DESIGN AND FABRICATION OF SOLAR DRYER FOR DRYING FISH USING MACHINE LEARNING

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report **"DESIGN AND FABRICATION OF SOLAR DRYER FOR DRYING FISH USING MACHINE LEARNING"** is the bonafide work of **"ARVIND RAVINDRAN (211419105016), HARSHAD SULTAN T (211419105045), KARTHIKRISHNA S N (211419105063), LOKESHWAR T (211419105074)"** who carried out the project work under my supervision.

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ABSTRACT

This project focuses on the design and fabrication of a solar dryer for drying fish, which utilizes machine learning techniques to optimize its performance. As the technology is growing immensely in recent years, certain improvisations need to be made to address the challenges of sustainability and efficiency in various industries, including fish processing. This project aims to address these challenges by offering a sustainable and efficient way to dry fish using renewable energy technology and advanced sensing and control systems. The proposed system utilizes solar energy to dry fish, which is an essential process in the fish industry to increase its shelf life and prevent spoilage. The system offers an efficient solution to drying fish while also improving the quality and increasing the shelf life of the dried fish. This project includes the design and development of the system hardware and software, including the solar collector, drying chamber, image processing unit, and micro-controller. The project also involves the testing and evaluation of the system's performance, including its energy efficiency, drying capacity, and fish quality. To improve the efficiency of the system, machine learning algorithms are utilized to optimize the drying process by monitoring the temperature and humidity inside the dryer. The results show that the system is effective in drying fish and can reduce the drying time and energy consumption compared to conventional drying methods. Moreover, the machine learning algorithms proved to be useful in optimizing the system's performance and enhancing its overall efficiency.

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SYMBOLS	ABBREVIATIONS
EMC	Equillibrium Moisture Content
dm/dt	Drying rate
t	Time
M	Moisture content
ω	Air absolute humidity
Φ	Absolute and relative humidity
DC	Direct current
V	Volt
LED	Light Emitting Diode
IoT	Internet Of Things
T	Air temperature
GND	Ground
RX	Receive data
TX	Transmit data
VCC	Voltage Common Collector)
ηd	Dryer efficiency
ηc	Collection efficiency

W	Mass of moisture evaporated
L	Latent heat of evaporation in the dryer temperature
Mi	Initial mass of the sample
Md	Final mass of the sample
DNN	Deep Neural Network
JS	Javascipt
CNN	Convolutional Neural Network
Kg	Kilogram
%	Moisture content

CHAPTER-1

INTRODUCTION

Fish is a very important component of the diet for people throughout the world because of its high protein content and nutritional value fish supplies approximately 6% of global protein Fish may be classed as either white, oily, or shell fish in most developing countries where there is high rate of malnutrition, fish provides nutritious food which is often cheaper than meat and therefore available to a larger number of people. Fish are an extremely perishable foodstuff. Fish invariably become putrid within a few hours of capture unless they are preserved or processed in some way to reduce this microbial and autolytic activity and, hence, retard spoilage. Spoilage therefore begins as soon as the fish dies and processing should therefore be done as quickly as possible to prevent the growth of spoilage bacteria. Spoilage occurs as a result of the action of enzymes (autolysis) and bacteria present in the fish, and also chemical oxidation of the fat which causes rancidity. At the high temperatures prevalent in tropical countries, bacterial and enzymic action is enhanced, the acid content of fish is low and is therefore, susceptible to the growth of poisoning bacteria. It has been affirmed that the moisture content of fish ranged between 65 - 80% if this is reduce to around 25%, bacteria cannot survive and autolytic activity will be greatly reduced. Mould will cease to grow at moisture content of 15 per cent or less; well dried fish if stored under right conditions can be kept for several months. Salting and drying are traditional methods of preserving fish; they have been used for centuries and dried salted products are still popular in many areas, particularly in Africa, SE Asia and Latin America. If the moisture content of fresh fish is reduced during drying to around 25%, bacteria cannot survive and autolytic activity will be greatly reduced, but to prevent mould growth, the moisture content must be reduced to

15%. The presence of salt retards bacterial action and, in addition, it aids the removal of water by osmosis. When salt is added to fish before drying, a final moisture content of 35 - 45% in the flesh, depending on the salt concentration may be sufficiently low to inhibit bacteria. In order to improve the drying techniques, the use of solar dryers has been investigated as an alternative to traditional sun drying. Solar dryers worked on the principle of collecting or concentrating solar radiation which resulted in elevated temperatures and, in turn, lower relative humidity favourable for drying. The advantages of solar drier are the zero energy cost and environmental friendly of its operation.

1.2 DESIGN METHODOLOGY

1.2.1 Types of solar dryers:

Solar-energy drying systems are classified primarily according to their heating modes in which the solar heat is utilized. These driers can be classified into two major groups, namely as shown in Fig.1.1:

(i) Active solar-energy drying systems (most types of which are often termed hybrid solar dryers)

(ii) Passive solar-energy drying systems (conventionally termed natural-circulation solar drying systems).

Three distinct sub-classes of either the active/passive solar drying systems can be identified namely as shown Fig 1.2:

- Direct-type solar dryers
- Indirect-type solar dryers
- Mixed-mode type solar dryers

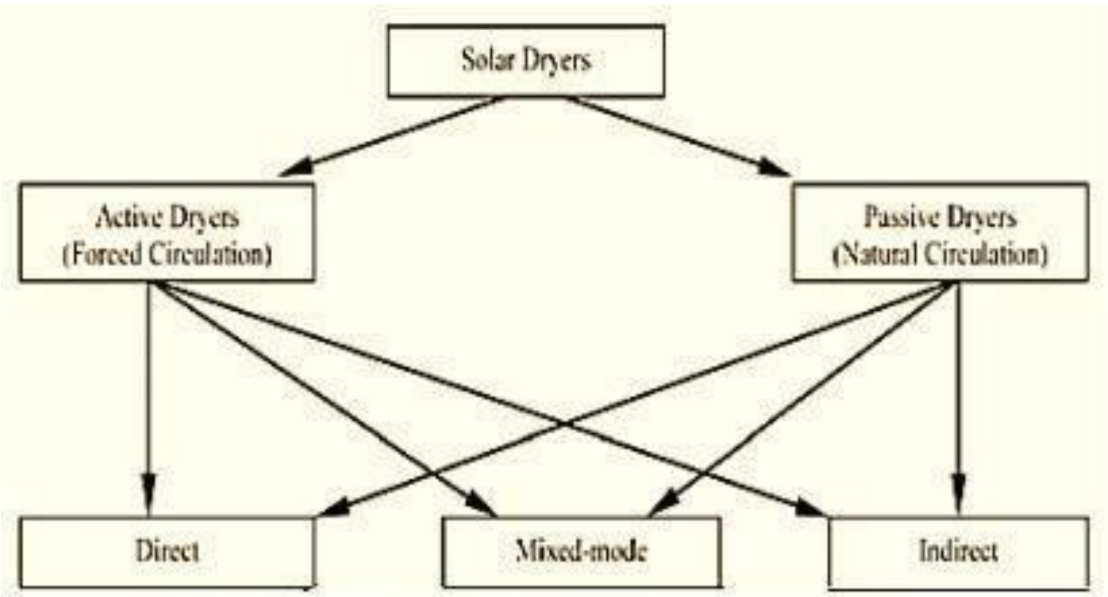


Fig1.1 Types of Solar Dryers

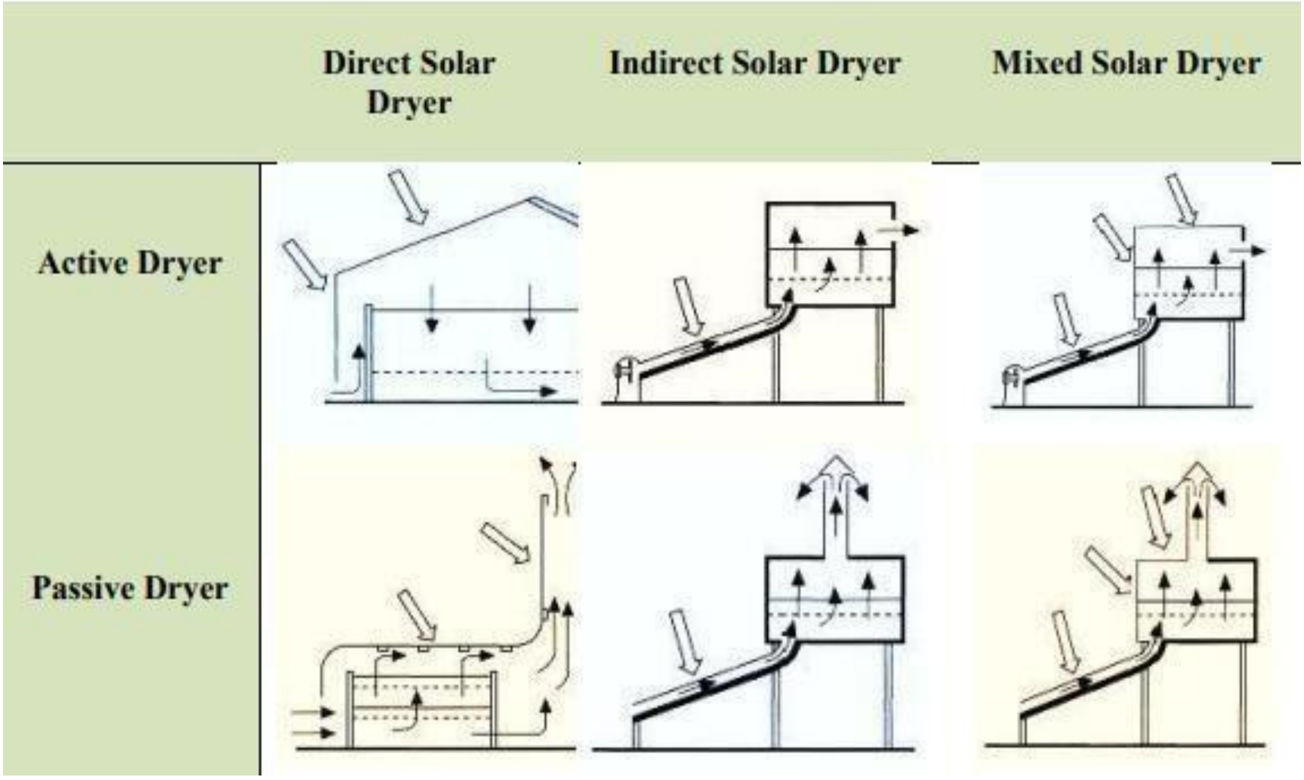


Fig.1.2 Three distinct sub-classes of active and passive dryer

1.2.1.1 Direct-type solar dryer:

It uses only the natural movement of heated air. It is a type of dryer in which solar radiation is directly absorbed by the product to be dried as shown in Fig 1.3. A part of incidence solar radiation on the glass cover is reflected back to atmosphere and remaining is transmitted inside cabin dryer. It is also called natural convection cabinet dryer. It is also called as natural convection cabinet dryer. The quality of product is reduced since the solar radiation is directly fall on the product. This dryer comprises of a drying chamber that is covered by a transparent cover made of glass or plastic. Due to presence of glass cover unlike open sun drying and the absorption of solar radiation, product temperature increase and the material starts emitting long wave length radiation that is not allowed to escape to atmosphere. Hence the temperature above the product inside chamber becomes higher.

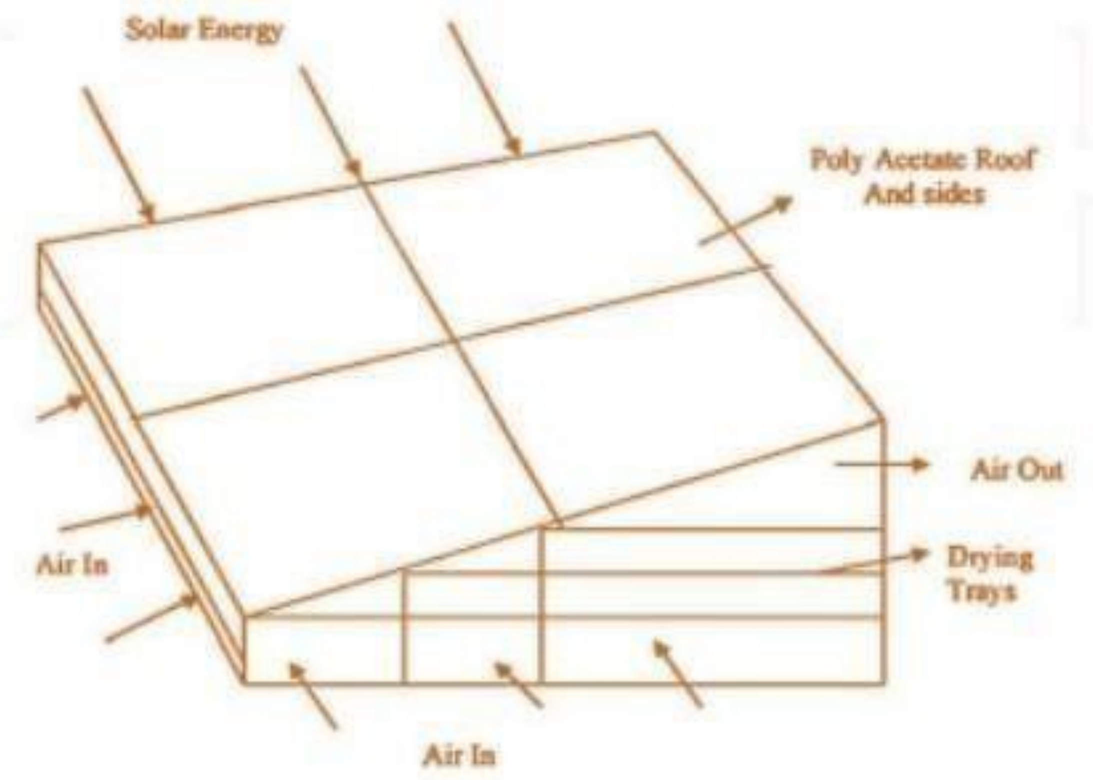


Fig.1.3 Direct-type Solar Dryer

1.2.1.2 Indirect-type solar dryer:

In an indirect solar dryer, at first the sun's heat is collected by the solar collectors and then it is passed onto the dryer cabinet, where the drying occurs as shown in Fig 1.4. Goyal (1997) designed a reverse observer dryer based on this concept, shown in Fig 4. Basunia (2001) says that the basic concept of reverse flat plate collector is used to dry food products in a solar cabinet-type dryer .The solar air that enters the chamber is heated and is then made to pass through over the wet crops. The air heaters are connected and a solar air heateris used to heat the air that enters the chamber. The heated air turns into warm humid air that passes through an outlet. This kind of dryer is better whencompared to other dryers in terms of solving various equations based on energy balance. Also has better performance than other conventional cabinet type of dryers. Because of its low-cost requirements it is ideal for small farms. The dryer contains a flat plate collector, a drying chamber, thermally and acoustically insulated pipes that joined between the collector and chamber. This drying unit can still produce good quality products, under unfavourable weather situations.

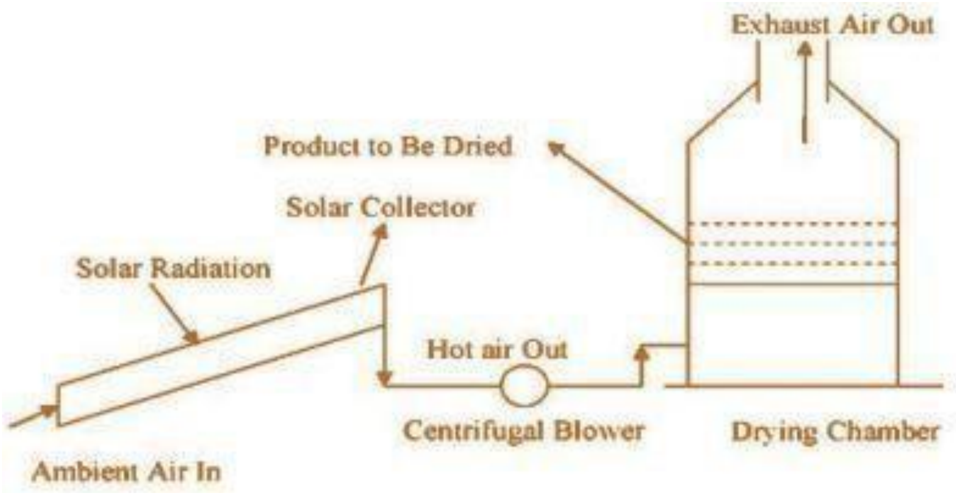


Fig.1.4 Indirect-type Solar Dryer

1.2.1.3 Mixed-mode type solar dryer:

The mixed-mode solar dryer has no moving part that's why it is called the passive dryer. This kind of dryer requires energy from the sun rays that enters through the collector listering. The sun rays are harnessed by trapping the heat of the air which is collected inside the chamber and the inside surface of the collector is painted black as shown in Fig 1.5. The mixed-mode dryer is the best of the three because of the highest drying rate when compared to the three kinds of dryers. Simate (2003) discussed the basic concepts of mixed-mode solar dryers by involving computer modelling.

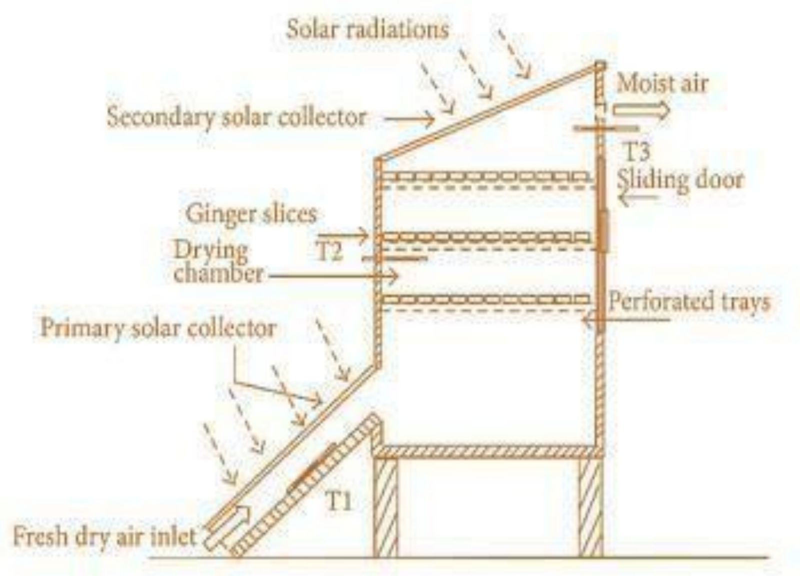


Fig.1.5 Mixed-mode type Solar Dryer

1.3 USES OF SOLAR DRYING SYSTEM

- Solar fish dryer is a multi-purpose facility, which is of great importance to the economic growth of coastal area fisheries folk.
- Better Quality of Products are obtained.
- It Reduces Losses and Better market price to the products.
- Product can be left in the dryer overnight during rain, since dryers are waterproof.
- It is more efficient and cheap.
- It can be used for drying and preservation of fish without using conventional drying fuel such as kerosene, firewood, charcoal etc.
- Reducing conventional fuel demand can result in significant cost savings.
- Drying materials at optimum temperatures and in a shorter amount of time enables them to retain more of their nutritional value such as vitamin C.

- It is hygienic and healthier. Since materials are dried in a controlled environment, they are less likely to be contaminated by pests, and can be stored with less likelihood of the growth of toxic fungi.

1.4 CLASSIFICATION OF DRYING SYSTEMS

Drying systems can be classified according to their operating temperature ranges into two main groups of high temperature dryers and low temperature dryers. However, dryers are more commonly classified broadly according to their heating sources into fossil fuel dryers (more commonly known as conventional dryers) and solar-energy dryers. Strictly, all practically realized designs of high temperature dryers are fossil fuel powered, while the low temperature dryers are either fossil fuel or solar energy based systems.

1.4.1 High temperature dryers:

High temperature dryers are necessary when very fast drying is desired. They are usually employed when the products require a short exposure to the drying air. Their operating temperatures are such that, if the drying air remains in contact with the product until equilibrium moisture content is reached,serious over drying will occur. Thus, the products are only dried to the required moisture contents and later cooled. High temperature dryers are usually classified into batch dryers and continuous-flow dryers. In batch dryers, the products are dried in a bin and subsequently moved to storage. Thus, they are usually known as batchin-bin dryers. Continuous-flow dryers are heated columns through which the product flows under gravity and is exposed to heated air while descending. Because of the temperature ranges prevalent in high temperature dryers, most known designs are electricity or fossil-fuel powered. Only a very few practically-realized designs of high temperature drying systems are solar-energy heated.

1.4.2 Low temperature dryers:

In low temperature drying systems, the moisture content of the product is usually brought in equilibrium with the drying air by constant ventilation. Thus, they do tolerate Intermittent or variable heat input. Low temperature drying enables products to be dried in bulk and is most suited also for long term storage systems. Thus, they are usually known as bulk or storage dryers. Their ability to accommodate intermittent heat input makes low temperature drying most appropriate for solar-energy applications. Thus, some conventional dryers and most practically-realized designs of solar-energy dryers are of the lowtemperature type.

Overall, solar dryers are a sustainable and cost-effective alternative to traditional drying methods, especially in regions with abundant sunlight. They are used extensively in agriculture, food processing, and other industries to preserve food.

CHAPTER-2

LITERATURE SURVEY

Abhijith KS et.al.,(2021) has done a modelling and analysis of an efficient solar dryer system is proposed to address the challenges faced by farmers in drying food products, particularly spices, in varied climatic conditions. Conventional methods like open air sun drying and smoke drying may result in insufficient product quality. The proposed dryer aims to increase product quality and quantity, ensuring desired characteristics such as colour, flavour, and appearance, while reducing the risk of microorganism growth,insect infestation, and contamination by foreign matters. Sensitivity analysis to different factors affecting dryer efficiency is also presented.

Samson A.Sotocinal et.al.,(1992) suggested design and testing of a natural convection solar fish dryer. A natural convection solar fish dryer was designed, constructed, and tested in the Philippines, capable of drying 5 kg of fish in 10 hours. Water was heated in a flat-plate solar collector, then transferredthrough a thermosyphon effect to a heat exchanger where heat was transferred to the air. Heated air flowed through the drying chamber with trays of fish, and data from seven drying experiments were used to determine system efficiency in solar energy utilization.

Nguyen Vu Lan et.al.,(2017) proposed improvement of conventionalsolar drying system.A combined-drying system with controlled and stabilized drying parameters, including temperature, humidity, and air velocity, was designed to improve the performance of solar drying systems. The systemutilized a special chamber geometrical structure for even distribution of hot air flow over crops, resulting in excellent taste and uniform humidity in dried crops with a maximum difference of 1.5%. Approximately 59% of the total energy consumption was contributed by absorbed solar energy, as confirmed through testing.

Hidetoshi Aoki et.al.,(2002) has done a development of drying technology utilizing solar energy to dry agricultural and marine products. Solar drying, using a hybrid solar collector that produces warm water and air simultaneously, was developed by the author to process agricultural and marine products while maintaining taste. The system utilizes solar energy passing through glass, achieving a total heat collection efficiency of 74% with balanced water and airflows. The effects of different rays on umami components were studied, showing that UV-A and UV-C rays increased amino acid content more than warm air drying without solar ray wavelengths.

Vaishnavi nair et.al.,(2022) has suggested iot based solar energy dryer. Postharvest loss of agricultural products is a significant issue in many developing nations due to insufficient knowledge and information about conservation measures. Proper postharvest technology, such as solar-powered drying and mechanical treatments, can reduce food waste, increase productquality, and allow for extended storage. Solar energy is a clean and efficient source of power that can be used to run the system, including lighting bulbs in rural areas by converting excess solar charge stored in batteries into AC.

Elita Fidiya Nugrahani et.al.,(2019) presented an experimental analysis of solar cabinet dryer for fish processing in gresik,indonesia. A solar cabinet dryer was designed and manufactured to improve efficiency and overcome weaknesses of a conventional fish dryer used by most fishermen in Gresik, East Java, Indonesia. The solar cabinet dryer, equipped with mirrors to maximize solar radiation, dried 3 kg of fish to below 40% moisture content based on Indonesian National Standard. The drying rate per hour ranged from 18.93% to 20.92% depending on the mirror angle, and the highest efficiency performance was 34.94%. The solar cabinet dryer also showed improved cleanliness with a decrease in bacteria colonies compared to the conventional drying method.

Oluwole et.al.,(2016) performed an evaluation of solar fish dryer Locally fabricated solar fish dryer was evaluated using Tilapia fish. Four set up of solar dryers were used - A- oven without reflector with air vent closed; B- oven without reflector with air vent opened; C- oven with reflector with air vent closed and D- oven with reflector with air vent opened. The experiments were performed between the hours of 7:00 am and 4:00 pm. Results obtained showed that from 7:00 am to 12:00 noon, the oven with reflector and vents closed removed moisture faster, followed by oven with reflector and vents opened, thereafter the rate of moisture removal reduces. However, the oven without reflector had final higher moisture removal.

Ibtihaj A. Abdulrazzak et.al.,(2019) proposed a humidity and temperature monitoring. A compact and affordable weather station is designed using a DHT22 sensor for accurate humidity and temperature measurement, and RF 433hc12 for data transmission. The system aims to provide high performance with low cost, utilizing the reliable DHT22 sensor and RF 433 hc12 for better range and portability. The data is displayed on an LCD screen after being transmitted and received by the system.

Er.R. Regupathi and S. Balasubramanian(2018) suggested and researched about a study on solar drying system for fish preservation. Solar fish dryer is an important facility for coastal area fisheries, used for fish drying to preserve aqua cultural products. Various designs of solar dryers, including indirect, direct, and mixed mode dryers, are discussed in the literature. These solar dryers utilize solar energy to heat up air and dry food substances, reducing product wastage and aiding in preservation, while avoiding the negative environmental impact offossil fuels or weather dependency of open sun drying.

Sandip Sengar et.al.,(2009) has given a detailed review which delivers information of low cost solar dryer for fish. Prawns (Kolambi) were dried using a low cost solar dryer (LCSD) in 8-15 hours, reducing moisture content from 75% to 15-16%. Salted prawns dried in the solar dryer were preferred in sensory evaluation for their color and texture. The overall collection efficiency of the solar dryer was 70.97%. The cost of the LCSD, at Rs. 1700/-, was found to be affordable for local fishermen and could be recovered within 0.19 years, making solar drying a beneficial option compared to costly mechanical dryers.

CHAPTER-3

SUN DRYING VERSUS SOLAR DRYING

Solar drying is a possible replacement for sun drying or for standard dehydration processes. In terms of sun drying, solar drying is competing with an approach that is deeply entrenched in the way of life for most potential users. Sun drying is by no means a perfect process with problems arising due to potential contamination of the produce, variability in drying times, rain damage and so on. However some of the reasons proposed for the lack of success in adoption of solar drying are as follows:

- Solar dryers have often been too expensive or initial investment capital or loan facilities were unavailable.
- Solar dryers have often been too complicated or poor training of local entrepreneurs and technicians was provided.
- Solar dryers have often required too big changes from traditional methods.
- Solar dryers have not been built for long term use.
- There is a lack of incentive to improve the quality of the product.People are willing to pay nearly the same amount for dis-coloured or damaged foods and there is therefore no incentive for producers to risk higher amounts of money in a dryer when there is not a great return. When comparing solar drying to the conventional dehydrationprocesses a new range of issues arises. These include:
- Solar dryers must provide the equivalent performance to that of the conventional processes in terms of capacity, labour input, the quality of the final product, the total drying costs and reliability.

A backup heating system should be installed to ensure drying during the critical periods when the weather is bad.

- Advantages of solar drying can be summarized as follows:
- The higher temperature, movement of the air and lower humidity, increases the rate of drying.
- Food is enclosed in the dryer and therefore protected from dust, insects, birds and animals.
- The higher temperature deters insects and the faster drying rate reduces the risk of spoilage by micro-organisms.
- The higher drying rate also gives a higher throughput of food and hence a smaller drying area (roughly 1/3).
- The dryers are water proof and the food does not therefore need to be moved when it rains.
- Dryers can be constructed from locally available materials and are relatively low cost.
- More complete drying allows longer storage.

3.1.1 Process during sun drying:

Sun drying is a traditional method of preserving fish by removing moisture using the heat and energy from the sun. The process involves several steps:

1. **Cleaning and washing:** The fish are first cleaned thoroughly to remove any dirt or debris. The heads, tails, and fins are usually removed as well. The cleaned fish are then washed in clean water to remove any remaining dirt or blood.
2. **Salting**: The fish are then salted heavily to help preserve them and toenhance their flavor. The salt also helps to draw out any remaining moisture.
3. **Drying:** The fish are then laid out on drying racks or on mats in the sun to dry. They are typically turned regularly to ensure that they dry evenly. The drying process can take several days, depending on the weather conditions.

4. **Storage:** Once the fish are completely dry, they are stored in a cool, dry place away from sunlight to prevent any moisture from re-entering the fish. They can be stored for several months, and even up to a year, if properly dried and stored.

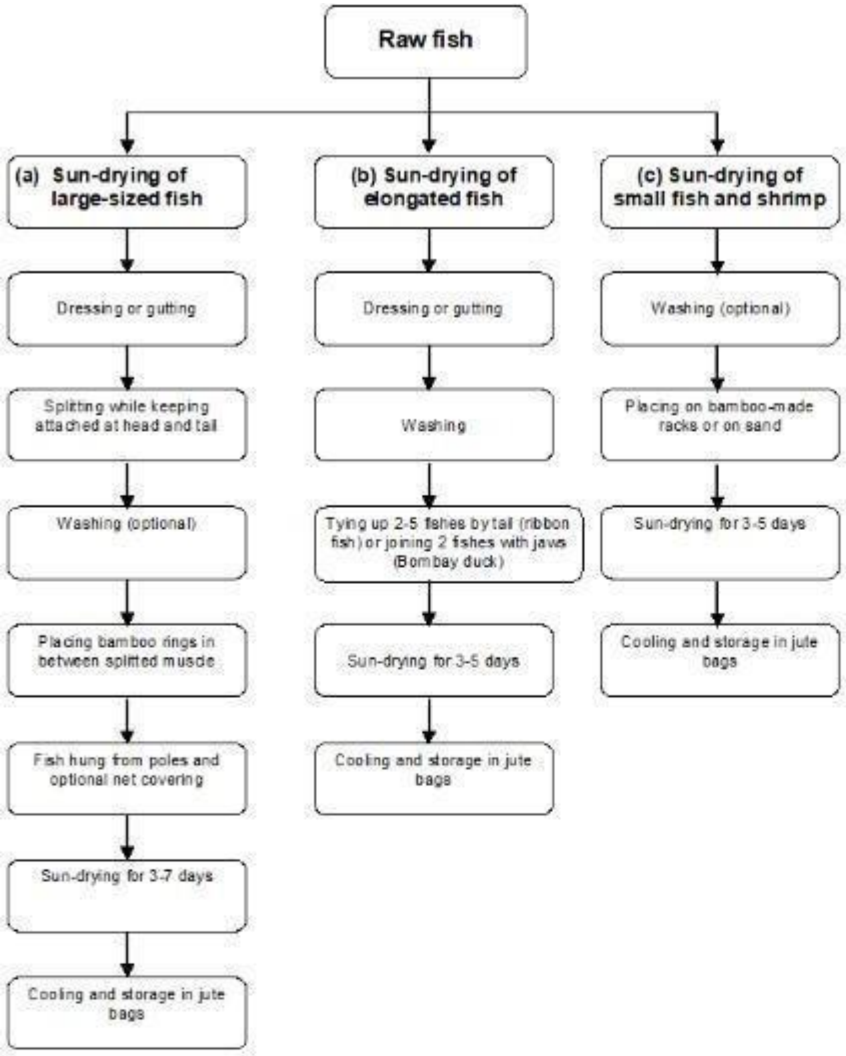


Fig 3.1 Three categories of traditional drying process

During the drying process, it is important to ensure that the fish are protected from flies and other insects that can contaminate the fish. Some fishermen also use smoke during the drying process to add flavor and to deter insects. However, smoking can also reduce the nutritional value of the fish, so it is not always recommended.

3.1.2 Process during solar drying:

Solar drying is a popular method for preserving fish and other seafood in areas where refrigeration is not readily available. The process involves exposingthe fish to the sun and wind to remove moisture, which helps to prevent spoilage and extend the shelf life of the product. Here are the typical steps involved in solar drying fish:

1. **Preparation:** The fish should be cleaned and gutted before drying. Large fish can be cut into fillets or smaller pieces to speed up the drying process.
2. **Salting:** Salt can be applied to the fish to help draw out moisture and preserve the product. This is optional but can improve the flavor and texture of the dried fish.
3. **Drying:** The fish should be placed on drying racks or mats that allow for good air circulation. The racks should be positioned in a sunny, dry location with good airflow. The fish should be turned regularly to ensure even drying.
4. **Protection:** The fish should be protected from insects and other pests while drying. Covering the racks with mesh or other netting can help to prevent contamination.
5. **Storage:** Once the fish is completely dry, it can be stored in a cool, dry place. Properly dried fish can be stored for several months to a year, depending on the conditions.

Overall, the key to successful solar drying is to ensure that the fish is properly cleaned and prepared, that it is exposed to sufficient sunlight and air circulation, and that it is protected from pests and other contaminants during the drying process.

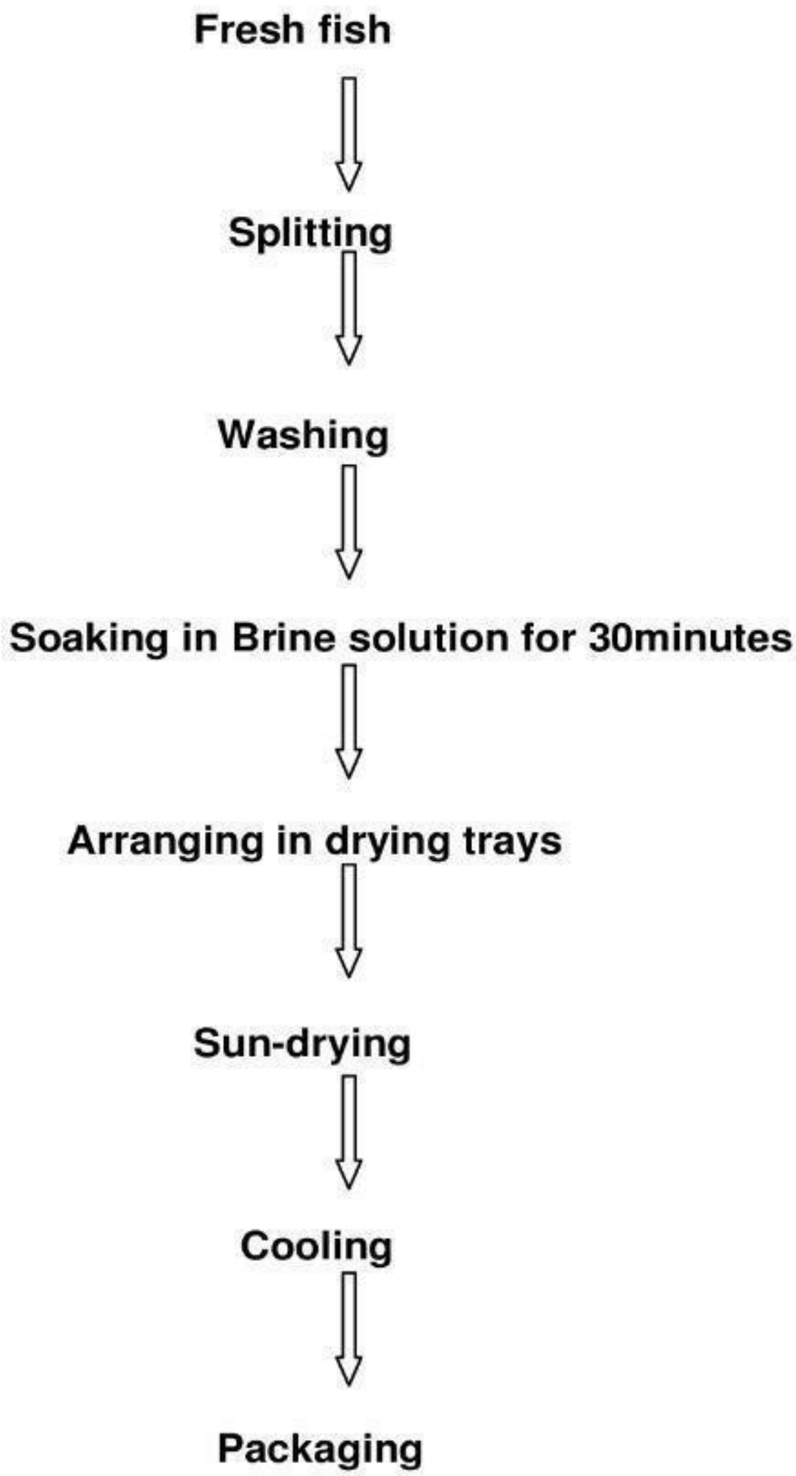


Fig 3.2 Flow chart of solar drying process

CHAPTER-4

EXISTING SYSTEM

A solar dryer is a device that utilizes the energy of the sun to dry and preserve food, herbs, and other materials. There are several existing systems for solar drying fish, each with its own advantages and limitations. Here are a few examples:

- Open-air solar dryer
- Solar tunnel dryer
- Solar cabinet dryer
- Hybrid dryer

4.1.1 Open -air solar dryer:

An open-air solar dryer is a simple and low-cost system for drying fish, fruits, vegetables, and other perishable goods using sunlight and natural airflow. The dryer typically consists of a wooden or metal frame with racks or screens for holding the product to be dried as shown in Fig4.1. The racks are usually placed at an angle to allow for good airflow and drainage. The open-air solar dryer is designed to take advantage of the natural heat and wind in the environment. The dryer is placed in a sunny, open location where it can be exposed to sunlight and airflow. The fish or other product to be dried is placed on the racks and left to dry for several days. To protect the fish from insects and other pests, a cover made of mesh or netting is often placed over the drying racks. This helps to prevent contamination while still allowing for good airflow. The open-air solar dryer is a low-cost and effective way to preserve fish and other perishable goods, especially in areas where refrigeration is not available.

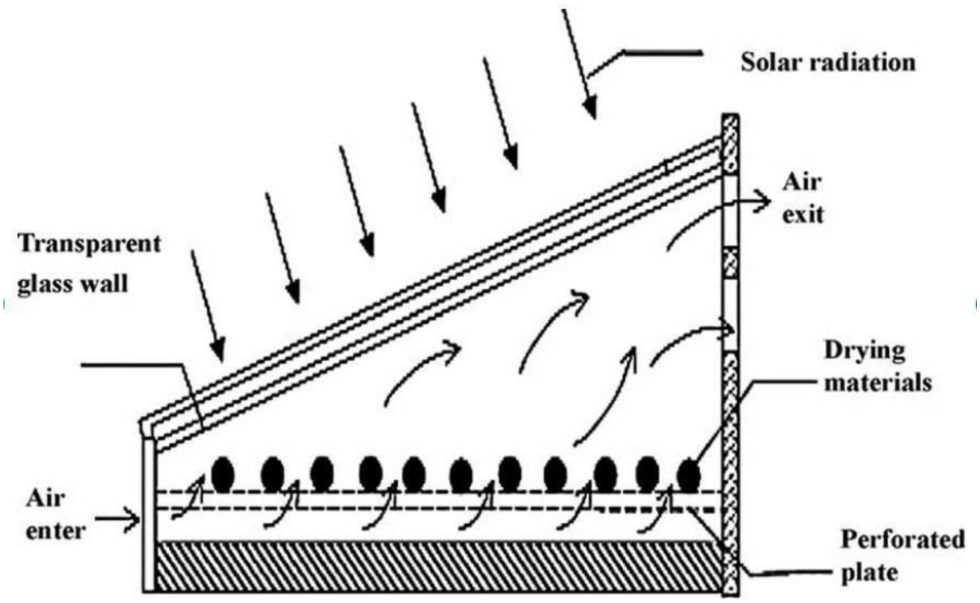


Fig 4.1 Open-air solar dryer

It is also a sustainable and eco-friendly method of food preservation, as it does not require electricity or other non-renewable resources.

4.1.2 Solar tunnel dryer:

A solar tunnel dryer is a type of solar dryer that uses an enclosed tunnel to trap heat and sunlight, creating a controlled drying environment for fish and other perishable goods. The tunnel is usually made of metal or plastic and has a transparent roof to allow sunlight to enter as shown in Fig 4.2. The fish or other product to be dried is placed on racks or screens inside the tunnel. The tunnel is designed to capture solar radiation, which heats the air inside the tunnel and causes moisture to evaporate from the product. To ensure good airflow and efficient drying, fans or vents are often used to circulate air inside the tunnel. This helps to remove moisture and prevent the product from becoming too hot. One of the advantages of a solar tunnel dryer is that it provides a more controlled environment for drying fish and other products. The enclosed tunnel protects the product from rain, wind, and other weather conditions, and allows for more consistent drying results. The tunnel can also be designed to be mobile, allowing it to be moved to different locations as needed.

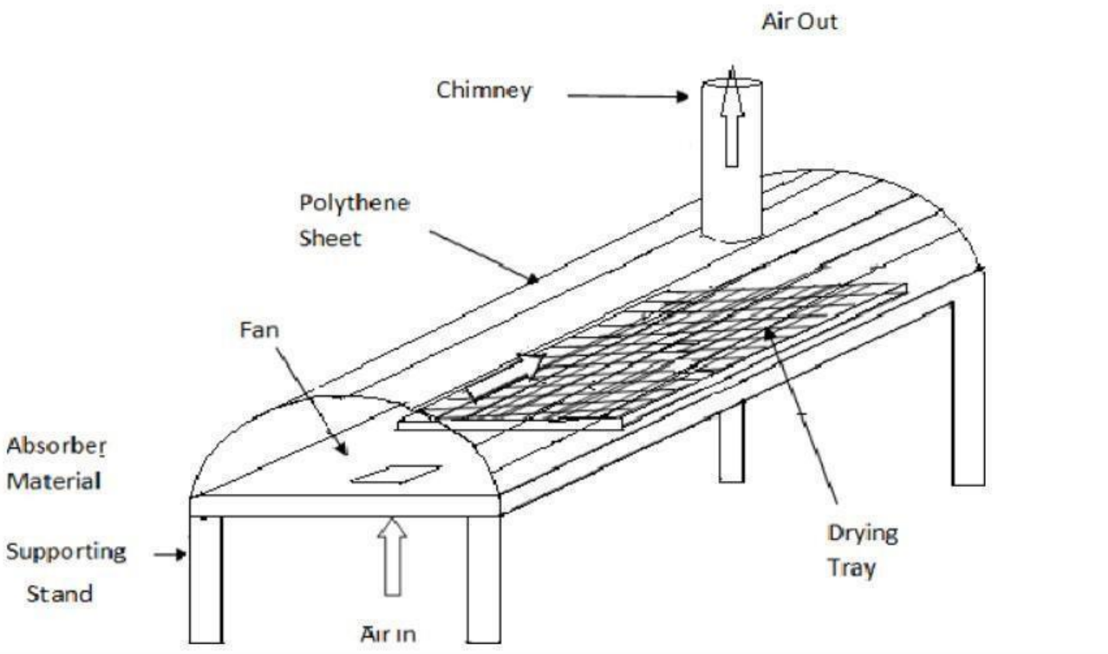


Fig 4.2 Solar tunnel dryer

Solar tunnel dryers can be built in various sizes and configurations, depending on the scale of the operation and the amount of product to be dried. They are a popular choice for small-scale fish drying operations in areas where sunlight and wind are abundant.

4.1.3 Solar cabinet dryer:

A solar cabinet dryer is a type of solar dryer that uses a small, insulated cabinet with a transparent front panel to trap heat and sunlight, creating a controlled drying environment for fish and other perishable goods. The cabinetis usually made of wood, metal, or plastic and has a sloped top to allow for good airflow. The fish or other product to be dried is placed on racks or screens inside the cabinet. The cabinet is designed to capture solar radiation, which heats the air inside the cabinet and causes moisture to evaporate from the product. To ensure good airflow and efficient drying, fans or vents are often used to circulate air inside the cabinet as shown in Fig 4.3. This helps to removemoisture and prevent the product from becoming too hot. One of the advantagesof a solar cabinet dryer is that it provides a more controlled environment for drying fish and other products, compared to open-air solar dryers.

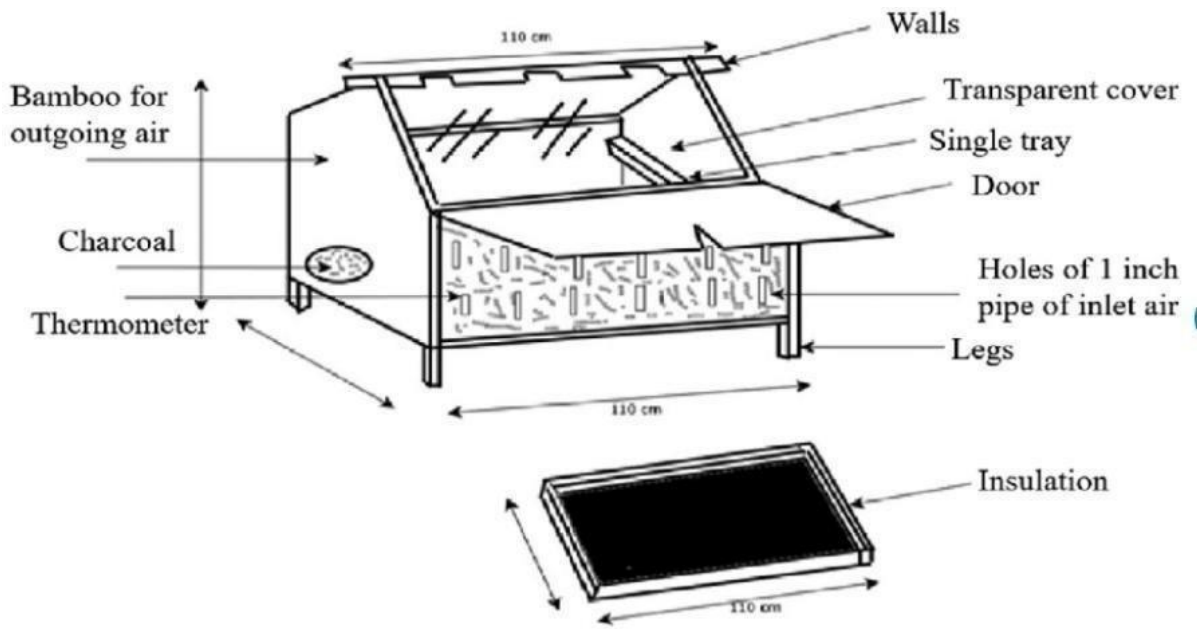


Fig 4.3 Solar cabinet dryer

The insulated cabinet protects the product from rain, wind, and other weather conditions, and allows for more consistent drying results. The cabinet can also be designed to be portable, allowing it to be moved to different locations as needed. Solar cabinet dryers can be built in various sizes and configurations, depending on the scale of the operation and the amount of product to be dried. They are a popular choice for small-scale fish drying operations in areas where space is limited or extreme weather conditions are common

4.1.4 Hybrid dryer:

A hybrid dryer is a type of dryer that uses a combination of two or more sources of energy to dry fish or other perishable goods. For example, a hybrid dryer may use solar energy during the day when the sun is shining, and biomass energy (such as wood or agricultural waste) or electricity during the night or on cloudy days when solar energy is not available as shown in Fig 4.4. The specific design of a hybrid dryer can vary depending on the available energy sources and the needs of the user. Some hybrid dryers may include a solar panel and a biomass or electric heater, while others may include a solar panel and a battery backup system to store excess solar energy for use during cloudy periods. Hybrid dryers offer several advantages over traditional dryers that rely on a single source of energy.By using multiple sources of energy, they can provide more consistent and reliable drying results, even in areas with unpredictable weather conditions. They can also be more energy-efficient and cost-effective than traditional dryers, as they can take advantage of free and renewable sources of energy such as solar and biomass. Hybrid dryers are often used in small-scale fish drying operations in rural areas where access to electricity is limited and biomass resources are abundant.

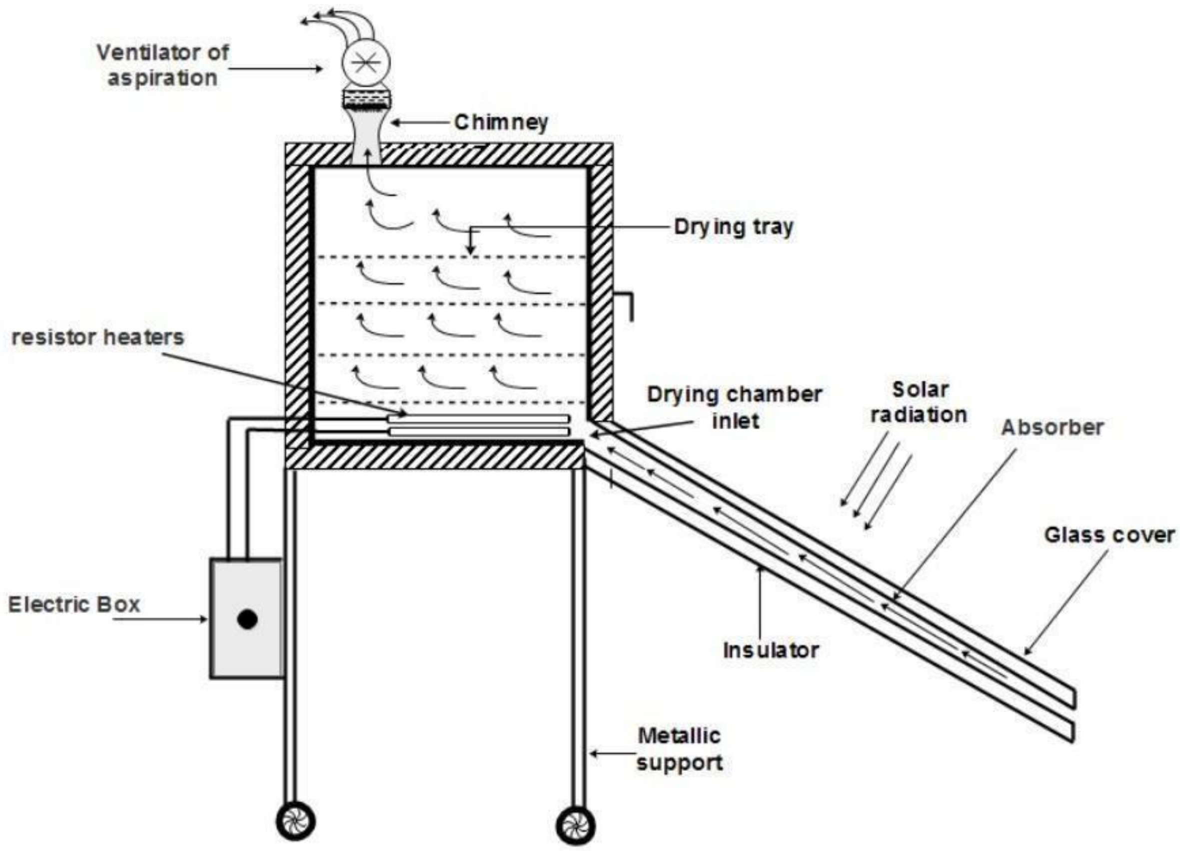


Fig 4.4 Hybrid dryer

4.2 OPERATION OF THE DRYER

The dryer is a passive system in the sense that it has no moving parts. It is energized by the sun‘s rays entering through the collector glazing. The trapping of the rays is enhanced by the inside surfaces of the collector that were painted black and the trapped energy heats the air inside the collector. The greenhouse effect achieved within the collector drives the air current through the drying chamber. If the vents are open, the hot air rises and escapes through the upper vent in the drying chamber while cooler air at ambient temperature entersthrough the lower vent in the collector.

4.3 DRYING MECHANISM

In the process of drying, heat is necessary to evaporate moisture from the material and a flow of air helps in carrying away the evaporated moisture. There are two basic mechanisms involved in the drying process:

1) The migration of moisture from the interior of an individual material to the surface is shown in Fig 4.5

The drying product is a complex heat and mass transfer process which depends on external variables such as temperature, humidity and velocity of the air stream and internal variables which depend on parameters like surface characteristics (rough or smooth surface), chemical composition (sugars, starches, etc.), physical structure (porosity, density, etc.), and size and shape of product. The rate of moisture movement from the product inside to the air outside differs from one product to another and depends very much on whether the material is hygroscopic or non-hygroscopic. Non-hygroscopic materials can be dried to zero moisture level while the hygroscopic materials like most of the food products will always have residual moisture content. This moisture, in hygroscopic material, may be bound moisture which remained in the material due to closed capillaries or due to surface forces and unbound moisture which remained in the material due to the surface tension of water.

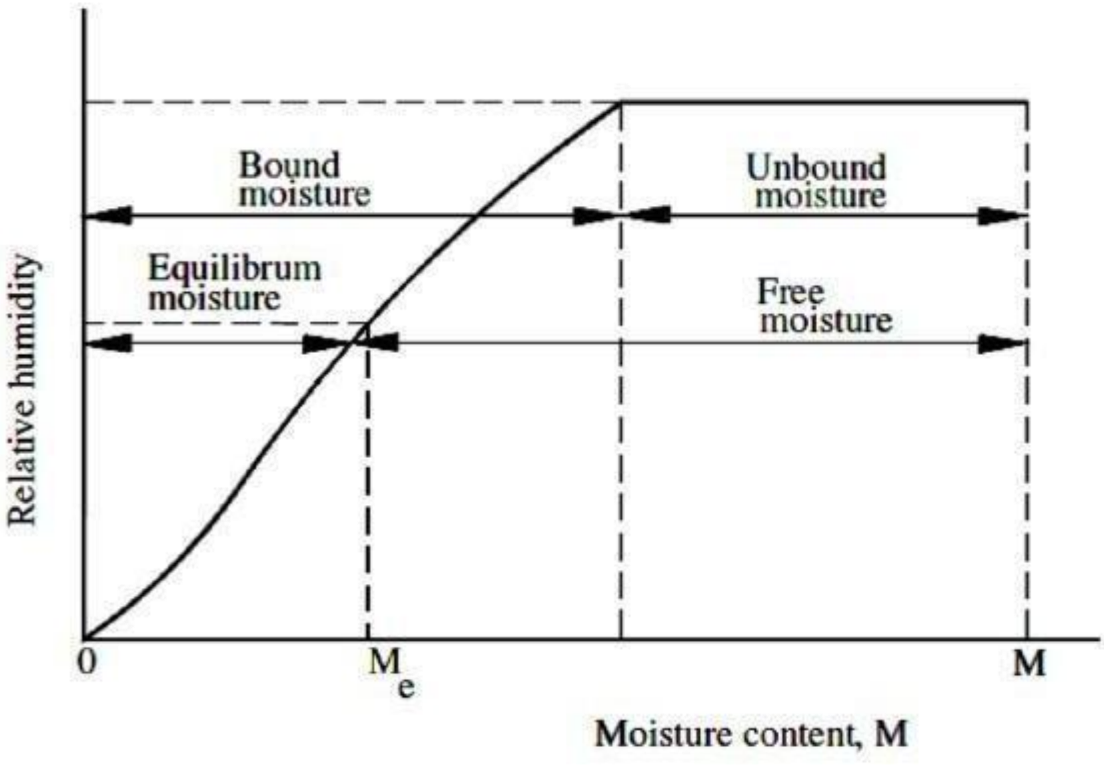


Fig 4.5 Moisture content of a body

When the hygroscopic material is exposed to air, it will absorb either moisture or desorbs moisture depending on the relative humidity of the air. The equilibrium moisture content (EMC = Me) will soon reach when the vapour pressure of water in the material becomes equal to the partial pressure of water in the surrounding air [14]. The equilibrium moisture content in drying is therefore important since this is the minimum moisture to which the material can be dried under a given set of drying conditions. A series of drying characteristic curves can be plotted. The best is if the average moisture content M of the material is plotted versus time. Fig 4.6 represents the rate of moisture loss.

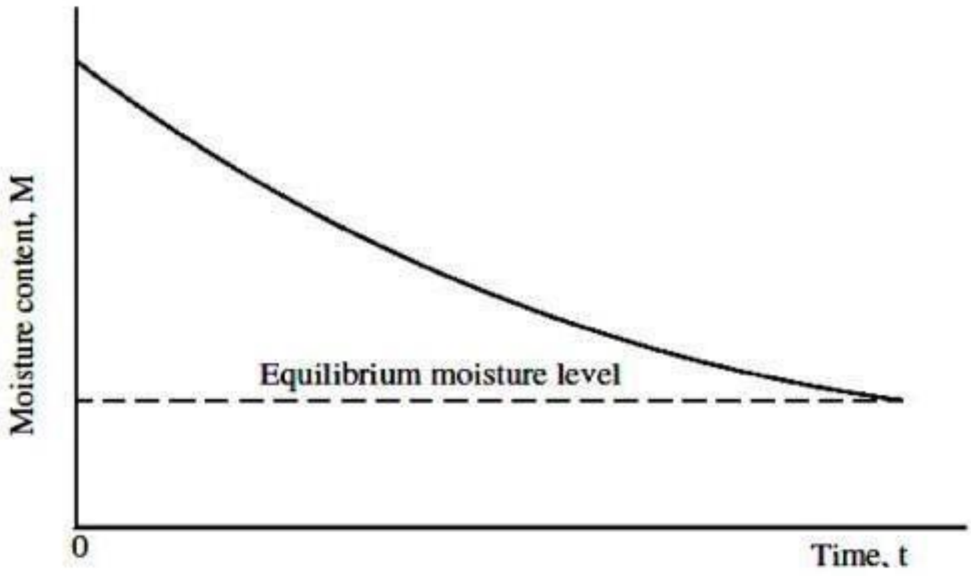


Fig 4.6 Rate of Moisture Loss

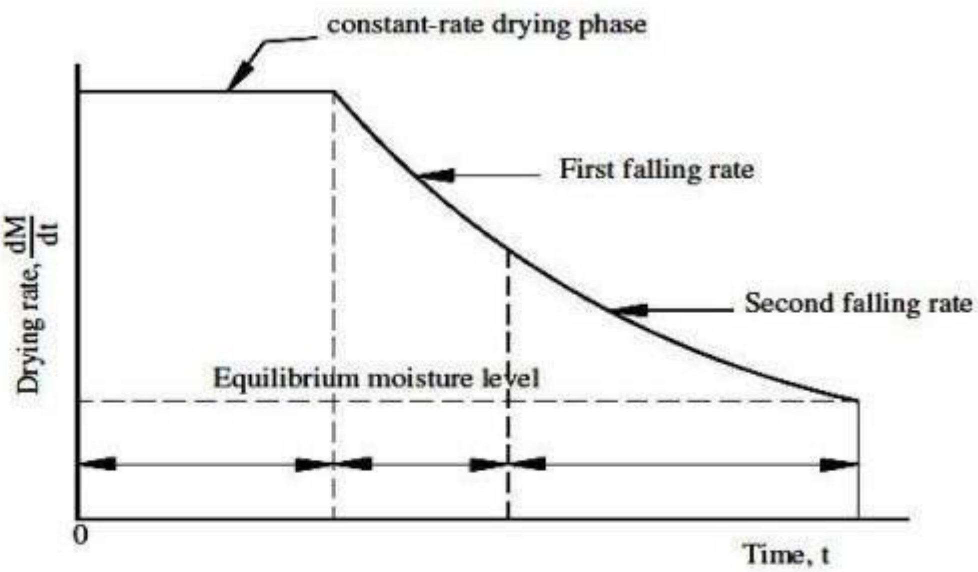


Fig 4.7 Rate of dM/dt versus moisture content M

As shown in Figure 4.7 for both non-hygroscopic and hygroscopic materials, there is a constant drying rate terminating at the critical moisture content followed by falling drying rate. The constant drying rate for both non- hygroscopic and hygroscopic materials is the same while the period of falling rate is little different. For non-hygroscopic materials, in the period of falling rate, the drying rate goes on decreasing till the moisture content become zero. While in the hygroscopic materials, the period of falling rate is similar until the unbound moisture content is completely removed, then the drying rate further decreases and some bound moisture is removed and continues till the vapour pressure of the material becomes equal to the vapour pressure of the drying air. When this equilibrium reaches then the drying rate becomes zero. The period of constant drying for most of the organic materials like fruits, vegetables, timber, etc. is short and it is the falling rate period in which is of more interest and which depends on the rate at which the moisture is removed. In the falling rate regime moisture is migrated by diffusion and in the products with high moisture content, the diffusion of moisture is comparatively slower due to turgid cells and filled interstices. In most agricultural products, there is sugar and mineralsof water in the liquid phase which also migrates to the surfaces, increase the viscosity hence reduce the surface vapour pressure and hence reduce the moisture evaporation rate

4.4 AIR PROPERTIES

The properties of the air flowing around the product are major factors in determining the rate of removal of moisture. The capacity of air to remove moisture is principally dependent upon its initial temperature and humidity; the greater the temperature and lower the humidity the greater the moisture removal capacity of the air. The relationship between temperature, humidity and other thermodynamic properties is represented by the psychometric chart. It is important to appreciate the difference between the absolute humidity and relative humidity of air. The absolute humidity is the moisture content of the air (mass of water per unit mass of air) whereas the relative humidity is the ratio, expressed as a percentage, of the moisture content of the air at a specified temperature to the moisture content of air if it were saturated at that temperature.

The changes in condition of air when it is heated using the solar energy and then passed through a bed of moist product are as shown in Fig. 4.8. The heating of air from temperature TA to TB is represented by the line AB. During heating the absolute humidity remains constant at A whereas the relative humidity falls. As air moves through the material to be dried, it absorbs moisture.

Under (hypothetical) adiabatic drying; sensible heat in the air is converted to latent heat and the change in the condition of air is represented along a line of constant enthalpy, BC. Both absolute humidity and relative humidity increase from ΦB and ΦC and from ΦA to ΦC, respectively, but air temperature decreases to, TC. The absorption of moisture by the air would be the difference between the absolute humidities at C and B. (ωC - ωA). If unheated air is passed through the bed, the drying process would be represented by the line AD. Assuming that the air at D to be at the same relative humidity, C , as the heated air at C, then the absorbed moisture would be((ωD - ωA), considerably less than that absorbed by the heated air ((Φc - ΦA).

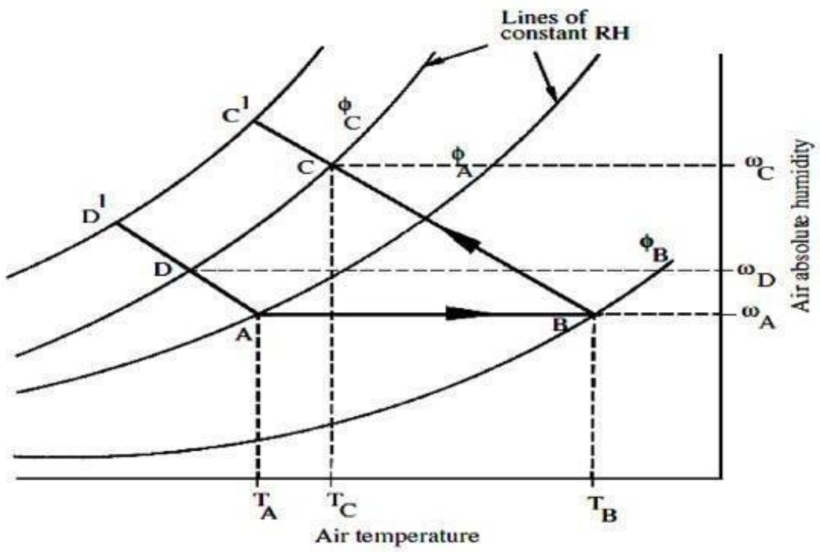


Fig. 4.8 Representation of drying process

CHAPTER-5

PROPOSED SYSTEM

5.1.1 Design specifications and assumptions

5.1.1.1 Introduction:

Solar dryers for fish are an effective and sustainable way to dry fish and preserve them for longer periods of time. However, monitoring the dryingprocess manually can be time-consuming and difficult, especially when the dryer is located in a remote area. Machine learning can be used to monitor the drying process and provide real-time information on the stage of the drying process. Here's how it could work:

i. **Data collection:**

A sensor network can be installed in the solar dryer to collect data on temperature, humidity, and airflow. This data can be collected at regular intervals and stored in a database.

ii. **Training data:**

A machine learning algorithm requires training data to learn the patterns and trends in the data. In this case, the training data would consist of examples of fish that have been dried to different stages, along with the corresponding sensor data. For example, we could collect data on fish that are 20%, 50%, and 80% dried.

iii. Feature engineering:

Once the training data is collected, we need to extract the relevant features from the data that will be used to train the machine learning algorithm. In this case, we might extract features such as temperature, humidity, andairflow, as well as other variables that may be relevant, such as the size and weight of the fish.

iv. Model selection and training:

Once the features are selected, we can train a machine learning model using a suitable algorithm, such as a decision tree, support vector machine, or neural network. The model will learn to predict the stage of drying based on the sensor data and the extracted features.

v. Deployment:

Once the model is trained, it can be deployed in the solar dryer to monitor the drying process in real-time. The sensor data is fed into the model, and the model predicts the stage of drying. This information can be displayed on a Teachable learning website and the temperature and humidity values detected by the sensor were sent to a mobile app, allowing the user to monitor the drying process remotely. By using machine learning to monitor the drying process, we can ensure that the fish are dried to the appropriate level and reduce the risk of spoilage.

This can improve the quality and shelf life of the dried fish, as well as make the drying process more efficient and cost-effective.

5.1.1.2 Solar dryer components:

The solar dryer consists of the following components

- Fabricated cuboid box

- Acrylic sheet
- Solar panel (22V)
- DC Exhaust Cooling fan
- Web-cam / Mobile
- Arduino
- Temperature and humidity sensor – DHT11
- HC-05 Bluetooth module

5.1.1.2.1 Fabricated cuboid box:

The fabricated cuboid box is made of steel material with an dimension of 4X2X2.Steel fabrication is a common method used in the construction of solar dryers for fish or other food products. Steel fabrication involves cutting, bending, and welding steel components to create a sturdy and durable structure as shown in Fig 5.1.

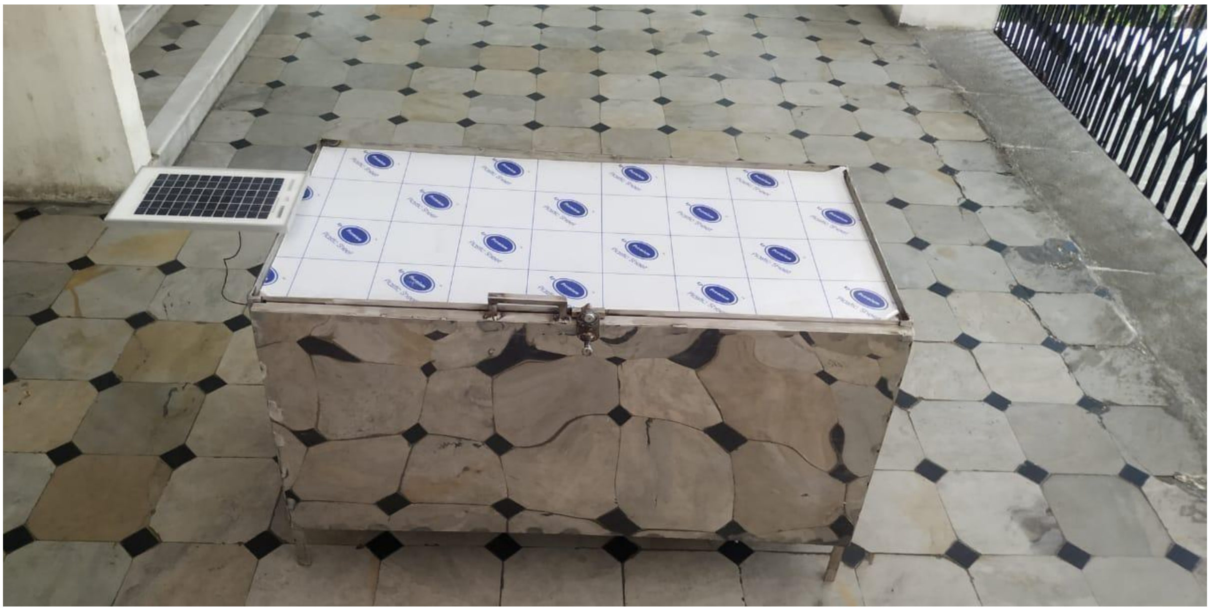


Fig. 5.1 Fabricated cuboid box

Steel fabrication allows for a high degree of customization and can be tailored to meet the specific needs of the solar dryer. By using steel, the dryer can be built to withstand harsh environmental conditions and provide a reliable and durable solution for drying fish.

5.1.1.2.2 Acrylic sheet:

Acrylic is a type of plastic that is lightweight, shatter-resistant, and transparent. Acrylic sheets offer several benefits in the construction of a solar dryer. They are lightweight and easy to work with, making them a cost-effective solution for customizing the dryer to meet specific needs as shown in Fig 5.2

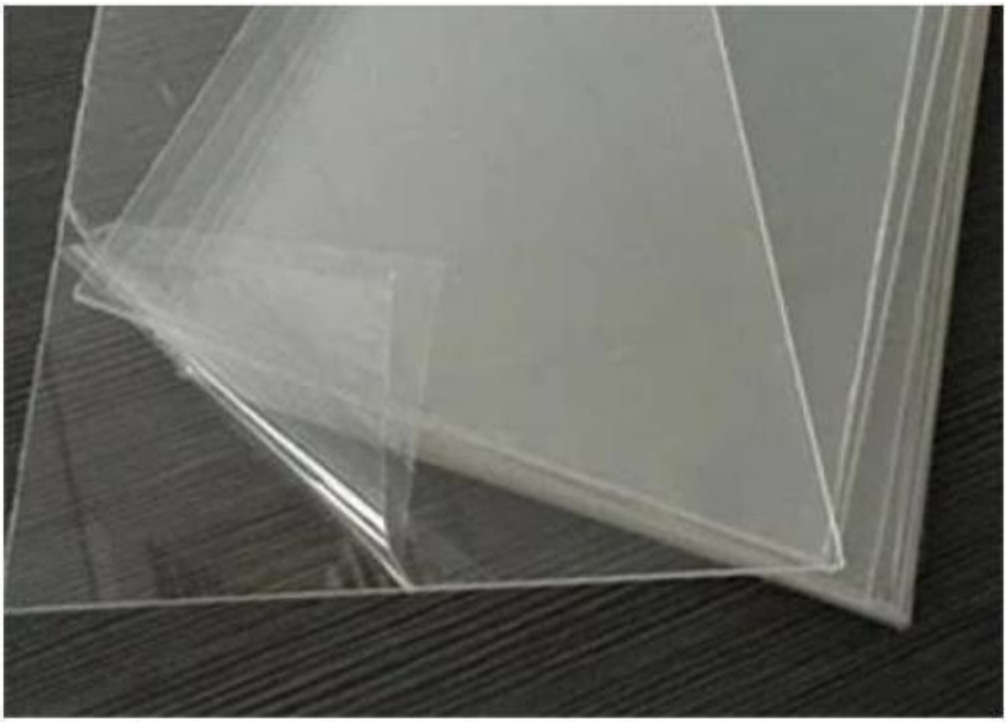


Fig 5.2 Acrylic sheet

Additionally, the transparency of acrylic allows for easy monitoring of the drying process, reducing the need for frequent opening of the chamber.

5.1.2.3 Solar panel:

The solar panel converts sunlight into electrical energy, which can be used to power the components of Arduino and exhaust fan. A 22V solar panel typically consists of multiple interconnected solar cells, which are usually made of silicon or other semiconductor materials. The number of solar cells in a panel and their arrangement determine the panel's voltage and power output as shown in Fig 5.3

A 22V solar panel can be used for various applications, such as charging batteries, powering small electronic devices, or as part of a larger solar power system for residential, commercial, or industrial use. When designing a solar power system, it's important to consider the voltage requirements of the devices or appliances you plan to power and properly size the solar panels, batteries, and other system components accordingly. It's also important to follow proper installation and safety guidelines when working with solar panels, as they generate DC electricity and can pose electrical hazards if not handled properly.

Fig 5.3 Solar panel

However, it is important to ensure that the system is designed and installed correctly to ensure safe and effective operation.

5.1.2.4 DC Exhaust Cooling Fan:

A DC exhaust cooling fan is a type of fan that operates on DC (direct current) power and is designed to exhaust hot air from an enclosed space. These fans are commonly used in a variety of applications, including solar dryers for fish or other food products.

DC exhaust fans are becoming increasingly popular due to their energy efficiency and potential for cost savings compared to traditional alternating current (AC) exhaust fans. DC motors are known for their high efficiency as shown in Fig 5.4, which means they can provide the same level of airflow while using less electricity compared to AC motors. This can result in lower electricity bills and reduced environmental impact.

Fig 5.4 DC Exhaust cooling fan

In a solar dryer for fish, a DC exhaust cooling fan can be used to exhaust hot air from the drying chamber, helping to maintain a consistent temperature and facilitate the drying process. The fan can be powered by a DC power source, such as a battery or solar panel. DC exhaust cooling fans are poweredby DC power sources, such as batteries or solar panels. They are commonly used in off-grid applications where AC (alternating current) power is not available.

5.1.2.5 Web-cam / Mobile:

A webcam can be used in a solar dryer for fish to monitor the stage of the drying process is shown in Fig 5.5. The webcam can be connected to a computer or other device that allows the user to view the drying chamberremotely. Using a webcam in a solar dryer for fish can provide a convenient and effective way to monitor the drying process remotely. This can help to ensure that the fish are dried to the desired stage and can help to reduce the need for frequent manual checks of the drying chamber. The webcam should be mounted securely in a location that provides a clear view of the drying chamber. It may be necessary to use a mount or bracket to position the webcam correctly.

Fig 5.5 Web-cam & Mobile

The webcam should be connected to a computer or other device that allows the user to view the images remotely. This can be done using a USB cable or wirelessly, depending on the webcam and the device being used. Specialized monitoring website can be used to capture and display images from the webcam. Using a webcam in a solar dryer for fish can provide a convenient and effective way to monitor the drying process remotely. This can help to ensure that the fish are dried to the desired stage and can help to reduce the need for frequent manual checks of the drying chamber.

5.1.2.6 Arduino:

Arduino Uno is a microcontroller board based on the ATmega328P microcontroller as shown in Fig 5.6. It is an open-source platform that can be used for a wide range of electronics projects, from simple LED blinking to more complex robotics projects. The Arduino Uno board is widely used in the maker community for a variety of projects, due to its versatility, ease of use, and open-source nature.

Fig 5.6 Arduino UNO

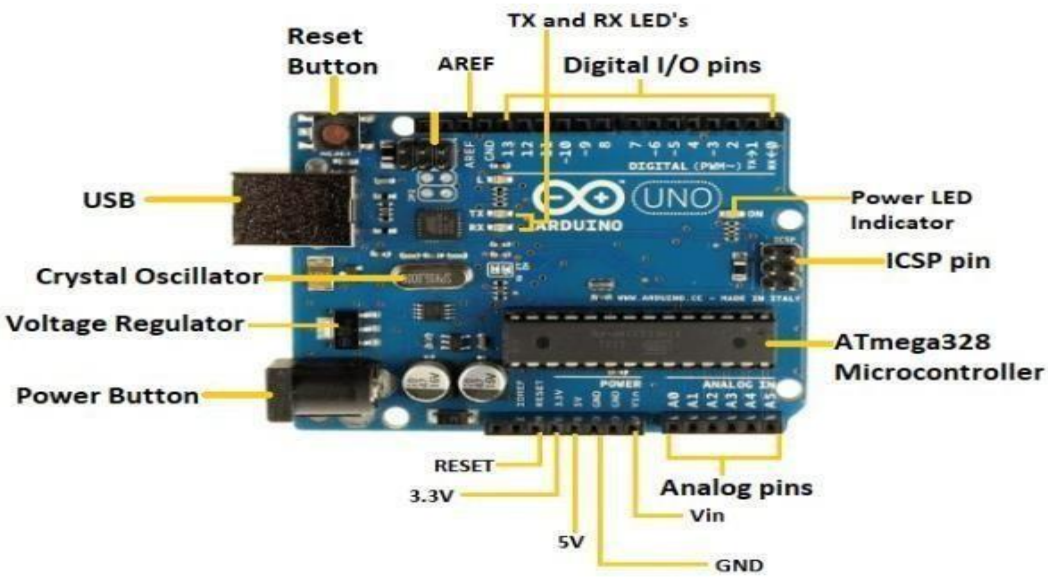


Fig 5.7 Arduino UNO pin diagram

. It can be programmed using a wide range of programming languages, including C,C++, and Python, and there are many libraries and examples available to help users get started with their projects. Arduino Uno can be used in a solar dryer for a variety of purposes, including monitoring and controlling various aspects of the drying process. Overall, using Arduino Uno in a solar dryer can help to improve the efficiency and accuracy of the drying process, resulting in better quality and more consistent dried products.You can ensure that the drying conditions are optimal for the products being dried. This can help to improve the quality and consistency of the dried products while also reducing the risk of spoilage or damage due to improper drying conditions.

5.1.2.7 Temperature and humidity sensor – DHT11 :

DHT11 is a low-cost, digital temperature and humidity sensor is shown in Fig 5.8. DHT11 sensor can be used in a solar dryer to monitor temperature and humidity levels during the fish drying process. It is commonly used in electronics projects and can be easily interfaced with micro-controllers like Arduino Uno. By using the DHT11 sensor to monitor temperature and humidity levels during the fish drying process, you can ensure that the fish are dried properly and reach the desired stage.

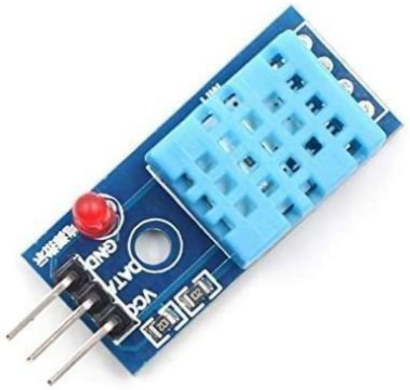


Fig 5.8 DHT-11 Sensor

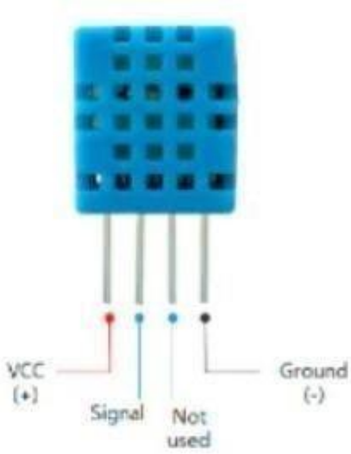


Fig 5.9 DHT-11 Sensor pin diagram

Monitor the temperature and humidity readings on the serial monitor to ensure that the drying conditions are optimal for the fish stage being dried. You can also set up alerts or notifications if the readings go outside the desired range. This can help to improve the quality and consistency of the dried fish while also reducing the risk of spoilage or damage due to improper drying conditions.

5.1.2.8 HC-05 Bluetooth module:

HC-05 is a popular Bluetooth module that can be used in a solar dryer to enable wireless communication with other devices like smartphones, tablets, or laptops is shown in Fig 5.10. It is a popular and inexpensive module that can be used in a wide range of applications, including robotics, home automation, and Internet of Things (IoT) projects. The HC-05 module can be easily interfaced with micro-controllers like Arduino, Raspberry Pi, or other micro-controllers using the serial interface.This allows the micro-controller to send and receive data wirelessly, which can be useful for remote control, data logging, or other applications. The HC-05 module typically operates on a voltage of 3.3V or 5V,

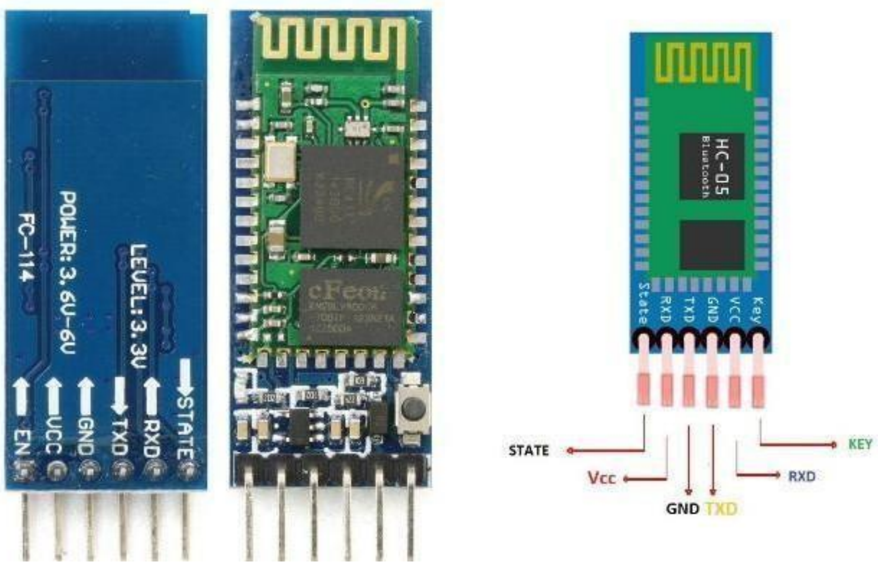


Fig 5.10 HC-05 Bluetooth module and its pin configuration

and it supports Bluetooth 2.0+EDR (Enhanced Data Rate) protocol. It has a range of up to 10 meters and can operate at a baud rate of up to 115200 bits per second.

5.1.3 Circuit diagram for temperature and humidity monitoring:

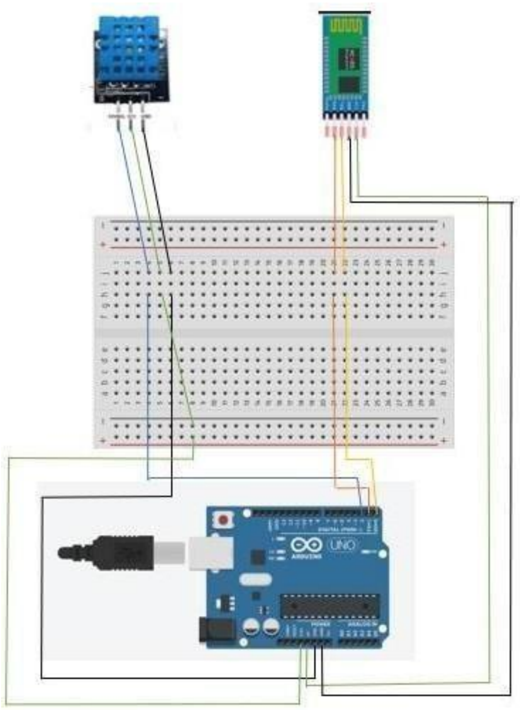


Fig 5.11 Circuit diagram

As shown in Fig.5.11 the circuit diagram of temperature and humidity monitoring had connected with the Arduino uno.

The signal pin form DHT-11 sensor were connected to the digital pin of 7,VCC and GND pins were connected with the 3.3V supply and GND ofArduino. RXD(Receive Data) from HC-05 Bluetooth module were connected with the Digital pin1.TXD(Transmit Data) were connected with 0 pin VCC were connected with 5V and GND were connected. When the Arduino is powered by any source it gets operate based upon the feed program to display the temperature and humidity through the app of “TX / RX Bluetooth serial monitoring”

The Arduino Uno with HC-05 and DHT-11 project is a simple and effective way to monitor temperature and humidity wirelessly. It is a great beginner-level project that teaches the basics of interfacing sensors with an Arduino board and using Bluetooth technology to transmit data wirelessly.

The project uses two main components: the DHT-11 sensor and the HC-05 Bluetooth module. The DHT-11 is a basic digital sensor that can measure temperature and humidity. It is relatively low-cost and easy to use, making it a popular choice for hobbyist projects. The HC-05 Bluetooth module is a small electronic component that allows you to wirelessly communicate with other devices. It can be used to send and receive data between the Arduino board and a smartphone, tablet, or computer.

The circuit diagram for this project is straightforward. The DHT-11sensor is connected to the Arduino board's digital pin 2, which is used to read the sensor's data. The HC-05 Bluetooth module is connected to the Arduino board's digital pins 9 and 10, which are used to transmit and receive datawirelessly. The module is also powered using the Arduino board's 5V and GND pins.

The software setup for this project involves installing two libraries: DHT.h and SoftwareSerial.h. These libraries provide the code necessary tocommunicate with the DHT-11 sensor and the HC-05 Bluetooth module. Once the libraries are installed, the Arduino code can be uploaded to the board. The code initializes the DHT-11 sensor and the HC-05 Bluetooth module and then continuously reads data from the sensor. If the sensor data is valid, the code sends the data wirelessly to the HC-05 Bluetooth module, which can then be received by another device.

This project has many practical applications. For example, it can be used to monitor the temperature and humidity in a greenhouse or indoor garden. It can also be used to monitor the temperature and humidity in a room, such as a baby's nursery, to ensure that the environment is comfortable and safe. Additionally, the project can be used to develop more advanced applications, such as creating a mobile app to monitor and control the temperature andhumidity remotely.

In conclusion, the Arduino Uno with HC-05 and DHT-11 project is a great beginner-level project that teaches the basics of interfacing sensors with an Arduino board and using Bluetooth technology to transmit data wirelessly. It is a simple and effective way to monitor temperature and humidity wirelessly and has many practical applications. By following the circuit diagram andsoftware setup instructions, anyone can build this project and use it for a variety of application.

5.1.4 Mathematical models and formulation:

5.1.4.1 Basic theory(formulations)

Some important formulae used are given as follows:

1. **Dryer efficiency(ηd) : Dryer efficiency** is the ratio of **collection efficiency (ηc)** and the **system efficiency (ηs).**

   $(\eta c) = Qu/ AcIs$

   Where, $Qu= mCp\Delta t$ Ac = collector surface area,

   Is = Insulation on tilted surface

   Efficiency $(\eta s) = WL / AcIs$

   Where, W= mass of moisture evapourated.

   L= latent heat of evapouration in the dryer temperature.

2. **Determination of moisture content :**

$$Mwb = (Mi - Md)/ Mi \times 100$$

Where, Mwb = moisture on wet basis

Mi= initial mass of the sample

Md= final mass of the sample

5.2 WORKING SOFTWARE

The values of temperature and humidity monitoring in the solar dryer fabrication can be monitored by the software called **"TX / RX Bluetooth serial monitor"** and the image recognition obtained by the camera which was connected to the device to identify the stage of fish can be valued and display the stage of fish below the monitoring display of "**TEACHABLE MACHINE"** website where we feeded the dataset of fish.

5.3. MACHINE LEARNING:

5.3.1 Deep Neural Network(DNN)

A deep neural network is a type of artificial neural network that has multiple layers between the input and output layers. These layers are composed of interconnected nodes, also called neurons, that process and transform input data to generate output predictions.

Deep neural networks are used in a wide range of applications, including image recognition, speech recognition, natural language processing, and robotics, among others. They are capable of learning complex relationships and patterns in the data by using multiple layers of nonlinear transformations.

The architecture of a deep neural network typically consists of an input layer, one or more hidden layers, and an output layer. Each layer contains multiple neurons that apply a mathematical function to the input data to generate an output value. The output from each neuron is passed through an activation function, which adds a nonlinear element to the network's calculations.

The most commonly used activation functions in deep neural networks are the rectified linear unit (ReLU) and the sigmoid function. The ReLU function is used to introduce nonlinearity into the network and has been foundto improve the speed and accuracy of deep neural networks. Training a deep neural network involves iteratively adjusting the weights and biases of theconnections between neurons to minimize the difference between the predicted output and the actual output.

This is done using an optimization algorithm, such as gradient descent, which adjusts the weights and biases in the direction of the steepest descent of the loss function. Overall, deep neural networks are a powerful tool for solving complex machine learning problems, and their flexibility and versatility make them suitable for a wide range of applications. However, they require a large amount of data and computing power to train effectively, and their high complexity can make them challenging to interpret and debug.

5.3.2 Tensor flow JS

TensorFlow.js is the JavaScript version of TensorFlow, which enables the training and deployment of machine learning models directly in the browser or on Node.js servers. It provides a simple and flexible platform for building and deploying machine learning models in web applications. Teachable Machine also provides support for TensorFlow.js, allowing users to create custom machine learning models directly in their web browser.

This enables users to train and deploy their models without needing to install any software or use complex programming tools.with Teachable Machine and TensorFlow.js, users can create custom models for a wide range of tasks, including image classification, object detection, and pose estimation.

They can train their models by providing examples of what they want the model to recognize or detect, and then export the model for use in their web applications.

Teachable Machine provides a user-friendly interface for training models and provides visual feedback on the quality of the model's predictions. Once the model is trained, it can be exported as a TensorFlow.js model that can be used in a variety of web applications, including websites, mobile apps, and games.

By using TensorFlow.js as its underlying technology, Teachable Machine makes it easy for users to integrate machine learning models into their web applications, opening up new possibilities for interactive and engaging experiences.

5.3.3 Convolutional Neural Network

A convolutional neural network (CNN) is a type of deep learning neural network that is commonly used for image recognition and classification tasks. It is designed to automatically learn and extract features from images, making it particularly useful for tasks such as object detection, facial recognition, and medical image analysis.

A CNN works by using a series of convolutional layers to scan an input image, detecting and extracting important features at each layer. These convolutional layers consist of a set of filters that are convolved across the input image, creating a set of feature maps that highlight important regions of the image.

After the convolutional layers, a series of pooling layers are used to reduce the dimensionality of the feature maps, making them more manageable and easier to process. This down sampling process helps to prevent overfitting and improves the computational efficiency of the network.

Finally, a set of fully connected layers are used to classify the image based on the features that have been extracted in the convolutional and pooling layers. These layers combine the features into a single vector and use it to make a prediction about the class of the input image.

The training process for a CNN involves adjusting the weights and biases of the network so that it can accurately classify images based on their features. This is typically done using a large dataset of labeled images and an optimization algorithm such as stochastic gradient descent.

CNNs have proven to be highly effective for a wide range of image recognition and classification tasks, and are widely used in industry and research.

5.3.3.1 Flow chart of Convolutional Neural Network

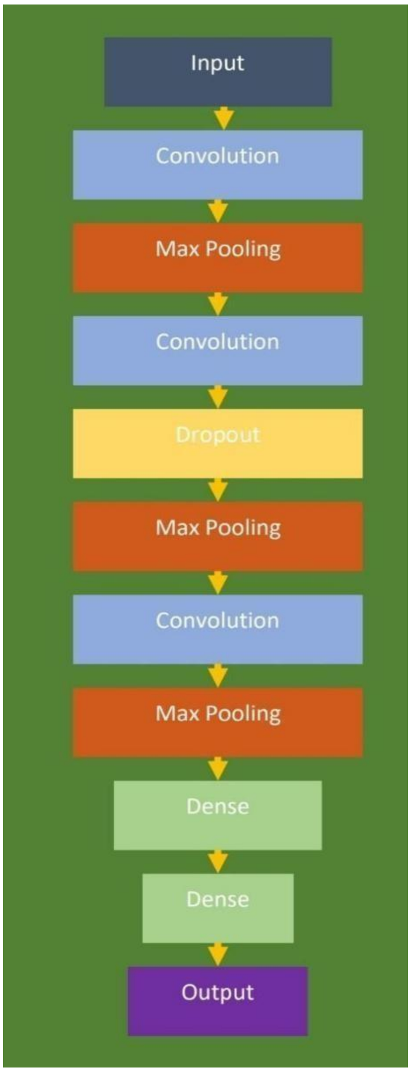


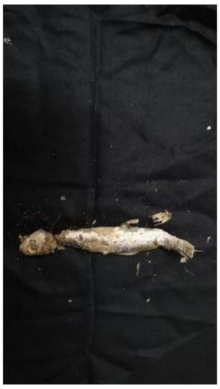
Fig 5.12 Convolutional Neural Network Architecture

Types of CNN Models:

- LeNet
- AlexNet
- ResNet
- GoogleNet
- MobileNetV1
- ZfNet

5.4 SAMPLE IMAGES OF ANCHOVY FISH:

Tab.1.1 Stages of fish

FRESH STAGE FISH			
PROCESSING STAGE FISH			
DRIED STAGE FISH			

5.5 SAMPLE OUTPUTS OF ANCHOVY FISH USING MACHINE LEARNING BY IMAGE PROCESSING:

5.5.1 By using fresh stage of fish:

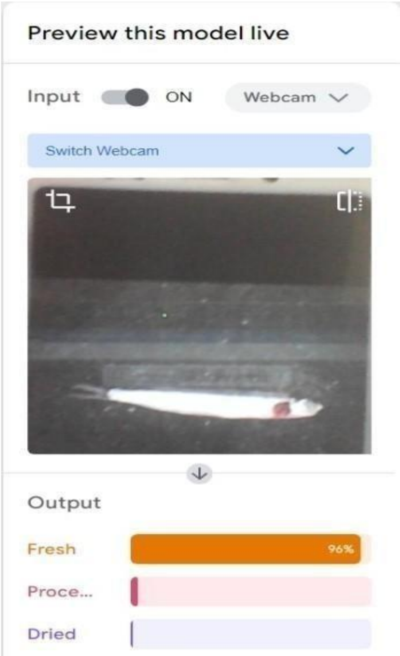


Fig 8.1 Fresh stage fish

5.5.2 By using processing stage of fish:

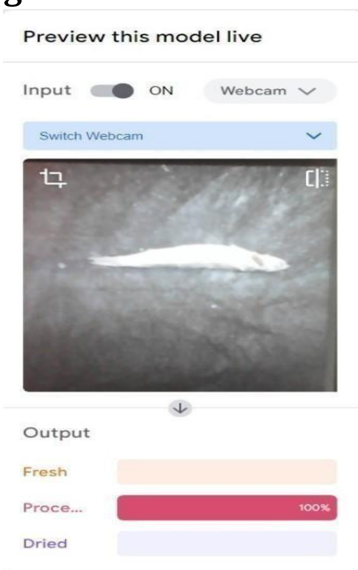


Fig 8.2 Processing stage fish

5.5.3 By using dried stage of fish:

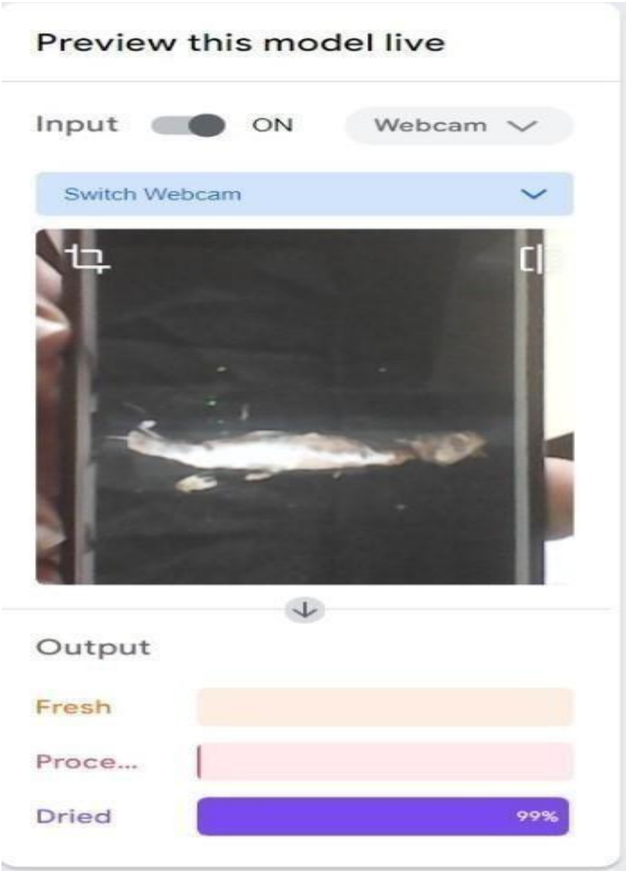


Fig 8.3 Dried stage fish

5.5 RESULT OF HARDWARE CONNECTIONS:

Fig 8.4 Hardware output

The above output will be monitored in “TX / RX Bluetooth serial monitoring” software.When the temperature gets vary the changed value will be display in the software.

5.6 WORKING HARDWARE

The DHT-11 and HC-05 Bluetooth module were used in the solar dryer to find the temperature and humidity of fabrication.DHT-11 sensor is used to find the level of temperature and humidity inside the fabrication of solar dryer and the Bluetooth module of HC-05 is used to transmit the data of temperature and humidity inside fabrication of solar dryer.

5.6.1 Hardware connections of DHT-11 and HC-05 with arduino:

In Fig 5.13 Circuit connection of temperature and humidity sensor of DHT-11 and HC-05 bluetooth module were connected with the Arduino Uno board with breadboard connection.Once the hardware connections are made, you can upload the Arduino code to read temperature and humidity data from the DHT-11 sensor and send it over Bluetooth using the HC-05 module. You can then use a Bluetooth terminal app on your smartphone or any other Bluetooth-enabled device to receive and display the temperature and humidity data sent by the Arduino wirelessly.

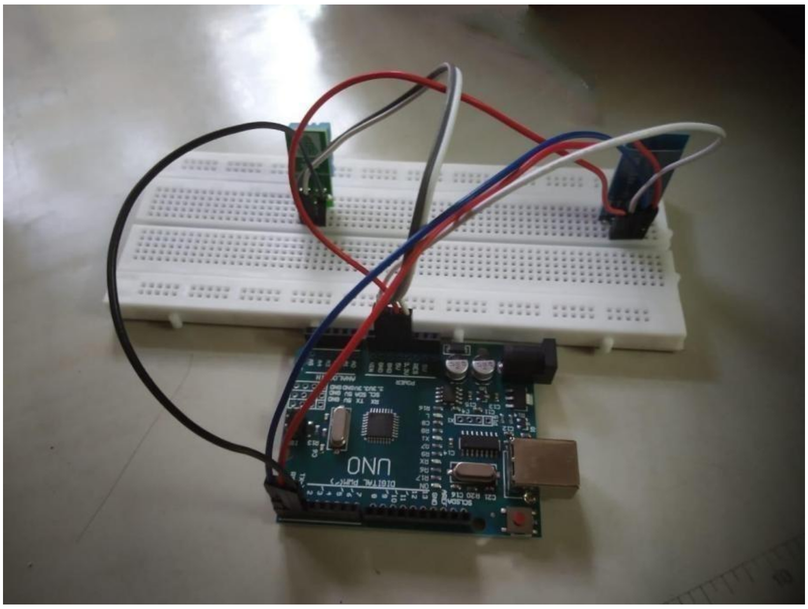


Fig 5.13 Circuit connection

5.7 TABLE OF OBSERVATION:

Here is an example of an observation table for dry fishes in a solar dryer:

Tab.1.2 Observation table

Fish species	**Initial weight (kg)**	**Final weight (kg)**	**Drying time (days)**	**Moisture content (%)**
Sardines	10	5	3	10
Mackerel	8	4	4	12
Anchovies	6	3	5	8
Tilapia	12	6	2	6

In this Tab. 1.2, we have recorded the date of observation, the fish species, the initial weight of the fish before drying, the final weight of the dried fish, the drying time in days, and the moisture content of the dried fish. The data in this table can be used to monitor the drying process and ensure that the fish are properly dried before storage or consumption. The moisture content of the dried fish is an important indicator of its quality and can be used to determine the shelf life of the product.

CONCLUSION & FUTURE SCOPE

In conclusion, the design and fabrication of a solar dryer for drying fish using machine learning is a promising application of emerging technologies. The use of machine learning algorithms can improve the performance andefficiency of the drying process, enabling better control over variables such as temperature and humidity. The solar dryer design makes use of renewableenergy sources, making it an environmentally friendly and sustainable solution. The use of the solar dryer can improve the quality and shelf-life of dried fish, which can benefit the fishing industry and local communities. Overall, this project demonstrates the potential of combining innovative technologies to address real-world challenges in a sustainable and effective manner. The integration of machine learning techniques in the design and fabrication of a solar dryer for drying fish has shown promising results and has significant potential for further research and development. This project encompasses optimization of machine learning algorithms, integration of sensor technology, scalability and commercialization, energy storage and hybrid drying systems, and sustainable and eco-friendly drying practices. Further advancements in this field can revolutionize the fish drying industry by improving the efficiency, quality, and sustainability of the drying process.

The future scope of this project is vast and holds great potential. Some potential areas for further research and development include: Optimization of machine learning algorithms: Further optimization and refinement of the machine learning algorithms used in the solar dryer system can lead to improved performance and accuracy in predicting drying conditions, resultingin better control over the drying process and enhanced product quality. Integration of sensor technology: Integration of advanced sensor technology, such as temperature, humidity, and moisture sensors, can provide real-time data on the drying conditions, which can be used to further enhance the machine learning models and improve the efficiency of the drying process. Scalability and commercialization: Exploring the scalability and commercialization potential of the solar dryer system with machine learning can lead to widespreadadoption of this technology in the fish drying industry. Further research can focus on cost-effective fabrication techniques, durability, and ease of maintenance for large-scale commercial production. Energy storage and hybrid drying systems: Incorporating energy storage technologies, such as batteries or thermal storage, can enable the solar dryer system to operate during non-sunny periods, ensuring continuous drying operations. Additionally, hybrid dryingsystems that combine solar drying with other drying methods, such as convective or microwave drying, can be explored to further improve the drying efficiency and product quality. Sustainable and eco-friendly drying: Future research can focus on making the solar dryer system more sustainable and eco- friendly by using recyclable materials, minimizing energy consumption, and reducing greenhouse gas emissions. This can help in addressing environmental concerns and promoting sustainable fish drying practices.

REFERENCES

[1] Abhijith K. S., Ananthakrishnan V. V., Ashok, K. S., Aswin T. A., Das J. and Varghese C. A.,(2020) "MODELLING AND ANALYSIS OF AN EFFICIENT SOLAR DRYER," International Conference on Futuristic Technologies in Control Systems & Renewable Energy (ICFCR), Malappuram, India, pp. 1-6, doi: 10.1109/ICFCR50903.2020.9249976.

[2] Anugrah Soy, (2016)"PROJECT REPORT ON SOLAR DRYER," https://www.slideshare.net/AnugrahSoy1/project-report-on-solar- dryer (accessed Apr. 05, 2023).

[3] Aoki H.(2001), "Development of drying technology utilizing solar energy to dry agricultural and marine products," Proceedings Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Tokyo, Japan,, pp. 470-, doi: 10.1109/ECODIM.2001.992401.

[4] BOOK Abdulrazzak, Ibtihaj Abdulwahhab Abdulrazzak Bierk, Hussain Ahmed, Luma (2018) "Humidity and temperature monitoring" 10.14419/ijet.v7i4.23225

[5] A. M. El-jummah,(2023) "PERFORMANCE EVALUATION OF SOLAR FISHDRYER,"*www.academia.edu*,.[Online].Available: https://www.academia.edu/28613180/PERFORMANCE_EVALUATION_OF_SOLAR_FISH_DRYER

[6] JOUR Regupathi Er.R, Balasubramanian.S.(2018) 2347 4793A STUDYON SOLAR DRYING SYSTEM FOR FISH PRESERVATION.

[7] Nalini K.,(1998) *Performance Evaluation of Low Cost Solar Dryer in the Preservation of Fish, Prawns and Meat*.

[8] Nair V., Nalawade V., Patil P. and Sahu R.,(2021) "IoT Based SolarEnergy Dryer," IEEE Pune Section International Conference (PuneCon), Pune,India, pp. 1-6, doi: 10.1109/PuneCon52575.2021.9686527.

[9] Nguyen Vu Lan,(2017) "Improvement of conventional solar drying system,"International Conference on System Science and Engineering (ICSSE), Ho Chi Minh City, Vietnam, pp. 690-693, doi: 10.1109/ICSSE.2017.8030964.

[10] Arifianti Q. A. M. O., Khoiro Ummatin K. , Nugrahani E. F., Pratiwi N. A. and (2018), "Experimental Analysis of Solar Cabinet Dryer for Fish Processing in Gresik, Indonesia," International Conference and Utility Exhibition on Green Energy for Sustainable Development (ICUE), Phuket, Thailand, pp. 1-5, doi: 10.23919/ICUE- GESD.2018.8635737.

[11] Sotocinal S. A. ,(2023) "Design and testing of a natural convection solar fishdryer,"*escholarship.mcgill.ca*.https://escholarship.mcgill.ca/concern/theses/rv042v04n .

[12] Buchinger, J. and Weiss, W.(2003) Solar Drying: Establishment of a Production Sales and Consulting Infrastructure for Solar Thermal Plants in Zimbabwe Arbeitsgemeinschaft Erneuerbare Energie(AEE) of the Institute for Sustainable Technologies, Austria.

APPENDIX

8.1 PROGRAM OF TEMPERATURE AND HUMIDITY MONITORING FOR ARDUINO:

```
#include <DHT.h>

#include <DHT_U.h>

#include <SoftwareSerial.h>



#define DHTPIN 2

#define DHTTYPE DHT11



SoftwareSerial BTSerial(10, 11); // RX | TX

DHT dht(DHTPIN, DHTTYPE);



void setup()

  { Serial.begin(9600);

  BTSerial.begin(9600);

  dht.begin();

}



void loop() {
```

```
  delay(2000);

  float h = dht.readHumidity();
  float t = dht.readTemperature();
  if (isnan(h) || isnan(t)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.print(" °C, Humidity: ");
  Serial.print(h);
  Serial.println(" %");

  BTSerial.print("Temperature: ");
  BTSerial.print(t);
  BTSerial.print(" °C, Humidity: ");
  BTSerial.print(h);
  BTSerial.println(" %");
}
```

This project uses an Arduino Uno board, a DHT11 temperature and humidity sensor, and an HC-05 Bluetooth module to wirelessly transmit the temperature and humidity data.

The DHT11 sensor is connected to the digital pin 2 of the Arduino board, and the HC-05 Bluetooth module is connected to the digital pins 9 and 10 of the Arduino board. The DHT11 sensor is used to measure the temperature and humidity of the environment and sends the data to the Arduino board.

The Arduino board reads the temperature and humidity data from the DHT11 sensor and stores it in variables 't' and 'h'. The 'isnan' function checks if the values are valid, and if not, the code prints an error message and returns.

If the sensor data is valid, the code sends the temperature and humidity data wirelessly to the HC-05 Bluetooth module using the 'HC05.print' function. The data is also printed on the serial monitor using the 'Serial.print' function. A delay of 2000ms is added before the next iteration of the loop to avoid flooding the serial monitor with data.

Overall, this project enables users to monitor the temperature and humidity of the environment remotely without having to physically check the sensor readings. This can be useful in various applications, including indoor gardening,weather monitoring, and HVAC system