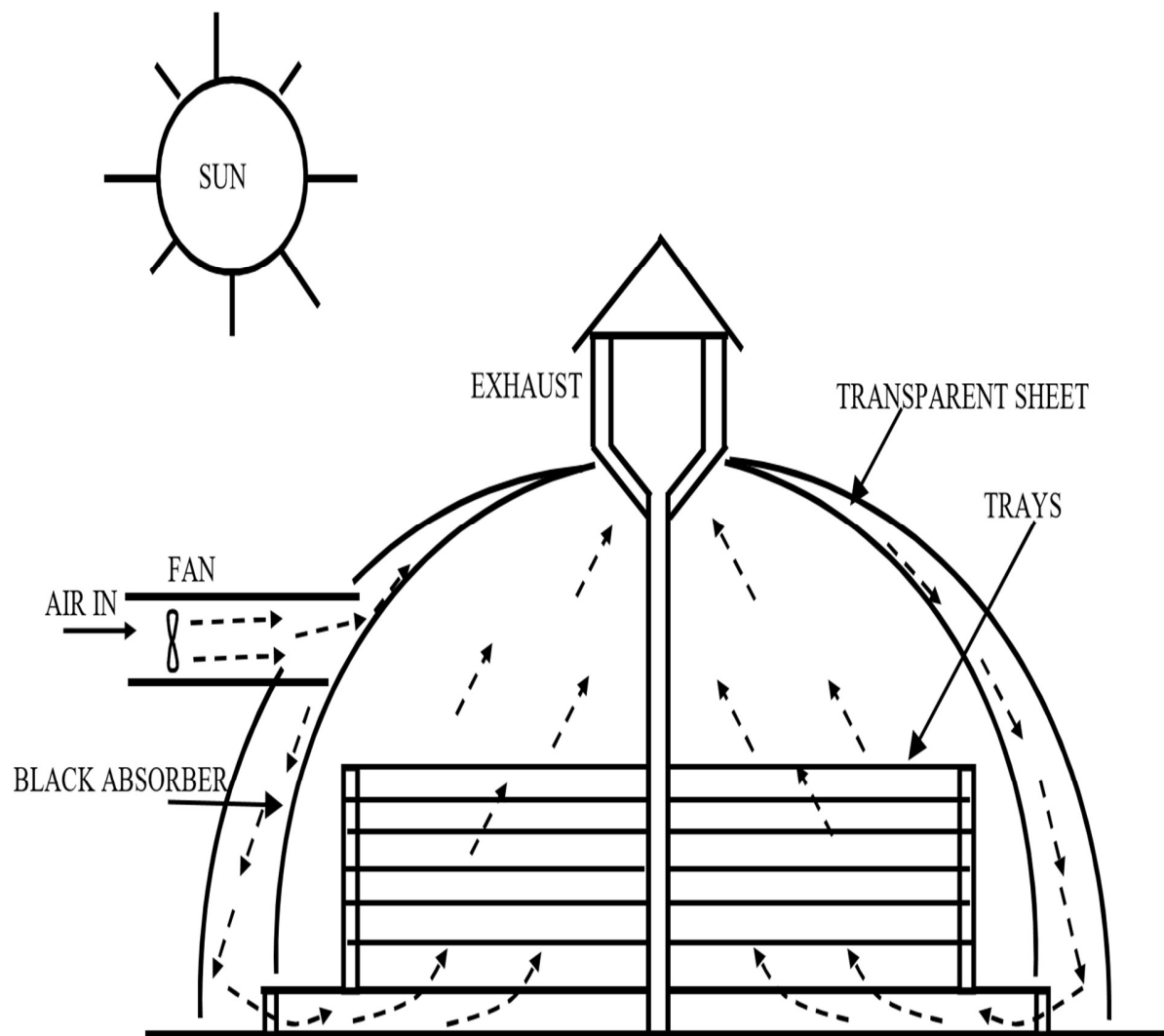


Fig.1.5 Geodesic Solar Dryer Dome

1.3 TYPES OF DIFFERENT FLOORS

1.3.1 MICA FLOORS

A characteristic happening mineral that depends on an assortment of silicate minerals and made out of conveying measure of potassium, iron, aluminum, magnesium and water is mica. It is discovered having dainty sheet like or plate like constructions with different organization and actual properties. Mica frames level six – sided monoclinic precious stones alongside an uncommon split toward bigger surfaces. This permits the mineral to be effectively cleared into optically level movies high in silica. This stone has the broad ability to stay versatile and extreme even at high temperature. This helps the people to handle and work with the stone in those places with high and humid temperature. A superior insulation and a biaxial birefringent crystal, mica processes average refractive index and its spectrum is about 1.6. Because of this nature mica can be utilized to cause a point delay between two symmetrical components of info straight polarization and consequently can be utilized as an impediment. Gadget nonetheless, the nibble finger isn't consistent and due to this change reason and optical and actual thickness will shift 11 has the ingestion of 2 to 5% in the noticeable reach. The best part is mica can resist nearly all medicines like chemical, acids, gasses, alkalis and oils. The mica sheet is shown in fig 1.6



Fig.1.6 Mica Sheet

1.3.2 FIBRE FLOORS

Not at all like glass fibre utilized for protection, for the last construction to be solid, the filaments. Surfaces should be primarily liberated from abandons, as this allows the fibre to reach gig apascal rigid qualities if a bult bits of glass were imperfection – free, it would be similarly pretty much as solid as glass filaments, anyway it is by and large unreasonable to create and keep up mass material in a deformity – free state outside of research facility conditions. The fibre sheet is shown in fig 1.7.



Fig.1.7 Fibre Sheet

1.3.3 CRUSHED STONE FLOORS

Substitute and manufactured aggregator crushed stone can generally substitute for sand and gravel and vice versa. These are only a few naturally occurring materials that have the properties necessary to make a in – kind replacement for aggregate shells caliches and clinkers cab substitute for aggregate in some low specification application. Some manufactured products iron steel refining, can sometimes be used as aggregateperlite, vermiculture and some type of day and used as light weight aggregate and occasionally other materials have been used as substitutes for aggregate in concrete and asphalt products designed for special application shredded rubber tires glass or cullet are sometimes used in aggregate base course. Burned coal cinder are used in cinder blocks. Plugged brick concrete block can substitute for low specification uses. The crushed stone is shown in fig 1.8



Fig.1.8 Crushed Stone

CHAPTER II

2. LITERATURE SURVEY

M Purusothaman Mani, et al.(2020) A hybrid insulated greenhouse solar dryer with a north wall has been designed and tested in natural convection mode. Two unique reflectors on the north side have been used in the courtroom. A sun-driven dryer is used to dry and secure farm goods for a long period of time. Open sun drying, in which objects are simply placed on the grass, sidewalks, mats, rooftops, and so on, is a very suitable and low-cost method. However, open sun drying has a few drawbacks, including a slow drying rate, reliance on a warm environment, and residue depletion, as well as the risk of birds and insects harming the goods. To overcome these obstacles, sun-based dryers with closed conditions are designed for drying, planting, and best use. Recently, a few experts around the world have established new drying mechanisms for improving item efficiency, increasing drying rate, and decreasing energy usage, and this trend is continuing. Difficulties and future consequences are also discussed. The survey would be beneficial to new analysts who are entering this constantly evolving and needed area of construction.

Pushpendra Singh et al.(2018) The world is moving towards the decrease of reliance on petroleum derivatives. Different advancements are going through to utilize wellsprings of environmentally friendly power like breeze, sunlight based, flowing and so on Among these sources, sun oriented energy is accessible in gigantic amount and most ideal alternative that might be utilized for space warming and age of electric energy. For drying farming and non-horticultural items, sunlight based energy can be utilized straightforwardly or by implication. Be that as it may, in open sun drying the items are influenced by outer disasters like downpour, creepy crawlies and creatures. To conquer the inadequacies of open sun drying different nursery sunlight based dryer had been proposed up until this point. Some of late investigates have been talked about in the paper. This paper gives the information of effectively created nurseries so the pressure can grow new and changed the nursery structure. To achieve this, different explores of late years have been examined and introduced in this survey.

Vipin Shrivastava et al.(2016) The convective warmth move coefficient is a fundamental boundary for planning of any sun based drying framework. In this paper heat move demonstrating in term of convective warmth move coefficient is performed and contrasted and open sun drying. The information acquired from experimentation under open sun and circuitous sun oriented drying conditions have been utilized to discover estimations of the exploratory consistent 'C' and type 'n' by relapse examination and, thus, convective warmth move coefficient. From this examination it is reasoned that the convective warmth move coefficient is diminishing with drying time it is because of abatement in dampness content. Results likewise showed that convective warmth move coefficients are more in circuitous sunlight based dryer framework than under open sun drying.

M Purusothaman Mani, et al.(2021) The sun is shining. Crop drying is popular in India, despite the fact that it takes a long time and generates a lot of dust. This is a major problem. To boost efficiency, better workmanship and time management are needed. In comparison to traditional drying, the introduction of a green house solar dryer could be a good one. The novel research focuses on maintaining higher nutritional values, keeping the ecosystem safe, and drying in a limited period of time, as well as providing assistance to farmers at a low cost of drying. The roofs of the four dryers are made of two distinct materials and shapes. Each dryer's bottom surface is made up of three layers: black painted plywood, 3 mm thick black PVC board, and stainless steel wire mesh tray. The moisture in the green peas was decreased from 76 percent to almost 9 percent in all dryers, according to the findings. The parabolic polyethylene greenhouse solar dryer took 20 solar hours, while the OSD took 32, resulting in a 37.5 percent decrease in drying time as compared to the OSD. To match the experimental results, different thin layer models were investigated. For the green peas, the Midilli and Kucuk model with PPEGHSD had demonstrated a greater agreement than the other thin layer models. To ensure the consistency of the dried items, a performance and nutrition study was conducted. All of the nutrition factor values in the PPEGHSD are higher than in all other dryers, which means that the PPEGHSD is the better option for drying food grains.

Anil Kumar et al.(2017) The expansion in cost of petroleum derivative and inaccessibility of power are the obstruction for ranchers to run their homestead apparatuses and their turn of events. Sun oriented drying is a method that not just aides in lessening non-renewable energy sources and ozone harming substance outflow by staying away from the utilization of machines in this area, yet additionally diminishes the post-collect food misfortunes as well. In present investigation, typified energy examination has been accomplished for backhanded sun based dryer unit. Fenugreek leaves of 02 kg were placed in every plate inside circuitous sun powered dryer unit for drying purposes. Different ecological and monetary boundaries have been assessed, which incorporates the restitution time frame by cost, the energy compensation time (EPBT), epitomized energy, CO₂ outflow and the procured carbon credit. The absolute epitomized energy of the framework is 1081.83 kWh. The EPBT and CO₂ emanation are discovered to be 4.36 years and 391.52 kg each year, separately.

Prashant Baredar et al.(2014) Food misfortunes are serious issue of the universes particularly for agricultural countries where 25% of food is lost by misusing, decay and vermin invasion. It is found by scientists that conservation of food by drying diminishes wastage as well as give better re-visitation of ranchers. In open sun drying the considerable misfortunes are attributable to tidy, birds, unsure climate, rodents, bugs, fungies, robbery are hard to maintain a strategic distance from. The immediate UV beams from sun additionally stained the trim and diminish the market estimation of harvest which is dry in open sun and direct sun oriented dryers. Hence roundabout dryers is the most ideal choice which save the yields from such issues as well as keeps up the supplements estimation of harvest which give the better re-visitations of the ranchers. In this correspondence, the improvements in aberrant sun based energy dryers have been canvassed in most recent thirty years in different piece of the world. Their plan & operating standards have likewise been talked about. Exhibitions of various dryers regarding drying rate, warm effectiveness are additionally tended to which shows if ranchers receive such advances they improve return and save time in enthusiasm for the hard exertion they have dedicated in crop development.

M Purusothaman, et al.(2021) Solar energy is abundant, and it is used to extract moisture from food materials and protect them. The aim of this experiment is to see how well a greenhouse solar dryer performs with North Wall insulation. When food items are put inside the dryer, the high temperature inside the dryer in contrast to the ambient temperature allows them to lose moisture easily and dry in a brief amount of time. The dryer is wrapped in PVC sheeting, and the dryer is constructed.

Vipin Shrivastava et al.(2017) In this paper, energy of fenugreek drying on various plate of a roundabout sun based dryer was inspected to build its timeframe of realistic usability. For this reason, a flimsy layer of 2 kg of fenugreek was set on three unique plate of measurements 0.7 m x 0.7 m, to be additionally dried until there is no variety in its mass. The drying rate is fitted in different models available in the literature and the best model is obtained by comparing the values of the diffusion coefficient, root means square error, and the sum of square due to error. The diffusion coefficient of fenugreek on different trays was also investigated and found in the range of 2.422×10^{-8} m²/s to 3.872×10^{-8} m²/s. An average efficiency of the dryer in peak hours on the first and second days of drying was 38.63% and 7.56%, respectively.

Vipin Shrivastava et al.(2017) In this paper, thermal performance assessment of greenhouse solar dryer is being carried out in a no load condition. The greenhouse solar dryer was operated under passive mode. The performance of greenhouse is evaluated in different conditions first uncovered floor, second when floor is covered with blue tarpaulin to prevent the heat loss to the ground, and the third when concrete floor is used. The data obtained during the experiment is used to evaluate the thermal performance of the greenhouse solar dryer by calculating various thermal parameters. The average room temperature inside the greenhouse solar dryer was 52% higher than the average ambient temperature in the case of concrete floor while it was 45% higher in tarpaulin covered floor as compared to 23% higher in without covered floor condition.

M Purusothaman, et al.(2019) When there is a surplus of seasonal agricultural products, they may be dried and eaten when they are not harvested. Food components require a lot of time and energy to dry. Since it uses naturally available solar energy, the green house dryer is the most cost-effective drying process. Using a green house dryer to keep food protected from soil, pollen, and even extreme weather conditions is preferable to leaving food out in the open sun. The most important tool for improving the architecture is computational fluid dynamics, which is used to analyze various roof configurations for greenhouse solar dryers, such as hemispherical, trapezium, and triangle. The dryer output was evaluated with free and forced convection for Triangular, hemispherical, and trapezoidal forms, as well as with no load. To find the most effective dryer, temperature profiles under different atmospheric conditions were studied. As a result, the trapezoidal roof type greenhouse dryer has a higher target temperature than other greenhouse solar dryer forms.

CHAPTER III

3. AIM AND SCOPE

3.1 AIM

Coconut and fish are abundant in Kanyakumari district. Use them as food with green house solar dryer to avoid wasting too much fish and coconut.

3.2 SCOPE

Kanyakumari district is experiencing high temperature for this reason the drying of coconuts and fish by the green house solar dry we get good healthy food in less time.

CHAPTER IV

4. MATERIALS AND METHODS

4.1 FABRICATION OF DRYER

With the support of locally available metal material, solar greenhouse dryers with various floor structures that function in passive and active convection modes have been created. For the dimensions of 10(10) dimensions in m and effective base area of the drying chamber, both even span and parabolic roof dryers have been built. The driver's bottom. In particular, these sheets can survive temperatures as high as 115°C. They are also lighter in weight, anti-corrosive, transparent, weatherproof, anti-dust, low cost, impact resistant, moisture resistant, and chemical resistant .To fit fair volume of the dryer, the central height of the drying mechanism is held at 6 feet. The tray for spreading wet goods is made of stainless steel wire mesh and measures 10 feet in length. It is positioned 6 feet from the bottom to ensure adequate air ventilation for all products. The front and side view of green house solar dryer are shown in fig 4.1 and 4.2



Fig 4.1 Front View of Green House Solar Dryer



Fig 4.2 Side View of Green House Solar Dryer

4.2 DETAILS OF INSTRUMENTS

For the research, the instrumentation and uncertainties are taken into account. With a digital thermo hygrometer with an accuracy of $\pm 1^{\circ}\text{C}$ with a resolution of 0.1°C and ± 5 percent with a resolution of 1 percent, the temperature and relative humidity of the air at different positions in the dryer are determined. the solar radiations with a $0.1\text{W}/\text{m}^2$ resolution An anemometer with a precision of $\pm 0.1\text{m}/\text{s}$ is used to calculate the air velocity at the dryer's inlet and exit. A automated weighting unit with a precision of 10g calculates the weight of the items per 2 hours. Table shows the different instruments used in the experiments, as well as their specifications. Variable temperature, relative humidity, air velocity, solar radiation, and weight have all been recorded as having uncertainties.

4.2.1 DIGITAL HYGROMETER

Most computerized stickiness screens utilize either a resistive or capacitive sensor. While the electrical properties vary between these two sort of sensor, the overall standard by the way they measure moistness is equivalent to the immersion level of the material changes, so does its electrical properties.

Hygrometers is a fundamental gadget for drugs since dampness in the climate causes incredible impact on drug items during assembling. Relative mugginess of the air is estimated by the hygrometer in rate. Hygrometer contains two thermometers one is called dry bulb and second as wet bulb. As indicated by their names, dry bulb stays dry noticeable all around and the wet bulb is encircled by a cotton wick that is plunged in the water. Wet bulb assumes principle part in the estimation of the stickiness.

Hygrometer deals with the marvel called evaporative cooling, when water dissipates from any surface, it becomes cool since water atoms take heat energy from the surface during the vanishing. Because of this cooling impact wet bulb consistently show low temperature than the dry bulb. You can comprehend this with the conditions when you are felling exceptionally hot and you wash up with water. Water vanishes from our body taking some warmth and you feel cool for quite a while.

Vanishing of water from the outside of wet bulb is contrarily corresponding to the dampness in the environment. In dry climate when moistness is low, the dissipation of water will high coming about the more decline in wet bulb temperature. However, when air is muggy having higher moistness, the dissipation of water from wet bulb stays low coming about the less abatement in the wet bulb temperature. At 100% stickiness the temperature of dry and wet bulb will be same because of no water vanishing from the wet bulb thus on cooling impact happens.

4.2.2 EXHAUST FANS

Air balance is something that we by and large underestimate. However, did you realize that indoor air after contains a scope of toxins, allergens, dampness and residue? To battle these airborne toxins, exhaust fans are frequently utilized as methods for ventilation. Here are five normal utilized for exhaust fans.

A considerable lot of us invest a larger part of our energy in the kitchen, however its additionally where are get inventive. What's more, every creation risks smells, smoke and oil. Regardless of whether for home or business utilizes a kitchen exhaust fan helps eliminates scents, smoke, oil and dampness from your kitchen.

A ton of dampness develops in washrooms, because of showers, group and the subsequent buildup. At the point when this dampness gathers on titer and mirrors the abundance buildup can prompt the development of shape spores. Washroom exhaust fans are generally costly and effectively dispense with this issue. In case you're hoping to fine a suitably estimated washrooms exhaust fan, essentially measure the room's volume and separation that number by five. Also, if your washrooms roof is astoundingly high, more than one vent might be required.

In order to keep products cool and dry and to keep production standard high, commercial exhaust fans are extremely efficient and useful for commercial spaces and warehouse. Additionally industrial exhaust fans de-fumigate preventing any safe or noxious air from remaining.



Fig 4.3 Exhaust Fan

Believe it or not the air inside of buildings can often be filled with more pollutants, allergens and unwanted moisture than outside air. For building such as hospitals, air quality is extremely important for keeping patients at optimal health in an environment conducive to healing. Exhaust fans ensure that patients can undergo procedures and recovers in a clean, allergen and pollutant free environment. Laminar fans are particularly popular in hospitals as they circulated air as fast as 300 times.

The moisture content removal in the active mode. Semi circle roof drier is higher than the other driers including open sun drying of coconut. The present investigation clearly denotes that the more moisture products can be dried in active mode based drier and low moisture product can be dried with passive mode drying. The drying rate of forced convection semi circle roof is higher than other higher more. The drying date takes place at faster rate than the final drying day due to the presents of more moisture in the crop. The exhaust fan is shown in fig 4.3.

4.2.3 SOLAR POWER METER

The meter measures apparent power (VA) by multiplying the current by the voltage, and power factor by comparing the current and voltage signals (Pf). To measure actual power, multiply the apparent power by the power factor (P). To measure real electricity, real power is integrated over time (kWh). The solar power meter is shown in fig 4.4.

FEATURES:

Digits 3 ½ LCD show measurement Units for solar display: W/m² Data Cosine with Radiation W/m² Data Cosine with Radiation W/m² Data Co (Watts maximum emitted reading by per square meter) The or 2000 sun's hold/max/min angular. Corrected BTU functions Precision: Temperature including error + 0.38 W/m²/C [+ 0.12 BTU/(12xh) °C] in sunlight is usually below +/- 10 W/m²[+/- 3 BTU/(12xh)] or +/- 5 percent, whatever is greater. from 25°C variance Accuracy.



Fig 4.4 Solar Power Meter

4.2.4 INFRARED THERMOMETERS



Fig 4.5 Infrared Thermometer

One of the most common types of thermometers is the infrared thermometer, which allows you to read temperatures without the possibility of spreading germs. They use infrared rays to read a person's or an object's temperature from a distance and view the result in a matter of seconds. The infrared thermometer is shown in fig 4.5.

4.2.5 ANEMOMETER

An anemometer is an instrument that measures the velocity of air in the atmosphere. It's a gadget that's usually used in weather stations. The horizontal three-armed windmills with the hemispherical cup make up the anemometer instrument. It is the most accurate in terms of determining the speed. The Anemometer is shown in fig 4.6.



Fig 4.6 Anemometer

WORKING

We all understand what an anemometer is and how critical it is in a weather station. But do you have any idea how it works? Many of them have no idea how it works or how to do it in other ways. To decide the rpm, the hemispherical cup is linked to the three-armed windmill. The cups will spin depending on whether the weight is applied to the front or back. The shaft will continue to spin as the wind blows. To start, we must count the number of times the cups rotate over a given period of time. Depending on that, calculate the ratio and then calculate the wind speed without difficulty. This is how an anemometer works to measure wind speed.

4.2.6 DIGITAL WEIGHING MACHINE

A single load cell is used in some measuring devices, while multiple load cells are used in others. The strain gauge transforms the stress applied by the load into an electrical signal as it is put on the meter. The load cell reverts to its original form until the load is removed from the cell. The Digital weighing machine is shown in fig 4.7.



Fig 4.7 Digital weighing machine

TABLE 1
SPECIFICATION OF THE INSTRUMENTS

Sl. No	Instrument Name	Range	Accuracy / Least count	Usage of the instrument
1	Anemometer (BENTECH GM816)	0-30 m/s	0.1 m/s	Air velocity
2	Digital Thermo – hygrometer (HTC -1)	Temperature 10 – 50° C	±0.1°C and ±5%	Inside and outside temperature and humidity of the dryer
3	Solar Power Meter(WACO 206)	0-2,000 W/m ²	Resolution 0.1 W/m ² and sampling time 0.25 sec	Solar Radiation Intensity
4	Digital Weighing Machine (ATOM)	5 – 10,000g	5g	Measuring weight of the crop

Table No. 4.1

4.2.7 SOLAR PANEL

The EU's new building directives require “near-zero energy” for all new and renovated properties as of 2021, which in most cases means that the property will be self-sufficient with solar collectors on the roof and facades. In Spain and parts of Italy. Enactment has effectively passed that orders establishment of sunlight based authorities for new houses and structures.

In the business, energy-requesting measures that as of now run on oil or gas will go through basic productivity measures. The energy that is required for creation will come to some extent from sun powered energy frameworks on the top of the industrial facility. Sunlight based concentrators can give both warmth and steam that can straightforwardly supplant expensive fuel.

The world's energy utilization is quickly ascending as expectations for everyday comforts increment for billions individuals in the creating scene. Petroleum derivatives are getting increasingly costly and as more nations satisfy their responsibilities for diminishing carbon dioxide discharges, the portion of

environmentally friendly power should increment to address most of the world's energy supply inside years and years.



Fig 4.8 Solar Panel

The quest for development in new source of energy has attracted significant investment in the past few years. The new European green deal will be leading the sustainable transition in Europe. In order to make this transition from costly fossil fuels to sustainable energy systems, industrial heat needs to be carbon free.

Solar heat can be integrated at multiple points to existing heating system and supply heat, steam and cooling processes with the same system. The solar collector field is placed near the facilities and is easy to install and remount if the need for land usage changes. The solar panel is shown in fig 4.8.

4.3 EXPERIMENTATION

The experiment was carried out in the Kanyakumari region, with the dryer oriented east-west. The roof inclination angle was held at the same as the location's latitude, and the experiments lasted eight hours, from 9:00 a.m. to 5:00 p.m. From March 7 to March 9, 2020, a series of experiments will be performed. The air temperature and humidity inside and outside the dryer is measured using a hygrometer. Four coconut samples were dried in a parabolic and even period of free convection, forced convection, and open sun. Temperature, weight, humidity, air velocity, and solar radiation are determined every 2 hours and the results are registered, and the sample is placed in a tight jar at the end of each day to dry. Following the receipt of the dry food, a nutritional test was conducted to determine its nutritional content. The different types of floor is shown in fig 4.9.



Fig 4.9 Different Types of Floor

CHAPTER V

5. RESULT AND DISCUSSION

5.1. INSIDE AND OUTSIDE OF POLYETHYLENE

The solar dryer temperature changes inside and outside on every hour of a day, variations of greenhouse and ambient temperatures are shown in fig 5.1. The inside of the polyethylene sheet temperature should be recorded at 9 a.m. is almost same in all the cases later changes in due to solar radiation inside to inside the dryer. It is noticed that temperature due is raised by 5°C inside convection and 3°C in free convection. Whereas the highest temperature is recorded at 3 pm.

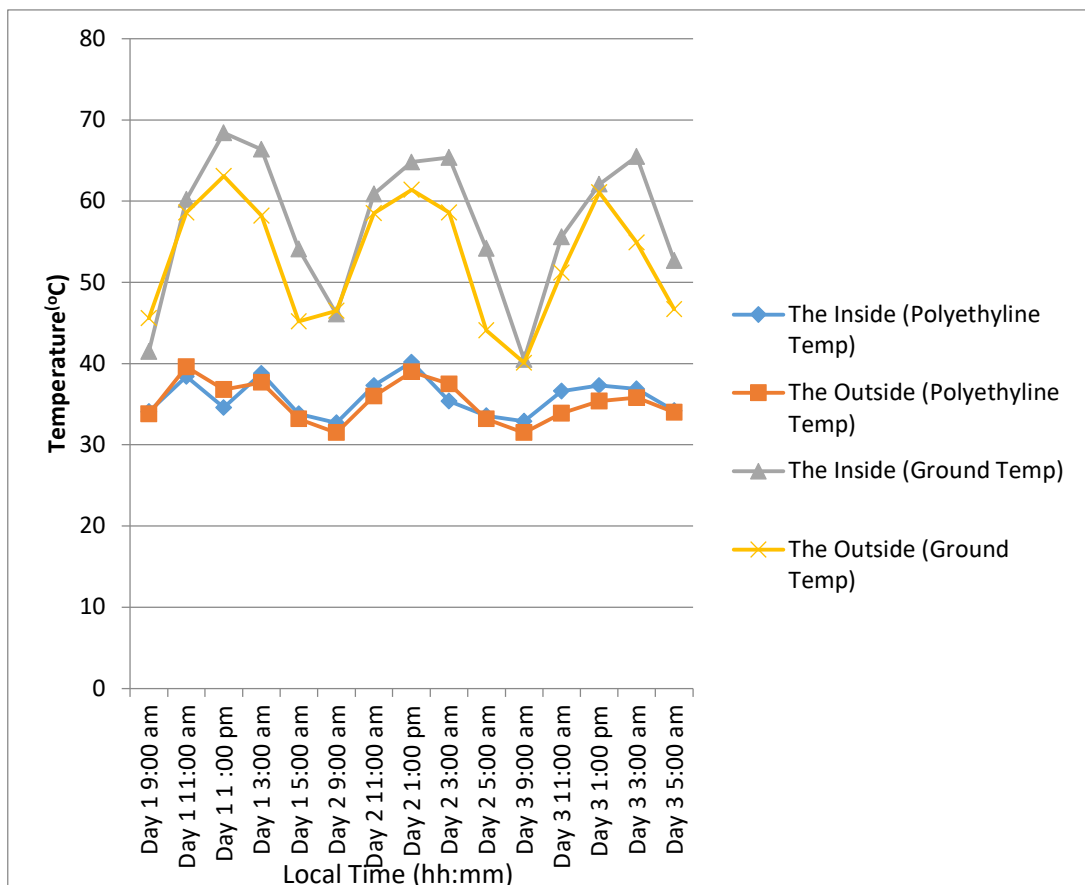


Fig 5.1 Polyethylene and Ground Temperature Inside and Outside values

5.2 INSIDE AND OUTSIDE GROUND TEMPERATURE

The bonding between heat efficiency and dryer air temperature was considerably inside and outside ground temperature range of 34-45°C and the solar dryer floor temperature. Evaporation of moisture from the product is slower during initial hours later it increases due to increasing in solar dryer with different floor heat radiation. Polyethylene roof greenhouse solar dryer inside and air temperature is higher than the open sun and other drying modes.

As solar radiation changes ,the humidity also varies during sunshine hours of Day 1 for parabolic as shown in figure 6,7 and even roof dryers are presented in figure 8. At 9 a.m., all the three models have recorded almost the same humidity but 11 a.m. the forced and free convection chambers show 10% decrease in humidity because of the increase in temperature of dryer due to trapped radiation inside the dryer.

5.3 INLET AND OUTLET VELOCITY

The inlet and outlet air velocity of forced convection is higher than the natural convection, which leads to faster drying of the coconuts. It is observed that the number of days taken for drying of the coconuts is 1(12hr),1.5(28hr),2(58hr) days for greenhouse solar dryer mode and open sun drying respectively. The weight of the coconuts is reduced from 11 to 6 kg due to moisture removal. The temperature and moisture reduction on coconuts compared to parabolic and even polyethylene roof have followed the similar trend (Jesu Inigo Nygil J, Jetheslin S ,2021).But the maximum temperature observed in the solar dryer is 40°C whereas in even inside solar roof dryer is 45°C at 1p.m.and the average temperature is also higher than the even polyethylene roof dryer. The inlet outlet velocity is shown in fig 5.2.

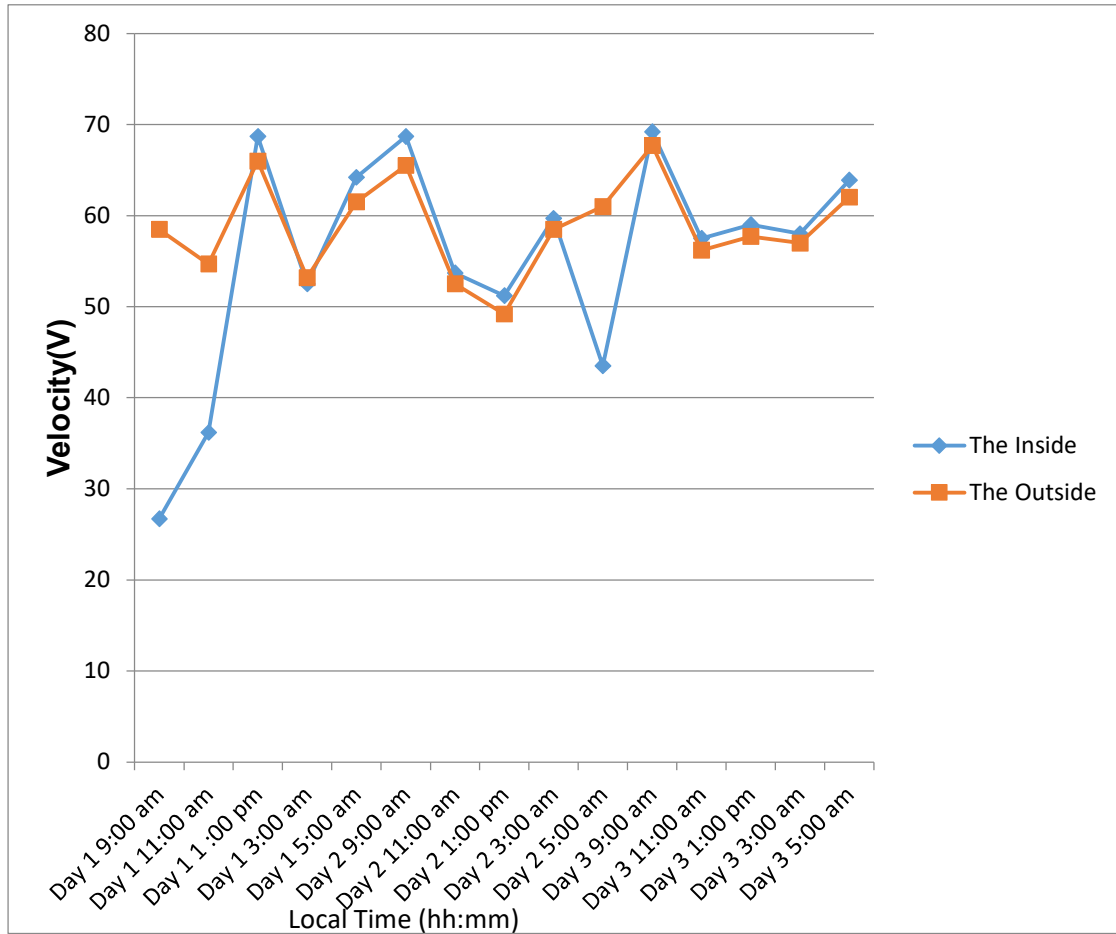


Fig 5.2 The Inlet Outlet Velocity

Compared the even span roof greenhouse solar dryer the different floor took half day shorter on both the drying modes. Among the three process the maximum temperature observed is in mica floor drying process, the difference between atmosphere and inside temperature of the dryer is 6-9°C for all the days with variations .

5.4 SOLAR RADIATION OF POLYETHYLENE

Moisture removed from the product with drying hours and solar radiation. The heat accumulation happens inside the greenhouse solar dryer due to solar radiation entering into the dryer. In parabolic roof there is an increase of solar radiation inside the greenhouse solar dryer by 8.2% compared with the even-span form because of roof curvature. The outside solar radiation changes is shown in figure 5.3.

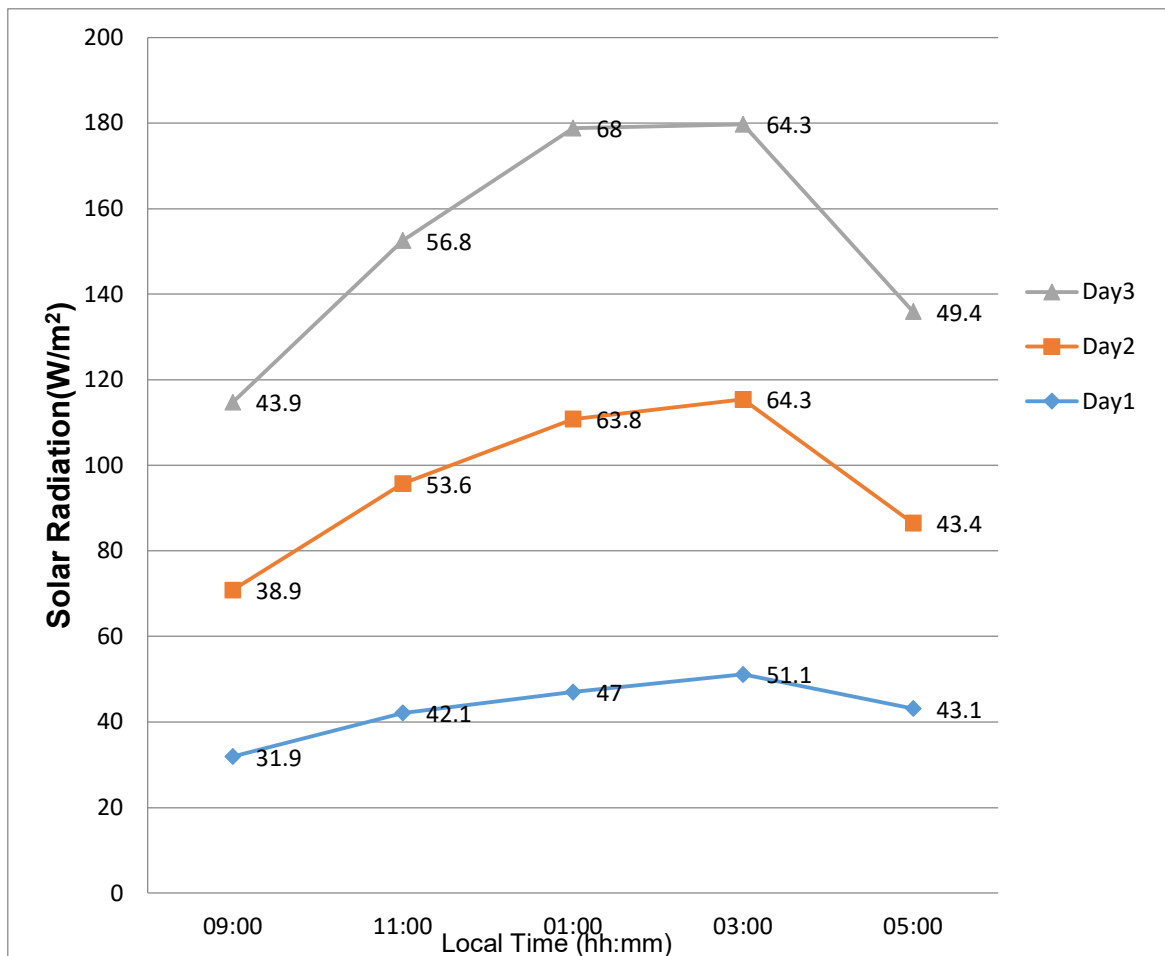


Fig 5.3 Solar Radiation

5.5 INSIDE HUMIDITY OF POLYETHYLENE

As the temperature is noticed to be maximum at 1 p.m. inside the dryer and at that time the humidity is the minimum. The humidity gradually started increasing from 1 p.m. onwards because of the decrease in temperature and at 1 p.m. onwards because of the decrease in temperature and at 1 p.m. it is almost equal to outside humidity. The lowest moisture recorded is for the forced convection chamber due to continuous extraction of humid air from the dryer. Due to that, the free solar dryer humidity is always higher than the forced convection dryer. The difference in humidity variation is higher on initial drying days and lower on final drying days. This is due to the continuous reduction of moisture present in the coconuts from initial to final drying days. The inside outside humidity values are shown in fig 5.4.

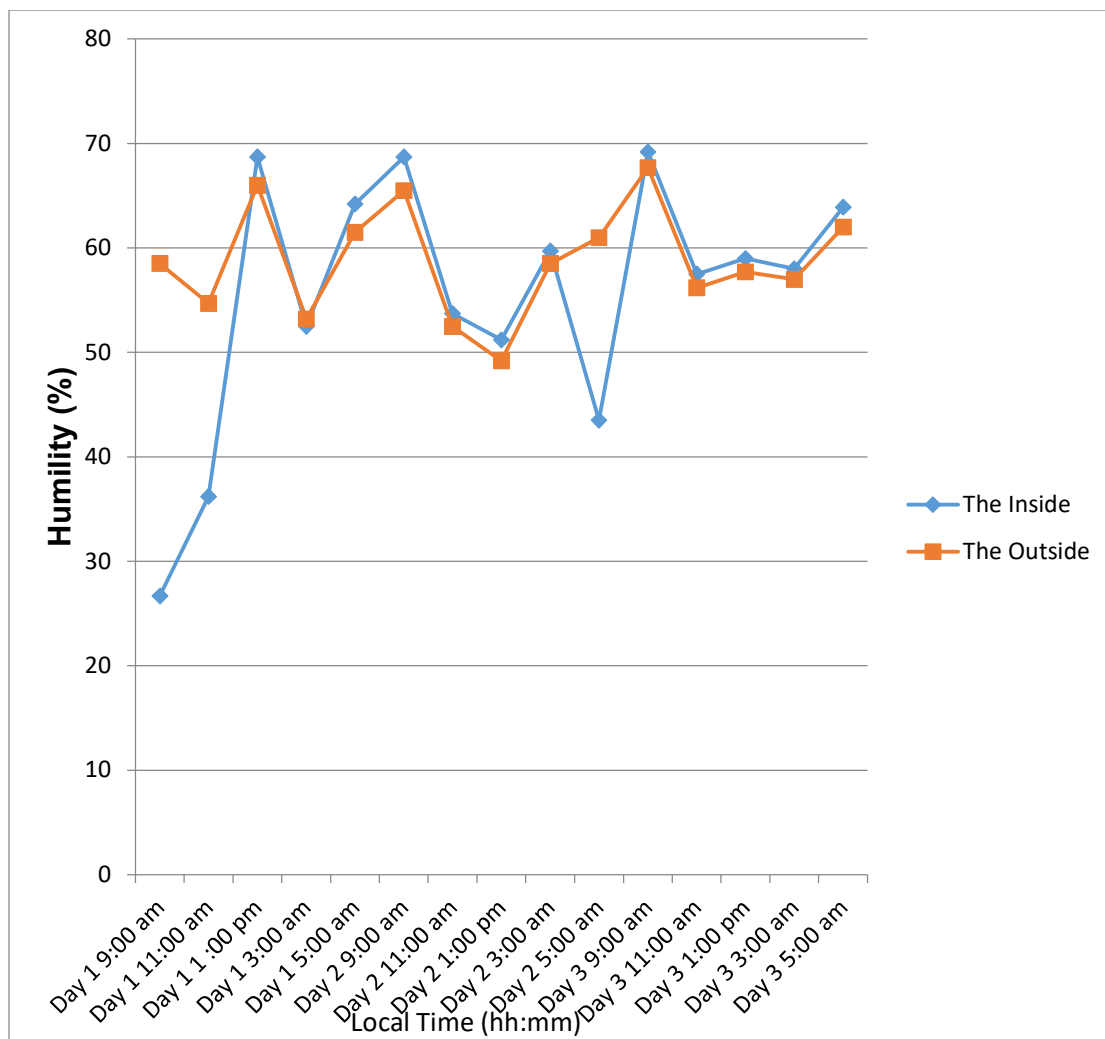


Fig 5.4 Inside Outside Humidity

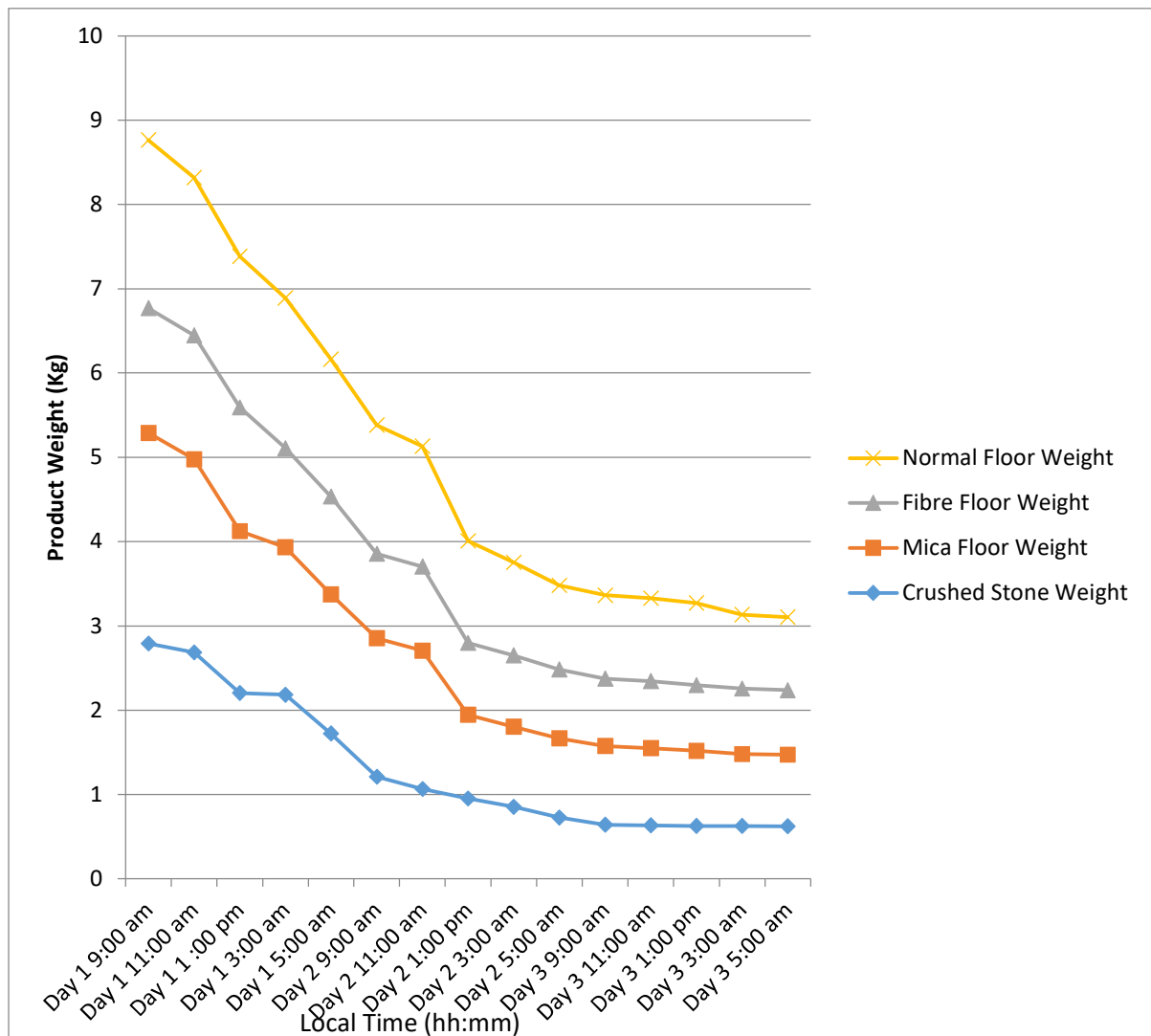


Fig 5.5 Weight of Product

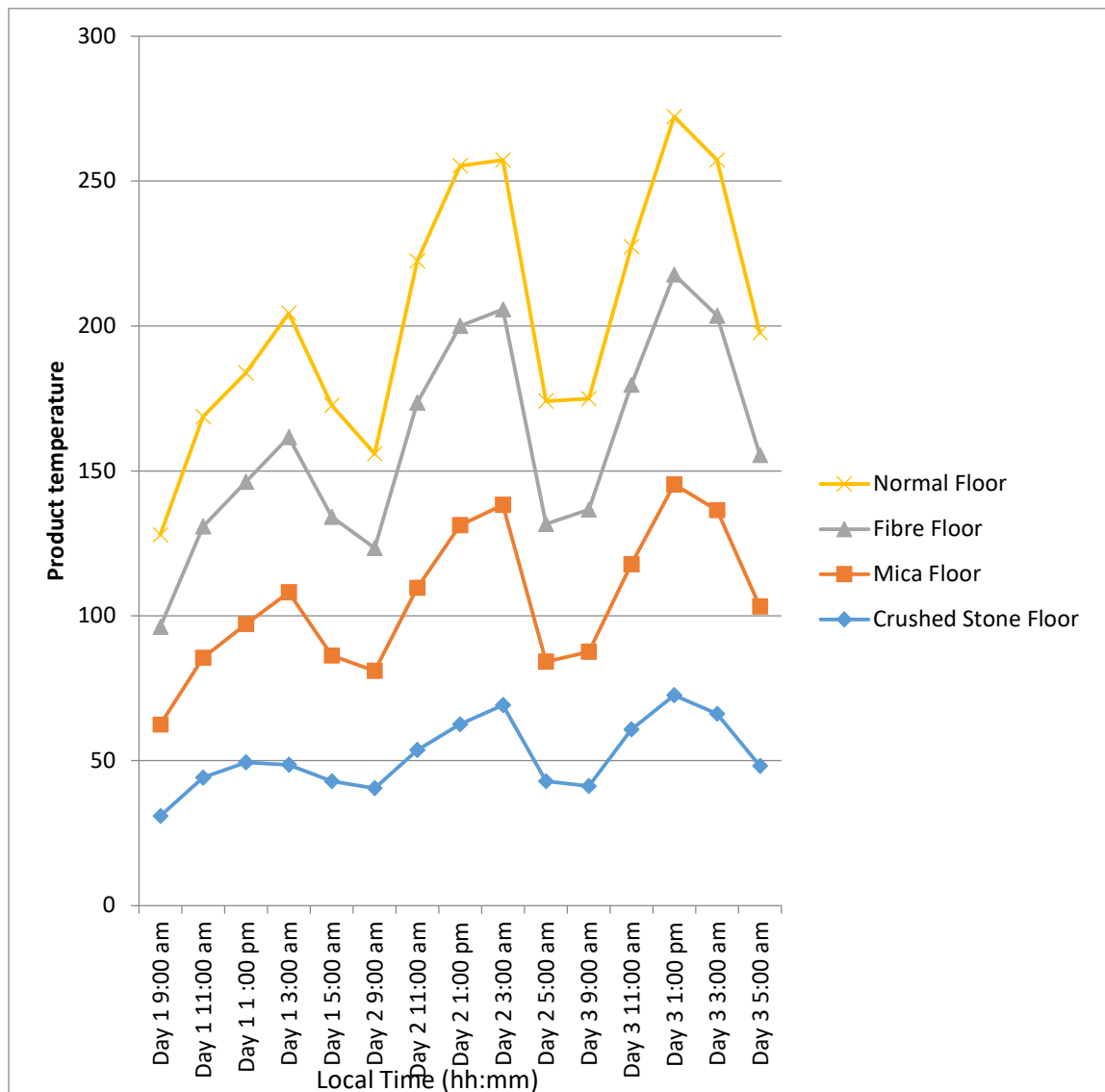


Fig 5.6 Product Temperature

CHAPTER VI

6. SUMMARY AND CONCLUSION

For simulation of solar drying of coconut in the solar greenhouse dryer, a system of partial differential equations for heat and moisture transfer was used. For confirmation, the simulated air temperature within the dryer accurately agreed with the measured temperature. The experiment and the simulated moisture content were found to be in fair agreement. The data obtained from simulations using this approach can be used to improve the design of solar greenhouse dryers. Solar radiation varies considerably over the duration of the experiment days like sun around noon, and the solar radiation affects the coconut's other atmospheric parameters. Inside the green house dryer, air temperature variation follows ambient relative humidity varies almost the inverse pattern with the solar radiations. The green house dryer are high-quality product.

REFERENCES

- [1] Anawe, P. A. L., & Adewale, F. J. (2018). Data on exergy and exergy analyses of drying process of onion in a batch dryer. *Data in Brief*, 21, 1784–1793. <https://doi.org/10.1016/j.dib.2018.10.132>
- Anum, R., Ghafoor, A., & Munir, A. (2016). Study of the drying behavior and performance evaluation of gas fired hybrid solar dryer. *Journal of Food Process Engineering*, 40(2), 1–11. <https://doi.org/10.1111/jfpe.12351>
- [2] Beigi, M., Tohidi, M., & Torki-Harchegani, M. (2017). Exergetic analysis of deep-bed drying of rough rice in a convective dryer. *Energy*, 140, 374–382.
- Chauhan, P. S., & Kumar, A. (2018a). Thermal analysis of insulated northwall greenhouse with solar collector under passive mode. *International Journal of Sustainable Energy*, 37(4), 325–339. <https://doi.org/10.1080/14786451.2016.1261866>
- Chauhan, P. S., & Kumar, A. (2018b). Thermal modeling and drying kinetics of gooseberry drying inside north wall insulated greenhouse dryer. *Applied Thermal Engineering*, 130, 587–597. <https://doi.org/10.1016/j.applthermaleng.2017.11.028>
- [4] Chauhan, P. S., Kumar, A., Nuntadusit, C., & Banout, J. (2018). Thermal modeling and drying kinetics of bitter gourd flakes drying in modified greenhouse dryer. *Renewable Energy*, 118, 799–813. <https://doi.org/10.1016/j.renene.2017.11.06>
- Chowdhury, M. M. I., Bala, B. K., & Haque, M. A. (2011). Energy and exergy analysis of the solar drying of jackfruit leather. *Biosystems Engineering*, 110(2), 222–229. <https://doi.org/10.1016/j.biosystemseng.2011.08.011>
- Das, T., & Tiwari, G. N. (2008). Heat and mass transfer of greenhouse fish drying under forced convection mode. *International Journal of Agricultural Research*, 3(1), 69–76. <https://doi.org/10.3923/ijar.2008.69.76>

- [6] Fadhel, A., Kooli, S., Farhat, A., &Belghith, A. (2014). Experimental study of the drying of hot red pepper in the open air, under greenhouse and in a solar drier. *International Journal of Renewable Energy & Biofuels*, 2014. <https://doi.org/10.5171/2014.515285>
- [7] Janjai, S., & Tung, P. (2005). Performance of a solar dryer using hot air from roof-integrated solar collectors for drying herbs and spices. *Renewable Energy*, 30(14), 2085–2095. <https://doi.org/10.1016/j.renene.2005.02.006> Karthikeyan, A. K., &Murugavelh, S. (2018). Thin layer drying kinetics and exergy analysis of turmeric in a mixed mode forced convection solar tunnel dryer. *Renewable Energy*, 128, 305–312. <https://doi.org/10.1016/j.renene.2018.05.061>
- [8] Kumar, A., & Tiwari, G. N. (2006a). Thermal modeling of a natural convection greenhouse drying system for jaggery: An experimental validation. *Solar Energy*, 80(9), 1135–1144. <https://doi.org/10.1016/j.solener.2005.09.011> Kumar, A., & Tiwari, G. N. (2006b). Effect of shape and size on convective mass transfer coefficient during greenhouse drying (GHD) of jaggery. *Journal of Food Engineering*, 73(2), 121–134. <https://doi.org/10.1016/j.jfoodeng.2005.01.011>
- [9] Lakshmi, D. V. N., Muthukumar, P., Ekka, J. P., Nayak, P. K., &Layek, A. (2019). Performance comparison of mixed mode and indirect mode parallel flow forced convection solar driers for drying Curcuma zedoaria. *Journal of Food Process Engineering*, 42,1–12. <https://doi.org/10.1111/jfpe.13045>
- [10] Lokeswaran, S., &Eswaramoorthy, M. (2013). An experimental analysis of a solar greenhouse drier: Computational fluid dynamics (CFD) validation. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 35(21), 2062–2071. <https://doi.org/10.1080/15567036.2010.532195> Montgomery, D.C., Peck, E.A., & Vining, G.G. (2012).

[11] Introduction to Linear Regression Analysis, 821, Hoboken: John Wiley & Sons.
Nimrotham, C., Songprakorp, R., Thepa, S., &Monyakul, V. (2017). Experimental research of drying red chili by two methods: Solar drying and low-temperature system drying. Energy Procedia, 138, 512–517. <https://doi.org/10.1016/j.egypro.2017.10.237>

[12] Odesola, I. F., &Ezekwem, C. (2012). The effect of shape and orientation on a greenhouse: A review. An International Journal of Science and Technology, 1, 122–130. Pankaew, P., Aumporn, O., Janjai, S., Pattarapanitchai, S., Sangsan, M., &Bala, B. K. (2020). Performance of a large-scale greenhouse solar dryer integrated with phase change material thermal storage system for drying of chili. International Journal of Green Energy, 17, 632–643. <https://doi.org/10.1080/15435075.2020.1779074>

APPENDIX



Take reading for solar power meter



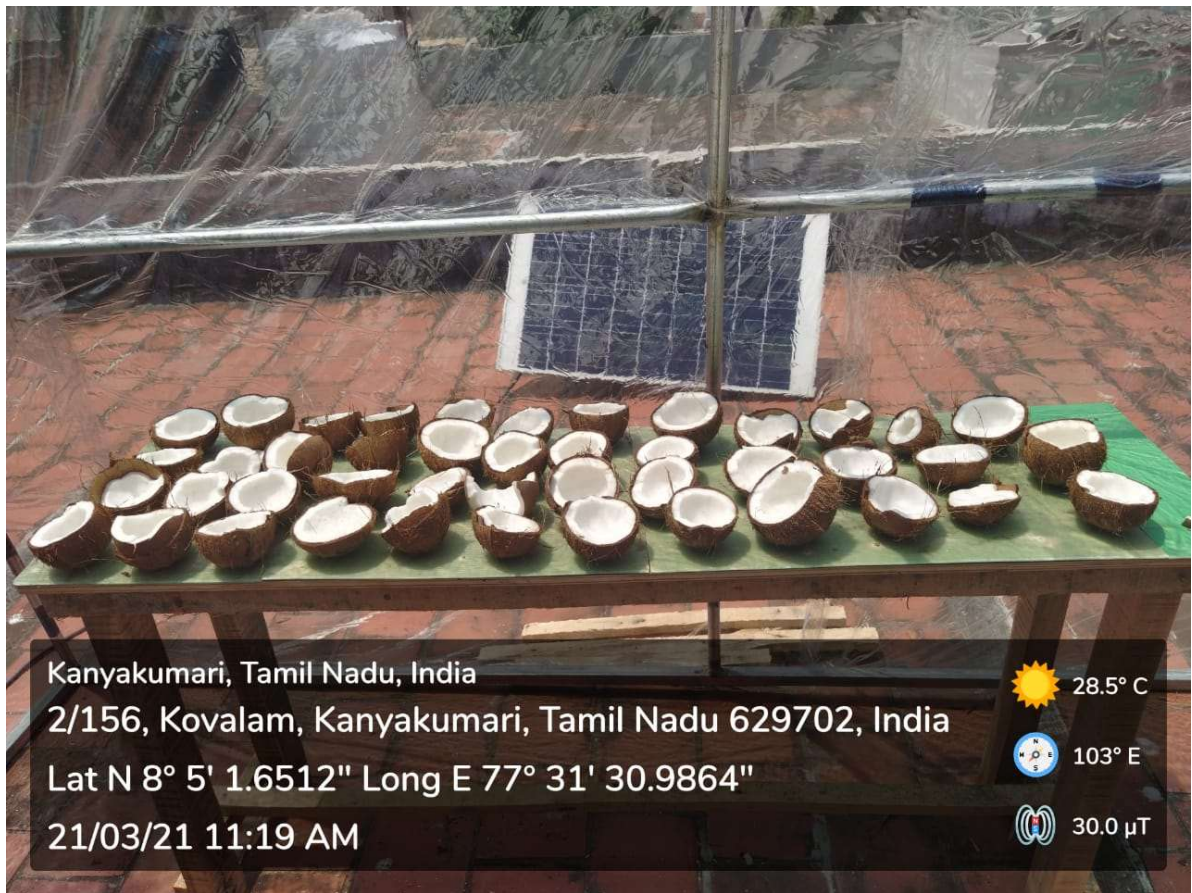
Take temperature reading for product



Take Humidity Readings Inside



Take temperature reading in other floor product



Drying product in floor



Different types of floors